Consumers Energy

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Hg CEMS RATA Test Report

EUBOILER3

Consumers Energy Company
J.H. Campbell Plant
17000 Croswell Street
West Olive, Michigan 49460

October 2, 2018

Test Dates: August 9 - 10, 2018

Test performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Department
Work Order No. 31682396
Initial Revision No.: 1.0

1.0 INTRODUCTION

Consumers Energy Company (Consumers Energy), Regulatory Compliance Testing Section (RCTS) performed a relative accuracy test audit (RATA) on the mercury (Hg) continuous emission monitoring system (CEMS) installed in the exhaust duct of emission unit EUBOILER3 (Unit 3) operating at the Consumers Energy J.H. Campbell Generating Station located in West Olive, Michigan. The Hg CEMS RATA was performed to satisfy United States Environmental Protection Agency (USEPA) requirements in 40 CFR 63, Subpart UUUUU, "National Emission Standards for Hazardous Air Pollutants: Coal and Oil-Fired Electric Utility Steam Generating Units," (aka Mercury and Air Toxics [MATS] Rule) as incorporated in Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-B2835-2013b.

A test notification and/or protocol containing detailed sampling, calibration and quality assurance procedures to be utilized during the test program was submitted to the USEPA and MDEQ on July 6, 2018. MDEQ representative Mr. Jeremy Howe approved the sampling protocol in a letter dated July 31, 2018. This Hg CEMS RATA test program followed the test protocol without deviation and incorporated USEPA test methods ALT-008, 30A, and 30B.

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1.1 CONTACT INFORMATION

RCTS representatives Gregg Koteskey, Joe Mason, and Thomas Schmelter conducted the RATA on August 9 and 10, 2018; Mr. Koteskey was the RCTS Lead Qualified Individual (QI) for the Hg CEMS RATA. Mr. John Olle, Senior Technician, and Roger Vargo, Senior Technician, at the Consumers Energy J.H. Campbell facility coordinated the tests with applicable plant personnel and verified CEMS data.

Table 1-1 presents the test program organization, major lines of communication, and names of responsible individuals.

Table 1-1 Test Program Contact List

Program Role	Contact	Address
EPA Regional Contact	Compliance Tracker, Air Enforcement and Compliance Assurance Branch	U.S. EPA Region 5 77 W. Jackson Blvd. (AE-18J) Chicago, IL 60604
State Regulatory Administrator	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-335-4874 kajiya-millsk@michigan.gov	Michigan Department of Environmental Quality Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Regulatory Inspector	Mr. Jeremy Howe Environmental Quality Analyst 231-878-6687 howej1@michigan.gov	Michigan Department of Environmental Quality Cadillac District Office 120 W. Chapin Street Cadillac, Michigan 49601
State Regulatory Inspector	Ms. Kaitlyn DeVries Environmental Quality Analyst 616-558-0552 devriesk1@michigan.gov	Michigan Department of Environmental Quality Grand Rapids District Office 350 Ottawa Avenue NW; Unit 10 Grand Rapids, Michigan 49503

Table 1-1 Test Program Contact List

Program Role	Contact	Address
Responsible Official	Mr. Norman J. Kapala Exec. Director of Coal Generation 616-738-3200 Norman.Kapala@cmsenergy.com	Consumers Energy J.H. Campbell Generating Complex 17000 Croswell Street West Olive, Michigan 49460
Test Facility	Mr. John Olle Senior Technician 616-738-3278 John.Olle@cmsenergy.com	Consumers Energy J.H. Campbell Generating Complex 17000 Croswell Street West Olive, Michigan 49460
	Mr. Roger Vargo Senior Technician 616-738-3270 Roger.Vargo@cmsenergy.com	Consumers Energy J.H. Campbell Generating Complex 17000 Croswell Street West Olive, Michigan 49460
Test Team Representative	Mr. Gregg Koteskey, QSTI Engineering Technical Analyst 616-738-3712 Gregg.Koteskey@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

2.0 SUMMARY OF RESULTS

The RATA results presented in Appendix B of this report indicate the Unit 3 Hg CEMS installed and operating at the J.H. Campbell Generating Station meets the RATA performance specification standards in the MATS Rule.

The RATA results are summarized in Table 2-1. RA equations and other applicable sample calculations are presented in Appendix A. Comprehensive test results are presented in Appendix B.

