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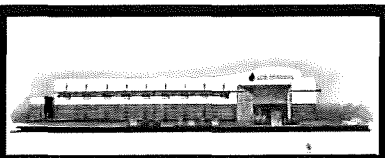
RELATIVE ACCURACY TEST AUDIT FOR THE GENERAL ELECTRIC, COMBUSTION TURBINE, UNIT #CTG1 CEMS PREPARED FOR INDECK NILES, LLC AT THE INDECK NILES ENERGY CENTER NILES, MICHIGAN JUNE 22, 2022

Permit to Install: 75-16B
Report Date: July 1, 2022

N6921-test_20220622(2)



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RELATIVE ACCURACY TEST AUDIT
FOR THE
GENERAL ELECTRIC, COMBUSTION TURBINE,
UNIT #CTG1 CEMS
PREPARED FOR
INDECK NILES, LLC
AT THE
INDECK NILES ENERGY CENTER
NILES, MICHIGAN
JUNE 22, 2022

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I,
Cole McBride, QSTI
Sr. Project Manager
certify that this testing was conducted and this report was created in conformance with the requirements of ASTM D7036

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CERTIFICATION OF INFORMATION

I certify under penalty of law that I believe the information provided in this document is true, accurate and complete. I am aware that there are significant civil and criminal penalties, including the possibility of fine or imprisonment or both, for submitting false, inaccurate or incomplete information.

Cole McBride, QSTI
Sr. Project Manager
Air Hygiene International, Inc.

July 4, 2022
Date

FACILITY CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attached documents and, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant civil and criminal penalties, including the possibility of fine or imprisonment or both, for submitting false, inaccurate or incomplete information.

I am the responsible official with direct knowledge and overall responsibility for the information contained in this report.

Thomas Krysiak
Name

Environmental, Health & Safety Manager
Title

Signature

7/19/2022
Date

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Relative Accuracy Test Audit
General Electric, Combustion Turbine, Unit #CTG1 CEMS
Indeck Niles, LLC
Indeck Niles Energy Center
Niles, Michigan
June 22, 2022

1.0 INTRODUCTION

Air Hygiene International, Inc. (Air Hygiene) has completed the Relative Accuracy Test Audit (RATA) for nitrogen oxides (NOx), carbon monoxide (CO), and oxygen (O_2) from the exhaust of the General Electric, Combustion Turbine, Unit #CTG1 for Indeck Niles, LLC at the Indeck Niles Energy Center in Niles, Michigan. This report details the background, results, process description, and the sampling/analysis methodology of the stack sampling survey conducted on June 22, 2022.

The accumulated data from the RATA provides the figures for evaluating the acceptability of the operation of the on-site continuous emission monitoring system (CEMS) for the monitoring of NOx, CO, and O_2 from the General Electric, Combustion Turbine, Unit #CTG1 for Indeck Niles, LLC at the Indeck Niles Energy Center in Niles, Michigan.

1.1 TEST PURPOSE AND OBJECTIVES

The purpose of the test was to perform the initial certification RATA on the CEMS that serves the General Electric, Combustion Turbine, Unit #CTG1 for Indeck Niles, LLC at the Indeck Niles Energy Center in Niles, Michigan. Reference method (RM) testing followed the Code of Federal Regulations (CFR), Title 40 (40 CFR), Part 60 (40 CFR 60), Appendix A, Methods 1, 3A, 7E, 10, and 19. RM values are compared with the on-site CEMS to document performance as required in the 40 CFR 60, Appendix B, Performance Specifications (PS) and 40 CFR 75 Appendix A and B. All relative accuracies were established on-site and were governed by the following sets of rules:

In accordance with 40 CFR 60, Appendix B, PS 2, Section 13.2, the NOx RATA results are acceptable if the relative accuracy (RA) does not exceed 20.0 percent when average emissions during the test are greater than 50 percent of the emission standard or alternative relative accuracy (ARA) does not exceed 10.0 percent when the average emissions during the test are less than 50 percent of the emission standard. Part 60 further requires that the unit be operating at greater than 50 percent of normal load.

In accordance with 40 CFR 75, Appendix A, Section 3.3.2(a) and (b), the NOx RATA results are acceptable if the relative accuracy (RA) does not exceed 10.0 percent or if during the RATA the average NOx emission rate is less than or equal to 0.200 lb/MMBtu and the average difference between the CEMS and reference method (RM) values does not exceed 0.020 lb/MMBtu. Passing this set of criteria requires the CEMS to be retested after no more than two operating quarters. Alternatively, in accordance with 40 CFR 75, Appendix B, Section 2.3.1.2(a) and (f), and Appendix B, Figure 2, the NOx RATA results are acceptable if the RA does not exceed 7.5 percent or if during the RATA the average NOx emission rate is less than or equal to 0.200 lb/MMBtu and the average difference between the CEMS and RM values does not exceed 0.015 lb/MMBtu. Passing this set of criteria allows the CEMS to be retested after four operating quarters or at least within eight calendar quarters.

In accordance with 40 CFR 60, Appendix B, PS 3, Section 13.2, the O_2 RATA results are acceptable if the relative accuracy (RA) does not exceed 20.0 percent or if the average difference between the CEMS and reference method (RM) values does not exceed plus or minus 1.0 percent of the measured value.

In accordance with 40 CFR 60, Appendix B, PS 4 and 4A, Sections 13.2 of each, the CO relative accuracy (RA) test results are acceptable if the RA does not exceed 10.0 percent, if the average difference between the CEMS and reference method (RM) values plus the 2.5 percent confidence coefficient (2.5%CC) does not exceed 5.0 parts per million (ppm), or if the alternative relative accuracy (ARA) does not exceed 5.0 percent. Part 60 further requires that the unit be operating at greater than 50 percent of normal load.

1.2 SUMMARY OF TEST PROGRAM

The following list details pertinent information related to this specific project:

1.2.1 Participating Organizations
- Michigan Department of Environment, Great Lakes, and Energy (EGLE)
- Indeck Niles, LLC
- Kiewit Corporation
- Air Hygiene

1.2.2 Industry
- Electric Utility / Electric Services

1.2.3 Air Permit and Federal Requirements
- Permit Number: 75-16B
- 40 CFR 60, Appendix B, Performance Specifications (PS)
- 40 CFR 75, Appendix A and B

1.2.4 Plant Location
- Indeck Niles Energy Center in Niles, Michigan
  - GPS Coordinates [Latitude 41.85831, Longitude -86.22417]
  - Physical Address: 2200 Progressive Dr., Niles, Michigan 49120
  - Federal Registry System / Facility Registry Service (FRS) No. – 110017413985
  - Source Classification Code (SCC) – 20100201

1.2.5 Equipment Tested
- General Electric, Combustion Turbine, Unit #CTG1
  - NOx Analyzer (Thermo 42IQLS-ABBNN, Serial No. 1201697936)
  - CO Analyzer (Thermo 48IQ-ABC, Serial No. 1201697932)
  - O_2 Analyzer (Thermo 48IQ-ABC, Serial No. 1201697932)

1.2.6 Emission Points
- Exhaust from the General Electric, Combustion Turbine, Unit #CTG1
- For all gases, one sample point in the exhaust duct from the General Electric, Combustion Turbine, Unit #CTG1, determined after conducting a stratification test

1.2.7 Emission Parameters Measured
- NOx
- CO
- O_2

1.2.8 Date of Emission Test
- June 22, 2022

1.2.9 Federal Certifications
- Stack Testing Accreditation Council AETB Certificate No. 3796.02
- International Standard ISO/IEC 17025:2005 Certificate No. 3796.01

1.3 KEY PERSONNEL

Indeck Niles, LLC:	Tom Krysiak (tkrysiak@indeckenergy.com)	716-225-6478
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Air Hygiene:	Harold Jones	918-307-8865
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Air Hygiene:	Trevor Thompson	918-307-8865
Air Hygiene:	Sean Barnes	918-307-8865

2.0 SUMMARY OF TEST RESULTS

Results from the sampling conducted on Indeck Niles, LLC's General Electric, Combustion Turbine, Unit #CTG1 located at the Indeck Niles Energy Center on June 22, 2022 are summarized in the following table and relate only to the items tested.

The RATA passed for all pollutants (NOx, CO, and O_2) in all units (ppmvd, ppmvd@15%O_2, lb/hr, lb/MMBtu, and %vd) under all 40 CFR 60 and 40 CFR 75 criteria.

