AECOM

Compliance Emissions Test Report

NOx and CO Emissions Testing for Title V Renewable Operating Permit Requirements

PM Emissions Testing for Determination of Emission Factors under MAERS Reporting Requirements

EU North Turbine/Duct-Burner (SV00007)
EU South Turbine/Duct-Burner (SV00009)

Corteva Agriscience, LLC - FG Utilities Plant
Harbor Beach, Michigan 48441
MI-ROP-B4942-2020b

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1. Introduction

1.1 Background and Overview

Corteva Agriscience, LLC of Harbor Beach, Michigan (SRN B4942) conducted 5-year Title V Renewable Operating Permit (ROP) emissions compliance testing on June 17 and 18, 2024. This testing is required at least once during the 5-year term of the ROP but not later than five years from the date of the previous performance test that was completed on November 8, 2019. The ROP requires compliance verification of nitrogen oxides (NOx) and carbon monoxide (CO) emission concentrations and emission rates for each turbine exhaust train defined in the ROP under FG-UTILITIES, which includes the North and South units. Each turbine exhaust train includes a combustion gas turbine (CGT) and a heat recovery steam generator (HRSG) in series. Each HRSG includes duct burners for supplementing steam output during increased process steam demand. Emissions from each CGT are regulated by 40 CFR Part 60, Subpart GG. Emissions from the duct burners are regulated by the ROP.

In addition to determining NOx and CO emissions for ROP compliance, PM emissions while firing duct burners were determined and will be used to establish emission factors to support Michigan Air Emissions Reporting System (MAERS) reporting requirements.

For each of the two similar CGT/HRSG sets, there are three operating modes that are explained in detail below. The Supplemental Mode is the operating mode with the greatest emission potential requiring operation of both the duct-burners and the CGT serving the tested exhaust stack simultaneously during emissions measurements. This is the operating mode regulated by FG-UTILITIES. Note that each CGT, when fired and loaded, can only be operated at full load capacity except for periods of startup, shutdown, or malfunction.

In addition to testing each exhaust stack in the Supplemental Mode, each B4942 stack was tested in a "turbine only" mode without duct-burners firing, known as Turbine Exhaust Gas (TEG) Mode, and in Fresh Air Mode where only the duct-burners are fired without firing the combustor in the respective CGT.

The TEG Mode testing of each stack (both the North and South Units) consisted of three test runs firing the tested turbine at >90% of maximum rated capacity while the SoLoNOx™ burner technology was operational, and no duct burners were fired. Similarly, three runs were conducted on each stack under the previously described Fresh Air and Supplemental Modes. This equated to a total of eighteen (18) test runs (nine test runs per stack) being conducted during this test program.

The NOx and CO emissions test results are used to demonstrate compliance with the current ROP. In addition, the NOx and CO emissions test results along with emissions test results for particulate matter (PM) will be used to establish emission factors to support Michigan Air Emissions Reporting System (MAERS) reporting requirements.

The tables in **Figure 1-1** present excerpts from the ROP that summarize the nitrogen oxides (NOx) and carbon monoxide (CO) permitted emissions limits for each of the operating modes.

The requirements of this test program were to perform a series of tests to measure exhaust gas emissions from each CTG/HRSG stack with each tested firing natural gas under three separate operating scenarios including Supplemental Mode, TEG Mode, and Fresh Air Mode. Gaseous emission parameters measured from each stack included oxides of nitrogen (NO_x), carbon monoxide (CO), and filterable particulate matter (PM). Sampling for PM emissions were only measured during firing of the duct burners. The measurement of oxygen (O_2) and carbon dioxide (CO_2) diluent gases were performed in conjunction with the emissions tests. Three test runs were conducted for each of the three operating conditions at both the North and South exhaust stacks.

Test program participants included: Peter Becker, James Edmister, Matt Collins, Jon Grech, and Erik Drake from AECOM. James McGee and Andrew Volmering participated on behalf of Corteva. Washburn is a Qualified Source Testing Individual (QSTI) for Groups I and III, and he conducted a review of the field program and drafted the project test report. Rob Sava is a QSTI for Groups I and III, and conducted a review of the project test report.

Additional information is contained in the Appendices as follows: Appendix A provides emissions data results and field datasheets, Appendix B contains facility process operating data, Appendix C contains reference method QA data and certificates-of-calibration for the compressed gases used, and Appendix D contains test plan documents.

Figure 1-1: Title V ROP (SRN B4942) Permitted Emission Limits

Pollutant	Limit	Time Period/ Operating Scenario	Equipment	Monitoring/ Testing Method	Underlying Applicable Requirements
1. Oxides of Nitrogen (NOx) - Fresh Air Mode	4.5 lbs/hr[1]	based upon a calendar day averaging period	Applies individually to EU_N_BURNER, EU_S_BURNER of FG-BURNERS	SC VI.1	R 336.1205(3)
2. Carbon Monoxide (CO) – Fresh Air Mode	4.8 lbs/hr[1]	based upon a calendar day averaging period	Applies individually to EU_N_BURNER, EU_S_BURNER of FG-BURNERS	SC VI.1	R 336.1205(3)

*Limits do not include startup, shutdown and malfunction conditions

Operating Modes:

- Supplemental Mode = gas turbine operating, heat recovery steam generator operating. Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- TEG (Turbine Exhaust Gas) Mode = gas turbine operating & heat recovery steam generator operating (the burner is not operating). Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- Fresh Air Mode = burner operating & heat recovery steam generator operating (the gas turbine is not operating). Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- Turbine Running (Air Generation) = gas turbine operating (the burners & heat recovery steam generator are not operating). Emissions for the north unit vent through SV00008 & the south unit through SV00010.