2.1 Operating Data

During the relative accuracy test the boiler was operated at the normal operating level(s) as defined in the site specific monitoring plan and determined following the provisions in 40 CFR 75, Appendix A, §6.5.2.1. Add-on controls were operated in a manner that allowed Hg concentrations to be measured by the reference method and CEMS systems. Due to variation in boiler operating conditions and residence of activated carbon within the control devices and exhaust duct system, mercury concentrations may not be detected by the CEMS system during normal operation. Boiler operating data recorded during the testing are provided in Appendix D.

2.2 Applicable Permit Information

The J.H. Campbell Generating Station operates under State of Michigan Registration Number (SRN) B2835 and in accordance with air permit MI-ROP-B2835-2013b. The air permit incorporates federal regulations and reporting requirements using Federal Registry Service (FRS) identification number 110000411108. EUBOILER3 is the emission unit source identification in the permit. Incorporated within the permit are the applicable requirements of the MATS Rule.

2.3 Results

The Hg CEMS installed and operated at J.H. Campbell Generating Complex Unit 3 meets 40 CFR, Part 63, Subpart UUUUU, Appendix A, Section 4.1.1.5 relative accuracy (RA)

requirements as summarized in Table 2-1. The results of the Hg CEMS RATA indicate that Unit 3 met the alternate performance specification criterion where the absolute difference of the RM and CEMS Hg concentrations plus the confidence coefficient must be ≤0.5 µg/scm when the average RM Hg concentration is <2.5 µg/scm under the MATS Rule.

Table 2-1 Summary of Hg CEMS RATA Results

Source	RATA Acceptance Criteria	RATA RA Result (%)	Alternate Acceptance Criteria (RM_{avg} <2.5 µg/scm)			
			RM_{avg} (µg/scm)	C_{avg} (µg/scm)	CC	RATA Result (µg/scm)
EUBOILER 3	≤20.0% RA[1] or |RMavg - Cavg| + |CC| ≤0.5 µg/scm [2]	30.92[1]	0.556	0.422	0.0384	**0.172**[2]

RA relative accuracy
C_{avg} mean CEMS value
RM_{avg} mean reference method value
CC confidence coefficient from Equation 2-5 of Performance Specification 2 in Appendix B of 40 CFR Part 60
[1] Relative Accuracy Performance as determined using the average RM value in the denominator of 40CFR60, Appendix A, Performance Specification 2, Eq. 2-6
[2] Alternate Performance Specification when the average measured reference method concentrations are <2.5 µg/scm; |RMavg - Cavg| + |CC| ≤0.5 µg/scm

The preceding Hg concentration RA results for Unit 3 meet the alternate performance requirements of less than or equal to 0.5 µg/scm difference between the mean RM and CEMs measurements, plus the confidence coefficient. To be consistent with the USEPA's Emission Collection Monitoring Plan System (ECMPS) reporting instructions[†], the above Hg CEMS values, as well as the RM values have been rounded to the nearest 0.1 µg/scm before evaluating the RA. Unrounded Hg CEMS and RM values are presented in Appendix B.

Sample calculations are presented in Appendix A. Detailed results are presented in Appendix B. Laboratory data is presented in Appendix C. Boiler operating data and supporting information are provided in Appendix D. Quality assurance data is presented in Appendix E.

3.0 SOURCE AND MONITOR DESCRIPTION

EUBOILER3 is a coal-fired EGU that turns a turbine connected to electricity producing generator.

3.1 Process

Unit 3 is a dry bottom wall-fired boiler which combusts pulverized sub-bituminous coal as the primary fuel and oil as an ignition/flame stabilization fuel.