Specifically, NOx in units of ppmvd, ppmvd@15%O_2, and lb/hr, passed 40 CFR 60 criteria with RAs less than 20 percent. NOx in units of lb/MMBtu passed the 40 CFR 75 annual incentive criteria with a RA less than 7.5 percent. Also, the Bias Adjustment Factor test passed with an adjustment factor equal to 1.0 (no adjustment required). O_2 in units of %vd passed the 40 CFR 60 criteria with a RA less than 20 percent. CO in units of ppmvd passed the 40 CFR 60 alternative criteria with a concentration difference between the RM and CEMS analyzers plus the confidence coefficient of less than 5 ppm. CO in units of ppmvd@15%O_2 and lb/hr passed the 40 CFR 60 alternative criteria with ARAs less than 5 percent, based on the CO permit limit in the same units.

Unit load was within the 40 CFR 60 required criteria of greater than 50 percent of the maximum load and also fell within the normal or secondary normal load criteria as defined by the plants Quality Control and Monitoring Plan which defined the upper and lower boundary on the unit and the normal and secondary normal load ranges.

The results of all measured pollutant emissions were below the required limits. All testing was performed without any real or apparent errors. All testing was conducted according to the approved testing protocol.

TABLE 2.1
SUMMARY OF GENERAL ELECTRIC, COMBUSTION TURBINE, UNIT #CTG1 RATA RESULTS

Pollutant	Units	Criteria			Results	Passed / Test Frequency
		CFR	Specification / Section	Standard		
NOx	ppmvd	Part 60	Appendix B, Performance Specification 2, Section 13.2	RA ≤ 20%, or ARA ≤ 10%	RA = 4.49%	YES / ANNUAL
NOx	ppmvd@15%O_2	Part 60	Appendix B, Performance Specification 2, Section 13.2	RA ≤ 20%, or ARA ≤ 10%	RA = 5.08%	YES / ANNUAL
NOx	lb/hr	Part 60	Appendix B, Performance Specification 2, Section 13.2	RA ≤ 20%, or ARA ≤ 10%	RA = 6.57%	YES / ANNUAL
NOx	lb/MMBtu	Part 75	Appendix A, Section 3.3.2(a),(b) Appendix B, Section 2.3.1.2(a),(f), Figure 2	RA ≤ 10%, or if lb/MMBtu ≤ 0.200, d ≤ ±0.020 lb/MMBtu Annual Incentive RA ≤ 7.5%, or if lb/MMBtu ≤ 0.2, d ≤ ±0.015 lb/MMBtu	RA = 6.01% BAF=1.000	YES / ANNUAL
O_2	%vd	Part 60	Appendix B, Performance Specification 3, Section 13.2	RA ≤ 20%, or d ≤ ±1.0%	RA = 0.59%	YES / ANNUAL
CO	ppmvd	Part 60	Appendix B, Performance Specification 4, 4A, from all Section 13.2	RA ≤ 10%, or d + 2.5% CC ≤ ±5 ppmv, or ARA ≤ 5%	|d|+2.5%CC = 0.1 ppm	YES / ANNUAL
CO	ppmvd@15%O_2	Part 60	Appendix B, Performance Specification 4, 4A, from all Section 13.2	RA ≤ 10%, or d + 2.5% CC ≤ ±5 ppmv, or ARA ≤ 5%	ARA = 0.92%	YES / ANNUAL
CO	lb/hr	Part 60	Appendix B, Performance Specification 4, 4A Section 13.2	RA ≤ 10%, or d + 2.5% CC ≤ ±5 ppmv, or ARA ≤ 5%	ARA = 1.51%	YES / ANNUAL
Load	MW	Part 60	Appendix B, Performance Specifications	> 50% max load	546.4	WITHIN TOLERANCE
Load	MW	Part 75	Appendix A and B	normal or secondary normal load range	546.4	WITHIN TOLERANCE

Notes: Changes pending confirmation of CEMS data, RA = relative accuracy, ARA = alternative relative accuracy, RM = reference method value, d = difference between RM and CEMS value, CC = confidence coefficient, BAF = bias adjustment factor

kie-22-niles.mi-start#1-CTG1-RATA-rpt

3.0 SOURCE OPERATION

3.1 PROCESS DESCRIPTION

Indeck Niles, LLC owns and operates the Indeck Niles Energy Center located at 2200 Progressive Dr., in Niles, Michigan. The facility includes two combined-cycle natural gas fired combustion turbine generators (CTGs). The two CTGS are rated at 3,651 million British thermal unit per hour (MMBtu/hr) and are coupled with heat recovery steam generators (HRSG) in a two-on-one configuration with a steam turbine generator. Each HRSG is equipped with a natural gas-fired duct burner rated at 71 MMBtu/hr to provide heat for additional steam production. The HRSGs are not capable of operating independently from each CTG. Each CTG/HRSG is equipped with dry low NOx burners (DLNB), selective catalytic reduction (SCR), and an oxidation catalyst.

3.2 SAMPLING LOCATION

The stacks are vertical, circular, and measure 21.7 feet (ft) (260 inches) in diameter at the test ports which are approximately 159 ft above grade level with an exit elevation of approximately 170 ft above grade level. The test ports are located approximately 55.2 ft (662 inches) [2.5 dia] downstream and approximately 11 ft (132 inches) [0.5 dia] upstream from the nearest disturbances. Air Hygiene has field verified the measurable dimensions. Non-field verified dimensions are provided by Indeck Niles, LLC. All exhaust samples for gaseous emissions were continuously drawn from the exhaust system at the sample ports from a single point determined after conducting a stratification test. During the stratification test three points were traversed from each of the four ports. The probe was allowed to remain at a point for at least two times the system response time.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

4.1 TEST METHODS

The emission test on the General Electric, Combustion Turbine, Unit #CTG1 at the Indeck Niles Energy Center was performed following United States Environmental Protection Agency (EPA) methods described by the Code of Federal Regulations (CFR). Table 4.1 outlines the specific methods performed on June 22, 2022.

TABLE 4.1
SUMMARY OF SAMPLING METHODS

Pollutant or Parameter	Sampling Method	Analysis Method
Sample Point Location	EPA Method 1	Equal Area Method
Oxygen	EPA Method 3A	Paramagnetic Cell
Nitrogen Oxides	EPA Method 7E	Chemiluminescent Analyzer
Carbon Monoxide	EPA Method 10	Nondispersive Infrared Analyzer
Stack Flow Rate	EPA Method 19	Dry Oxygen F Factor

4.2 INSTRUMENT CONFIGURATION AND OPERATIONS FOR GAS ANALYSIS

The sampling and analysis procedures used during these tests conform with the methods outlined in the Code of Federal Regulations (CFR), Title 40, Part 60, Appendix A, Methods 1, 3A, 7E, 10, and 19.

Figure 4.1 depicts the sample system used for the real-time gas analyzer tests. The gas sample was continuously pulled through the probe and transported, via heat-traced Teflon® tubing, to a stainless-steel minimum-contact condenser designed to dry the sample. Transportation of the sample, through Teflon® tubing, continued into the sample manifold within the mobile laboratory via a stainless steel/Teflon® diaphragm pump. From the manifold, the sample was partitioned to the real-time analyzers through rotameters that controlled the flow rate of the sample.

Figure 4.1 shows that the sample system was also equipped with a separate path through which a calibration gas could be delivered to the probe and back through the entire sampling system. This allowed for convenient performance of system bias checks as required by the testing methods.

All instruments were housed in a climate controlled, trailer-mounted mobile laboratory. Gaseous calibration standards were provided in aluminum cylinders with the concentrations certified by the vendor. EPA Protocol No. 1 was used to determine the cylinder concentrations where applicable (i.e., NOx calibration gases).

Table 4.2 provides a description of the analyzers used for the instrument portion of the tests. All data from the continuous monitoring instruments were recorded on a Logic Beach Portable Data Logging System which retrieves calibrated electronic data from each instrument every one second and reports an average of the collected data every 30 seconds.