Pollutant	Limit	Time Period/ Operating Scenario	Equipment	Monitoring/ Testing Method	Underlying Applicable Requirements
1. NOx – TEG & Turbine Running Modes	25 Parts per million, by volume, at 15% oxygen[2]	instantaneous	Applies individually to EU_N_TURBINE, EU_S_TURBINE of FG-TURBINES	SC VI.2	40 CFR Part 60, Subparts A & GG
2. NOx – TEG & Turbine Running Modes	3.8 lbs/hr[1]	based upon a calendar day averaging period	Applies individually to EU_N_TURBINE, EU_S_TURBINE of FG-TURBINES	SC VI.2	40 CFR Part 60, Subparts A & GG
3. CO – TEG & Turbine Running Modes	50 Parts per million, by volume, at 15% oxygen[2]	instantaneous	Applies individually to EU_N_TURBINE, EU_S_TURBINE of FG-TURBINES	SC VI.2	R 336.1205(3)
4. CO – TEG & Turbine Running Modes	4.65 lbs/hr[1]	based upon a calendar day averaging period	Applies individually to EU_N_TURBINE, EU_S_TURBINE of FG-TURBINES	SC VI.2	R 336.1205(3)

*Limits do not include startup, shutdown and malfunction conditions

ppm = parts per million by volume at 15 percent oxygen and on a dry gas basis

Operating Modes:

- Supplemental Mode = gas turbine operating, heat recovery steam generator operating. Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- TEG (Turbine Exhaust Gas) Mode = gas turbine operating & heat recovery steam generator operating (the burner is not operating). Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- Fresh Air Mode = burner operating & heat recovery steam generator operating (the gas turbine is not operating). Emissions for the north unit vent through SV00007 & the south unit through SV00009.
- Turbine Running (Air Generation) = gas turbine operating (the burners & heat recovery steam generator are not operating). Emissions for the north unit vent through SV00008 & the south unit through SV00010.

1.2 Executive Summary

Corteva (SRN B4942) conducted Title V Renewable Operating Permit (ROP) emissions compliance testing on June 17 and 18, 2024. This testing is required at least once during the term of the ROP but not later than five years from the date of the previous performance test. The ROP requires compliance verification of nitrogen oxides (NOx) and carbon monoxide (CO) concentrations and mass emission rates defined in FG-UTILITIES. There are three operating modes (detailed earlier in this document). The Supplemental Mode is the operating mode with the greatest emission potential, requiring operation of both the respective duct burners and turbine simultaneously during emissions testing. This is the operating mode regulated by FG-UTILITIES.

In addition to testing in the Supplemental Mode (both turbine and duct burners fired together), Corteva tested in TEG Mode (only turbine fired) and Fresh Air Mode (only duct burners fired). The TEG Mode consisted of three runs at greater than 90% of the maximum rated capacity. The SoLoNOx™ burner technology was operational on both the North and South Units. Three runs were conducted in both Fresh Air and Supplemental Modes on each unit. This equated to a total of 18 runs conducted during this testing event.

The NOx and CO emissions test results are used to demonstrate compliance with the current ROP, and all NOx and CO emissions were within permitted limits. In addition, the NOx and CO along with particulate matter (PM) emissions test results will be used to establish emission factors to support MAERS reporting.

The table below presents a summary of the nitrogen oxides (NOx) and carbon monoxide (CO) overall compliance results compared to the permitted emissions limits. The results for each of the test runs, including PM results, are presented in Section 2 of this report.

Table 1-1: Summary of Results Compared to Permitted Emission Limits

Utilities Units/Operational Mode	Parameter	Permit Limits	Test Result
Supplemental Mode EU North Burner/EU North Turbine	NOx CO	13.6 lb/hr 14.1 lb/hr	4.2 lb/hr 5.9 lb/hr
Supplemental Mode EU South Burner/EU South Turbine	NOx CO	13.6 lb/hr 14.1 lb/hr	4.7 lb/hr 1.1 lb/hr
Supplemental Mode Total EU's North and South	NOx CO	13.6 lb/hr 14.1 lb/hr	8.9 lb/hr 7.0 lb/hr
TEG Mode EU North (Permitted Individually)	NOx CO	25 ppmv @ 15% O_2 50 ppmv @ 15% O_2	10.2 ppmv @ 15% O_2 2.0 ppmv @ 15% O_2
TEG Mode EU South (Permitted Individually)	NOx CO	25 ppmv @ 15% O_2 50 ppmv @ 15% O_2	11.1 ppmv @ 15% O_2 4.0 ppmv @ 15% O_2
Fresh Air Mode EU North Burner (Permitted Individually)	NOx CO	4.5 lb/hr 4.8 lb/hr	3.5 lb/hr 2.9 lb/hr
Fresh Air Mode EU South Burner (Permitted Individually)	NOx CO	4.5 lb/hr 4.8 lb/hr	3.6 lb/hr 1.5 lb/hr

2. Summary and Discussion of Results

2.1 Results Summary

This section presents a detailed summary of the NOx, CO, and PM emissions results obtained during the performance testing completed during June 17 and 18, 2024 on the HRSG exhaust stacks serving the North and South CGTs. As previously discussed in Section 1.0, three test runs for each operating mode were completed on each HRSG exhaust stack for the purpose of quantifying NOx and CO emissions while the turbine and/or duct burners, as applicable, fired natural gas under three different operating scenarios, including Supplemental Mode (turbine with duct burners fired), TEG Mode (only turbine fired), and Fresh Air Mode (only duct burners fired).

