Consumers Energy
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RATA Test Report

EU-Karn 2

NOx/Diluent, SO2 & Flow CEMS

EU-KARN1

SO2 CEMS

Consumers Energy Company
D.E. Karn Generating Complex
2742 N. Weadock Highway
Essexville, Michigan 48732
SRN: B2840
ORIS: 1702

August 19, 2019

Test Dates: EU-KARN2: July 10-11, 2019
EU-KARN1 SO_2: July 17, 2019

Test Performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Section
Work Order No. 34250852

CERTIFICATION FOR 40 CFR PART 75 TEST REPORT

(To be completed by authorized AETB firm representative and included in source test report)

Facility ID: EU-KARN1-S1 and EU-KARN2-S1 Date(s) Tested: July 10-11 and 17, 2019

Facility Name: D.E. Karn Generating Station

Facility Address: 2742 N. Weadock Hwy., Essexville, MI 48732

Equipment Tested: EU-KARN2-S1: SO2, NOx, and Volumetric Flow CEMS; EU-KARN1-S1: SO2 CEMS

AETB Firm: CECo/RCTS AETB

Business Address: 2742 N Weadock Hwy, ESD Trailer #4, Essexville, MI 48732

Phone: (989) 891-3492 Email: brian.pape@cmsenergy.com

As the legally authorized representative of the RCTS AETB, I certify that I have reviewed this test report in conjunction with the relevant Quality Manual Appendix D checklist. Having checked each item, I believe the information provided in this test report is true, accurate, and complete.

Signature: [signature] Date: August 19, 2019

Name: Brian C Pape Title: AETB Technical Director

Phone: (989) 891-3492 Email: brian.pape@cmsenergy.com

RELATIVE ACCURACY TEST REPORT CHECKLIST

	Description (Typical location(s) in report) [ASTM D 7036-04 Section Reference]
✓	Title (Title Page) [15.3.1]
✓	AETB name & address (QM App. D pg. D-2) [15.3.2]
✓	Unique identification number on each page and a clear identification of the end of the report (Headers & Footers; "End of Report" page) [15.3.3]
✓	Name and address of the customer (Title Page; QM App. D pg. D-2) [15.3.4]
✓	Date(s) the testing was performed (Title page; Introduction; QM App. D pg. D-2) [15.3.10]
✓	Identification of the units tested (Title page; Introduction) [15.3.9]
✓	Identification of regulatory personnel that observed testing (Introduction; Appendix D1) [Note 13]
✓	Clear identification of the pollutants/parameters tested (Summary & Discussion) [15.3.5]
✓	Identification of the test methods used (Sampling and Analytical Procedures) [15.3.8]
✓	Identification of the sampling location, including diagrams, sketches or photographs (Figures) [15.3.6]
✓	Detailed process description and process operations for each test run (Source and Monitor Description; Appendix B CEMS data sheets) [15.3.7]
✓	Reference to the test protocol and procedures used by the AETB (Introduction) [15.3.11] [15.3.11]
✓	Test results and units of measure (Summary and Discussion) [15.3.12]
✓	Information on specific test conditions, including text description of process operations for each test run and description of any operational issues with the unit or the control device (Discussion of Test Results) [15.3.14]
✓	Discussion of the test results including the uncertainty associated with the test and discussion of possible errors or limiting conditions (Quality Assurance Procedures) [15.3.15]
✓	Reference Method analyzer calibrations for each RM gas RATA run. (Appendix B) [15.3.16]
✓	Raw plant CEMS data for each RATA run and each CEMS component (i.e. all gas analyzers, flow monitors). (Appendix B) [15.3.17]
✓	Raw Reference Method DAS data for each RM gas RATA run. (Appendix B) [15.3.17]
✓	CEMS "Operating Load Analysis" report. (Appendix C) [15.3.11]
✓	Meter box pre- and post-test calibration results (Appendix C) [15.3.16]
✓	NO_x converter check results (Appendix C) [15.3.16]
✓	Pitot calibrations and inspections (Appendix C) [15.3.16]
✓	FRRS/manometer/Magnehelic gage calibration results (Appendix C) [15.3.16]
✓	Reference Method calibration gas certificates of analysis (Appendix C) [15.3.16]
✓	RATA field data sheets verified against spreadsheet data (Field data sheets in project file) [15.3.17]
✓	RCTS AETB Letter of Certification (Appendix D1) [15.3.19]
✓	Completed QM Appendix F – "AETB Field Test Signature Form" (Appendix D1) [3.1.3; 3.1.9; 3.1.14; 8.3; Note 14; 12.2; 12.3; 12.4; 14.1.1]
N/A	Deviations from, additions to, or exclusions from the test protocol, test methods, or AETB Quality Manual entered on QM App. F pg. F-2 (Appendix D2) [15.3.13]
✓	Names, titles and signatures of persons authorizing the test report – "QM App. D pg. D-2" (After Title Page) [15.3.18]
✓	QSTI certificates for Qualified Individuals overseeing/performing the test (Appendix D2) [3.1.12]
✓	Table of Contents is correct (Report Body) [Neatness & professionalism]
✓	Report Headers & Footers are correct (Report Body) [Neatness & professionalism]
✓	RM and CEMS run data in correct order (Appendix B) [Neatness & professionalism]

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1.0 INTRODUCTION

Consumers Energy Company (CECo), Regulatory Compliance Testing Section (RCTS) performed Relative Accuracy Test Audits (RATA) on continuous emission monitoring systems (CEMS) at the exhaust location associated with emission unit EU-KARN1 (Unit 1) and EU-KARN2 (Unit 2) operating at the Consumers Energy D.E. Karn Generating Complex located in Essexville, Michigan.

The RATAs were performed to satisfy requirements in Appendix 3.2-A-S1 of the Michigan Department of Environmental Quality (MDEQ) Renewable Operating Permit (ROP) No. MI-ROP-B2840-2014c, and the United States Environmental Protection Agency (USEPA) Title 40, Code of Federal Regulations (CFR) Part 75, Appendices A and B. Note that as of April 22, 2019, the MDEQ was re-organized and re-named the Michigan Department of Environment, Great Lakes, and Energy (EGLE). A test notification/sampling protocol describing the sampling, calibration and quality assurance procedures in USEPA Reference Methods (RM) 1, 2, 2H, 3, 3A, 4 (Alt-008), 6C, 7E, and 19, in conjunction with Part 75 Appendices A and B was submitted May 22, 2019 to the USEPA Region V and EGLE offices. EGLE representative Ms. Regina Angellotti approved the protocol in a letter dated June 14, 2019.

RCTS representatives Brian Pape, Gregg Koteskey, Dillon King, and Joe Mason conducted the Unit 2 RATAs on July 10 and 11, 2019 and the Unit 1 SO2 RATA on July 17, 2019; Mr. Mason was the RCTS Lead Qualified Individual (QI) directing the gas RATAs, while Mr. Pape was the lead QI for the flow RATA. Mr. George Eurich, CECo Senior Laboratory Technical Analyst Lead, coordinated the tests with plant personnel and Ms. Karen Gauld, Senior Technician at D.E. Karn Generating Complex, collected CEMS data. Ms. Angellotti witnessed portions of the testing on July 10 and 17, 2019.

