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REPORT ON HYDROGEN CHLORIDE COMPLIANCE TESTING

Performed for:
CONSUMERS ENERGY
UNIT 2 EXHAUST DUCT
J.H. CAMPBELL GENERATING COMPLEX

Client Reference No: 4400058909
CleanAir Project No: 13046-2
Revision 0: September 28, 2016

To the best of our knowledge, the data presented in this report are accurate, complete, error free and representative of the actual emissions during the test program. Clean Air Engineering operates in conformance with the requirements of ASTM D7036-04 Standard Practice for Competence of Air Emission Testing Bodies.

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REVISION HISTORY

REPORT ON HYDROGEN CHLORIDE COMPLIANCE TESTING

DRAFT REPORT REVISION HISTORY

Revision:	Date	Pages	Comments
D0a	09/22/16	All	Draft version of original document.

FINAL REPORT REVISION HISTORY

Revision:	Date	Pages	Comments
0	09/28/16	All	Final version of original document.

PROJECT OVERVIEW

INTRODUCTION

Consumers Energy contracted Clean Air Engineering (CleanAir) to perform hydrogen chloride (HCl) testing at the J.H. Campbell Generating Complex, located in West Olive, Michigan, for Mercury and Air Toxics Standards (MATS) compliance purposes.

This report summarizes Consumers Energy's demonstration of compliance with the 40 CFR Part 63 UUUUU MATS emission limit of 0.002 lb/MMBtu for HCl on EUBOILER2 (Unit 2) Exhaust Duct (AQD Source ID B2835), in accordance with procedures outlined in EPA Method 320 of 40 CFR Part 63, Appendix A.

All testing was conducted in accordance with the regulations set-forth by the United States Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (DEQ).

Key Project Participants

Individuals responsible for coordinating and conducting the test program were:

K. Cunningham – Consumers Energy
S. Lachance – DEQ
K. Sullivan – CleanAir

Test Program Parameters

The testing was performed at the Unit 2 Exhaust Duct on July 8 and August 9, 2016, and included the following emissions measurements:

- hydrogen chloride (HCl)
- flue gas composition (e.g., CO_2 and H_2O)

Consumers Energy attempted to demonstrate compliance with the applicable limit while Unit 2 burned both a 100% Powder River Basin (PRB) fuel (July 8) and a 60%/40% blend of PRB and Eastern fuel (August 9). The test programs were conducted while Unit 2 was operating at full load (90% to 110% design capacity) conditions during burning of 60%/40% PRB/Eastern fuel and 70% to 85% design capacity during burning of 100% PRB fuel. Unit 2 is de-rated while burning of 100% PRB coal.

PROJECT OVERVIEW

TEST PROGRAM SYNOPSIS

Test Schedules

The on-site schedules followed during the test program is outlined in Tables 1-1 and 1-2.

Table 1-1:
Schedule of Activities – Unit 2 100% PRB

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	7/08/16	08:45	10:10
2	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	7/08/16	10:25	11:27
3	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	7/08/16	11:43	12:45

Table 1-2:
Schedule of Activities – Unit 2 60%/40% PRB/Eastern Blend

Run Number	Location	Method	Analyte	Date	Start Time	End Time
1	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	8/09/16	10:50	11:50
2	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	8/09/16	12:06	13:06
3	Unit 2 Exhaust Duct	USEPA M320/3A	HCl/CO_2	8/09/16	14:13	15:14

Results Summary

Table 1-3 summarizes the results of the test program. A more detailed presentation of the test conditions and results of analysis is shown on page 2-1.

Table 1-3:
Summary of Test Results

Source Constituent	Sampling Method	Average Emission	Applicable Limit[1]
Unit 2 Exhaust Duct (100% PRB)			
HCl (lb/MMBtu)	EPA M320/3A	0.00050	0.0020
Unit 2 Exhaust Duct (60%/40% PRB/Eastern Blend)			
HCl (lb/MMBtu)	EPA M320/3A	0.00024	0.0020

[1] Compliance limits obtained from 40 CFR 63, Subpart UUUUU Mercury and Air Toxics Standards.