PM emissions testing was conducted only while the duct burners fired natural gas under two of the three different operating scenarios (Supplemental Mode and Fresh Air Mode). When operated for emissions testing, each turbine and/or duct-burners were operated at maximum achievable load under normal process conditions. The remainder of this section provides summaries of the test results for each measured parameter of each CGT/HRSG exhaust under each operating scenario.

2.2 NOx and CO Emissions Results

2.2.1 North HRSG Stack NOx and CO – Supplemental Mode

As shown in **Table 2-1**, NOx concentrations averaged 16.0 parts per million by volume corrected to fifteen percent oxygen on a dry basis (ppmvd @ 15% O_2) and corresponding NOx mass emission rates averaged 4.2 pounds per hour (lb/hr) during Supplemental Mode operations. CO concentrations averaged 36.7 ppmvd @ 15% O_2, and corresponding CO mass emission rates averaged 5.9 lb/hr.

Supplemental Mode testing was performed while the turbine and duct burners operated at a nominal combined fuel input rate of approximately 1,105 standard cubic feet per minute (scfm) of natural gas.

Table 2-1: Summary of North Stack NOx and CO Emissions – Supplemental Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/17/24	6/17/24	6/17/24	
Run Time	14:15-15:25	16:05-17:10	18:02-19:06	
Exhaust Gas Conditions				
Oxygen (%, dry)	12.99	12.97	13.09	
Carbon Dioxide (%, dry)	4.34	4.35	4.31	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Flue Gas Moisture (%)	10.84	10.75	10.95	10.85
Flue Gas Flow Rate (dscfm)	26,929	27,536	28,068	27,511
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	49.74	45.80	51.47	49.00
Concentration (ppmvd @15% Oxygen)	37.12	34.09	38.86	36.69
Emissions (lb/MMBtu)	0.0833	0.0765	0.0872	0.0823
Emission rate (lb/hr)	5.85	5.50	6.30	5.88
Nitrogen Oxides				
Nitrogen Oxides (ppmv dry)	21.18	21.54	21.49	21.41
Concentration (ppmvd @15% Oxygen)	15.81	16.03	16.23	16.02
Emissions (lb/MMBtu)	0.0583	0.0592	0.0599	0.0591
Emission rate (lb/hr)	4.09	4.26	4.33	4.23

2.2.2 North HRSG Stack NOx and CO – TEG Mode

As shown in **Table 2-2**, NOx concentrations averaged 10.2 ppmvd @ 15% O_2, and corresponding NOx emission rates normalized to heat input averaged 0.038 lb/MMBtu during TEG Mode operations. CO concentrations averaged 2.0 ppmvd @ 15% O_2, and corresponding CO emission rates normalized to heat input averaged 0.0045 lb/MMBtu.

TEG Mode testing was performed while the turbine alone, with no duct burners fired, operated at a nominal fuel input rate of approximately 624 scfm of natural gas.

Table 2-2: Summary of North Stack NOx and CO Emissions – TEG Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/18/24	6/18/24	6/18/24	
Run Time	19:55-20:16	20:16-20:37	20:37-20:58	
Exhaust Gas Conditions				
Oxygen (%, dry)	16.57	16.57	16.57	
Carbon Dioxide (%, dry)	2.49	2.50	2.51	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	1.42	1.45	1.52	1.46
Concentration (ppmvd @15% Oxygen)	1.93	1.98	2.07	1.99
Emissions (lb/MMBtu)	0.00434	0.00444	0.00465	0.00448
Nitrogen Oxides				
Nitrogen Oxides (ppmv dry)	7.83	7.36	7.17	7.45
Concentration (ppmvd @15% Oxygen)	10.65	10.02	9.77	10.15
Emissions (lb/MMBtu)	0.0393	0.0370	0.0361	0.0375

2.2.3 North HRSG Stack NOx and CO – Fresh Air Mode

As shown in **Table 2-3**, NOx concentrations averaged 26.8 ppmvd @ 15% O_2, and corresponding NOx mass emission rates averaged 3.5 lb/hr during Fresh Air Mode operations. CO concentrations averaged 36.6 ppmvd @ 15% O_2, and corresponding CO mass emission rates averaged 2.9 lb/hr.

Fresh Air Mode testing was performed while the duct burners alone, with no turbine fired, operated at a nominal fuel input rate of approximately 511 standard cubic feet per minute (scfm) of natural gas.