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	Mr. Michael Compher Air Monitoring 312-886-5745 compher.michael@epa.gov	USEPA Region 5 Air and Radiation Division 77 W. Jackson Blvd. (AR-18J) Chicago, Illinois 60604
State Regulatory Administrator	Ms. Karen Kajiya-Mills Technical Programs Unit Manager 517-256-0880 kajiya-millsk@michigan.gov	Michigan Department of Environment, Great Lakes, and Energy Technical Programs Unit 525 W. Allegan, Constitution Hall, 2nd Floor S Lansing, Michigan 48933
State Field Inspector	Ms. Regina Angellotti Environmental Quality Analyst 313-418-0895 angellottir1@michigan.gov	Michigan Department of Environment, Great Lakes, and Energy Cadillac Place 3058 West Grand Boulevard; Suite 2-300 Detroit, Michigan 48202
Responsible Official	Mr. Norman J. Kapala Executive Director Coal Generation 616-738-3200 norman.kapala@cmsenergy.com	Consumers Energy J.H. Campbell Power Plant 17000 Croswell Street West Olive, Michigan 49460

Program Role	Contact	Address
Test Facility	Mr. George Eurich Sr. Laboratory Technical Analyst Lead 989-891-3317 george.eurich@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Highway Essexville, Michigan 48732
	Ms. Karen Gauld Senior Technician 989-891-3168 karen.gauld@cmsenergy.com	
Test Team Representatives	Mr. Brian Pape, QSTI Sr. Engineering Technical Analyst Lead 989-891-3492 brian.pape@cmsenergy.com	Consumers Energy Company D.E. Karn Generating Complex 2742 N. Weadock Highway, ESD Trailer #4 Essexville, Michigan 48732
	Mr. Joe Mason, QSTI Sr. Engineering Technical Analyst II 616-738-3385 joe.mason@cmsenergy.com	Consumers Energy Company L&D Training Center 17010 Croswell Street West Olive, Michigan 49460

RCTS operates as a self-accredited Air Emission Testing Body (AETB) as described in the AETB Letter of Certification contained in Appendix D of this report and is therefore qualified to conduct test programs required in 40 CFR Part 75. RCTS' AETB program has been developed in accordance with the American Society for Testing and Materials (ASTM) D 7036-04, Standard Practice for Competence of Air Emissions Testing Bodies.

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2.0 SUMMARY AND DISCUSSION

The RATA results presented in Appendix B of this report indicate the Unit 2 carbon dioxide (CO_2), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and volumetric airflow and the Unit 1 sulfur dioxide (SO_2) CEMS installed and operating at the D.E. Karn Generating Complex meet the semi-annual relative accuracy (RA) frequency standards in 40 CFR 75 Appendix A and the annual reduced test frequency incentives in 40 CFR 75, Appendix B at the evaluated operating levels.

The Unit 1 carbon dioxide (CO2), oxides of nitrogen (NOx), and volumetric airflow CEMS RATAs were completed on June 24 and 25, 2019 and the results were presented in a separate report dated July 25, 2019.

The RATA results are summarized in Tables 2-1 through 2-4. RA equations and other applicable sample calculations are presented in Appendix A. Comprehensive test results are presented in Appendix B.

2.1 WALL ADJUSTMENT FACTOR

On July 11, 2019, prior to performing the Unit 2 volumetric flowrate RATAs, USEPA Method 2H, *Determination of Stack Gas Velocity Taking into Account Velocity Decay Near the Stack Wall*, was used to evaluate the magnitude of flue gas velocity decay near the circular stack walls and calculate a site-specific wall effect adjustment factor (WAF). For the high-load testing at Unit 2, a WAF of 0.9805 (dimensionless) was determined and used to adjust the measured reference method flue gas velocity and calculate volumetric flow rate. The default WAF of 0.9950, based upon the stack construction material being gunite-lined, was applied to calculate the mid- and low-load volumetric flow rates. Refer to Appendix B1 for the WAF measurements.

2.2 VOLUMETRIC FLOWRATE

The Unit 2 flow monitoring system consists of two ultrasonic volumetric air flow monitors configured in an X-pattern. These monitors are referred to as the Unit 2 A Monitor (monitoring plan system identification 241, component identification F03) and Unit 2 B Monitor (242, F04). In this configuration, the dual monitor data is averaged to report primary volumetric flow (Unit 2 = System 240) and calculate continuous emissions, while each individual flow monitor also operates as a redundant backup. Relative accuracy test audits were performed on the primary system and each individual redundant backup system.

As part of the RATA test program, trial flow RATA runs were performed on Unit 2 on July 10, 2019. The trial flow RATA runs were performed at the high, mid, and low operating loads for the purpose of evaluating and optimizing the flow CEMS if necessary, as allowed in 40 CFR 75, Appendix B §2.3.2(b)(2). The Unit 2 A and B flow monitors and the primary volumetric flow monitor met the trial RATA passing criteria with average RM and CEMS readings differing by less than ±10% for each of the trial runs at each load level.

However, the Unit 2 B flow monitor results at the high and low load trial flow runs were greater than 7.5% difference, indicating that the Unit 2 B flow monitor was unlikely to pass the ≤7.5% annual RATA test frequency criterion in 40 CFR 75, Appendix A §3.3.4(a).

RCTS subsequently re-initialized the Unit 2 B flow monitor by adjusting the velocity look up table (LUT) values at the high and low load levels. Following the LUT changes, a probationary calibration of the flow monitor was successfully performed, followed by a three-load flow RATA, which successfully met the relative accuracy (RA) requirements in 40 CFR 75, Appendix A and the annual test frequency incentives of Appendix B. Trial flow RATA documentation generated during the RATA will be maintained on-site as part of the D.E. Karn Unit 2 official test log.

The results indicate the primary (average) flow and both redundant backup flow monitors meet the ≤10.0% criterion in 40 CFR 75, Appendix A §3.3.4(a) and the annual reduced test frequency incentive standard of ≤7.5% in 40 CFR 75, Appendix B §2.3.1.2(c). Table 2-1 summarizes the volumetric air flow RATA results.

Table 2-1 Summary of Volumetric Air Flow RATA Results

CEMS Make/ Model	CEMS Duct Location & Serial Number	RATA Criteria	Required RATA Performance	Actual RATA Performance		
				Primary (Avg)	A Monitor	B Monitor
Teledyne Monitor Labs Model 150	Unit 2 A Monitor SN 1500538 B Monitor SN 1500531	High Load	≤ 10% of mean RM	1.27%	2.85	0.41%
		Mid Load		1.48%	0.70%	3.51%
		Low Load		3.31%	0.56%	6.24%
		Bias	|d| ≤ |CC| = Pass	Fail (1.011)	Fail (1.027)	Pass

|d| average absolute difference between the RM and CEMS
|CC| confidence coefficient

2.3 SO_2 GAS RATA

The SO_2 results do not meet the ≤10% RA specification in 40 CFR 75, Appendix A §3.3.1(a); rather, because the average reference method measurements of SO_2 concentration during the RATA were ≤250 ppm and the difference between the mean value of the monitor measurements and the reference method mean did not exceed ±15.0 ppm, the SO_2 CEMS met the alternative RA specification in 40 CFR 75, Appendix A §3.3.1(b) as well as the reduced RATA test frequency incentive standard of ±12.0 ppm in 40 CFR 75, Appendix B §2.3.1.2(e). Table 2-2 summarizes the SO_2 RATA results.

An explanation of RM measurement problems encountered while performing the Unit 1 SO_2 RATA is included in Section 6.2 of this report.