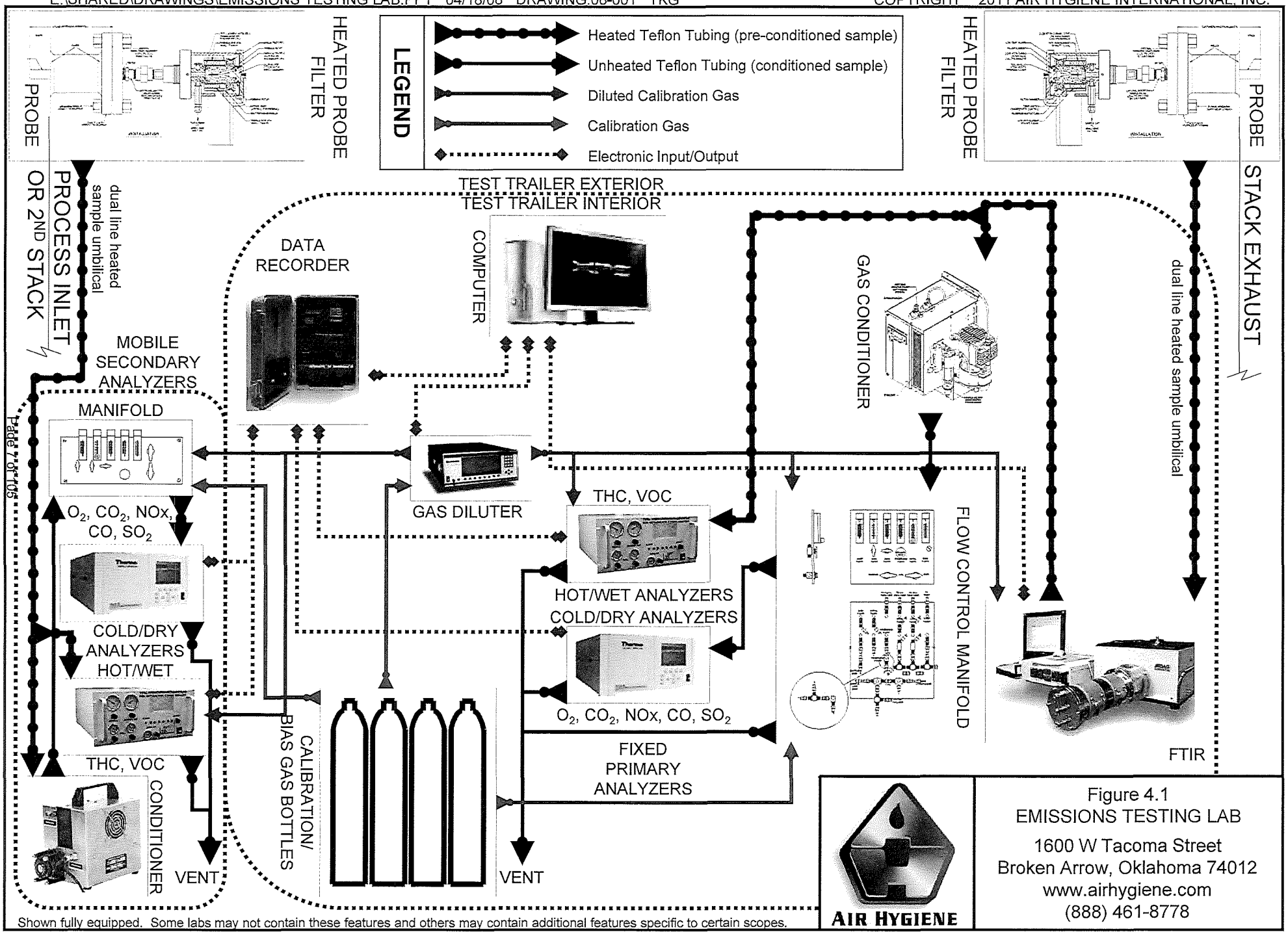
The stack gas analysis for O_2 concentrations was performed in accordance with procedures set forth in EPA Method 3A. The O_2 analyzer uses a paramagnetic cell detector.

EPA Method 7E was used to determine concentrations of NOx. A chemiluminescent analyzer was used to determine the nitrogen oxides concentration in the gas stream. A NO_2 in nitrogen certified gas cylinder was used to verify at least a 90 percent NO_2 conversion on the day of the test.

CO emission concentrations were quantified in accordance with procedures set forth in EPA Method 10. A continuous nondispersive infrared (NDIR) analyzer was used for this purpose.

TABLE 4.2
ANALYTICAL INSTRUMENTATION

Parameter	Manufacturer and Model	Range	Sensitivity	Detection Principle
NOx	THERMO 42 series	User may select up to 5,000 ppm	0.1 ppm	Thermal reduction of NO_2 to NO. Chemiluminescence of reaction of NO with O_3. Detection by PMT. Inherently linear for listed ranges.
CO	THERMO 48 series	User may select up to 10,000 ppm	0.1 ppm	Infrared absorption, gas filter correlation detector, microprocessor-based linearization.
O_2	SERVOMEX 1440	0-25%	0.1%	Paramagnetic cell, inherently linear.



Shown fully equipped. Some labs may not contain these features and others may contain additional features specific to certain scopes.

AIR HYGIENE

Figure 4.1
EMISSIONS TESTING LAB

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APPENDIX A

TEST RESULTS AND CALCULATIONS

TABLE A.1:
EMISSIONS TESTING SCHEDULE

Unit	Load	Test Type	Run	Date	Start	Stop	Time Sync	Duration
CTG1	Normal	Stratification Test	1	06/22/22	12:55:56	13:34:56	DAHS	0:39:30
CTG1	Normal	Gas RATA	1	06/22/22	13:43:26	14:03:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	2	06/22/22	14:11:26	14:31:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	3	06/22/22	14:39:26	14:59:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	4	06/22/22	15:07:26	15:27:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	5	06/22/22	15:36:26	15:56:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	6	06/22/22	16:04:26	16:24:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	7	06/22/22	16:32:26	16:52:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	8	06/22/22	17:08:26	17:28:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	9	06/22/22	17:36:26	17:56:56	DAHS	0:21:00
CTG1	Normal	Gas RATA	10	06/22/22	18:04:26	18:24:56	DAHS	0:21:00

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
NOx RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(ppmvd)	(ppmvd)	(diff)	($diff^2$)
1	13:43 - 14:03	NO	547.3	3.40	4.40		
2	14:11 - 14:31	YES	547.1	2.50	2.50	0.0000	0.00
3	14:39 - 14:59	YES	546.8	2.40	2.50	-0.1000	0.01
4	15:07 - 15:27	YES	547.0	2.40	2.40	0.0000	0.00
5	15:36 - 15:56	YES	546.3	2.40	2.40	0.0000	0.00
6	16:04 - 16:24	YES	545.4	2.30	2.40	-0.1000	0.01
7	16:32 - 16:52	YES	546.0	2.30	2.40	-0.1000	0.01
8	17:08 - 17:28	YES	545.6	2.30	2.40	-0.1000	0.01
9	17:36 - 17:56	YES	546.1	2.70	2.40	0.3000	0.09
10	18:04 - 18:24	YES	545.9	2.50	2.50	0.0000	0.00
11		NO					
12		NO					
	Total		**4916.2**	**21.80**	**21.90**	**-0.100000**	**0.130000**
	Average		**546.2**	**2.42**	**2.43**	**-0.011111**	

Number of Runs	9
Standard Deviation	0.126930
T-value	2.306
Confidence Coefficient	0.097567

Relative Accuracy = 4.5%

Part 60, Appendix B, Performance Specification 2,
8.4.1 RA Test Period. Conduct the RA test according to the procedure given in Sections 8.4.2 through 8.4.6 while the affected facility is operating at more than 50 percent of normal load, or as specified in an applicable subpart.
13.2 Relative Accuracy Performance Specification. The RA of the CEMS must be no greater than 20 percent when RM is used in the denominator of Eq. 2-6 (average emissions during test are greater than 50 percent of the emission standard) or 10 percent when the applicable emission standard (permit limit) is used in the denominator of Eq. 2-6 (average emissions during test are less than 50 percent of the emission standard).
Eq. 2.6 RA=([|d|+|CC|]*100)/RM

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
CO RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(ppmvd)	(ppmvd)	(diff)	($diff^2$)
1	13:43 - 14:03	YES	547.3	0.10	0.00	0.1000	0.01
2	14:11 - 14:31	YES	547.1	0.10	0.00	0.1000	0.01
3	14:39 - 14:59	YES	546.8	0.10	0.00	0.1000	0.01
4	15:07 - 15:27	YES	547.0	0.10	0.00	0.1000	0.01
5	15:36 - 15:56	YES	546.3	0.10	0.00	0.1000	0.01
6	16:04 - 16:24	YES	545.4	0.10	0.00	0.1000	0.01
7	16:32 - 16:52	YES	546.0	0.10	0.00	0.1000	0.01
8	17:08 - 17:28	YES	545.6	0.10	0.00	0.1000	0.01
9	17:36 - 17:56	NO	546.1	0.10	0.00		
10	18:04 - 18:24	YES	545.9	0.10	0.00	0.1000	0.01
11		NO					
12		NO					
	Total		**4917.4**	**0.90**	**0.00**	**0.900000**	**0.090000**
	Average		**546.4**	**0.10**	**0.00**	**0.100000**	

Number of Runs	9
Standard Deviation	0.000000
T-value	2.306
Confidence Coefficient	0.000000

Relative Accuracy =	**100.0%**
|d (difference in ppm)| + CC =	**0.1**

Part 60, Appendix B, Performance Specification 4,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS having span values of 1,000 ppmv CO.
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA or 5 percent when the applicable emission standard (permit limit) is used to calculate RA.

