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SOURCE EMISSIONS COMPLIANCE TESTING

NATURAL GAS-FIRED TURBINE
HEAT RECOVERY STEAM GENERATOR
NATURAL GAS-FIRED DRYER

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HEAT RECOVERY STEAM GENERATOR
NATURAL GAS-FIRED DRYER

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1. INTRODUCTION

O'Brien & Gere Engineers, Inc., a Ramboll company (Ramboll) was retained by Cargill Salt (Cargill) to conduct emissions testing on the exhausts of a natural gas-fired salt dryer (Emission Unit ID EUACLREFINERY), natural gas-fired turbine (Emission Unit ID EUTURBINE), and a heat recovery steam generator system (Emission Unit ID EUHRSG) at the Cargill Salt Division facility located in Hersey, Michigan. The objective of the test program was to satisfy requirements of the facility's permit to install (PTI) issued by the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

The compliance test program was performed on December 4-5, 2019. Ms. Kip Cosan of Cargill was present to coordinate process operations with the test program and collect process data. Mr. Robert Dickman of EGLE was present to witness a portion of the test program.

Results of the test program indicate that the facility is operating within the applicable emission limits outlined in the PTI. Results of the testing are summarized in Section 4.0 of this report.

1.1 Facility ID, Mailing Address, and Primary Contacts

Facility
Cargill Salt
EGLE Permit ID: 338-06D
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Hersey, Michigan 49639
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Source Testing Company

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Liverpool, New York 13090
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1.2 Purpose and Objective of the Emissions Test

The objective of the test program was to provide the necessary data to evaluate compliance with emission standards as outlined in the facility's PTI. Testing of each emission unit was performed to determine emissions of carbon monoxide (CO) and oxides of nitrogen (NO_x). The permit limits for each emission unit that were evaluated are summarized in Table 1-1.

Table 1-1 Permit Emission Standards

Emissions Source	CO Compliance Limit	NOx Compliance Limit	
	(lb/hr)	(lb/hr)	(lb/MMBtu)
EUNACLREFINERY	2.36	2.8	0.100
EUTURBINE	5.8	8.5	0.120
EUHRSG	13.4	10.78	0.161

1.3 Document Organization

The remainder of this document is structured as follows:

- Section 2 provides a summary of the test program.
- Section 3 provides a description of the test methods and the quality assurance/control procedures.
- Section 4 provides the test program results and discussion.
- Appendix A provides copies of facility process data.
- Appendix B provides the traverse point locations.
- Appendix C provides copies of all field data and calculations.
- Appendix D provides copies of equipment calibration data.

2. SUMMARY OF TEST PROGRAM

This section provides a summary of the source emission testing conducted. Test methods can be found in Section 3.

2.1 Testing Program Summary

Testing was conducted in triplicate (three test runs) on the salt dryer, turbine, and HRSG exhaust during typical process operating conditions and production rates as maintained by facility personnel. Process conditions and production rates were maintained in a manner to provide for the highest amount of expected emissions during the test. All test runs were 60 minutes in duration.

The HRSG and turbine emissions are typically exhausted through a common stack. In order to evaluate the turbine and HRSG emissions independently, the turbine emissions were tested separately through a bypass stack followed by the turbine and HRSG together through the combined stack to evaluate the HRSG emissions by difference.

The following process operating data was monitored and recorded by facility personnel approximately every 15 minutes during each test run. Copies of the process data are presented in **Appendix A**.

Salt Dryer

- Hot Salt Weight Belt Average (tons/hr)
- Natural Gas Usage (mcf)
- Scrubber Inlet Pressure (in. H_2O)
- Scrubber Spray Pressure (in. H_2O)
- Scrubber Fan Differential Pressure (in. H_2O)

Turbine and HRSG

- Natural Gas Usage (mcf)
- Steam Load (klb/hr)

3. TEST METHODS

This section describes the test methods and quality control procedures that were utilized as part of the testing program.

3.1 Test Methods

PTI tests were conducted in accordance with the most recent updates to the USEPA reference methods described in 40 CFR 60; Appendix A.

Method 1:	Sample and Velocity Traverses for Stationary Sources
Method 2:	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Method 3A:	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources – Instrumental Analyzer Procedure
Method 4:	Determination of Moisture Content in Stack Gases
Method 7E:	Determination of Nitrogen Oxides Emissions from Stationary Sources – Instrumental Analyzer Procedure
Method 10:	Determination of Carbon Monoxide Emissions from Stationary Sources – Instrumental Analyzer Procedure
Method 19:	Determination of SO_2 Removal Efficiency and PM, SO_2 and NO_x Emission Rates

3.1.1 Oxygen and CO_2 Concentration

The percent O_2 and CO_2 levels in the exhaust gas were evaluated in accordance with USEPA Reference Method (RM) 3A procedures using a Servomex Model 1440 paramagnetic analyzer. A continuous gas sample was extracted from the exhaust stack through a sintered filter, stainless steel probe, heated Teflon line and through a conditioning system used to remove moisture from the gas stream. All material that came in contact with the sample was constructed of either stainless steel, glass, or Teflon.