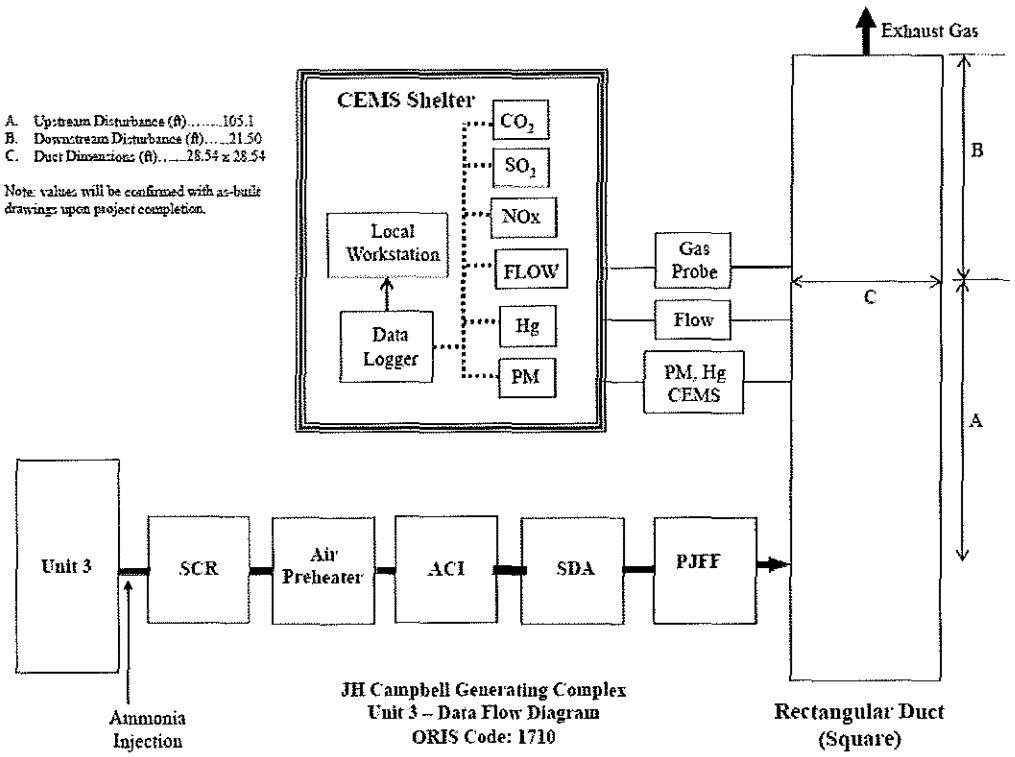
Coal is fired in the furnace where the combustion heats boiler tubes containing water and producing steam. The steam is used to turn a turbine that is connected to an electricity producing generator. The electricity is routed through the transmission and distribution system to consumers.

[†] Refer to Page 65 of the ECMPS Reporting Instructions for Quality Assurance and Certification (March 7, 2018).

3.2 Process Flow

The flue gas generated through coal combustion is controlled by multiple pollution control devices. Unit 3 is equipped with low nitrogen oxides (NO_x) burners, selective catalytic reduction (SCR), activated carbon injection (ACI) systems for mercury (Hg) reduction, spray dryer absorber (SDA) systems for control of sulfur dioxides (SO_2) and other acid gasses, and pulse jet fabric filter (PJFF) baghouses to control particulate matter emissions. After passing through the control device systems, flue gas is exhausted to atmosphere through an approximate 650-feet high dedicated stack. Refer to Figure 2-1 for the Unit 3 Data Flow Diagram.

Figure 2-1. Unit 3 Data Flow Diagram



3.3 Rated Capacity

Unit 3 has a nominally rated heat input capacity of 8,240 mmBtu/hr and can generate a gross electrical output of approximately 910 megawatts (MWg).

The boiler operates in a continuous manner in order to meet the electrical demands of Midcontinent Independent System Operator, Inc. (MISO) and Consumers Energy customers. EUBOILER3 is considered a baseload unit because it is designed to operate 24 hours a day, 365 days a year.

Relative accuracy testing was performed with the unit operating at its current normal operating level(s), as defined in 40 CFR 75, Appendix A, §6.5.2.1. The range of operation for Unit 3 is 380 to 910 MWg. The low operating level is the first 30% of the range of operation, mid is between 30% and 60% of the range of operation, and high is greater than

60% of the range of operation. During the test, Unit 3 average load was approximately 855 MWg.

3.4 Process Instrumentation

The process was continuously monitored by boiler operators, environmental technicians, and data acquisition systems during testing. One-minute data for the following parameters were collected during each Hg RATA test run: Load (MWg), total vapor phase Hg (µg/scm), heat input (MBtu/hr), and percent Carbon Dioxide (CO_2). The mercury sampling console clock time was synchronized with the Unit CEMS data logger time prior to beginning sampling.

The facility measures Hg concentrations using a Tekran Instruments Corporation Series 3300 Mercury CEMS dilution-based system with data recorded by an Environmental Systems Corporation (ESC) data acquisition and handling system (DAHS). Table 3-1 provides a summary of the mercury CEMS analyzer used to evaluate compliance with 40 CFR 63, Subpart UUUUU that was audited during this test program.