Table 2-3: Summary of North Stack NOx and CO Emissions – Fresh Air Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/18/24	6/18/24	6/18/24	
Run Time	09:45-10:50	11:40-12:45	13:20-14:25	
Exhaust Gas Conditions				
Oxygen (%, dry)	16.65	16.78	16.61	
Carbon Dioxide (%, dry)	2.37	2.34	2.44	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Flue Gas Moisture (%)	6.64	6.15	6.87	6.55
Flue Gas Flow Rate (dscfm)	25,469	25,155	24,849	25,158
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	26.91	25.35	26.18	26.15
Concentration (ppmvd @15% Oxygen)	37.35	36.33	35.98	36.55
Emissions (lb/MMBtu)	0.0838	0.0815	0.0807	0.0820
Emission rate (lb/hr)	2.99	2.78	2.84	2.87
Nitrogen Oxides				
Nitrogen Oxides (ppmv dry)	19.08	18.88	19.59	19.19
Concentration (ppmvd @15% Oxygen)	26.49	27.06	26.93	26.82
Emissions (lb/MMBtu)	0.0977	0.0999	0.0994	0.0990
Emission rate (lb/hr)	3.49	3.41	3.49	3.46

2.2.4 South HRSG Stack NOx and CO – Supplemental Mode

As shown in **Table 2-4**, NOx concentrations averaged 17.6 ppmvd @ 15% O_2, and corresponding NOx mass emission rates averaged 4.7 lb/hr during Supplemental Mode operations. CO concentrations averaged 6.6 ppmvd @ 15% O_2, and corresponding CO mass emission rates averaged 1.1 lb/hr.

Supplemental Mode testing was performed while the turbine and duct burners operated at a nominal combined fuel input rate of approximately 1,099 standard cubic feet per minute (scfm) of natural gas.

Table 2-4: Summary of South Stack NOx and CO Emissions – Supplemental Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/18/24	6/18/24	6/18/24	
Run Time	09:45-10:50	11:40-12:45	13:20-14:25	
Exhaust Gas Conditions				
Oxygen (ppm dry)	12.84	12.84	12.82	
Carbon Dioxide (ppm dry)	4.79	4.72	4.71	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Flue Gas Moisture (%)	10.46	9.83	10.05	10.11
Flue Gas Flow Rate (dscfm)	27,566	27,079	27,288	27,311
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	9.16	8.67	9.30	9.04
Concentration (ppmvd @15% Oxygen)	6.70	6.34	6.79	6.61
Emissions (lb/MMBtu)	0.0150	0.0142	0.0152	0.0148
Emission rate (lb/hr)	1.10	1.02	1.11	1.08
Nitrogen Oxides				
Nitrogen Oxides (ppm dry)	21.99	26.19	23.91	24.03
Concentration (ppmvd @15% Oxygen)	16.09	19.17	17.46	17.57
Emissions (lb/MMBtu)	0.0594	0.0707	0.0644	0.0648
Emission rate (lb/hr)	4.35	5.09	4.68	4.71

2.2.5 South HRSG Stack NOx and CO – TEG Mode

As shown in **Table 2-5**, NOx concentrations averaged 11.1 ppmvd @ 15% O_2, and corresponding NOx emission rates normalized to heat input averaged 0.041 lb/MMBtu during TEG Mode operations. CO concentrations averaged 4.0 ppmvd @ 15% O_2, and corresponding CO emission rates normalized to heat input averaged 0.0090 lb/MMBtu.

TEG Mode testing was performed while the turbine alone, with no duct burners fired, operated at a nominal fuel input rate of approximately 612 scfm of natural gas.

Table 2-5: Summary of South Stack NOx and CO Emissions – TEG Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/18/24	6/18/24	6/18/24	
Run Time	21:03-21:24	21:24-21:45	21:45-22:06	
Exhaust Gas Conditions				
Oxygen (%, dry)	16.59	16.58	16.59	
Carbon Dioxide (%, dry)	2.29	2.29	2.29	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	2.88	2.92	2.96	2.92
Concentration (ppmvd @15% Oxygen)	3.94	4.00	4.05	4.00
Emissions (lb/MMBtu)	0.00885	0.00897	0.00909	0.00897
Nitrogen Oxides				
Nitrogen Oxides (ppmv dry)	8.01	8.10	8.11	8.07
Concentration (ppmvd @15% Oxygen)	10.96	11.07	11.11	11.05
Emissions (lb/MMBtu)	0.0404	0.0408	0.0410	0.0408

2.2.6 South HRSG Stack NOx and CO – Fresh Air Mode

As shown in **Table 2-6**, NOx concentrations averaged 29.3 ppmvd @ 15% O_2, and corresponding NOx mass emission rates averaged 3.6 lb/hr during Fresh Air Mode operations. In addition, CO concentrations averaged 20.8 ppmvd @ 15% O_2, and corresponding CO mass emission rates averaged 1.5 lb/hr.

Fresh Air Mode testing was performed while the duct burners alone, with no turbine fired, operated at a nominal fuel input rate of approximately 515 standard cubic feet per minute (scfm) of natural gas.

Table 2-6: Summary of South Stack NOx and CO Emissions – Fresh Air Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	6/17/24	6/17/24	6/17/24	
Run Time	14:15-15:25	16:05-17:10	18:02-19:06	
Exhaust Gas Conditions				
Oxygen (%, dry)	17.38	17.06	17.20	
Carbon Dioxide (%, dry)	2.00	2.03	1.98	
Fuel Used	Natural Gas	Natural Gas	Natural Gas	
Fuel F Factor, dry (F_d, dscf/MMBtu)	8,710	8,710	8,710	
Flue Gas Moisture (%)	6.38	6.76	5.85	6.33
Flue Gas Flow Rate (dscfm)	26,633	26,617	27,645	26,965
Carbon Monoxide				
Carbon Monoxide (ppmv dry)	12.70	13.18	13.12	13.00
Concentration (ppmvd @15% Oxygen)	21.28	20.25	20.91	20.81
Emissions (lb/MMBtu)	0.0478	0.0454	0.0469	0.0467
Emission rate (lb/hr)	1.48	1.53	1.58	1.53
Nitrogen Oxides				
Nitrogen Oxides (ppmv dry)	14.82	19.87	20.32	18.34
Concentration (ppmvd @15% Oxygen)	24.83	30.52	32.39	29.25
Emissions (lb/MMBtu)	0.0916	0.1126	0.1195	0.1079
Emission rate (lb/hr)	2.83	3.80	4.03	3.55