3.1.2 Nitrogen Oxides and Carbon Monoxide Emissions

CO emissions were determined in accordance with procedures outlined in USEPA RM 10. A Thermo Model 48i CO analyzer was used to determine CO concentrations by measuring the absorbance of the sample in the infrared spectrum. Gas filter correlation techniques are designed into the instrument to improve its specificity and sensitivity. NO_x emissions were determined in accordance with procedures outlined in USEPA RM 7E. A Thermo Model 42i chemiluminescent analyzer was used to determine NO_x concentrations by converting all NO_x in the sample gas stream to NO and reacting the NO with ozone. The chemiluminescence produced by the reaction is proportional to the concentration of NO_x and is measured as voltage.

Emissions of NO_x and CO were evaluated in accordance with USEPA RMs 7E and 10. A continuous gas sample was extracted from the exhaust stack through a sintered filter, stainless steel probe, heated Teflon line and through a conditioning system used to remove moisture from the gas stream. All material that came in contact with the sample was constructed of either stainless steel, glass, or Teflon.

The sample delivery system consisted of a stainless steel sintered filter, stainless steel probe, a three-way valve assembly for delivery of calibration gases to the system, a heat-traced Teflon sample line, a refrigerated gas conditioning system (for moisture and particulate removal), a sample gas manifold, and a sample pump. Instrument outputs were monitored continuously using a laptop personal computer (PC) programmed with Microsoft Windows™ compatible software. The instruments were linked to the PC via USB interface. The PC polled data from each analyzer five times per second and displayed instantaneous data as two-second averages. Thirty-second averages were displayed, written to, and stored in a database.

NO_x emissions in units of lb/MMBtu was determined in accordance with EPA RM 19 procedures using the tabulated fuel F-factor of 8,710 dscf/MMBtu for natural gas.

3.2 Gas Velocity, Volumetric Flow Rate, and Molecular Weight

Exhaust gas volumetric flow rate was determined at each test location in units of dry standard cubic feet per minute and was derived from velocity, temperature, molecular weight, and moisture measurements. CO and NO_X mass emission rates in units of lb/hr were calculated using pollutant concentrations and volumetric flow rates.

Velocity was determined from differential pressure measurements using a stainless steel Type-S pitot tube and oil manometer or magnehelic gauge in accordance with USEPA RMs 1 and 2. These methods were conducted in conjunction with each test run. These measurements were conducted utilizing test ports located 90° apart in the same plane that meet USEPA RM 1 criteria.

The molecular weight of the exhaust gas was determined by measurements of carbon dioxide (CO_2) and oxygen (O_2) concentrations in accordance with USEPA RM 3A. Moisture content was determined in accordance with USEPA RM 4 procedures.

3.3 Test Port and Traverse Point Locations

3.3.1 Salt Dryer

The sample ports in the circular 66-inch inside diameter (ID) exhaust stack are located approximately 11-feet (2 diameters) downstream from the nearest disturbances and greater than 33-feet (6 diameters) upstream of the exit of the stack exhaust.

3.3.2 Turbine

Sample ports in the circular 54-inch ID exhaust stack are located approximately 35-feet downstream from the nearest disturbances and greater than 40-feet (9 diameters) upstream of the exit of the stack exhaust.

3.3.3 Heat Recovery Steam Generator

Sample ports in the circular 54-inch ID exhaust stack are located approximately 35-feet downstream from the nearest disturbances and greater than 40-feet (9 diameters) upstream of the exit of the stack exhaust.

Actual traverse point locations are presented in **Appendix B**.

3.4 Equipment Calibration

Calibration of equipment was conducted in accordance with the procedures outlined in the EPA document entitled "Quality Assurance Handbook for Air Pollution Measurement Systems; Volume III—Stationary Source Specific Methods" (EPA-600/4-77-027b). Equipment calibration was performed in accordance with EPA guidelines and/or manufacturer's recommendations. Documentation of all calibration records are kept in the project file during the field program and are available for inspection by test observers. Examples of field equipment to be used and typical calibration requirements follows:

- Pitot tubes (QA Handbook Section 3.1.2, pp. 1-13) - measured for appropriate spacing and dimensions or to calibrate in a wind tunnel. Rejection criteria are given on the calibration sheet. Post-test check - inspect for damage.

- Thermocouples (QA Handbook Section 3.4.2, pp. 15-18) - verify against a mercury-in-glass thermometer at two or more points including the anticipated measurement range. Acceptance limits - impinger ±2°F; DGM ±5.4°F; stack ±1.5 percent of stack temperature.

- Dry gas meters (QA Handbook Section 3.4.2, pp. 1-12) - dry gas meters are calibrated using critical orifices. The procedure entails four runs using four separate critical orifices running at an actual vacuum 1-2 in. greater than the theoretical critical vacuum. The minimum sample volume required per orifice is 5 ft^3. Meter boxes are calibrated annually and then verified by use of the alternative Method 5 post-test calibration procedure. This procedure is referenced as Approved Alternate Method ALT-009 (June 21, 1994) by EPA's Emission Measurement Center. The average Y-value obtained by this method must be within 5% of the initial Y-value.