PROJECT OVERVIEW

Discussion of Test Program

CleanAir performed three (3) 60-minute test runs for each fuel tested, utilizing EPA Method 320 in conjunction with EPA Method 3A, to determine HCl emission rates in lb/MMBtu. CleanAir conducted testing at Unit 2 while the unit was operated at 70% to 85% load while burning 100% PRB fuel and at 100% load while burning 60%/40% PRB/Eastern fuel.

All HCl concentrations were measured as parts per million on a wet volumetric basis (ppmwv). HCl concentrations measured in ppmwv were converted to lb/MMBtu by measuring diluent CO_2 concentrations concurrently through the utilization of EPA Method 3A. In accordance with specifications outlined in 40 CFR Part 75, Appendix F, Section 3.3.6 and in Section 63.10007 of the MATS rule, a default Fc factor of 1840 was utilized to convert HCl concentrations to emission rates (as presented in Table 1 in Section 3.3.5 of Part 75, Appendix F).

Sample calculations for concentrations and emission rates are presented in Appendix B of this report. Further description of the sample location and process schematic are presented in Section 3 of this report. Further description of test methodology is presented in Section 4 and in Appendix A of this report.

All sampling data presented in this report is based on Eastern Standard Time (EST).

End of Section 1 – Project Overview

RESULTS

Table 2-1:
Unit 2 – 100% PRB

Run No.		1	2	3	Average
Date (2016)		Jul 8	Jul 8	Jul 8	
Start Time (approx.)		08:45	10:25	11:43	
Stop Time (approx.)		10:10	11:27	12:45	
Process Conditions					
R_P	Gross Load (MW)	297	298	299	**298**
F_c	Carbon dioxide-based F-factor (dscf/MMBtu)	1,840	1,840	1,840	**1,840**
Gas Conditions					
CO_2	Carbon dioxide (dry volume %)	12.1	12.1	12.1	**12.1**
B_w	Actual water vapor in gas (% by volume)	11.6	11.6	11.7	**11.6**
HCl Results					
C_{sw}	Concentration (ppmwv)	0.47	0.29	0.29	**0.35**
C_{sd}	Concentration (lb/scf)	4.5E-08	2.7E-08	2.7E-08	**3.3E-08**
E_{Fc}	Emission Rate - F_c-based (lb/MMBtu)	0.00068	0.00041	0.00041	**0.00050**

Table 2-2:
Unit 2 – 60%/40% PRB/Eastern Blend

Run No.		1	2	3	Average
Date (2016)		Aug 9	Aug 9	Aug 9	
Start Time (approx.)		10:50	12:06	14:13	
Stop Time (approx.)		11:50	13:06	15:14	
Process Conditions					
R_P	Gross Load (MW)	348	367	338	**351**
F_c	Carbon dioxide-based F-factor (dscf/MMBtu)	1,840	1,840	1,840	**1,840**
Gas Conditions					
CO_2	Carbon dioxide (dry volume %)	12.6	12.7	12.6	**12.6**
B_w	Actual water vapor in gas (% by volume)	10.4	10.4	10.2	**10.3**
HCl Results					
C_{sw}	Concentration (ppmwv)	0.24	0.14	0.14	**0.17**
C_{sd}	Concentration (lb/scf)	2.3E-08	1.3E-08	1.3E-08	**1.6E-08**
E_{Fc}	Emission Rate - F_c-based (lb/MMBtu)	0.00033	0.00019	0.00019	**0.00024**

End of Section 2 – Results

DESCRIPTION OF INSTALLATION

PROCESS DESCRIPTION

Consumers Energy owns and operates the J.H. Campbell Generating Complex, located in West Olive, Michigan. The complex is comprised of three units with the combined electrical generating capacity of 1,450 megawatts (MW) and capable of consuming 6 million tons of coal per year. Testing described in this report was performed at the exhaust duct of Unit 2.

Unit 2 is rated at approximately 380 MW gross (360 MW net). Unit 2 is equipped with dry sorbent injection (DSI), activated carbon injection (ACI) and a pulse jet fabric filter (PJFF) baghouse to control emissions. Unit 2 also utilizes a selective catalytic reduction (SCR) reactor for additional abatement of emissions.