Part 60, Appendix B, Performance Specification 4A,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS that comply with low emission standards (less than 200 ppmv).
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA, 5 percent when the applicable emission standard (permit limit) is used to calculate RA, or within 5 ppmv when the RA is calculated as the absolute average difference between the RM and CEMS plus the 2.5 percent confidence coefficient.

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
O_2 RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(%vd)	(%vd)	(diff)	($diff^2$)
1	13:43 - 14:03	YES	547.3	12.00	12.00	0.0000	0.00
2	14:11 - 14:31	YES	547.1	12.00	12.10	-0.1000	0.01
3	14:39 - 14:59	YES	546.8	12.00	12.10	-0.1000	0.01
4	15:07 - 15:27	YES	547.0	12.10	12.00	0.1000	0.01
5	15:36 - 15:56	YES	546.3	12.10	12.00	0.1000	0.01
6	16:04 - 16:24	YES	545.4	12.00	12.00	0.0000	0.00
7	16:32 - 16:52	YES	546.0	12.00	12.00	0.0000	0.00
8	17:08 - 17:28	YES	545.6	12.00	12.00	0.0000	0.00
9	17:36 - 17:56	NO	546.1	11.90	12.00		
10	18:04 - 18:24	YES	545.9	12.00	12.10	-0.1000	0.01
11		NO					
12		NO					
	Total		**4917.4**	**108.20**	**108.30**	**-0.100000**	**0.050000**
	Average		**546.4**	**12.02**	**12.03**	**-0.011111**	

Number of Runs	9
Standard Deviation	0.078174
T-value	2.306
Confidence Coefficient	0.060089

Average Difference =	**0.0**
Relative Accuracy =	**0.6%**

Part 60, Appendix B, Performance Specification 3,
13.2 CEMS Relative Accuracy Performance Specification. The RA of the CEMS must be no greater than 20 percent of the mean value of the reference method (RM) data. The results are also acceptable if the absolute value of the difference between the mean RM value and the mean CEMS value is less than or equal to 1.0 percent O2 (or CO2).

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
NOx RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(ppmvd@15%O_2)	(ppmvd@15%O_2)	(diff)	(diff^2)
1	13:43 - 14:03	NO	547.3	2.30	2.90		
2	14:11 - 14:31	YES	547.1	1.70	1.70	0.0000	0.00
3	14:39 - 14:59	YES	546.8	1.60	1.70	-0.1000	0.01
4	15:07 - 15:27	YES	547.0	1.60	1.60	0.0000	0.00
5	15:36 - 15:56	YES	546.3	1.60	1.60	0.0000	0.00
6	16:04 - 16:24	YES	545.4	1.60	1.60	0.0000	0.00
7	16:32 - 16:52	YES	546.0	1.50	1.60	-0.1000	0.01
8	17:08 - 17:28	YES	545.6	1.50	1.60	-0.1000	0.01
9	17:36 - 17:56	YES	546.1	1.80	1.60	0.2000	0.04
10	18:04 - 18:24	YES	545.9	1.70	1.70	0.0000	0.00
11		NO					
12		NO					
	Total		**4916.2**	**14.60**	**14.70**	**-0.100000**	**0.070000**
	Average		**546.2**	**1.62**	**1.63**	**-0.011111**	

Number of Runs	9
Standard Deviation	0.092796
T-value	2.306
Confidence Coefficient	0.071329

Relative Accuracy =	**5.1%**
Applicable Standard =	**2.00**
Alternative Relative Accuracy =	**4.1%**

Part 60, Appendix B, Performance Specification 2,
8.4.1 RA Test Period. Conduct the RA test according to the procedure given in Sections 8.4.2 through 8.4.6 while the affected facility is operating at more than 50 percent of normal load, or as specified in an applicable subpart.
13.2 Relative Accuracy Performance Specification. The RA of the CEMS must be no greater than 20 percent when RM is used in the denominator of Eq. 2-6 (average emissions during test are greater than 50 percent of the emission standard) or 10 percent when the applicable emission standard (permit limit) is used in the denominator of Eq. 2-6 (average emissions during test are less than 50 percent of the emission standard).
Eq. 2.6 RA=([|d|+|CC|]*100)/RM

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
CO RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(ppmvd@15%O_2)	(ppmvd@15%O_2)	(diff)	(diff^2)
1	13:43 - 14:03	YES	547.3	0.00	0.00	0.0000	0.00
2	14:11 - 14:31	YES	547.1	0.00	0.00	0.0000	0.00
3	14:39 - 14:59	YES	546.8	0.10	0.00	0.1000	0.01
4	15:07 - 15:27	YES	547.0	0.00	0.00	0.0000	0.00
5	15:36 - 15:56	YES	546.3	0.00	0.00	0.0000	0.00
6	16:04 - 16:24	YES	545.4	0.00	0.00	0.0000	0.00
7	16:32 - 16:52	YES	546.0	0.00	0.00	0.0000	0.00
8	17:08 - 17:28	YES	545.6	0.00	0.00	0.0000	0.00
9	17:36 - 17:56	NO	546.1	0.10	0.00		
10	18:04 - 18:24	YES	545.9	0.00	0.00	0.0000	0.00
11		NO					
12		NO					
	Total		**4917.4**	**0.10**	**0.00**	**0.100000**	**0.010000**
	Average		**546.4**	**0.01**	**0.00**	**0.011111**	

Number of Runs	9
Standard Deviation	0.033333
T-value	2.306
Confidence Coefficient	0.025622

Relative Accuracy =	**330.6%**
Applicable Standard =	**4.00**
Alternative Relative Accuracy =	**0.9%**
|d (difference in ppm)| + CC =	**0.1**

Part 60, Appendix B, Performance Specification 4,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS having span values of 1,000 ppmv CO.
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA or 5 percent when the applicable emission standard (permit limit) is used to calculate RA.

Part 60, Appendix B, Performance Specification 4A,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS that comply with low emission standards (less than 200 ppmv).
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA, 5 percent when the applicable emission standard (permit limit) is used to calculate RA, or within 5 ppmv when the RA is calculated as the absolute average difference between the RM and CEMS plus the 2.5 percent confidence coefficient.

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
NOx RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(lb/hr)	(lb/hr)	(diff)	($diff^2$)
1	13:43 - 14:03	NO	547.3	28.10	37.30		
2	14:11 - 14:31	YES	547.1	20.90	21.40	-0.5000	0.25
3	14:39 - 14:59	YES	546.8	19.90	21.10	-1.2000	1.44
4	15:07 - 15:27	YES	547.0	19.70	20.70	-1.0000	1.00
5	15:36 - 15:56	YES	546.3	20.10	20.30	-0.2000	0.04
6	16:04 - 16:24	YES	545.4	19.30	20.40	-1.1000	1.21
7	16:32 - 16:52	YES	546.0	19.00	20.30	-1.3000	1.69
8	17:08 - 17:28	YES	545.6	19.20	20.30	-1.1000	1.21
9	17:36 - 17:56	YES	546.1	22.30	20.30	2.0000	4.00
10	18:04 - 18:24	YES	545.9	20.70	21.10	-0.4000	0.16
11		NO					
12		NO					
	Total		**4916.2**	**181.10**	**185.90**	**-4.800000**	**11.000000**
	Average		**546.2**	**20.12**	**20.66**	**-0.533333**	

Number of Runs	9
Standard Deviation	1.027132
T-value	2.306
Confidence Coefficient	0.789522

Relative Accuracy =	**6.6%**
Applicable Standard =	**27.40**
Alternative Relative Accuracy =	**4.8%**