Table 3-1 Mercury Analyzer Specification Summary

Unit	Manufacturer and Model Number	Serial Number	Span Value (µg/scm)
EUBOILER3	Tekran Model 2537 S	3092	10.0

4.0 SAMPLING AND ANALYTICAL PROCEDURES

Consumers Energy performed the Hg CEMS RATA using the USEPA reference methods listed in 40 CFR 63, Subpart UUUUU, Appendix A §4.1.1.5. The applicable reference methods utilized during this test program are presented in Table 4-1. A total of 17 sample runs were performed, with 7 of those runs being invalidated per the reference method quality assurance requirements. Ten valid 30-minute runs were conducted to calculate the mercury CEMS RA. Descriptions of the sampling and analytical procedures are presented in the following sections.

Table 4-1 Test Methods

Parameter	USEPA	
	Method	Title
Moisture	ALT-008	Alternative Moisture Measurement Method - Midget Impingers
Mercury (sampling location)	30A	Determination of Total Vapor Phase Mercury Emissions from Stationary Sources (Instrumental Analyzer Procedure)
Mercury (sampling and analysis)	30B	Determination of Total Vapor Phase Mercury Emissions from Coal-Fired Combustion Sources using Carbon Traps

4.1 Sample Location and Traverse Points (USEPA Method 30A)

The location and number of traverse points used to measure mercury concentrations were determined in accordance with USEPA Method 30A, *Determination of Total Vapor Phase Mercury Emissions from Stationary Sources (Instrumental Analyzer Procedure*). Prior to testing, a minimum of one hour of representative Hg emissions data was collected by the CEMS. This data indicated the expected Hg concentration at the time of the Hg monitoring system RATA to be ≤3 µg/m^3, which met the stratification testing exemption provisions of Section 8.1.3.4 of Method 30A. Quality assured data from the certified Unit 3 mercury

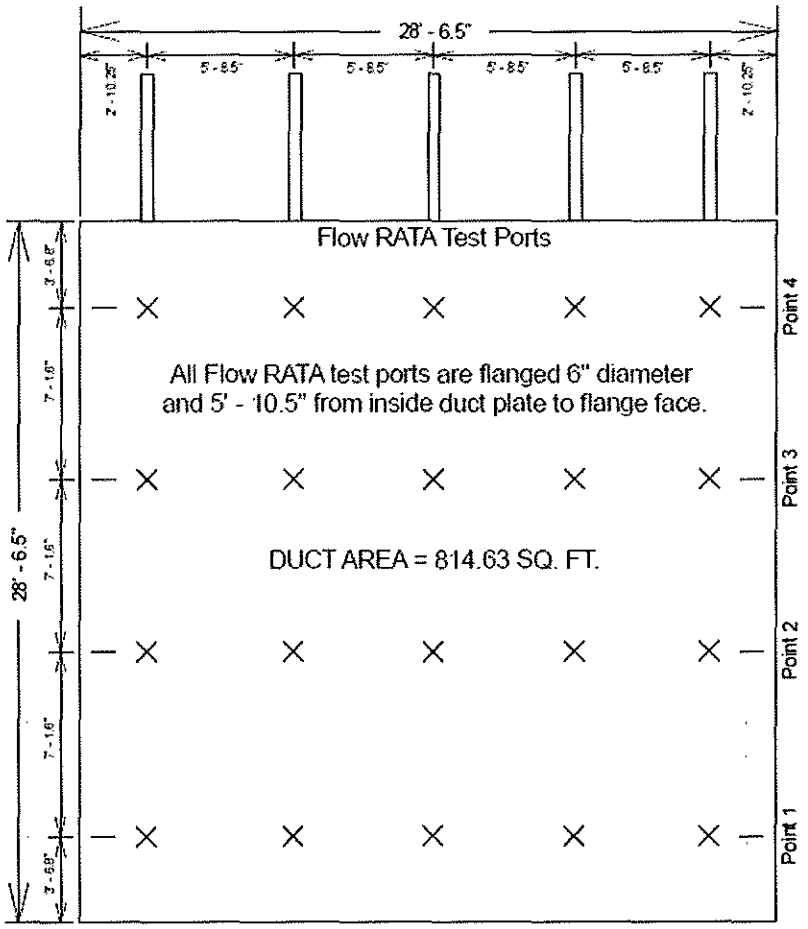
CEMS used to document Hg concentrations prior to the RATAs and the associated sixty-minute stratification exemption report for Unit 3 is presented in Appendix D. In accordance with Section 8.1.2 of Method 30A, samples were collected at three traverse points located at 0.4, 1.2, and 2.0 meters from the stack wall.