Unit 2 burns 100% PRB subbituminous low-sulfur coal with the capability of burning a blend of 60% subbituminous coal and 40% bituminous coal. When Unit 2 is burning the 100% PRB fuel, it is de-rated to a maximum gross capacity of 300 MW. Thus, during testing, Unit 2 was operating within 10% of maximum achievable load.

Consumers Energy collected and logged gross load generation (MW) data during the test program and provided this data to CleanAir for presentation in this report. Consumers Energy accessed this data via the J.H. Campbell's CEMS DAHS.

Schematics of the processes for Unit 2 are shown in Figures 3-1 and 3-2 on pages 3-2 and 3-3, respectively.

Consumers Energy changed the location of the Unit 2 DSI system after 100% PRB testing was completed and before 60%/40% PRB/Eastern blend testing had commenced. During 100% PRB testing, the DSI was located before the air pre-heater. During 60%/40% PRB/Eastern testing, the DSI was located after the air pre-heater. Figures 3-1 and 3-2 reflect this change.

DESCRIPTION OF INSTALLATION

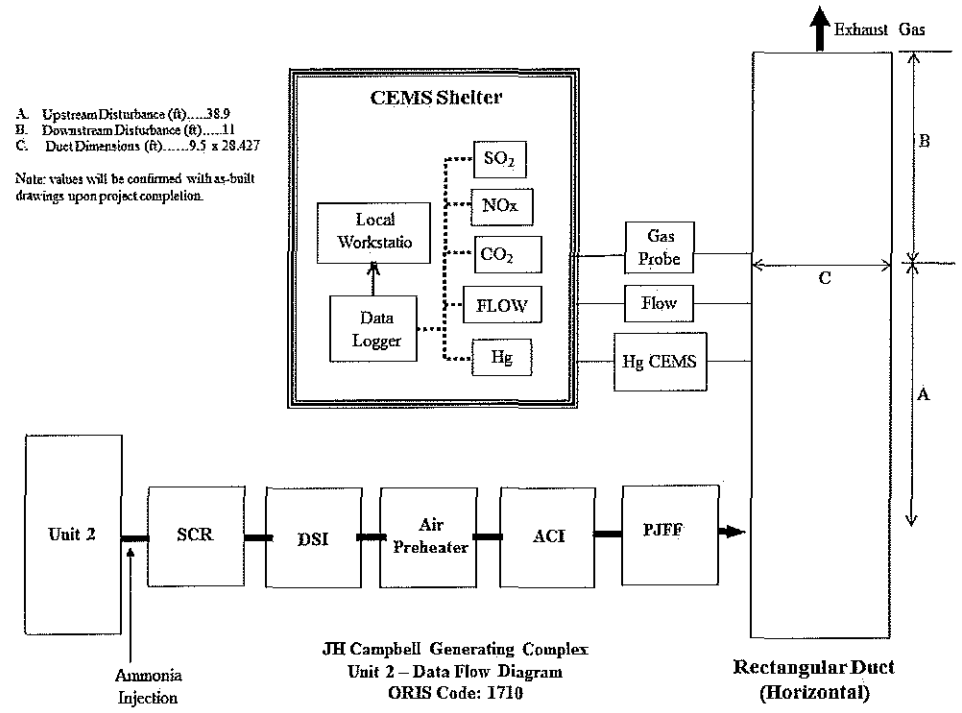


Figure 3-1: Unit 2 Process Schematic (July - DSI before Air Heater)