Part 60, Appendix B, Performance Specification 2,
8.4.1 RA Test Period. Conduct the RA test according to the procedure given in Sections 8.4.2 through 8.4.6 while the affected facility is operating at more than 50 percent of normal load, or as specified in an applicable subpart.
13.2 Relative Accuracy Performance Specification. The RA of the CEMS must be no greater than 20 percent when RM is used in the denominator of Eq. 2-6 (average emissions during test are greater than 50 percent of the emission standard) or 10 percent when the applicable emission standard (permit limit) is used in the denominator of Eq. 2-6 (average emissions during test are less than 50 percent of the emission standard).
Eq. 2.6 RA=([|d|+|CC|]*100)/RM

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
CO RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(lb/hr)	(lb/hr)	(diff)	($diff^2$)
1	13:43 - 14:03	YES	547.3	0.40	0.00	0.4000	0.16
2	14:11 - 14:31	YES	547.1	0.30	0.00	0.3000	0.09
3	14:39 - 14:59	YES	546.8	0.40	0.00	0.4000	0.16
4	15:07 - 15:27	YES	547.0	0.30	0.00	0.3000	0.09
5	15:36 - 15:56	YES	546.3	0.30	0.00	0.3000	0.09
6	16:04 - 16:24	YES	545.4	0.30	0.00	0.3000	0.09
7	16:32 - 16:52	YES	546.0	0.30	0.00	0.3000	0.09
8	17:08 - 17:28	YES	545.6	0.30	0.00	0.3000	0.09
9	17:36 - 17:56	NO	546.1	0.50	0.00		
10	18:04 - 18:24	YES	545.9	0.40	0.00	0.4000	0.16
11		NO					
12		NO					
	Total		**4917.4**	**3.00**	**0.00**	**3.000000**	**1.020000**
	Average		**546.4**	**0.33**	**0.00**	**0.333333**	

Number of Runs	9
Standard Deviation	0.050000
T-value	2.306
Confidence Coefficient	0.038433

Relative Accuracy =	**111.5%**
Applicable Standard =	**24.70**
Alternative Relative Accuracy =	**1.5%**
|d (difference in ppm)| + CC =	**0.1**

Part 60, Appendix B, Performance Specification 4,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS having span values of 1,000 ppmv CO.
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA or 5 percent when the applicable emission standard (permit limit) is used to calculate RA.

Part 60, Appendix B, Performance Specification 4A,
1.2.1 This specification is for evaluating the acceptability of carbon monoxide (CO) continuous emission monitoring systems (CEMS) at the time of installation or soon after and whenever specified in an applicable subpart of the regulations. This specification was developed primarily for CEMS that comply with low emission standards (less than 200 ppmv).
13.2 Relative Accuracy. The RA of the CEMS must be no greater than 10 percent when the average RM value is used to calculate RA, 5 percent when the applicable emission standard (permit limit) is used to calculate RA, or within 5 ppmv when the RA is calculated as the absolute average difference between the RM and CEMS plus the 2.5 percent confidence coefficient.

Indeck Niles, LLC
June 22, 2022
General Electric, Combustion Turbine, Unit #CTG1
NOx RATA Data Sheet
Indeck Niles Energy Center

RUN #	RUN TIME	USED	UNIT LOAD	RM	CEMS	RM-CEMS	
			(MW)	(lb/MMBtu)	(lb/MMBtu)	(diff)	($diff^2$)
1	13:43 - 14:03	NO	547.3	0.008	0.011		
2	14:11 - 14:31	YES	547.1	0.006	0.006	0.0000	0.0000
3	14:39 - 14:59	YES	546.8	0.006	0.006	0.0000	0.0000
4	15:07 - 15:27	YES	547.0	0.006	0.006	0.0000	0.0000
5	15:36 - 15:56	YES	546.3	0.006	0.006	0.0000	0.0000
6	16:04 - 16:24	YES	545.4	0.006	0.006	0.0000	0.0000
7	16:32 - 16:52	YES	546.0	0.006	0.006	0.0000	0.0000
8	17:08 - 17:28	YES	545.6	0.006	0.006	0.0000	0.0000
9	17:36 - 17:56	YES	546.1	0.007	0.006	0.0010	0.0000
10	18:04 - 18:24	YES	545.9	0.006	0.006	0.0000	0.0000
11		NO					
12		NO					
	Total		**4916.2**	**0.055**	**0.054**	**0.001000**	**0.000001**
	Average		**546.2**	**0.006**	**0.006**	**0.000111**	

Number of Runs	9
Standard Deviation	0.000333
T-value	2.306
Confidence Coefficient	0.000256

Relative Accuracy = 6.01%

If the mean difference is less than or equal to the absolute value of the confidence coefficient, then the Bias Test passes and the bias adjustment factor is not applicable.

Mean Difference =	0.0001
Confidence Coefficient =	0.0003

BAF = 1 + (abs. value mean difference/avg. CEMS reading)

Average CEMS Reading =	0.006
BAF =	**1.000**

Part 75, Appendix A,
3.3.2 Relative Accuracy for NOX-Diluent Continuous Emission Monitoring Systems
(a) The relative accuracy for NOX-diluent continuous emission monitoring systems shall not exceed 10.0 percent.
(b) For affected units where the average of the reference method measurements of NOX emission rate (this means lb/MMBtu) during the relative accuracy test audit is less than or equal to 0.200 lb/mmBtu, the difference between the mean value of the continuous emission monitoring system measurements and the reference method mean value shall not exceed ±0.020 lb/mmBtu, wherever the relative accuracy specification of 10.0 percent is not achieved.

7.6.5 Bias Adjustment
(b) For single-load RATAs of SO2 pollutant concentration monitors, NOX concentration monitoring systems, and NOX-diluent monitoring systems and for the single-load flow RATAs required or allowed under section 6.5.2 of this appendix and sections 2.3.1.3(b) and 2.3.1.3(c) of Appendix B to this part, the appropriate BAF is determined directly from the RATA results at normal load, using Equation A-12. Notwithstanding, when a NOX concentration CEMS or an SO2 CEMS or a NOX-diluent CEMS installed on a low-emitting affected unit (i.e., average SO2 or NOX concentration during the RATA ≦ 250 ppm or average NOX emission rate ≦ 0.200 lb/mmBtu) meets the normal 10.0 percent relative accuracy specification (as calculated using Equation A-10) or the alternate relative accuracy specification in section 3.3 of this appendix for low-emitters, but fails the bias test, the BAF may either be determined using Equation A-12, or a default BAF of 1.111 may be used.

Part 75, Appendix B,
2.3.1.2 Reduced RATA Frequencies. Relative accuracy test audits of primary and redundant backup SO2 pollutant concentration monitors, CO2 pollutant concentration monitors (including O2 monitors used to determine CO2 emissions), CO2 or O2 diluent monitors used to determine heat input, moisture monitoring systems, NOX concentration monitoring systems, flow monitors, NOX-diluent monitoring systems or SO2-diluent monitoring systems may be performed annually (i.e., once every four successive QA operating quarters, rather than once every two successive QA operating quarters) if any of the following conditions are met for the specific monitoring system involved:
(a) The relative accuracy during the audit of an SO2 or CO2 pollutant concentration monitor (including an O2 pollutant monitor used to measure CO2 using the procedures in appendix F to this part), or of a CO2 or O2 diluent monitor used to determine heat input, or of a NOX concentration monitoring system, or of a NOX-diluent monitoring system, or of an SO2-diluent continuous emissions monitoring system is ≤ 7.5 percent;

(f) For units with low NOX emission rates (average NOX emission rate measured by the reference method during the RATA ≤ 0.200 lb/mmBtu), when a NOX-diluent continuous emission monitoring system fails to achieve a relative accuracy ≤ 7.5 percent, but the monitoring system mean value from the RATA, calculated using Equation A-7 in appendix A to this part, is within ± 0.015 lb/mmBtu of the reference method mean value;

Figure 2 to Appendix B of Part 75_Relative Accuracy Test Frequency Incentive System.