Table 2-2 Summary of SO_2 RATA Results

CEMS Make and Model	CEMS Location & Serial Number	RATA Performance Criteria	Required RATA Performance	Actual RATA Performance
Thermo SO_2 Model 43i	Unit 1 SN 0711721593	ppm	10% of mean RM or ±15.0 ppm RM/CEMS difference	164.44%
				-8.72 ppm
		lb/mmBtu[1]	≤20% of mean RM	166.51%
			≤10% of emission limit[2]	1.65%
		Bias (ppm)	|d|≤|CC|=Pass	Pass
	Unit 2 SN 0711721594	ppm	10% of mean RM or ±15.0 ppm RM/CEMS difference	38.17%
				-3.78 ppm
		lb/mmBtu[1]	≤20% of mean RM	38.14%
			≤10% of emission limit[2]	0.78%
		Bias (ppm)	|d|≤|CC|=Pass	Pass

|d| average absolute difference between the RM and CEMS
|CC| confidence coefficient

[1]SO_2 pound per million British thermal unit (lb/mmBtu) RA is reported to comply with the MDEQ Air Pollution Control (APC) Rules, Part 4, R336.1401, *Emissions of Sulfur Dioxide from Power Plants* and Part 10, R336.2150, *Performance Specifications for Continuous Emission Monitoring Systems*, Rule 1150(1)(c).

[2]As the average RM SO_2 lb/mmBtu emission rates were less than 50% of the facility SO_2 emission limit of 1.67 lb/mmBtu, the emission limit was used in the denominator of the percent RA calculation in lieu of the average RM value per §13.2 of 40 CFR Part 60, Appendix B, Performance Specification 2. While both DE Karn units 1 and 2 are also subject to additional 30-day (0.090 lb/mmBtu) and 365-day (0.075 lb/mmBtu) SO_2 emission limits originating from a Federal Consent Decree (CD), compliance with these additional limits is assessed by calculating a lb/mmBtu rate as CEMS derived SO_2 mass divided by CEMS derived heat input (as opposed to averaging the CEMS derived SO_2 lb/mmBtu emission rates). Therefore, using the facility SO_2 emission limit of 1.67 lb/mmBtu rather than CD derived SO_2 limits is more applicable for assessing lb/mmBtu RA.

2.4 NO_x GAS RATA

The NO_x results met the ≤10% RA specification in 40 CFR 75, Appendix A §3.3.2(a) as well as the reduced RATA test frequency incentive criterion of ≤7.5% in 40 CFR 75, Appendix B §2.3.1.2(a). Table 2-3 summarizes the NO_x RATA results.

Table 2-3 Summary of NO_x RATA Results

CEMS Make and Model	CEMS Location & Serial Number	RATA Performance Criteria	Required RATA Performance	Actual RATA Performance
Thermo NO_x Model 42iQ	Unit 2 SN 1183330003	lb/mmBtu	≤10% of mean RM	2.12%
		Bias	|d|≤|CC|=Pass	Pass

|d| average absolute difference between the RM and CEMS
|CC| confidence coefficient

In May of 2019, the NO_x analyzer evaluated during this RATA was installed as a like-kind replacement analyzer as described in the 40 CFR Part 75 Emissions Monitoring Policy Manual (Policy Manual), Question 7.13 (replaced the previous analyzer, Thermo NO_x Model 42i, SN 0711721595). In accordance with §75.20(c)(1) and Policy Manual Question 12.10, the required recertification testing includes a 7-day calibration error test, linearity test, and RATA and bias test. Results of the preceding will be included in a recertification application to be submitted in accordance with §75.63(a)(2) within 45-days after the completion of testing.

2.5 CO_2 Gas RATA

The CO_2 results met the ≤10% RA and the mean difference of no greater than ±1.0% CO_2 specifications in 40 CFR 75, Appendix A §3.3.3 and the reduced RATA test frequency incentive standard in 40 CFR 75, Appendix B §2.3.1.2(a) and (h) where the RA is ≤7.5% or the mean difference does not exceed ±0.7% CO_2, respectively. Table 2-3 summarizes the CO_2 RATA results.

Table 2-4 Summary of CO_2 RATA Results

CEMS Make and Model	CEMS Location & Serial Number	Required Performance Criteria	Actual RATA Performance
Thermo CO_2 410i	Unit 2 SN 0711721598	≤10% of mean RM	0.56%

3.0 SOURCE AND MONITOR DESCRIPTION

The D.E. Karn Generating Complex operates a 2,500 mmBtu/hr, 255 MW net, dry bottom, tangential-fired boiler designated as EU-KARN1 (Unit 1). Unit 1 fires low sulfur pulverized coal and incorporates selective catalytic reduction (SCR) to control NO_x, a pulse-jet fabric filter, or PJFF (i.e., Baghouse), to control particulate emissions, and a spray dry absorber (SDA) system to control SO_2 and other acid gases.

The D.E. Karn Generating Complex also operates a 2,540 mmBtu/hr, 260 MW net, dry bottom wall-fired boiler designated as EU-KARN2 (Unit 2). Unit 2 fires low sulfur pulverized coal and incorporates selective catalytic reduction (SCR) and low-NO_x burners to control NO_x, a pulse-jet fabric filter, or PJFF (i.e., Baghouse), to control particulate emissions, and a spray dry absorber (SDA) system to control SO_2 and other acid gases.

Prior to the RATA, in accordance with 40 CFR Part 75, Appendix A, Section 6.5.2.1(c), Operating Load Analyses were obtained for Unit 1 and Unit 2 for the July 1, 2018 through

June 30, 2019 time span. Based on these four quarters of representative historical operating data, the first (i.e., normal) and second most frequently (i.e., an optional 2nd normal load) used load levels were identified to ensure the appropriate load level(s) were tested during the gas RATA. The load analyses indicated EU-KARN1 operated at High Load level for the majority of the time and High Load was therefore designated as normal, while Mid Load was the second most frequently used load level (and designated as a 2nd normal load in the respective source Monitoring Plan). For EU-KARN2, the load analyses show the unit operated at Mid Load level for the majority of the time and Mid Load was therefore designated as normal, while High Load was the second most frequently used load level (and designated as a 2nd normal load in the respective source Monitoring Plan). Refer to Appendix C for the operating load analyses for Units 1 and 2.

The NOx/Diluent and SO_2 gas RATA was conducted with each boiler operating at its respective normal/2nd normal High load. The flow RATA was performed at high, mid, and low loads as required by 40 CFR Part 75.20(b)(1), "...after changing the flow rate polynomial coefficients, the owner or operator must complete a 3-level RATA." Because the source Monitoring Plan lists both the high and mid load levels as normal loads, the Bias Test was applied to flow RATA results at both load levels.

Thermo Scientific (Thermo) dilution-extractive CO_2, SO_2 and NO_x CEMS and Teledyne ultrasonic air flow CEMS are installed at the exhaust stack location. The air flow CEMS incorporates dual ultrasonic flow monitors (A and B) configured in an X-pattern in the stack. In this configuration, the individual monitors act in tandem as components of the primary flow system or as redundant backup flow systems, if necessary. The CEMS interface with a data acquisition handling system (DAHS) manufactured by Environmental Systems Corporation (ESC). The DAHS records various data including exhaust gas flow rates, concentrations and emissions, as well as operating unit parameters.

4.0 SAMPLING AND ANALYTICAL PROCEDURES

A minimum of nine 21-minute gas test runs were conducted on Units 1 and 2 and a minimum of nine 5-minute flow test runs were conducted on Unit 2 to calculate the CEMS RA. Specific test procedures as detailed in 40 CFR Part 60, Appendix A, Reference Methods 1, 2, 2H, 3, 3A, Alt-008, 7E, and 19 were followed, in conjunction with Part 75 Appendices A and B. Conformance with quality system documents of the AETB program, and where applicable, the *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume III, Stationary Source Specific Methods, was used as a reference. The following sections describe the sampling and analytical procedures.