DESCRIPTION OF INSTALLATION

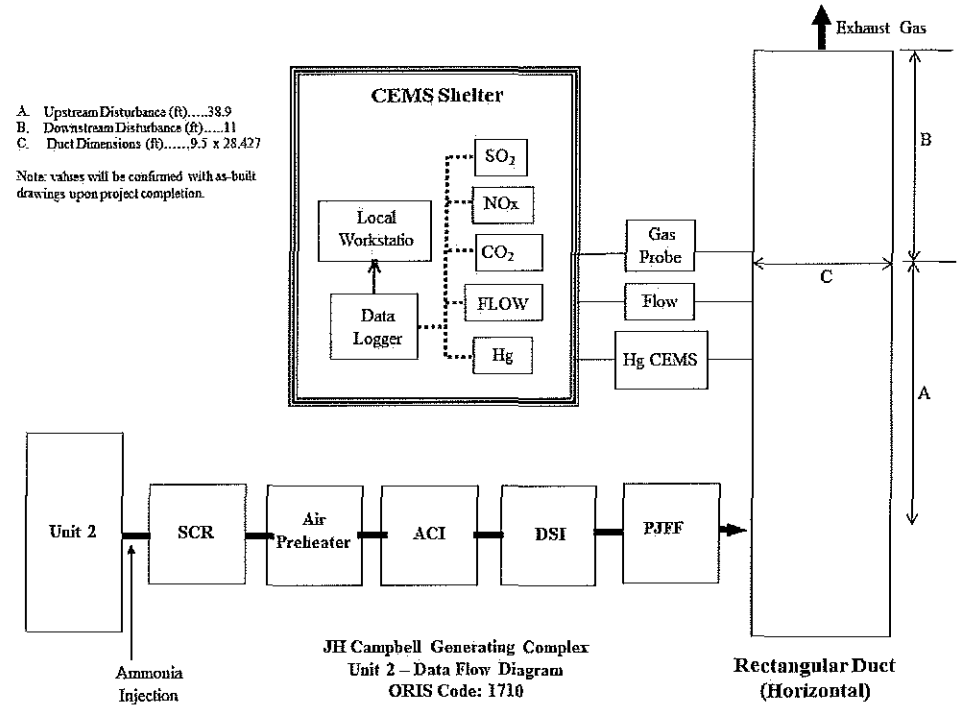


Figure 3-2: Unit 2 Process Schematic (August - DSI after Air Heater)

DESCRIPTION OF INSTALLATION

DESCRIPTION OF SAMPLING LOCATIONS

Sampling point locations were determined according to EPA Method 3A, with references to EPA Methods 1 and 7E.

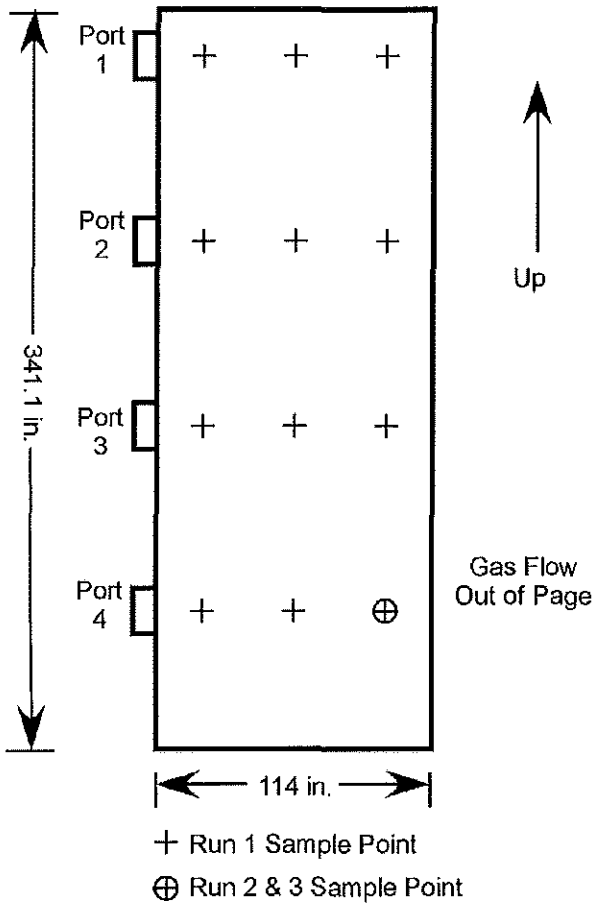
Table 3-1 outlines the sampling point configurations. The figures shown on pages 3-5 and 3-6 illustrate the sampling points and orientation of sampling ports for the source tested in the program.