For the Unit 3 sampling location, five test ports are located in the vertical plane on the top of the 28.54 feet by 28.54 feet square duct. The ports are situated:

- Approximately 107.5 feet or 3.8 duct diameters downstream of a sound deadening silencer flow disturbance, and
- Approximately 23.1 feet or 0.8 duct diameters upstream of flow disturbance caused by a curve in the duct as it enters the exhaust stack.

The sample ports are 6-inches in diameter and extend 5.875 feet (70.5 inches) beyond the stack wall. A diagram of the Unit 3 duct cross section is presented in Figure 4-1. For this test event, the samples were collected from the central test port.

Figure 4-1. Unit 3 Duct Cross Section and Test Port/Traverse Point Detail

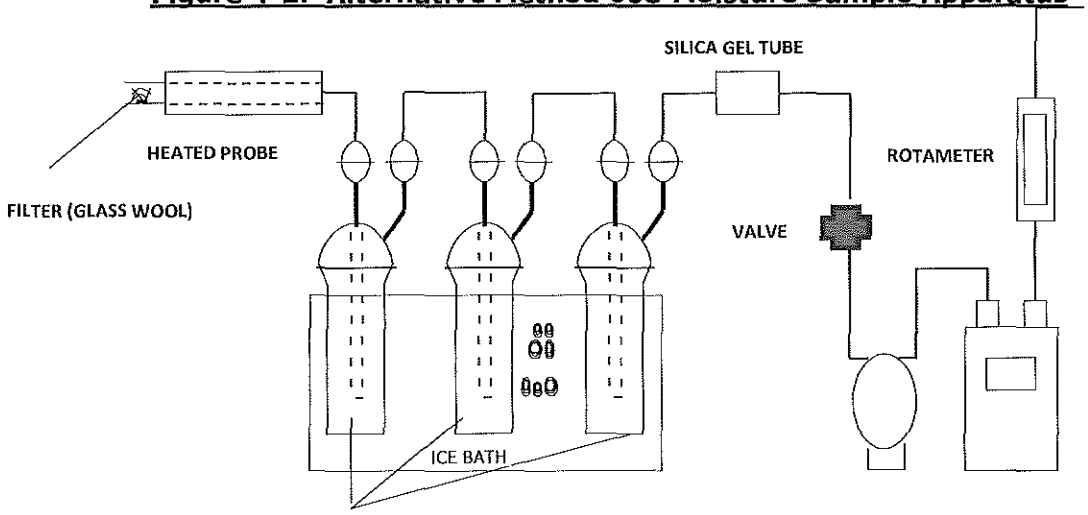


4.2 Moisture Content (USEPA ALT-008)

Exhaust gas moisture content was measured in accordance with USEPA ALT-008, *Alternative Moisture Measurement Method Midget Impingers*, an alternative method for correcting pollutant concentration data to appropriate moisture conditions (e.g. pollutant and/or air flow data on a dry or wet basis) validated May 19, 1993 by the USEPA Emission Measurement Branch. The procedure is incorporated into Method 6A of 40 CFR Part 60 and is based on field validation tests described in *An Alternative Method for Stack Gas Moisture Determination* (Jon Stanley, Peter Westlin, 1978, U.S. EPA Emissions Measurement Branch). The sample apparatus configuration follows the general guidelines contained in Figure 4-2 and § 8.2 of USEPA Method 4, *Determination of Moisture Content in Stack Gases,* and ALT-008 Figure 1 or 2.

The exhaust gas was drawn through a series of midget impingers immersed in an ice bath to condense water in the flue gas. The amount of water collected was measured gravimetrically and used to calculate the exhaust gas moisture content. In accordance with Method 30B, Section 8.3.3.7, one moisture sample was collected for each pollutant sample run performed in order to correct the measured Hg concentrations from a dry basis to a wet basis (consistent with the Hg CEMS measurement). Refer to Figure 4-2 for a figure of the Alternative Method 008 Moisture Sample Apparatus.