2.3 Particulate Matter Emissions Results

2.3.1 North HRSG Stack PM – Supplemental Mode

As shown in **Table 2-7**, PM (sampled as FPM) concentrations averaged 0.00031 grains per dry standard cubic feet (gr/dscf) during Supplemental Mode operations, and corresponding mass emission rates averaged 0.073 lb/hr.

Supplemental Mode testing was performed while the turbine and duct burners operated at a nominal combined fuel input rate of approximately 1,105 standard cubic feet per minute (scfm) of natural gas resulting in an average PM Emission Factor of 1.10 pounds per million standard cubic foot (lb/MMscf).

Table 2-7: Summary of North Stack PM Emissions – Supplemental Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	17Jun24	17Jun24	17Jun24	
Start Time	14:15	16:05	18:02	
Stop Time	15:25	17:10	19:06	
Process Conditions				
Natural Gas Flow (scfm)	1,123	1,096	1,097	1,105
Natural Gas Flow (MMscf/hr)	0.0674	0.0658	0.0658	0.0663
Exhaust Gas Conditions				
Temperature (deg. F)	303	301	303	302
Moisture (volume %)	10.82	10.74	10.94	10.83
Oxygen (dry volume %)	12.99	12.97	13.09	13.02
Carbon Dioxide (dry volume %)	4.34	4.35	4.31	4.33
Volumetric Flow Rate				
acfm	44,602	45,552	46,667	45,607
dscfm	26,922	27,529	28,061	27,504
Total Filterable Particulate Matter				
gr/dscf	0.000166	0.000531	0.000229	0.000309
lb/hr	0.0383	0.1254	0.0552	0.0730
Emission Factor (lb/MMscf)	0.57	1.91	0.84	1.10

2.3.2 North HRSG Stack PM – Fresh Air Mode

As shown in **Table 2-8**, PM (sampled as FPM) concentrations averaged 0.00024 gr/dscf during Fresh Air Mode operations, and corresponding mass emission rates averaged 0.051 lb/hr.

Fresh Air Mode testing was performed while the duct burners alone, with no turbine fired, operated at a nominal fuel input rate of approximately 511 standard cubic feet per minute (scfm) of natural gas resulting in an average PM Emission Factor of 1.68 lb/MMscf.

Table 2-8: Summary of North Stack PM Emissions – Fresh Air Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	18Jun24	18Jun24	18Jun24	
Start Time	09:45	11:40	13:20	
Stop Time	10:50	12:45	14:25	
Process Conditions				
Natural Gas Flow (scfm)	520	499	515	511
Natural Gas Flow (MMscf/hr)	0.0312	0.0299	0.0309	0.0307
Exhaust Gas Conditions				
Temperature (deg. F)	303	303	301	302
Moisture (volume %)	6.63	6.14	6.78	6.52
Oxygen (dry volume %)	16.65	16.78	16.61	16.68
Carbon Dioxide (dry volume %)	2.37	2.34	2.44	2.38
Volumetric Flow Rate				
acfm	40,134	39,420	39,117	39,557
dscfm	25,460	25,146	24,857	25,154
Total Filterable Particulate Matter				
gr/dscf	0.000247	0.000248	0.000219	0.000238
lb/hr	0.0540	0.0536	0.0467	0.0514
Emission Factor (lb/MMscf)	1.73	1.79	1.51	1.68

2.3.3 South HRSG Stack PM – Supplemental Mode

As shown in **Table 2-9**, PM (sampled as FPM) concentrations averaged 0.00017 gr/dscf during Supplemental Mode operations, and corresponding mass emission rates averaged 0.040 lb/hr.

Supplemental Mode testing was performed while the turbine and duct burners operated at a nominal combined fuel input rate of approximately 1,099 standard cubic feet per minute (scfm) of natural gas resulting in an average PM Emission Factor of 0.61 lb/MMscf.

Table 2-9: Summary of South Stack PM Emissions – Supplemental Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	18Jun24	18Jun24	18Jun24	
Start Time	09:45	11:40	13:20	
Stop Time	10:50	12:45	14:25	
Process Conditions				
Natural Gas Flow (scfm)	1,102	1,095	1,101	1,099
Natural Gas Flow (MMscf/hr)	0.0661	0.0657	0.0660	0.0660
Exhaust Gas Conditions				
Temperature (deg. F)	298	297	297	297
Moisture (volume %)	10.44	9.81	10.14	10.13
Oxygen (dry volume %)	12.84	12.84	12.82	12.83
Carbon Dioxide (dry volume %)	4.79	4.72	4.71	4.74
Volumetric Flow Rate				
acfm	45,097	43,903	44,349	44,450
dscfm	27,558	27,071	27,253	27,294
Total Filterable Particulate Matter				
gr/dscf	0.000112	0.000167	0.000234	0.000171
lb/hr	0.0265	0.0388	0.0547	0.0400
Emission Factor (lb/MMscf)	0.40	0.59	0.83	0.61

2.3.4 South HRSG Stack PM – Fresh Air Mode

As shown in **Table 2-10**, PM (sampled as FPM) concentrations averaged 0.00031 gr/dscf during Fresh Air Mode operations, and corresponding mass emission rates averaged 0.071 lb/hr.