RATA	Semiannual(percent)(1)	Annual(1)
SO2 or NOX(3)	7.5% < RA ≤ 10.0% or ± 15.0 ppm(2)	RA ≤ 7.5% or ± 12.0 ppm(2)
SO2-diluent	7.5% < RA ≤ 10.0% or ± 0.030 lb/mmBtu(2)	RA ≤ 7.5% or ± 0.025 lb/mmBtu(2)
NOX-diluent	7.5% < RA ≤ 10.0% or ± 0.020 lb/mmBtu(2)	RA ≤ 7.5% or ± 0.015 lb/mmBtu(2)
Flow	7.5% < RA ≤ 10.0% or ± 2.0 fps(2)	RA ≤ 7.5% or ± 1.5 fps
CO2 or O2	7.5% < RA ≤ 10.0% or ± 1.0% CO2/O2(2)	RA ≤ 7.5% or ± 0.7% CO2/O2(2)
Moisture	7.5% < RA ≤ 10.0% or ± 1.5% H2O(2)	RA ≤ 7.5% or ± 1.0% H2O(2)

(1) The deadline for the next RATA is the end of the second (if semiannual) or fourth (if annual) successive QA operating quarter following the quarter in which the CEMS was last tested. Exclude calendar quarters with fewer than 168 unit operating hours (or, for common stacks and bypass stacks, exclude quarters with fewer than 168 stack operating hours) in determining the RATA deadline. For SO2 monitors, QA operating quarters in which only very low sulfur fuel as defined in § 72.2, is combusted may also be excluded. However, the exclusion of calendar quarters is limited as follows: the deadline for the next RATA shall be no more than 8 calendar quarters after the quarter in which a RATA was last performed.
(2) The difference between monitor and reference method mean values applies to moisture monitors, CO2, and O2 monitors, low emitters, or low flow, only.
(3) A NOX concentration monitoring system used to determine NOX mass emissions under § 75.71.

Calculations, Formulas, and Constants

The following information supports the spreadsheets for this testing project.

Given Data:

Ideal Gas Conversion Factor = 385.23 SCF/lb-mol at 68 deg F & 14.696 psia

Fuel Heating Value is based upon Air Hygiene's fuel gas calculation sheet. All calculations are based upon a correction to 68 deg F & 14.696 psia

High Heating Values (HHV) are used for the Fuel Heating Value, F-Factor, and Fuel Flow Data per EPA requirements.

ASTM D 3588

Molecular Weight of NOx (lb/lb-mole) = 46.01
Molecular Weight of CO (lb/lb-mole) = 28.00
Molecular Weight of SO_2 (lb/lb-mole) = 64.00
Molecular Weight of THC (propane) (lb/lb-mole) = 44.00
Molecular Weight of VOC (methane) (lb/lb-mole) = 16.00
Molecular Weight of NH_3 (lb/lb-mole) = 17.03
Molecular Weight of HCHO (lb/lb-mole) = 30.03
Molecular Weight of CO_2 (lb/lb-mole) = 44.01

40CFR60, App. A., RM 19, Table 19-1

Conversion Constant for NOx = 0.0000001194351
Conversion Constant for CO = 0.0000000726839
Conversion Constant for SO_2 = 0.0000001661345
Conversion Constant for THC = 0.0000001142175
Conversion Constant for VOC (methane) = 0.0000000415336
Conversion Constant for NH_3 = 0.0000000442074
Conversion Constant for HCHO = 0.0000000779534
Conversion Constant for CO_2 = 0.0000001142434

NOTE: units are lb/ppm*ft^3

Formulas:

1. Corrected Raw Average (C_{Gas}), 40CFR60, App. A, RM 7E, Eq. 7E-5 (08/15/06)

$$C_{Gas} = (C_{Avg} - C_o) \times \left(\frac{C_M}{C_M - C_o} \right)$$

2. Correction to % O_2, 40CFR60, App. A, RM 20, Eq. 20-5 (11/26/02)

$$C_{adj} = C_{Gas(Target)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}} \right)$$

3. Correction to % O_2 and ISO Conditions

$$C_{ISO} = C_{Adj} \times \sqrt{\frac{P_r}{P_o}} \times e^{(19 \times (H_o - 0.00633))} \times \left(\frac{288}{T_a} \right)^{1.53}$$

4. Method 19 stack exhaust flow (scfh) [ref. EPA EMC FAQ Method 19]

$$Q_S = \left(\frac{FFactor \times Q_f \times HHV}{1{,}000{,}000} \right) \times \left(\frac{20.9\%}{20.9\% - C_{Gas(O2)}} \right)$$

5. Emission Rate in lb/hr

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

6. Emission Rate in tons per year

$$E_{ton/yr} = \frac{E_{lb/hr} \times hr_{year}}{2000}$$

7. Emission Concentration in lb/MMBtu (O_2 based)

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 20.9\%}{20.9\% - C_{Gas(O2)}}$$

8. Emission Concentration in g/hp*hr

$$E_{g/hp \cdot hr} = \frac{E_{lb/hr} \times 453.6}{mw \times 1341.022} or \frac{E_{lb/hr} \times 453.6}{hp}$$

RATA SHEET CALCULATIONS

d = Reference Method Data - CEMS Data
S_d = Standard Deviation
CC = Confident Coefficient
n = number of runs
$t_{0.025}$ = 2.5 percent confidence coefficient T-values
RA = relative accuracy
ARA = alternative relative accuracy
BAF = Bias adjustment factor

n	t	n	t	n	t
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

1. Difference

$$d = \sum_{i=1}^{n} d_i$$

2. Standard Deviation

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \left[\frac{\left(\sum_{i=1}^{n} d_i \right)^2}{n} \right]}{n-1}}$$

3. Confident Coefficient

$$CC = t_{0.025} \times \frac{S_d}{\sqrt{n}}$$

4. Relative Accuracy

$$RA = \frac{|d_{AVG}| + |CC|}{RM_{AVG}} \times 100$$

5. Alternative Relative Accuracy

$$ARA = \frac{|d_{AVG}| + |CC|}{AS} \times 100$$

5. Bias Adjustment Factor

$$BAF = 1 + \left(\frac{|d_{AVG}|}{CEM_{AVG}} \right)$$

RM 7E, (08-15-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

ACE = Analyzer calibration error, percent of calibration span.
B_{WS} = Moisture content of sample gas as measured by Method 4 or other approved method, percent/100.
C_{Avg} = Average unadjusted gas concentration indicated by data recorder for the test run.
C_D = Pollutant concentration adjusted to dry conditions.
C_{Dir} = Measured concentration of a calibration gas (low, mid, or high) when introduced in direct calibration mode.
C_{Gas} = Average effluent gas concentration adjusted for bias.
C_M = Average of initial and final system calibration bias (or 2-point system calibration error) check responses for the upscale calibration gas.
C_{MA} = Actual concentration of the upscale calibration gas, ppmv.
C_O = Average of the initial and final system calibration bias (or 2-point system calibration error) check responses from the low-level (or zero) calibration gas.
C_S = Measured concentration of a calibration gas (low, mid, or high) when introduced in system calibration mode.
C_{SS} = Concentration of NOx measured in the spiked sample.
C_{Spike} = Concentration of NOx in the undiluted spike gas.
C_{Calc} = Calculated concentration of NOx in the spike gas diluted in the sample.
C_V = Manufacturer certified concentration of a calibration gas (low, mid, or high).
C_W = Pollutant concentration measured under moist sample conditions, wet basis.
CS = Calibration span.
D = Drift assessment, percent of calibration span.
E_p = The predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level response.
Eff_{NO2} = NO_2 to NO converter efficiency, percent.
H = High calibration gas, designator.
L = Low calibration gas, designator.
M = Mid calibration gas, designator.
NOFinal = The average NO concentration observed with the analyzer in the NO mode during the converter efficiency test in Section 16.2.2.
NOxCorr = The NOx concentration corrected for the converter efficiency.
NOxFinal = The final NOx concentration observed during the converter efficiency test in Section 16.2.2.
NOxPeak = The highest NOx concentration observed during the converter efficiency test in Section 16.2.2.
Q_{Spike} = Flow rate of spike gas introduced in system calibration mode, L/min.
Q_{Total} = Total sample flow rate during the spike test, L/min.
R = Spike recovery, percent.
SB = System bias, percent of calibration span.
SB_i = Pre-run system bias, percent of calibration span.
SB_f = Post-run system bias, percent of calibration span.
SB / D_{Alt} = Alternative absolute difference criteria to pass bias and/or drift checks.
SCE = System calibration error, percent of calibration span.
SCE_i = Pre-run system calibration error, percent of calibration span.
SCE_{final} = Post-run system calibration error, percent of calibration span.
Z = Zero calibration gas, designator.