4.1 Traverse Points (USEPA Method 1)

The number and location of traverse points for determining Unit 2 exhaust gas velocity and flow RA was determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources*. The area of the exhaust stack was calculated and the cross-section divided into a number of equal areas based on the location of existing air flow disturbances. The stack was sampled at the location illustrated in Figure 1 using 16 traverse points (4 traverse points in each of the 4 test ports) as presented in Figure 3.

Because the sampling locations for both Unit 1 and Unit 2 are at least 2 duct diameters downstream and 0.5 duct diameters upstream from a flow disturbance as illustrated in Figure 1, and the ducts are greater than 7.8 feet in diameter, SO_2, CO_2 and NO_x concentrations were measured for 7-minutes at each of three traverse points located at 15.7, 47.2 and 78.7 inches from the stack wall (the short reference method measurement line) as illustrated in Figures 2 and 3.

4.2 Velocity and Volumetric Flow (USEPA Method 2 and 2H)

The Unit 2 exhaust gas velocity and temperature measurements were conducted in accordance with USEPA Method 2*, Determination of Stack Gas Velocity and Volumetric Flow Rate*. The pressure differential across the positive and negative openings of an S-type Pitot tube connected to a pressure transducer was used to measure exhaust gas velocity, as illustrated in Figure 4.

One set of auxiliary measurements (i.e. diluent and moisture content for gas composition) was performed for every three volumetric air flow runs or at least once per every clock hour of the flow RATA consistent with 40 CFR Part 75, Appendix A, Section 6.5.7(a).

Please note that the high-load level RM flow data incorporates wall effect adjustment factor (WAF) of 0.9805 for Unit 2. This value was derived from one RATA test run performed at high-load level on the source using USEPA Method 2H*, Determination of Stack Gas Velocity Decay near the Stack Wall*, with the WAF subsequently applied to all high-load level RM RATA runs. Furthermore, a Method 2H default WAF value of 0.9950 corresponding to gunite-lined stacks was applied to the Unit 2 mid- and low-load level RM data.

4.3 Diluent/Molecular Weight (USEPA Method 3 and 3A)

CO_2 diluent concentrations were measured using a non-dispersive infrared (NDIR) analyzer following guidelines in USEPA Method 3A, *Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure)*. Refer to Section 4.6 for a description of the Method 3A sampling apparatus.

Oxygen (O_2) and CO_2 concentrations were also obtained via USEPA Method 3, *Gas Analysis for the Determination of Dry Molecular Weight* to determine flue gas composition during the air flow RATA using calibrated Fyrite gas analyzers. Triplicate grab samples were captured in absorbing fluid resulting in a proportional rise in the fluid to the gas concentration absorbed. Each sample concentration was read on the instrument scale, and the calculated dry molecular weight was verified to not differ from the triplicate sample mean by more than 0.3 g/g-mole (0.3 lb/lb-mole), and the average result was reported to the nearest 0.1 g/g-mole (0.1 lb/lb-mole).

4.4 Moisture Content (USEPA ALT-008)

Exhaust gas moisture content was determined 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, USEPA 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 flue gas is withdrawn from the stack at a constant rate through a heated sample probe, umbilical, four midget impingers, and a metering console with pump. The moisture is removed from the gas stream in the ice-bath chilled impingers and determined gravimetrically. Refer to Figure 5 for a figure of the Alternative Method 008 Moisture Sample Apparatus.

4.5 Sulfur Dioxide (USEPA Method 6C)

SO_2 concentrations were measured using an NDIR analyzer following the guidelines of U.S. EPA Reference Method 6C, *Determination of Sulfur Dioxide Emissions from Stationary*

Sources (Instrumental Analyzer Procedure). Refer to Section 4.6 for a description of the sample apparatus.

4.6 Oxides of Nitrogen (USEPA Method 7E)

A chemiluminescence analyzer was used to measure concentrations of NO_x following the guidelines of USEPA Method 7E, *Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)*. Diluent (and sulfur dioxide) concentrations were measured following USEPA Methods 3A and 6C, which refer to USEPA Method 7E. The sample system is the same for these parameters, with the exception of the analytical technique.

All components of the extractive gaseous RM system in contact with flue gas were constructed of Type 316 stainless steel and Teflon. Flue gas was drawn from the stack via a heated sample probe and line, and routed through an electronic chilled gas conditioning system to remove moisture prior to passing through a distribution manifold for delivery to the analyzers. The output signal from each analyzer was connected to a computerized data acquisition system (DAS). The RM analyzers were calibrated with USEPA Protocol calibration gases and operated to ensure that zero drift, calibration gas drift, bias and calibration error met the specified method requirements. Refer to Figure 6 for a drawing of the reference method gaseous RATA sample apparatus.

Data collected from the RM analyzers were averaged for each run with NO_x (and SO_2) concentrations measured in parts per million by volume, dry basis (ppmvd) and CO_2 concentrations as percent, dry (%, dry). Since the extractive RM analyzers and dilution CEMS operate on different principles (dry vs. wet measurement), flue gas moisture content was measured concurrently with each gas RATA run to convert RM concentrations from a dry to a wet basis.

4.7 Emission Rates (USEPA Method 19)

USEPA Method 19, *Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxide Emission Rates*, was used to calculate emission rates in units of lb/mmBtu. Measured carbon dioxide concentrations and F factors (ratios of combustion gas volumes to heat inputs) were used to calculate emission rates using equation 19-6 from the method.

USEPA Method 19 Equation 19-6

$$E=C_dF_c\frac{100}{\%CO_{2d}}$$

Where:

E	=	Pollutant emission rate (lb/mmBtu)
C_d	=	Pollutant concentration, dry basis (lb/dscf)
F_c	=	Volumes of combustion components per unit of heat content, 1,840 scf CO_2/mmBtu for subbituminous coal from 40 CFR 75, Appendix F, Table 1
$\%CO_{2d}$	=	Concentration of carbon dioxide on a dry basis (%, dry)

Refer to Appendix A for a RATA calculation summary presenting the calculations used in this report.

5.0 QUALITY ASSURANCE PROCEDURES

The objective of a Quality Assurance (QA) program is to produce data that are complete, representative, and of known precision and accuracy. Within the RATA test program, completeness can be defined as the percentage of the required field measurements and associated documentation achieved. Representativeness, defined as the "when," "how," and "how many" measurements taken, is typically specified within the regulations governing the source to be tested as well as the Test Protocol submitted to the regulatory agency prior to the test event. Precision and accuracy are measures of data quality and exist by design within each of the USEPA reference test methods and procedures incorporated during the RATA.

RCTS addresses these QA goals by operating within a Quality System in compliance with ASTM D 7036-04, Standard Practice for Competence of Air Emissions Testing Bodies; a practice specifying the general competence requirements applicable to all AETB staff engaged in air emission testing at stationary sources, regardless of testing scope. By employing these requirements in conjunction with the precision and accuracy standards in each reference method, RCTS is better able to ensure consistently accurate data quality from an individual and AETB perspective. RCTS' AETB Letter of Accreditation and individual QSTI Certificates are contained in Appendix D.