Fresh Air Mode testing was performed while the duct burners alone, with no turbine fired, operated at a nominal fuel input rate of approximately 515 standard cubic feet per minute (scfm) of natural gas resulting in an average PM Emission Factor of 2.29 lb/MMscf.

Table 2-10: Summary of South Stack PM Emissions – Fresh Air Mode

Run Identification	Run 1	Run 2	Run 3	Average
Run Date	17Jun24	17Jun24	17Jun24	
Start Time	14:15	16:05	18:02	
Stop Time	15:25	17:10	19:06	
Process Conditions				
Natural Gas Flow (scfm)	532	516	497	515
Natural Gas Flow (MMscf/hr)	0.0319	0.0310	0.0298	0.0309
Exhaust Gas Conditions				
Temperature (deg. F)	303	301	303	302
Moisture (volume %)	6.37	6.75	5.84	6.32
Oxygen (dry volume %)	17.38	17.06	17.20	17.21
Carbon Dioxide (dry volume %)	2.00	2.03	1.98	2.00
Volumetric Flow Rate				
acfm	42,041	42,156	43,431	42,543
dscfm	26,625	26,609	27,635	26,956
Total Filterable Particulate Matter				
gr/dscf	0.000292	0.000377	0.000253	0.000307
lb/hr	0.0666	0.0860	0.0600	0.0709
Emission Factor (lb/MMscf)	2.09	2.78	2.01	2.29

3. Test Program and Sampling Methodology

3.1 Overview

This section outlines the test locations, operating conditions and test methodologies adhered to throughout the test program. The sampling activities described below were conducted during all runs. Throughout the overall program, all sampling was performed using sampling procedures described herein and specified by US EPA and Michigan EGLE. All field activities were documented in accordance with US EPA accepted procedures and copies of all reference method field data sheets and calculations are included in **Appendix A** of this report.

3.2 Test Program

For measurement of gaseous exhaust gas parameters, AECOM used our mobile instruments laboratory following US EPA Instrumental Analyzer Procedures specified in Methods 3A, 7E, and 10 from 40 CFR 60, Appendix A for the determination of O_2/CO_2, NO_x, and CO, respectively. In addition, PM was measured using isokinetic sampling equipment as filterable particulate matter (FPM) in accordance with EPA Method 5.

Pollutant measurements at each exhaust stack included PM, NO_x, and CO. Each location was sampled concurrently for three 60-minute test runs while the turbine and/or duct burners fired natural gas at 100% Load and for three 21-minute test runs at 100% Load while operating the turbine alone on natural gas when no duct burners were fired.

Concurrent with pollutant measurements, diluent gas measurements of O_2 and CO_2 were made in accordance with Method 3A using instrumental analyzers. The following table summarizes the test program.

Table 3-1: Test Program Summary

Test Location	Operating Mode	Pollutants	US EPA Test Methods	No. of Test Runs	Test Run Duration
North HRSG Exhaust Stack	Supplemental	PM, NOx, and CO	5, 7E, and 10	3	60 minutes each
	TEG	NOx and CO	7E and 10	3	21 minutes each
	Fresh Air	PM, NO_x, and CO	5, 7E, and 10	3	60 minutes each
South HRSG Exhaust Stack	Supplemental	PM, NOx, and CO	5, 7E, and 10	3	60 minutes each
	TEG	NOx and CO	7E and 10	3	21 minutes each
	Fresh Air	PM, NO_x, and CO	5, 7E, and 10	3	60 minutes each

NOx and CO emission concentrations for each test run, expressed in units of ppmvd @ 15% O_2, were calculated in accordance with US EPA Method 7E (40 CFR 60, Appendix A). Mass emission rates, expressed in units of lb/hr, were calculated in accordance with Method 5 using the exhaust gas volumetric flow rates at the HRSG Stack where exhaust gas flow rate was measured directly in accordance with Method 2. Corteva provided AECOM with the fuel feed rate during each test run (scfm). These data are presented in **Appendix B**.

Process operations were monitored during the testing and the following parameters recorded by Corteva personnel:

North Stack:

- Turbine and duct burners gas usage
- Mode of Operation
- NO rate (lb/15min)
- CO rate (lb/15min)

These data are presented in **Appendix B** of this report.

3.3 Sampling and Monitoring Methodology

3.3.1 Isokinetic Sampling Procedures

Filterable particulate matter emissions were measured using a US EPA Method 5 sampling train. The basic EPA Method 5 FPM sampling train configuration was employed, which required a glass nozzle, heated probe, heated filter oven, a tared quartz or Teflon coated glass matte filter and a Teflon frit. The front half rinses were transferred into lightweight tarred Teflon beakers for analysis in order to improve sample analytical precision.

The sampling train included a series of leak free impingers that contained a known amount of water and known quantity of silica gel. The sampling train was operated isokinetically (±10%) by extracting a gas sample from the stack and collecting the particulate matter from the gas sample for subsequent gravimetric analysis. At the conclusion of sampling, the probe and filter assembly were recovered. Finally, the volume of liquid collected in the impingers was measured to allow for determination of gas stream moisture content (EPA Method 4).