Figure 4-2. Alternative Method 008 Moisture Sample Apparatus



The silica gel tube depicted in this figure was replaced with a midget impinger (bubbler) with a straight tube insert, as allowed in ALT-008, §1.

4.3 Mercury (USEPA Method 30B)

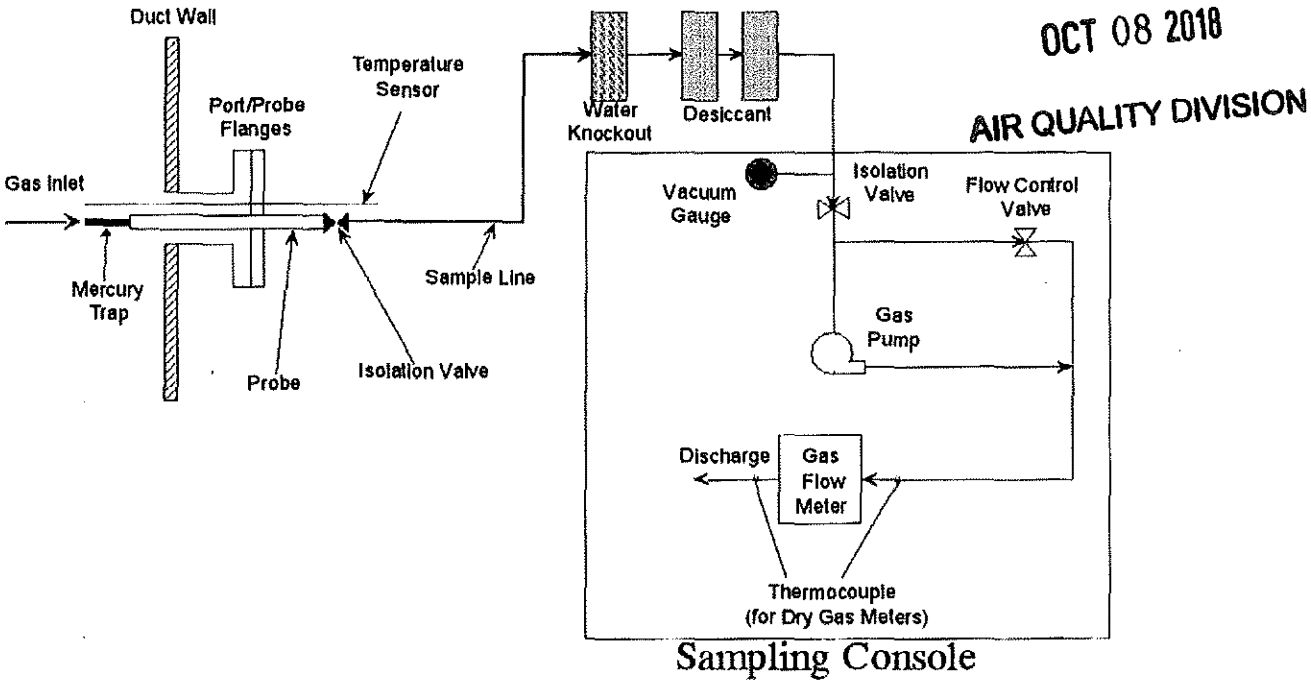
Mercury concentrations were measured following the procedures of USEPA Method 30B, *Determination of Total Vapor Phase Mercury Emissions from Coal-Fired Combustion Sources Using Carbon Traps.* Flue gas was extracted from the duct through paired, in-stack sorbent media traps situated in a heated probe at a constant flow rate. Each sorbent trap contained two sections, the first section quantitatively captured Hg and the second section was used to evaluate vapor phase Hg breakthrough. A heated sample line connected to the end of the probe transferred the sampled gas through a moisture removal system and into a dry gas

metering console where sample volume and other parameters were recorded. Refer to Figure 4-3 for a depiction of the Method 30B sample train.

At the conclusion of the test run and after the post-test leak check, the sorbent traps were recovered from the sampling system and analyzed on-site using an Ohio Lumex RA-915+ analyzer. The contents of each section of the traps were carefully extracted onto a quartz glass ladle and placed into an oven where the captured mercury was thermally desorbed from the sample matrix (i.e., charcoal) at 680° Celsius. Vapor phase mercury was then measured using a calibrated atomic absorption spectrometry analyzer.