- Field barometer (QA Handbook Section 3.4.2, pp. 18-19) - compare against a mercury-in-glass barometer or use Airport Station BP and correct for elevation. Acceptance criteria - ± 0.02 in. Hg; post-test check - same.

3.5 Quality Assurance/Quality Control Procedures

Analyzers were calibrated in accordance with the procedures outlined in the corresponding USEPA test methods and/or the USEPA document entitled Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III - Stationary Source Specific Methods (USEPA 600/R-94/038c).

Continuous emission monitoring analyzer response time tests were conducted on each analyzer and the entire measurement system, as applicable. Each analyzer and the entire instrument measurement system was challenged with USEPA Protocol No. 1 gas standards (zero and mid gas) in accordance with procedures specified in each respective test method at the beginning and end of every test run. The calibration gases were introduced to the sampling system at the sample probe to expose the calibration standards to as much of the sampling system as possible. NO_x, CO, O_2, and CO_2 concentrations were bias corrected in accordance with USEPA RM 7E procedures. The calibration gases used during the test program are presented in Table 4-1 below.

Protocol calibration standards were prepared in accordance with USEPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards. The accuracy of these gases was +/- 2% or better. Copies of the calibration certificates are included in **Appendix D** of this test report.

3.5.1 Test Data and Report Review

Test data input and emission calculations were double-checked for accuracy. The test results were reviewed by senior personnel for reasonableness and accuracy. The final report was peer reviewed by senior personnel and certified by the project manager.

Table 4-1 Analyzer Operating Range and Calibration Gases

Analyzer ID	Source ID	Principle of Operation	Operating Range	Calibration Gases[a]
NO_x (TEI 42i-HL)	HRSG Turbine Salt Dryer	Chemiluminescence	0-49 ppm	25.1 ppm NO_x in N_2 48.6 ppm NO_x in N_2
CO (TEI 48i)	HRSG Turbine Salt Dryer	NDIR/Gas Filter Correlation (GFC)	0-56 ppm	25.5 ppm CO in N_2 55.7 ppm CO in N_2
O_2 (Servomex 1440)	HRSG Turbine Salt Dryer	Paramagnetic	0–22 percent	11.91 percent O_2 in N_2 21.98 percent O_2 in N_2
CO_2 (Servomex 1440)	HRSG Turbine Salt Dryer	Non-Dispersive Infrared	0-17 percent	8.83 ppm CO_2 in N_2 17.17 ppm CO_2 in N_2

[a] Analyzers were zeroed with ultra high purity (UHP) grade nitrogen

4. RESULTS AND DISCUSSION

A brief discussion of the test results is presented below. A detailed summary of the test results is presented in Tables 1-3. Supporting field data and calculations are presented in **Appendix C** of this test report.

4.1 Salt Dryer Exhaust (Table 1)

CO concentrations at the dryer exhaust averaged approximately 4.80 ppm for the test program. Corresponding mass emission rates averaged approximately 1.00 lb/hr, well within the permit limit of 2.36 lb/hr.

NO_x concentrations at the dryer exhaust averaged approximately 4.88 ppm for the test program. Corresponding mass emission rates averaged approximately 1.67 lb/hr, well within the permit limit of 2.8 lb/hr. NO_x emission rates normalized to heat input averaged approximately 0.072 lb/MMBtu for the three RM test runs which are within the permit limit of 0.100 lb/MMBtu.

4.2 Turbine Exhaust (Table 2)

CO concentrations at the turbine exhaust averaged approximately 1.70 ppm for the test program. Corresponding mass emission rates averaged approximately 0.34 lb/hr, well within the permit limit of 5.8 lb/hr.

NO_x concentrations at the dryer exhaust averaged approximately 13.4 ppm for the test program. Corresponding mass emission rates averaged approximately 4.39 lb/hr, well within the permit limit of 8.5 lb/hr. NO_x emission rates normalized to heat input averaged approximately 0.056 lb/MMBtu for the three RM test runs which are well within the permit limit of 0.120 lb/MMBtu NO_x.

4.3 Heat Recovery Steam Generator (Table 3)

CO concentrations from the HRSG averaged approximately 33.7 ppm for the test program. Corresponding mass emission rates averaged approximately 6.64 lb/hr, well within the permit limit of 13.4 lb/hr.

NO_x concentrations from the HRSG averaged approximately 3.29 ppm NO_X for the test program. Corresponding mass emission rates averaged approximately 0.95 lb/hr NO_X, well within the permit limit of 10.78 lb/hr. NO_x emission rates normalized to heat input averaged approximately 0.0025 lb/MMBtu for the three RM test runs which are well within the permit limit of 0.161 lb/MMBtu NO_x.

There were no operational or testing problems that impacted the test results and all test data is believed to be representative of the emissions encountered during the test program.