3.3.2 Continuous Emissions Monitoring Procedures

A transportable instrumental measurements system was used to monitor O_2/CO_2, NOx, and CO emissions from each HRSG exhaust stack in accordance with the procedures in EPA Reference Methods 3A, 7E, and 10, respectively. The sample delivery system at each location consisted of a stainless-steel sample probe with a heated particulate filter, a heated calibration valve assembly for delivery of calibration gases to the system, a heat-traced Teflon sample line, a refrigerated gas conditioning system (for moisture and fine particulate removal), a sample gas manifold, and sample pump. The sample gas passed through the moisture removal system, after which, the clean, dry sample gas was subsequently directed via the sample gas manifold to the gas analyzers for determination of O_2/CO_2, NO_x, and CO, as applicable.

The output signals from each analyzer were connected to an I/O Tech Data Acquisition System (DAS). The DAS stored the collected data in engineering units and provided 1-minute averages based upon 60 readings per minute. The IBM PC also displayed real time data for all analyzers on a concentration basis.

The following sequences of events were performed in the conduct of this monitoring program for each source:

1. Set up and leak check each sample delivery system.
2. Perform initial calibrations by introducing calibration gas directly to the dry measurement O_2, CO_2, NOx, and CO analyzers using nitrogen (zero concentration) and two upscale concentrations of the respective calibration gases certified in accordance with EPA Protocol 1 procedures.
3. Perform a sample delivery bias check for each dry measurement analyzer by introducing calibration gases at the sample probe via a three-way valve and comparing the results to the previous calibration data (introduced directly to the analyzers).
4. Perform a system response time test of each analyzer in order to confirm the system response time.
5. Monitor O_2, CO_2, CO, and NOx (as applicable) for three test runs of specified duration for each sample location and operating condition as previously specified. Perform system calibration drift and bias tests between each set of test runs.
6. Perform final calibration checks, as needed.

3.3.2.1 Instrumental Analyzers Calibration Procedures

The AECOM instrumental measurements system was leak-checked prior to the start of the monitoring program. The instrumental analyzers were calibrated before and after each set of test runs using calibration standards prepared in accordance with EPA Protocol #1 supplied by Air Gas East. In addition, response time checks and NO_2 to NO converter checks were performed on each analyzer (as applicable) and the entire measurement system before field use.

Direct calibrations of the O_2, CO_2, NO_x, and CO analyzers were conducted using nitrogen (zero) and two compressed gas cylinder standards containing certified concentrations of calibration gas in a balance of pure nitrogen. System calibrations of the O_2, CO_2, NOx, and CO analyzers were conducted using nitrogen (zero) and an upscale compressed

gas cylinder standard (as applicable) containing certified concentrations of calibration gases in a nitrogen balance. These calibration procedures were used to determine instrument calibration error, calibration drift, and system bias in order to ensure valid test runs were conducted. These calibrations were also used to correct the monitoring data for the observed system drift and bias.

The criteria for valid test runs are as follows;

- Calibration error = +/- 2% of calibration span
- Zero and Calibration Drift = +/- 3% of calibration span
- System Bias = +/- 5% of calibration span

The equation used to correct the data for bias and drift is presented below:

$$C_{gas} = \left(\overline{C} - C_o\right)\frac{C_{ma}}{C_m - C_o}$$

Where:

C_{gas} = Effluent gas concentration, dry basis, ppm
C = Average gas concentration indicated by gas analyzer, dry basis, ppm
C_o = Average of initial and final system calibration bias check responses for the zero gas, ppm
C_m = Average of initial and final system calibration bias check responses for the upscale calibration gas, ppm
C_{ma} = Actual concentration of the upscale calibration gas, ppm

3.4 Monitoring Locations for HRSG Exhaust Stacks

As previously specified, each CGT/HRSG exhaust train shares a common exhaust stack. This follows the sample locations that were used for the previous initial performance test program.