A minimum of three field recovery test runs were performed where one of the paired sorbent tubes was spiked with a known mass of mercury and used to sample flue gas during the test run. The field recovery test assesses the recovery of the elemental mercury spike to determine measurement bias and verify data acceptability. The results of the field recovery test met the acceptable performance criteria for Unit 3 and are presented in Appendix B.

Figure 4-3. Method 30B Sorbent Trap Sampling Train



5.0 TEST RESULTS AND DISCUSSION

The Hg CEMS RATA was performed to satisfy USEPA requirements in 40 CFR 63, Subpart UUUUU. The test results indicate that Unit 3 Hg CEMS meets the acceptance criteria listed in Table A-2 of Appendix A of the MATS Rule.

The mercury sampling console clock time was synchronized with the Hg CEMS DAHS clock (Eastern Standard Time) prior to beginning the RATA. Test runs were 30 minutes in duration and RM field data run times were reported consistent with the Hg CEMS format (where the start minute and end minute are inclusive), however the field datasheets generated by the sampling console included in Appendix B will show what could be

perceived as an additional minute at the end of each run, in comparison to the Hg CEMS reports. This additional minute is the time when sampling was completed (i.e., the last reading was taken) and does not represent an average minute data value. Moisture sample data was reported in Eastern Daylight Time, one hour ahead of the CEMS DAHS and mercury console times.

5.1 Variations and Upset Conditions

On August 9, 2018, RCTS performed five RATA runs using their RM 30B sampling console serial number 3310. Each of these five runs utilized an unspiked sorbent trap, and a sorbent trap spiked with 50 nanograms of elemental Hg for the purposes of conducting a Field Recovery Test. The calculated average field recovery of these five runs was 118.8%, and averaging only the three most favorable runs resulted in a field recovery average of 116.6%, exceeding the method criteria. Being that a passing field recovery test could not be demonstrated using these five runs, the Quality Assurance requirements of RM 30B necessitated that these field sample runs be invalidated. RCTS replaced the mercury sampling console with their second unit, serial number 3311, and continued performing subsequent RATA runs utilizing similar spiked sorbent traps, paired with unspiked sorbent traps.

The sixth RATA run performed on August 9 (12:27 – 12:56), the first run using sampling console serial number 3311, was invalidated during post-run sorbent trap recovery when one of the glass sorbent traps broke, compromising the integrity of the carbon beds. The seventh RATA run (14:10 – 14:39), was performed and analyzed, however the spectrometer analyzer software switched from "analysis mode" to "calibration mode" and the sorbent trap analysis RM results from the initial 5 invalidated runs and Run 7 were not saved by the software and could not be recovered. Since the RM analysis data for the seventh run could not be presented, the run was invalidated. The eighth run conducted on August 9 (15:00 - 15:29), became the first RATA run for the evaluation of the JHC Unit 3 Hg CEMS which was not invalidated by the QA/QC criteria of RM 30B, and for the purposes of this test event, was identified as RATA Run 1. The available invalidated run data, moisture analysis data, CEMS reports, and analyzer calibration report are presented in Appendix F.

Several analyses of the Section 2 carbon beds of the sorbent traps during the Unit 3 RATA test resulted in slightly negative Hg mass values. These negative values are presented in the Hg analysis results data tables in Appendix E, however in these instances, a mass of zero (0.00) nanograms Hg was used for calculating Hg concentrations.

The process and control equipment were operating in a manner to allow Hg concentrations to be measured by the reference method and CEMS systems and no upsets were encountered.

5.2 Field Quality Assurance / Quality Control Procedures

The USEPA reference methods performed state reliable results are obtained by persons equipped with a thorough knowledge of the techniques associated with each method. Factors with the potential to cause measurement errors are minimized by implementing quality control (QC) and assurance (QA) programs into the applicable components of field testing. QA/QC components were included in this test program. Table 5-1 summarizes the primary field quality assurance and quality control activities that were performed. Refer to Appendix E for supporting documentation.

Method 30B requires that a field recovery test, which evaluates the performance of the combined sampling and analytical practices, must be successfully passed with a three-run average elemental Hg spike recovery of 85 to 115%, once per field test. The Method also

allows for these field recovery test runs to be used as test runs when conducting an Hg CEMs RATA under 40 CFR 63, Subpart UUUUU, providing the relative deviation of the calculated Hg concentrations of the paired sorbent traps for each field recovery test run meet the QA criteria specified in Table 9-1 of Method 30B. Sorbent traps spiked with 50 nanograms of elemental Hg were utilized in Runs 1 through 3 for the Unit 3 Hg CEMS RATA, with a calculated field recovery result of 114.0%. Field recovery test results are presented in the Sorbent Trap Results Table in Appendix B.