Table 3-1:
Sampling Points

Source Constituent	Method	Run No.	Ports	Points per Port	Minutes per Point	Total Minutes	Figure
Unit 2 Exhaust Duct (100% PRB)							
HCl/CO_2	EPM M320/3A	1	4	3	5	60	3-3
HCl/CO_2	EPM M320/3A	2-3	1	1	60	60	3-3
Unit 2 Exhaust Duct (60%/40% PRB/Eastern Blend)							
HCl/CO_2	EPM M320/3A	1-3	1	1	60	60	3-4

A stratification check for CO_2 was conducted during Run 1 of 100% PRB testing in order to comply with specifications outlined in EPA Method 3A. The stratification check passed criteria required for single port, single point testing. Consequently, subsequent to Run 1 of 100% PRB testing, test runs were conducted at a single point most representative of the average CO_2 concentration during the stratification check.

DESCRIPTION OF INSTALLATION

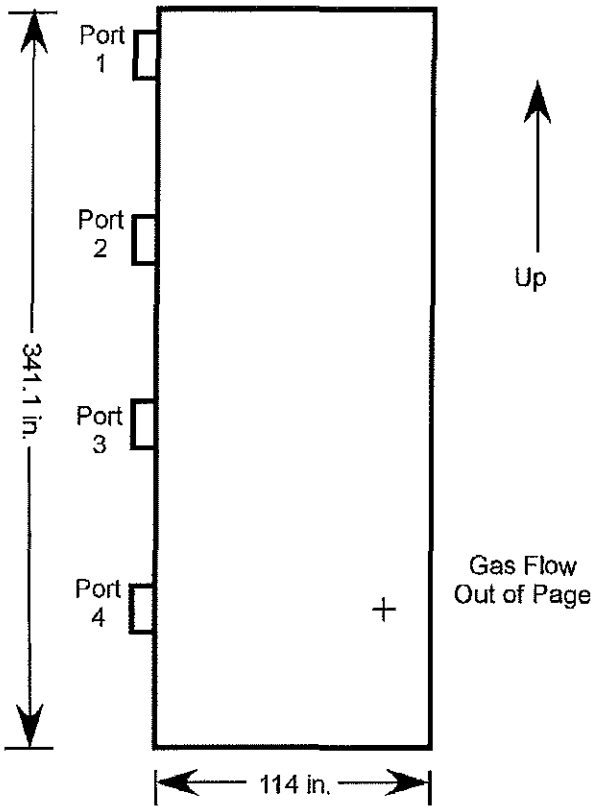


Stratification Point	Port to Point Distance (in.)
1	95.0
2	57.0
3	19.0

Equivalent Duct diameters upstream from flow disturbance (A):	0.8	Limit: 0.5
Equivalent Duct diameters downstream from flow disturbance (B):	2.7	Limit: 2.0

Figure 3-3: Unit 2 Sampling Point Determination - 100% PRB (Mod. EPA Method 3A)

DESCRIPTION OF INSTALLATION



Sampling Point	Port to Point Distance (in.)
1	95.0

Equivalent Duct diameters upstream from flow disturbance (A):	0.8	Limit: 0.5
Equivalent Duct diameters downstream from flow disturbance (B):	2.7	Limit: 2.0

Figure 3-4: Unit 2 Sampling Point Determination - 60%/40% PRB/Eastern Blend (EPA Method 3A)

End of Section 3 – Description of Installation

METHODOLOGY

Clean Air Engineering followed procedures as detailed in EPA Methods 1, 3A, 301 and 320. The following table summarizes the methods and their respective sources.

Table 4-1:
Summary of Sampling Procedures

Title 40 CFR Part 60 Appendix A	
Method 1	"Sample and Velocity Traverses for Stationary Sources"
Method 3A[1]	"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
Title 40 CFR Part 63 Appendix A	
Method 301	"Field Validation of Pollutant Measurement Methods from Various Waste Media"
Method 320	"Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy"

[1] Method 3A references various Method 7E provisions which were followed.