5.1 Pitot Tube and Thermocouples

The Pitot tubes and thermocouples used to measure the exhaust gas volumetric flow were inspected and/or calibrated according to procedures outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems:* Volume III, Stationary Source-Specific Methods, Method 2, Type S Pitot Tube Inspection, and the *Alternative Method 2 Thermocouple Calibration Procedure* (ALT-011). ALT-011 describes the inherent accuracy and precision of the thermocouple within ±1.3°F in the range of -32°F and 2,500°F and states that a system that performs accurately at one temperature is expected to behave similarly at other temperatures. Therefore, the calibration procedure described in Method 2 may be replaced with a single point calibration procedure that verifies a thermocouple system is operating within ±1.0 percent of the absolute measured temperature, while taking into account the presence of disconnected wire junctions, other loose connections or a potential miscalibrated temperature display.

The differential pressure transmitters used in conjunction with Method 2 were calibrated in accordance with §6.2.1 of the method. Refer to Appendix C for Pitot tube, thermocouple and pressure transmitter/gauge inspection and calibration sheets.

5.2 Dry Gas Metering Console

The dry gas metering consoles and associated pumps used for measuring exhaust gas moisture content following the procedures of ALT-008 were calibrated against a dry gas meter calibration standard as described in Method 5, §16.1, using the procedures in Method 5, §10.3.2. Refer to Appendix C for dry gas metering console calibration data.

5.3 USEPA Protocol Gas Standards

USEPA Protocol gas standards used by RCTS were purchased from an outside vendor participating in the USEPA Protocol Gas Verification Program (PGVP) calibration gas audit program described 40 CFR Part 75 § 75.21(g). The standards are certified to have a total relative uncertainty of no greater than ±2.0 percent according to the *USEPA Traceability Protocol for Assay & Certification of Gaseous Calibration Standards; EPA – 600/R-97/121; September 1997* or the current version of the traceability protocol (*EPA – 600/R-12/531; May 2012*). Refer to Appendix C for a summary of the PGVP calibration gas standards used during this test program.

5.4 ANALYZER CALIBRATIONS

The RM instruments measuring gaseous concentrations were calibrated on-site and operated following manufacturer's specifications and the applicable reference method based in part on the quality assurance and quality control requirements contained in USEPA Method 7E.

A nitrogen dioxide (NO_2) to nitric oxide (NO) conversion efficiency (CE) test was conducted on the NO_x analyzer prior to the test program. The NO_2-NO conversion efficiency test verified the analyzer's ability to convert NO_2 to NO in order to accurately measure NO_x by chemiluminescence. Refer to Appendix C for the NO_2-NO conversion efficiency documentation.

Before beginning the gas RATA, a three-point analyzer calibration error (ACE) check was conducted on each RM analyzer by injecting zero-, mid-, and high-level calibration gases directly into the instruments and measuring the responses. The instrument response must be within ±2.0% of the respective analyzer span or within ±0.5 ppmv or ±0.5% for O_2 and/or CO_2 absolute difference to be acceptable. An initial system bias check was then performed by measuring the instrument response while introducing zero- and mid- or high-level (upscale) calibration gases at the probe, upstream of all sample conditioning components, and drawing it through the various sample components in the same manner as flue gas. The initial system bias check is acceptable if the instrument response at the zero and upscale calibration is within ±5.0% of the calibration span or ±0.5 ppmv or ±0.5% for O_2 and/or CO_2 absolute difference.

After each gaseous RATA run, post-test zero and upscale system bias checks were performed to quantify and compensate for RM analyzer drift and bias. The RM system bias is acceptable if those values remain within ±5.0% of the calibration span or 0.5 ppmv or ±0.5% for O_2 and CO_2 absolute difference. The RM drift is acceptable if the zero and upscale values are within ±3.0% of the calibration span. Measurement system response times were documented during the initial system bias tests and calibration gas flow rates thereafter were maintained at the target sample rate, with each subsequent run started after twice the system response time had elapsed. Analyzer calibration data is presented in Appendix C.

6.0 DISCUSSION OF TEST RESULTS

The CEMS RATA results presented in Appendix B indicate the CEMS operating at D.E. Karn Generating Complex Units 1 and 2 meet the performance specifications in 40 CFR 75, Appendix A, and the annual reduced RATA test frequency incentive standards in 40 CFR 75, Appendix B. These data indicate compliance with the CEMS monitoring and recordkeeping requirements of the facility's air permit MI-ROP-B2840-2014c.

During the test event, no deviations were observed by the QI's in attendance. The criteria specified in the applicable Reference Methods and the agency-approved Test Protocol were followed. Hard copy and/or electronic field data were completed in the field and upon return to the home office, verified for data precision and accuracy, further ensuring the appropriate AETB and Reference Method quality measures were met.

The Quality Assurance data include the EU-KARN1 and EU-KARN2 Operating Load Analyses, protocol gas certificates of analysis, analyzer calibration error and system response time, NO_2 to NO converter efficiency check, instrument interference checks, flow instrument calibration, moisture, thermocouple and Pitot tube calibration sheets, all of which are contained in Appendix C. Gas RATA instrument calibration and system bias/drift data are contained in Appendix B-4 for Unit 2 and Appendix B-6 for Unit 1. AETB certification and field test signature forms are provided in Appendix D.

6.1 Clock Time Synchronization

The flow traverse and gaseous RM data is presented in time synchronized to the CEMS DAHS which is in Eastern Standard Time (EST). However, the time reported on the moisture analyses associated with the flow and gaseous RATA runs for Unit 2 were reported in Eastern Daylight Time (EDT), 60 minutes later than EST. To align the Unit 2 flow and gaseous RATA moisture run start and stop times to CEMS time, subtract 60 minutes from the times reported on the appropriate flow RATA moisture field datasheets presented in Appendix B.

6.2 Unit 2 SO_2 RATA Runs Excluded

Pursuant to Section 6.5(c) of 40 CFR Part 75, Appendix A, for monitoring systems with dual ranges and associated pollutant controls that operate on a year-round basis, the RATA should be conducted on the low measurement range. During the Karn Unit 2 RATA conducted on July 11, 2019, process upsets in the plant and/or AQCS equipment during runs 5 (12:11-12:31) and 7 (13:30-13:50) caused the CEMS PPM measurement average to exceed the normal low range SO_2 analyzer range of 30 ppmv. For that reason, runs 5 and 7 were excluded when determining the relative accuracy for both SO_2 ppmv and Lb/mmBtu assessments.

6.3 Unit 1 SO_2 Reference Method Measurements and Run 1 Moisture

Although an SO_2 gas RATA was proposed in the May 22, 2019 test protocol, issues with the reference method SO_2 sampling system during the RATA of Unit 1 on June 25, 2019 prevented the RATA from being completed as originally scheduled with this test program.

During the Karn Unit 1 RATA conducted on June 25, 2019, the RM SO_2 measurement exhibited a negative bias. Specifically, once preliminary QA ACE and Initial Bias checks were performed, RM one-minute concentrations were significantly less and in a state of gradual decline when compared to the associated CEMS SO_2 values. RCTS attempted to diagnose and correct the apparent condensed moisture issue without success. Rather than jeopardizing ongoing NO_x and CO_2 RATAs, the RCTS QI proposed rescheduling the SO_2 RATA to Ms. Angellotti (the EGLE representative onsite), and Ms. Angellotti accepted the proposed schedule change.

In accordance with 40 CFR 75, Appendix B §2.3.2(h), RATA attempts that are aborted due to problems with the reference method need not be reported; records of the aborted SO_2 RATA will be kept on-site as part of the official test log.

The Unit 1 SO_2 RATA was rescheduled to commence on July 9, 2019, with July 10 scheduled as a contingency date. During equipment setup and QA checks, excess moisture and/or other interferences from the stack flue were observed to be biasing the reference method SO_2 concentrations low. The test team attempted to eliminate the bias by reconfiguring the sampling system, replacing equipment, and/or adding moisture removal components; however, the problem could not be definitively resolved. After two days of troubleshooting, the Unit 1 SO_2 RATA was postponed to July 17, 2019, and sampling equipment was moved to Unit 2 to commence the RATA at that source.