40CFR60.355(b)(1), (09-20-06), Nomenclature. The terms used in the equations are defined as follows:

P_r = reference combustor inlet absolute pressure at 101.3 kilopascals ambient pressure, mm Hg
P_o = observed combustor inlet absolute pressure at test, mm Hg
H_o = observed humidity of ambient air, g H_2O/g air
e = transcendental constant, 2.718
T_a = ambient temperature, K

Small Engine and FTIR Nomenclature. The terms used in the equations are defined as follows:

bhp = brake horsepower
hp = horsepower
Q_{sys} = system flow (lpm)
Q_m = matrix spike flow (lpm)

RM 19, (07-29-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

AdjFactor = Percent oxygen or carbon dioxide adjustment applied to a target pollutant
B_{wa} = Moisture fraction of ambient air, percent.
Btu = British thermal unit
$\%_C$ = Concentration of carbon from an ultimate analysis of fuel, weight percent.
$\%_{CO2d}$,$\%_{CO2w}$ = Concentration of carbon dioxide on a dry and wet basis, respectively, percent.
CIP / CDP = Combustor inlet pressure / compressor discharge pressure (mm Hg); note, some manufactures reference as PCD.
E = Pollutant emission rate, ng/J (lb/million Btu).
E_a = Average pollutant rate for the specified performance test period, ng/J (lb/million Btu).
E_{ao}, E_{ai} = Average pollutant rate of the control device, outlet and inlet, respectively, for the performance test period, ng/J (lb/million Btu).
E_{bi} = Pollutant rate from the steam generating unit, ng/J (lb/million Btu).
E_{bo} = Pollutant emission rate from the steam generating unit, ng/J (lb/million Btu).
E_{ci} = Pollutant rate in combined effluent, ng/J (lb/million Btu).
E_{co} = Pollutant emission rate in combined effluent, ng/J (lb/million Btu).
E_d = Average pollutant rate for each sampling period (e.g.,24-hr Method 6B sample or 24-hr fuel sample) or for each fuel lot (e.g., amount of fuel bunkered), ng/J (lb/million E
E_{di} = Average inlet SO_2 rate for each sampling period d, ng/J (lb/million Btu).
E_g = Pollutant rate from gas turbine, ng/J (lb/million Btu).
E_{ga} = Daily geometric average pollutant rate, ng/J (lbs/million Btu) or ppm corrected to 7 percent O_2.
E_{jo},E_{ji} = Matched pair hourly arithmetic average pollutant rate, outlet and inlet, respectively, ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
E_h = Hourly average pollutant, ng/J (lb/million Btu).
E_{hj} = Hourly arithmetic average pollutant rate for hour "j," ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
EXP = Natural logarithmic base (2.718) raised to the value enclosed by brackets.
Fc = Ratio of the volume of carbon dioxide produced to the gross calorific value of the fuel from Method 19
F_d, F_w, F_c = Volumes of combustion components per unit of heat content, scm/J (scf/million Btu).
ft^3 = cubic feet
G = ideal gas conversion factor
(385.23 SCF/lb-mol at 68 deg F & 14.696 psia)
GCM = gross Btu per SCF (constant, compound based)
GCV = Gross calorific value of the fuel consistent with the ultimate analysis, kJ/kg (Btu/lb).
GCV_p, GCV_r = Gross calorific value for the product and raw fuel lots, respectively, dry basis, kJ/kg (Btu/lb).
$\%_H$ = Concentration of hydrogen from an ultimate analysis of fuel, weight percent.
H_b = Heat input rate to the steam generating unit from fuels fired in the steam generating unit, J/hr (million Btu/hr).
H_g = Heat input rate to gas turbine from all fuels fired in the gas turbine, J/hr (million Btu/hr).
$\%_{H2O}$ = Concentration of water from an ultimate analysis of fuel, weight percent.
H_r = Total numbers of hours in the performance test period (e.g., 720 hours for 30-day performance test period).
K = volume of combustion component per pound of component (constant)
K = Conversion factor, 10^{-5} (kJ/J)/(%) [10^6 Btu/million Btu].
K_c = (9.57 scm/kg)/% [(1.53 scf/lb)/%].
K_{cc} = (2.0 scm/kg)/% [(0.321 scf/lb)/%].
K_{hd} = (22.7 scm/kg)/% [(3.64 scf/lb)/%].
K_{htw} = (34.74 scm/kg)/% [(5.57 scf/lb)/%].
K_n = (0.86 scm/kg)/% [(0.14 scf/lb)/%].
K_o = (2.85 scm/kg)/% [(0.46 scf/lb)/%].
K_s = (3.54 scm/kg)/% [(0.57 scf/lb)/%].
K_{sulfur} = $2x10^4$ Btu/wt%-MMBtu
K_w = (1.30 scm/kg)/% [(0.21 scf/lb)/%].
lb = pound
ln = Natural log of indicated value.
L_p,L_r = Weight of the product and raw fuel lots, respectively, metric ton (ton).
$\%_N$ = Concentration of nitrogen from an ultimate analysis of fuel, weight percent.
$M_{\%}$ = mole percent
mol = mole
MW = molecular weight (lb/lb-mol)
MW_{AIR} = molecular weight of air (28.9625 lb/lb-mole)[1]
NCM = net Btu per SCF (constant based on compound)
$\%_O$ = Concentration of oxygen from an ultimate analysis of fuel, weight percent.
$\%_{O2d}$, $\%_{O2w}$ = Concentration of oxygen on a dry and wet basis, respectively, percent.
P_B = barometric pressure, in Hg
P_s = Potential SO2 emissions, percent.
$\%_S$ = Sulfur content of as-fired fuel lot, dry basis, weight percent.
S_e = Standard deviation of the hourly average pollutant rates for each performance test period, ng/J (lb/million Btu).
$\%_{Sf}$ = Concentration of sulfur from an ultimate analysis of fuel, weight percent.
S(wt%) = weight percent of sulfur, per lab analysis by appropriate ASTM standard
S_i = Standard deviation of the hourly average inlet pollutant rates for each performance test period, ng/J (lb/million Btu).
S_o = Standard deviation of the hourly average emission rates for each performance test period, ng/J (lb/million Btu).
$\%S_p$, $\%S_r$ = Sulfur content of the product and raw fuel lots respectively, dry basis, weight percent.
SCF = standard cubic feet
SH = specific humidity, pounds of water per pound of air
$t_{0.95}$ = Values shown in Table 19-3 for the indicated number of data points n.
T_{amb} = ambient temperature, °F
W/D Factor = 1.0236 = conv. at 14.696 psia and
68 deg F (ref. Civil Eng. Ref. Manual, 7th Ed.)
X_{CO2}=CO_2 Correction factor, percent.
X_k = Fraction of total heat input from each type of fuel k.

EXAMPLE CALCULATIONS (INFORMATION)

Specific Humidity (RH_{sp})

Note: RHsp (gr/lb) calculated using temperature, relative humidity, and barometric pressure with psychrometric chart, psychrometric calculator, or built in psychrometric algorithm.

$$RH_{sp}(lb/lb) = \left[\left(\frac{gr}{lb}\right) \times \frac{lb}{7000\,gr}\right]$$

RH_{sp}= $\frac{64.53 \text{ gr}}{\text{lb}}$ x $\frac{1 \text{ lb}}{7000 \text{ gr}}$ = 0.009219 $\frac{\text{lb } H_2O}{\text{lb Air}}$

EXAMPLE CALCULATIONS (CALIBRATION)

Analyzer Calibration Error

RM 7E, (02-27-14), 12.2 Analyzer Calibration Error. For non-dilution systems, use Equation 7E-1 to calculate the analyzer calibration error for the low-, mid-, and high-level calibration gases. (calc for NOx analyzer mid gas, if applicable)

$$ACE = \left(\frac{C_{Dir} - C_V}{CS}\right) \times 100$$ Eq. 7E-1

ACE = $\frac{5.30 \text{ ppm} - 5.14 \text{ ppm}}{8.92 \text{ ppm}}$ x 100 = 1.79 %

EXAMPLE CALCULATIONS (BIAS, DRIFT, AND CORRECTED RAW AVERAGE)

System Bias

RM 7E, (02-27-14), 12.3 System Bias. For non-dilution systems, use Equation 7E-2 to calculate the system bias separately for the low-level and upscale calibration gases. (calc for NOx analyzer upscale gas, Run 1 initial bias, if applicable)

$$SB = \left(\frac{C_S - C_{Dir}}{CS}\right) \times 100$$ Eq. 7E-2

SB = $\frac{5.13 \text{ ppm} - 5.30 \text{ ppm}}{8.92 \text{ ppm}}$ x 100 = -1.91 %