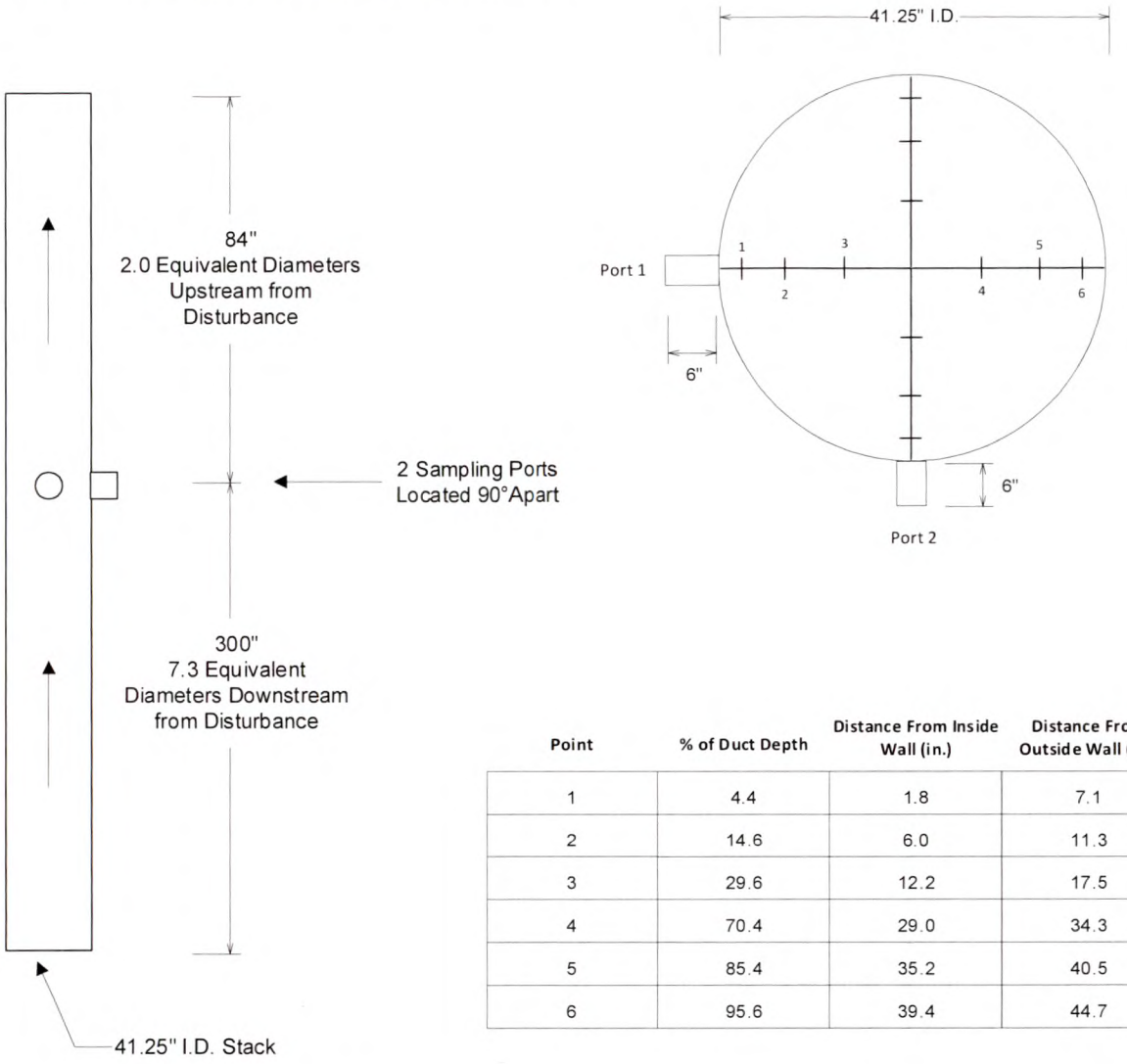
3.4.1 HRSG Exhaust Stacks (Typical)

Two (2) sampling ports are located in each vertical stack, which are identical in dimensions. The internal cross-sectional dimension of each stack at the test ports is 41.25 inches in diameter. The test ports of each stack are located approximately 300 inches downstream from the nearest flow disturbance (the top of the HRSG breeching). This equates to approximately 7.3 equivalent diameters. The test ports of each stack are located approximately 84 inches upstream from the stack exhaust point to atmosphere. This equates to approximately 2.0 equivalent diameters. Based on the upstream and downstream equivalent diameters, a total of 12 traverse points were required (6 points per each of two ports at 90 degrees) for particulate sampling.

AECOM installed a fixed-position instrumental measurements system probe in each stack, equipped with a heated particulate filter for the gaseous parameter sampling. Stratification tests showed each stack to be unstratified. The fixed probe provided continuous sampling from a single measurement point. NO_x determinations were conducted following EPA Method 7E and CO determinations were conducted following EPA Method 10. PM determinations were conducted only when duct burners were fired during Supplemental and Fresh Air Modes following EPA Method 5 for total filterable PM. CO_2 and O_2 were determined by EPA Method 3A measurements in conjunction with the gaseous pollutant parameters. The CO_2 and O_2 determined were used to determine the molecular weight of the gas stream and were included in the exhaust gas volumetric flow rate calculations. In addition, measured O_2 concentrations (dry basis) were used to correct measured emission concentrations (dry) of NOx and CO to an exhaust gas excess oxygen concentration of 15 percent oxygen by volume (i.e., ppmvd @ 15% O_2) as well as calculating emission rates relative to heat input expressed in units of pounds per million British thermal units (lb/MMBtu).

A schematic of the typical HRSG exhaust stack is presented in **Figure 3-1**.

Figure 3-1: Schematic of Stack Sample Port Locations



Point	% of Duct Depth	Distance From Inside Wall (in.)	Distance From Outside Wall (in.)
1	4.4	1.8	7.1
2	14.6	6.0	11.3
3	29.6	12.2	17.5
4	70.4	29.0	34.3
5	85.4	35.2	40.5
6	95.6	39.4	44.7

(Not to Scale)

3.5 QA/QC and Data Reporting

The Field Team Leader reviewed the data that were collected from each sampling system in its entirety in the field. Field data reduction (checking sampling parameters) was accomplished using a laptop computer employing standardized Excel spreadsheets. Copies of these spreadsheets and the raw field data forms that were completed by hand during the testing program are provided in **Appendix A**.

All sampling, analytical and quality assurance/quality control (QA/QC) procedures outlined in the above referenced methods were followed. The principal goal in this regard was to provide for proper collection and organization of accurate information followed by clear and concise reporting of the data. Instrument calibration data and cylinder gas certifications are provided in **Appendix C**.