The Unit 1 SO_2 RATA was completed on July 17, 2019. With approval from onsite EGLE representative Ms. Angellotti, RCTS used the previously Quality Assured CEMS CO_2 values for calculating RM SO_2 Lb/mmBtu emission rates for each run of the RATA.

Lastly, the moisture result for Run 1, at 17.3%, was higher than expected for the fuel blend and unit operating conditions on July 17, 2019. The QI performing the ALT-008 moisture determinations suspected the balance used to weigh the impinger set was inaccurate. A QA validation of the balance was performed following Run 1 and the balance was found out of tolerance against a certified calibration weight. The balance was replaced, QA validation for the new balance was successfully completed, and the RATA was resumed. The moisture determinations for runs 2-10 achieved results between 15.1% and 16.5%, further corroborating the suspect result for Run 1. Out of an abundance of caution, the Run 1 gas RATA results have been excluded when determining the relative accuracy.

Figures

Figure 1 – D.E. Karn Units 1 and 2 In-Stack Test Port Location Elevation

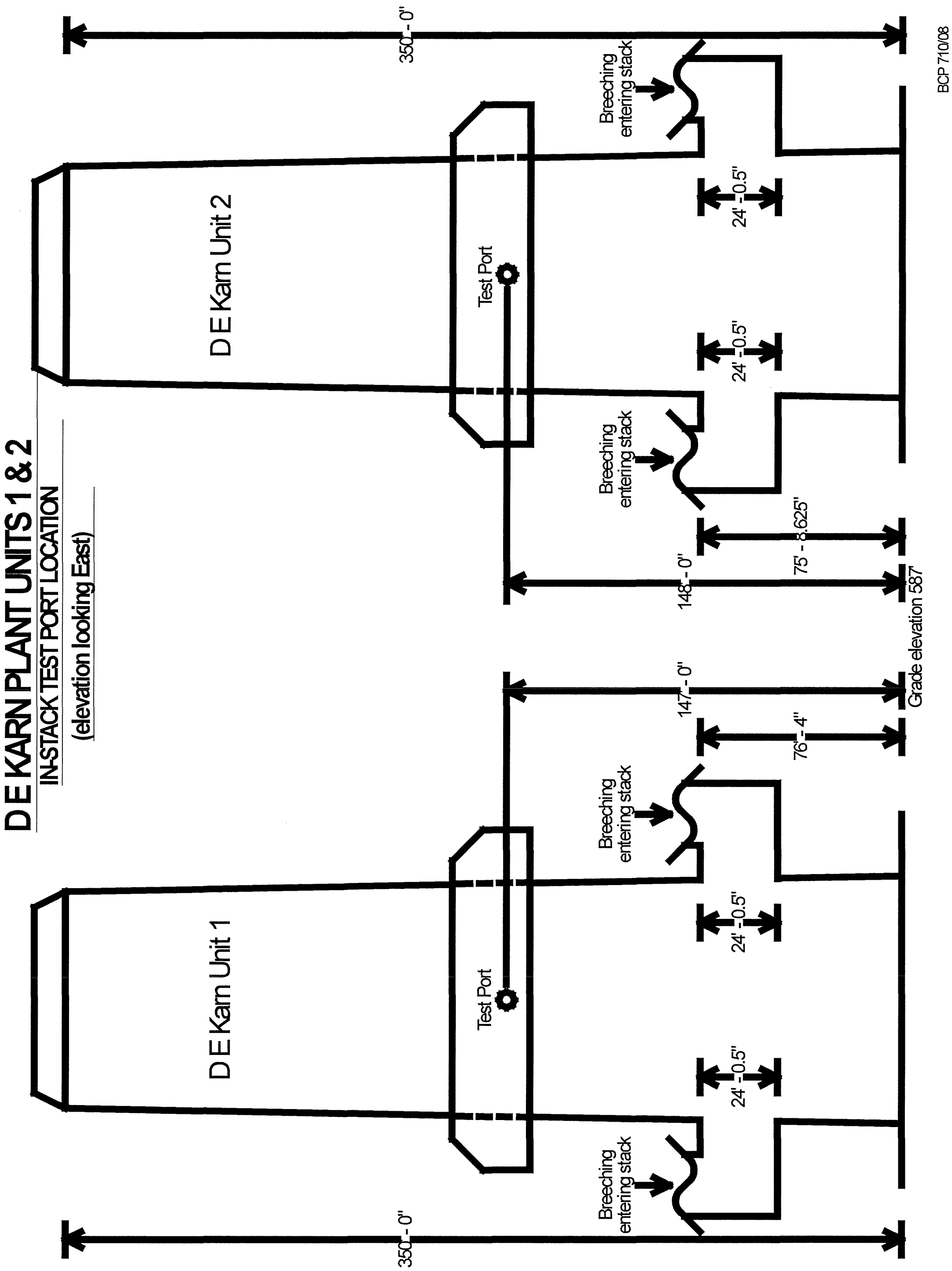
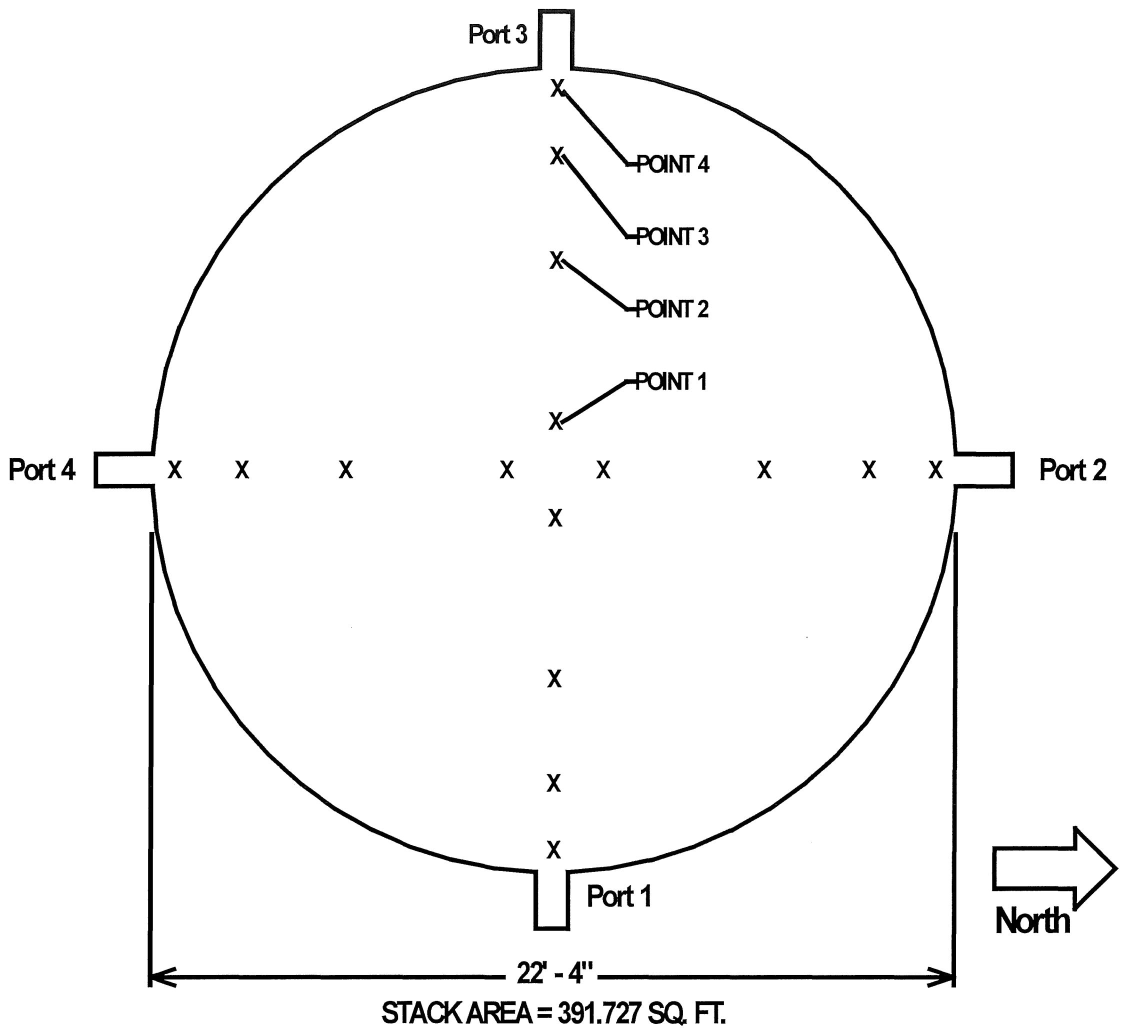