Drift Assessment

RM 7E, (02-27-14), 12.5 Drift Assessment. Use Equation 7E-4 to separately calculate the low-level and upscale drift over each test run. (calc for NOx analyzer upscale drift, Run 1, if applicable)

$$D = |SB_{final} - SB_i|$$ Eq. 7E-4

D = | -1.01 % - -1.91 % | = 0.90 %

Alternative Drift and Bias

RM 7E, (02-27-14), 13.2 / 13.3 System Bias and Drift. Alternatively, the results are acceptable if |Cs – Cdir| is ≤ 0.5 ppmv or if |Cs – Cv| is ≤ 0.5 ppmv (as applicable). (calc for NOx analyzer initial upscale, Run 1, if applicable)

$$SB/D_{Alt} = |C_S - C_{Dir}|$$ Eq. Section 13.2 and 13.3

SB / D_{Alt} = | 5.13 ppm - 5.30 ppm | = 0.17 ppm

Bias Adjusted Average

RM 7E, (02-27-14), 12.6 Effluent Gas Concentration. For each test run, calculate Cavg, the arithmetic average of all valid NOx concentration values (e.g., 1-minute averages). Then adjust the value of Cavg for bias, using Equation 7E-5b. (calc for NOx analyzer, Run 1, if applicable)

$$C_{Gas} = (C_{Avg} - C_O) \times \left(\frac{C_M}{C_M - C_O}\right)$$ Eq. 7E-5b

C_{Gas} = (3.50 ppm - 0.23 ppm) $\left(\frac{5.14 \text{ ppm}}{5.17 \text{ ppm} - 0.23 \text{ ppm}}\right)$ = 3.41 ppm

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (RUNS)

Stack Exhaust Flow (Q_S) - RM19

$$Q_s = \left(\frac{FFactor \times Q_f \times HHV}{1{,}000{,}000}\right) \times \left(\frac{20.9\%}{20.9\% - C_{Gas(O2)}}\right)$$

Note: Equation presented in EPA Emission Measurement Center (EMC), Frequently Asked Questions (FAQ) for Method 19

$$Q_S = \frac{8{,}710.00\ SCF}{MMBtu} \times \frac{3{,}211{,}886.00\ SCF}{hr} \times \frac{1{,}050.00\ Btu}{SCF} \times \frac{MMBtu}{10^6\ Btu} \times \left[\frac{20.90\%}{20.9\% - 12.0\ \%}\right] = 68{,}921{,}127.39\ SCFH$$

Diluent-Corrected Pollutant Concentration, O_2 Based

RM 20, (11-26-02), 7.3.1 Correction of Pollutant Concentration Using O_2 Concentration. Calculate the O_2 corrected pollutant concentration, as follows: (calc for NOx gas, Run 1, if applicable) [now contained in applicable Subpart]

$$C_{adj} = C_{Gas(Tmgt)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}}\right) \quad \text{Eq. 20-4}$$

$$C_{adj} = 3.41\ ppm \times \left[\frac{20.9\% - 15.00\ \%}{20.9\% - 11.99\ \%}\right] = 2.26\ ppm@15\%O_2$$

Emissions Rate (lb/hr)

Calculation for pound per hour emission rate. Calculate, as follows: (calc for NOx gas Run 1, if applicable)

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

$$E_{lb/hr} = \frac{3.41\ ppmvd}{10^6\ ppm/part} \times \frac{68{,}921{,}127\ DSCFH \times 46.01\ lb/lb\text{-}mol}{385.23\ SCF/lb\text{-}mol} = \frac{28.05\ lb}{hr}$$

Emissions Rate (lb/MMBtu)

RM 19, (02-27-14), 12.2 Emission Rates of PM, SO_2, and NOx. Select from the following sections the applicable procedure to compute the PM, SO_2, or NOx emission rate (E) in ng/J (lb/million Btu). (calc for NOx gas Run 1, if applicable)

Oxygen Based

12.2.1 Oxygen-Based F Factor, Dry Basis. When measurements are on a dry basis for both O_2 ($\%O_2d$) and pollutant (Cd) concentrations, use the following equation:

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_o Factor \times Conv_c \times 20.9\%}{20.9\% - C_{Gas(O2)}} \quad \text{Eq. 19-1}$$

$$E_{lb/MMBtu} = \frac{3.41\ ppm \times 8{,}710.00\ SCF/MMBtu \times 0.0000001194\ lb/ppm*ft^3 \times 20.9\%}{20.9\% - 11.99\ \%} = \frac{0.008\ lb}{MMBtu}$$

Conversion Constant

Convc for NOx

$$Conv_c\ (lb/ppm \cdot ft^3) = \frac{\frac{MW}{G}}{10^6}$$

$$Conv_c = \frac{\frac{46.01\ lb}{lb\text{•}mole} \times \frac{lb\text{•}mole}{385.23\ SCF}}{10^6} = \frac{0.0000001194\ lb}{ppm\text{-}ft^3}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (RATA RESULTS)

Difference (d)

40 CFR 75, App A, (12-17-09), 7.3.1 Arithmetic Mean. Calculate the arithmetic mean of the differences, d , of a data set as follows. (calc for NOx lb/MMBtu data, if applicable. Note: This is an example calculation which may not have any bearing on the actual test requirements.)

$$d = \sum_{i=1}^{n} d_i \qquad \text{Eq. A-7}$$

d = 0.006 lb/MMBtu - 0.006 lb/MMBtu = 0.000 lb/MMBtu

Standard Deviation

40 CFR 75, App A, (12-17-09), 7.3.2 Standard Deviation. Calculate the standard deviation, Sd, of a data set as follows:
(calc for NOx lb/MMBtu data, if applicable. Note: This is an example calculation which may not have any bearing on the actual test requirements.)

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \left[\frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}\right]}{n-1}} \qquad \text{Eq. A-8}$$

$$S_d = \sqrt{\frac{0.000 \text{ lb/MMBtu}^2 - \left[\frac{(0.001 \text{ lb/MMBtu})^2}{9}\right]}{9 - 1}} = 0.000 \text{ lb/MMBtu}$$

Confidence Coefficient

40 CFR 75, App A, (12-17-09), 7.3.3 Confidence Coefficient. Calculate the confidence coefficient (one-tailed), cc, of a data set as follows. (calc for NOx lb/MMBtu data, if applicable. Note: This is an example calculation which may not have any bearing on the actual test requirements.)

$$CC = t_{0.025} \times \frac{S_d}{\sqrt{n}} \qquad \text{Eq. A-9}$$

$$CC = 2.306 \times \frac{0.000 \text{ lb/MMBtu}}{\sqrt{9}} = 0.000 \text{ lb/MMBtu}$$

T-Values	n	2	3	4	5	6	7	8	9
	$t_{0.025}$	12.706	4.303	3.182	2.776	2.571	2.447	2.365	2.306

2.5 percent confidence coefficients

Relative Accuracy

40 CFR 75, App A, (12-17-09), 7.3.4 Relative Accuracy. Calculate the relative accuracy of a data set using the following equation. (calc for NOx lb/MMBtu data, if applicable. Note: This is an example calculation which may not have any bearing on the actual test requirements.)

$$RA = \frac{|d_{AVG}| + |CC|}{RM_{AVG}} \times 100 \qquad \text{Eq. A-10}$$

$$RA = \frac{|0.000 \text{ lb/MMBtu}| + |0.000 \text{ lb/MMBtu}|}{0.006 \text{ lb/MMBtu}} \times 100 = 6.01 \%$$

Bias Adjustment Factor (BAF)

40 CFR 75, App A, (12-17-09), 7.6.5 Bias Adjustment. (a) If the monitor or monitoring system fails to meet the bias test requirement, adjust the value obtained from the monitor using the following equation: (calc for NOx lb/MMBtu data, if applicable. Note: This is an example calculation which may not have any bearing on the actual test requirements.)

$$BAF = 1 + \left(\frac{|d_{AVG}|}{CEM_{AVG}}\right) \qquad \text{Eq. A-12}$$

d_{AVG}= 0.000 < |CC| = 0.000 ⇨ BAF = $1 + \frac{|\ \text{lb/MMBtu}|}{\text{lb/MMBtu}}$ = 1.000 lb/MMBtu

Note: BAF only applies if the mean difference (d) is greater than the absolute value of the confidence coefficient.

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

APPENDIX B

CEMS AND REFERENCE METHOD DATA