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR) and on the World Wide Web at http://ecfr.gpoaccess.gov.

Diagrams of the sampling apparatus and major specifications of the sampling, recovery and analytical procedures are summarized for each method in Appendix A.

CleanAir followed specific quality assurance and quality control (QA/QC) procedures as outlined in the individual methods and as prescribed in CleanAir's internal Quality Manual.

Sampling System

The FTIR sampling system was utilized to determine concentrations for both HCl (ppmwv) and CO_2 (%wv). The FTIR sampling system extracted effluent gas at a constant rate and utilized a stainless steel probe and heated filter box maintained at 375°F. The back-end of the probe was connected to a heated Teflon sample line maintained at approximately 375°F, which delivered the sample gas from the stack to the FTIR. The gas entered the FTIR on a hot-wet basis.

The FTIR was calibrated/validated according to each respective analyte reference method (EPA Method 320 and 3A) procedures. All calibration gas certificates are included in Appendix D of this report.

EPA Method 320 Sampling

CleanAir incorporated guidelines as stated in 40 CFR 63, Appendix A, EPA Method 320, "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy."

METHODOLOGY

Prior to each testing, a calibration transfer standard (CTS) was used to demonstrate suitable agreement between sample spectra and reference spectra. The CTS was introduced at a point as close as practical to the probe tip right before the external particulate filter.

Subsequent to the CTS check, a spike/tracer gas (in this case, a mixed HCl/SF_6 cylinder) was introduced into the sampled exhaust gas stream prior to the FTIR at a constant flow rate of no more than 10% of the total sample flow. The system "passed" the QA spikes when the average spike concentration was within 0.7 to 1.3 times the expected concentration. All QA spike checks are included in Appendices D and E of this test report.

Data was validated and corrected per specifications outlined in EPA Method 301. If the QA spike-check was not within a range of ±10% of the expected value, then a correction factor (CF) was applied to the average concentration of the applicable run (i.e. the average concentration of HCl for the run was "bias adjusted"). A unique CF was applied for data pertaining to each fuel because testing occurred during different mobilizations with different sample systems. The CF applied to data for 100% PRB testing was established pre-Run 1 to testing for a different unit which occurred during the same mobilization. Sample calculations for QA spikes and CF are presented in Appendix B.

A total of 60 minutes of reference spectra were collected for each run. Each sample spectrum was documented with the sampling conditions, the sampling time (period when the cell is being filled), the time the spectrum was recorded, the instrumental conditions (path length, temperature, pressure, resolution and signal integration time) and a spectral filename.

Following each sampling run, another CTS spectrum was recorded. The pre- and post-test CTS spectra were then compared. The peak absorbance in pre- and post-test CTS was compared to the required ±5% of the mean value for the run to be valid.

An on-site minimum detectable concentration (MDC) analysis was performed for target analytes using procedures outlined in ASTM D 6348 A2.3. The MDC is calculated as three times the standard deviation of the concentrations from ten representative background spectra taken during the MDC analysis. The results of this study is shown in Appendix D of this report. The MDC concentration was used for HCl resultant run concentrations for any runs that resulted in an HCl concentration less than the MDC.

EPA Method 3A Sampling

The FTIR sample system was also utilized to determine the diluent CO_2 concentration of the effluent gas. In addition to all QA/QC procedures outlined in EPA Method 320, all QA/QC procedures outlined in EPA Method 3A were performed.

Calibration error-checks were performed by introducing zero nitrogen (N_2), high-range and mid-range calibration gases to the inlet of the FTIR. The FTIR was challenged on-site using certified mixtures of O_2/CO_2 calibration gases. Analyzer bias checks were conducted before and after each run. Bias checks were performed by introducing calibration gas to the inlet of the sampling system's heated external filter. Per EPA Method 3A specifications, the average results for each run were drift-corrected. EPA Method 3A diluent QA/QC checks are presented in Appendix F of this report.

An FTIR CO_2 interference check with moisture and the FTIR calibration curve used to quantify CO_2 concentrations are presented in Appendix D of this report.

End of Section 4 – Methodology