Figure 2 – D.E. Karn Unit 1 Test Port and Traverse Point Detail



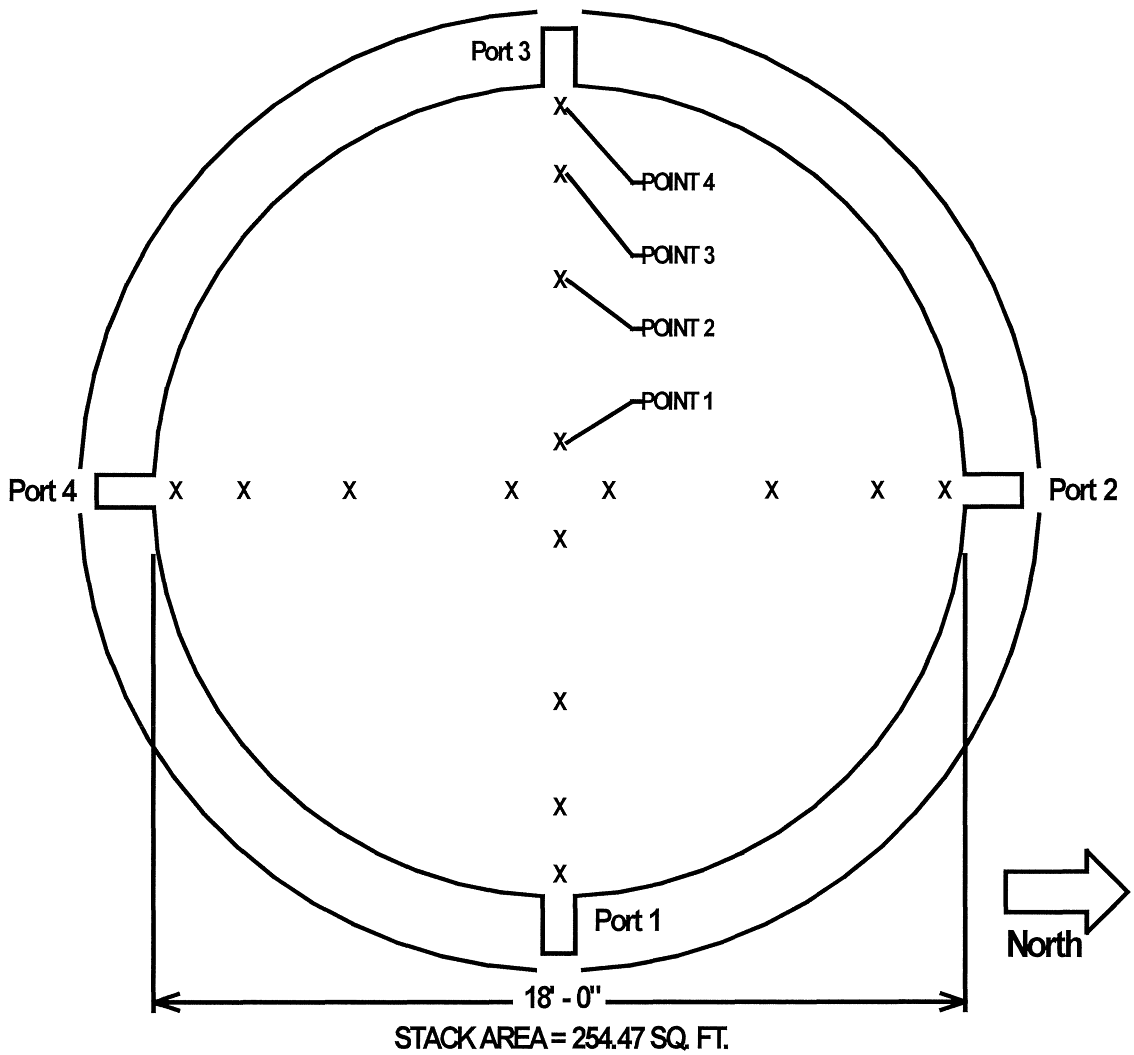
Gas RATA Probe Depths
From Inside Stack Wall
Gas Port Length = 24"

POINT 1 = 78.7"
POINT 2 = 47.2"
POINT 3 = 15.7"

Flow RATA Probe Depths
From Inside Stack Wall
Flow Port Length = 24"

POINT 1 = 86.56"
POINT 2 = 51.99"
POINT 3 = 28.14"
POINT 4 = 8.58"

Figure 3 – D.E. Karn Unit 2 Test Port and Traverse Point Detail



Gas RATA Probe Depths
From Inside Stack Wall
Gas Port Length = 14"

POINT 1 = 78.7"
POINT 2 = 47.2"
POINT 3 = 15.7"

Flow RATA Probe Depths
From Inside Stack Wall
Flow Port Length = 14"

POINT 1 = 69.77"
POINT 2 = 41.90"
POINT 3 = 22.68"
POINT 4 = 6.91"