Prior to the Unit 3 Hg CEMS RATA, the mercury sampling console serial number 3311 B train dry gas meter (DGM serial number 20151488), had failed to meet the Method 30B 5% Y_i calibration factor deviation requirements. This DGM was replaced with a similar model, calibrated DGM, serial number 20181204, and a pre-test console audit was passed to confirm satisfactory operation of the repaired mercury sampling console before the unit was used in the field. The initial DGM flow calibration sheets used to calculate the DGM correction factors are presented in Appendix E.

Following the completion of the Unit 3 Hg CEMS RATA, RCTS performed a post-test console audit on the Hg sampling equipment, serial number 3311, used during the test. The console audit is a series of quality verification procedures which confirm that the sampling console barometric pressure sensor, vacuum sensors, thermocouples, and dry gas meter (DGM) correction values meet the QA requirements of Method 30B. The sample console met the method requirements and results of the audit are presented in Appendix E.

Table 5-1 Summary of USEPA Method 30B Sampling QA/QC Requirements

QA/QC Test or Specification	Acceptance Criteria	Frequency	Consequences if not met
Gas flow meter calibration (At 3 settings or points)	Calibration factor (Yi) at each flow rate must be within ± 2% of the avg. value (y).	Prior to initial use and when post-test check is not within ± 5% of Y.	Recalibrate at 3 points until acceptance criteria are met.
Gas flow meter post-test calibration check	Calibration factor (Yi) at each flow rate must be within ± 5% of the Y value form most recent 3-pt. calibration.	After each field test. For mass flow meters must be done onsite, using stack gas.	Recalibrate gas flow meter at 3 pts. To determine a new value for Y. For mass flow meters, must be done onsite. Apply the new Y value to the field test data.
Temperature sensor calibration	Absolute temperature measured by the sensor within ± 1.5% of the reference sensor.	Prior to initial use and before each test thereafter.	Recalibrate: sensor may not be used until specification is met.
Barometer calibration	Absolute pressure measured by the instrument within ± 10 mmHg of reading with a mercury barometer.	Prior to initial use and before each test thereafter.	Recalibrate: instrument may not be used until specification is met.
Pre-test leak check	≤ 4% of target sampling rate	Prior to sampling	Sampling shall not commence until the

Table 5-1 Summary of USEPA Method 30B Sampling QA/QC Requirements

QA/QC Test or Specification	Acceptance Criteria	Frequency	Consequences if not met
			leak check is passed.
Post-test leak check	Following daily calibration, 4% of average sampling rate	After sampling	Sample invalidated.
Multipoint analyzer calibration	Each analyzer reading within ±10% of true value and $r^2 \geq 0.99$	On the day of analysis, before analyzing any samples	Recalibrate until successful.
Analysis of independent calibration standard	Within ±10% of true value	Following daily calibration, prior to analyzing field samples	Recalibrate and repeat independent standard analysis until successful.
Analysis of continuing calibration verification standard (CCVS)	Within ±10% of true value	Following daily calibration, after analyzing ≤10 field samples, and at end of each set of analyses	Recalibrate and repeat independent standard analysis, reanalyze samples until successful, if possible; for destructive techniques, samples invalidated
Test run total sample volume	Within ± 20% of the total volume sampled during the field recovery test.	Each individual sample	Sample invalidated.
Sorbent trap section 2 breakthrough	≤ 10% of section 1 Hg mass for Hg concentrations > 1 µg/dscm; ≤ 20% of section 1 Hg mass for Hg concentrations ≤ 1 µg/dscm	Every sample	Sample invalidated.
Paired sorbent trap agreement	≤ 10% Relative Deviation mass for Hg concentrations > 1 µg/dscm; ≤ 20% or ≤ 0.2 µg/dscm absolute difference for Hg concentrations ≤ 1 µg/dscm.	Every run	Run invalidated.
Field recovery	Average recovery between 85% and 115% for Hg.	Average from a minimum three spiked sorbent traps.	Field sample runs not validated without successful field recovery test.