Figure 4 – Volumetric Air Flow RATA Sample Apparatus

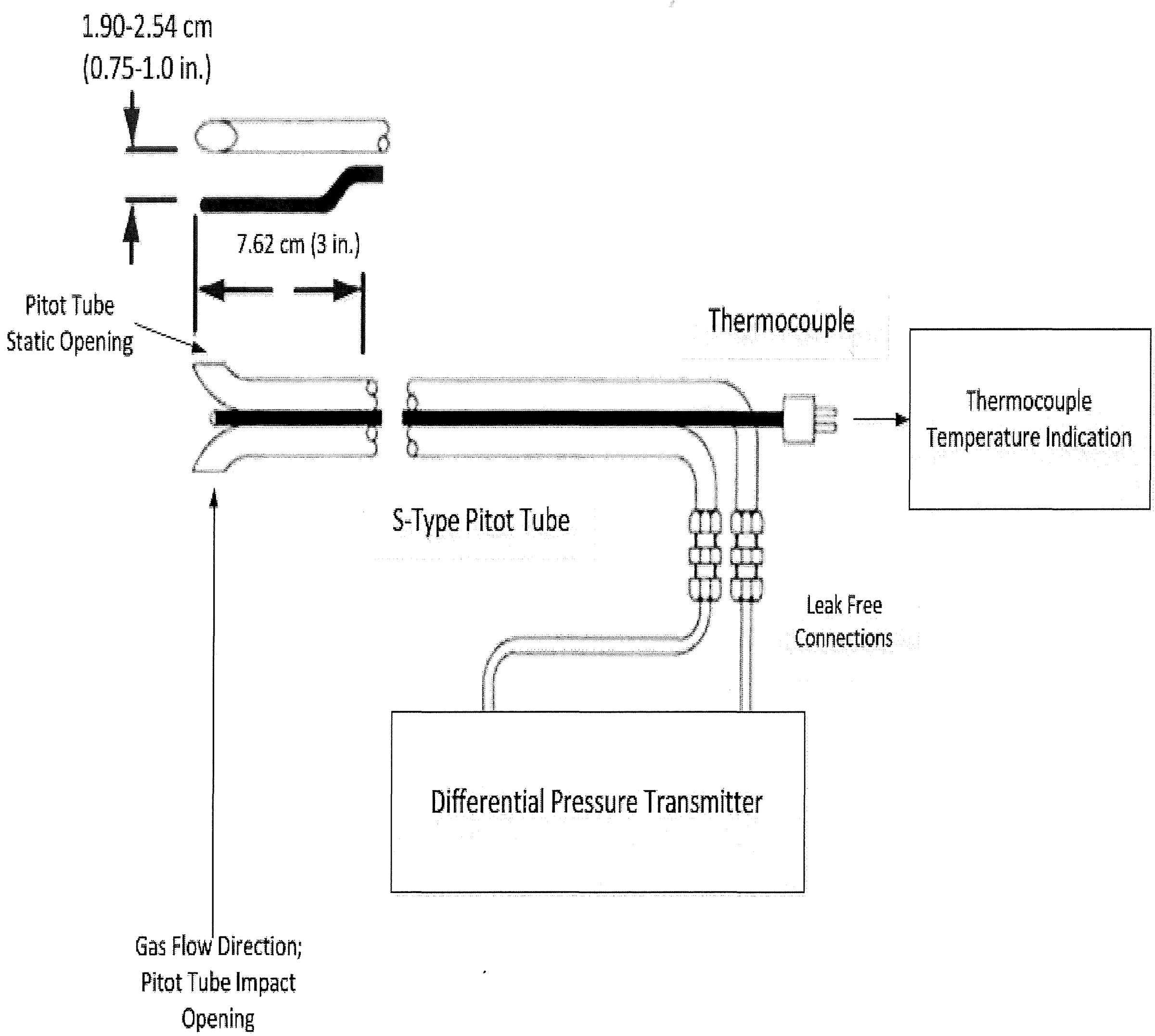
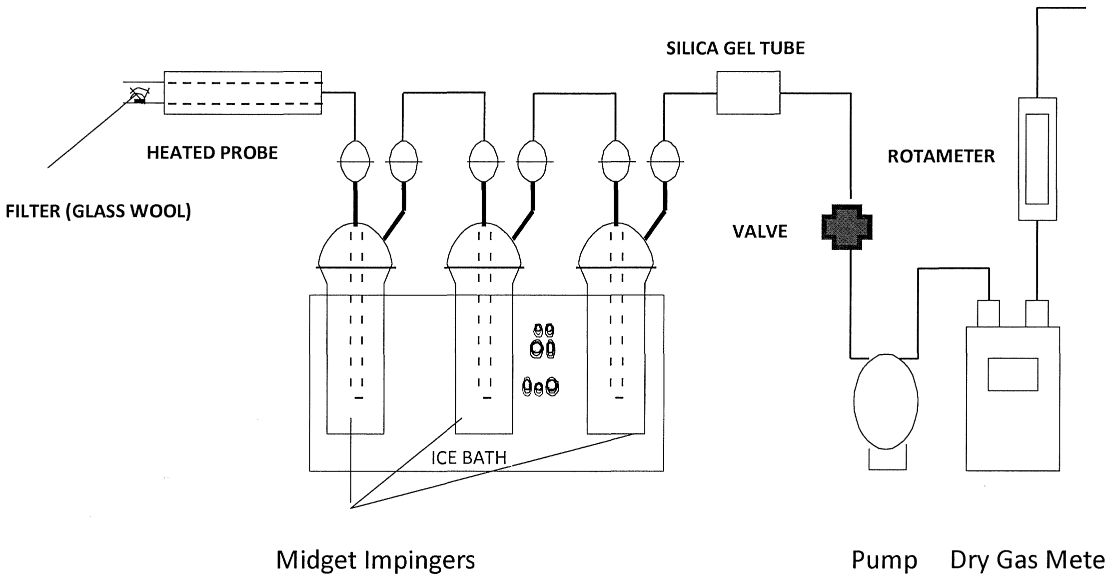
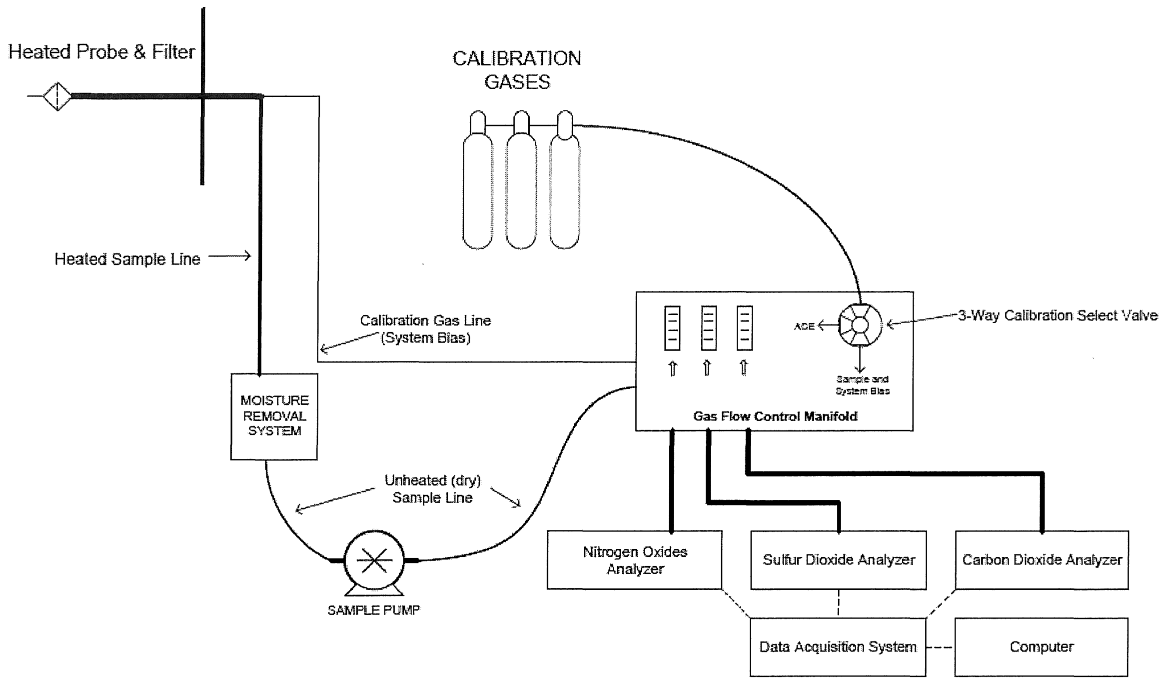


Figure 5 – Alternative Method 008 Moisture Sample Apparatus



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

Figure 6 – Reference Method Gaseous RATA Sample Apparatus



Appendix A
RATA Calculation Summary