Consumers Energy
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# Relative Accuracy Test Report

## EUBOILER3

Consumers Energy Company
J.H. Campbell Plant
17000 Croswell Street
West Olive, Michigan 49460
SRN: B2835
ORIS: 1710
FRS: 110000411108
September 16, 2019

**Test Dates: August 5, 6 and 8, 2019**

Test performed by the Consumers Energy Company
Regulatory Compliance Testing Section
Air Emissions Testing Body
Laboratory Services Department
Work Order No. 31731632
Version No.: 1.0

# TABLE OF CONTENTS



# TABLES

# FIGURES



# APPENDICES

## CERTIFICATION FOR 40 CFR PART 75 TEST REPORT

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

Facility ID: ORIS 1710; SRN B2835 Date(s) Tested: August 5, 6 & 8, 2019

Facility Name: Consumers Energy J.H. Campbell Plant

Facility Address: 17000 Croswell Street, West Olive, Michigan 49460

Equipment Tested: EUBOILER3 - $CO_2$, $SO_2$, $NO_x$, and Volumetric Flow 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: September 17, 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] |

# 1.0 INTRODUCTION

Consumers Energy Company (CECo), Regulatory Compliance Testing Section (RCTS) conducted continuous emission monitoring systems (CEMS) quality assurance (QA) audits at the exhaust of emission unit EUBOILER3 (Unit 3) operating at the Consumers Energy J.H. Campbell Plant in West Olive, Michigan.

The relative accuracy test audits (RATA) conducted on August 5, 6 and 8, 2019 satisfy requirements in the Michigan Department of Environment, Great Lakes and Energy (EGLE) Renewable Operating Permit (ROP) No. MI-ROP-B2835-2013b, Appendix 3-S1, and the United States Environmental Protection Agency (USEPA) Title 40, Code of Federal Regulations (40 CFR) Part 60, Subpart D and Part 75, Appendices A and B.

A test protocol describing the sampling, calibration and QA procedures in 40 CFR 60, Appendix A, Reference Methods (RM) 1, 2, Conditional Test Method (CTM)-041, 3, 3A, 4, Alternate Test Method (ALT)-008, 6C, 7E, and 19 was submitted to the USEPA and EGLE on July 3, 2019. The protocol was subsequently approved in a letter dated July 24, 2019 by EGLE representative Mr. David Patterson.

The Unit 3 CEMS audit was conducted by RCTS representatives Gregg Koteskey, Dillon King, Thomas Schmelter, and Joe Mason. Mr. John Olle, CECo Senior Technician, coordinated the tests with applicable plant personnel and collected CEMS data. EGLE representatives Mr. David Patterson and Mr. Tom Gasloli were onsite to witness portions of the audit.

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 accordingly qualified to conduct 40 CFR Part 75 test programs. RCTS' AETB program is developed in accordance with the American Society for Testing and Materials (ASTM) D 7036-04, *Standard Practice for Competence of Air Emissions Testing Bodies*, in which the AETB is required during test projects to provide at least one qualified individual (QI), qualified in the specific methods for that project, to be on-site at all times. RCTS representatives Mr. Mason (Gas RATA) and Mr. King (Flow RATA) met these requirements and assumed on-site QI roles for the duration of the EUBOILER3 CEMS audits.

This document is compiled based on the March, 2018 EGLE document entitled *Format for Submittal of Source Emission Test Plans and Reports*. Misinformation or contextual omissions may occur if portions of this report are reproduced. Please exercise due care in this regard.

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<br>312-886-5745<br>compher.michael@epa.gov | U.S. EPA Region 5<br>77 W. Jackson Blvd. (AR-18J)<br>Chicago, Illinois 60604 |
| State Regulatory Administrator | Ms. Karen Kajiya-Mills<br>Technical Programs Unit Manager<br>517-335-4874<br>kajiya-millsk@michigan.gov | Michigan Department of Environment<br>Great Lakes and Energy<br>Technical Programs Unit<br>525 W. Allegan<br>Constitution Hall, 2nd Floor S<br>Lansing, Michigan 48933 |
| State Field Inspector | Mr. Tom Gasloli<br>Environmental Quality Analyst<br>517-284-6778<br>gaslolit@michigan.gov | |
| | Mr. David Patterson<br>Environmental Quality Analyst<br>517-284-6782<br>pattersond2@michigan.gov | |
| Responsible Official | Mr. Norman J. Kapala<br>Executive Director Coal Generation<br>616-738-3200<br>norman.kapala@cmsenergy.com | Consumers Energy Company<br>J.H. Campbell Power Plant<br>17000 Croswell Street<br>West Olive, Michigan 49460 |
| Test Facility | Mr. Joe Firlit<br>Senior Engineering Technical Analyst<br>616-738-3260<br>joseph.firlit@cmsenergy.com | Consumers Energy Company<br>J.H. Campbell Plant<br>17000 Croswell Street<br>West Olive, Michigan 49460 |
| | Mr. John Olle<br>Senior Technician<br>616-738-3278<br>john.olle@cmsenergy.com | |
| Test Team Representative | Mr. Dillon King, QSTI<br>Engineering Technical Analyst<br>989-891-5585<br>dillon.king@cmsenergy.com | Consumers Energy Company<br>D.E. Karn Generating Complex<br>2742 N. Weadock Highway, ESD Trailer #4<br>Essexville, Michigan 48732 |
| | Mr. Joe Mason, QSTI<br>Engineering Technical Analyst<br>616-738-3385<br>joe.mason@cmsenergy.com | Consumers Energy Company<br>L&D Training Center<br>17010 Croswell Street<br>West Olive, Michigan 49460 |

# 2.0 SUMMARY AND DISCUSSION

The J.H. Campbell Unit 3 volumetric airflow, sulfur dioxide ($SO_2$), oxides of nitrogen ($NO_x$), and carbon dioxide ($CO_2$) CEMS relative accuracy (RA) results shown in Tables 2-1 through 2-4 and Appendix B of this report indicate the CEMS meet the semi-annual RA frequency standards in 40 CFR 75, Appendix A and the annual RA frequency incentives in 40 CFR 75, Appendix B

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

In August 2016, prior to performing the volumetric flowrate RATAs, USEPA CTM-041, *Determination of Volumetric Gas Flow in Rectangular Ducts or Stacks Taking into Account Velocity Decay near the Stack or Duct Walls*, was performed to evaluate the magnitude of flue gas velocity decay near the rectangular duct walls and calculate a site-specific wall effect adjustment factor (WAF). The resulting calculated WAF of 0.9740 (dimensionless) was then applied to the Unit 3 duct area and CEMS volumetric flow rate.

Accordingly, reviewing detailed volumetric flow data in Appendix B reveals the actual flue duct area in square feet ($ft^2$) is less after WAF adjustment. Specifically, the 814.63 $ft^2$ *Flue Duct Dimension* ($ft^2$) represents the physical inner flue duct dimensions, while the 793.45 $ft^2$ *Flue Area* ($ft^2$) entry represents the duct area after WAF adjustment.

CTM-041 rectangular duct criteria allows application of a single operating load WAF to all operating loads and subsequent tests, unless the affected duct work configuration was changed. The Unit 3 duct work configuration remains unchanged; thus the 0.9740 WAF is valid and no additional WAF tests were necessary.

## 2.2 Volumetric Flowrate

Two ultrasonic volumetric air flow monitors are installed in an X-pattern within the duct. The monitors operate in tandem as the primary flow monitoring system, with volumetric flowrate and continuous emission rates calculated and reported based on the average of both. The individual monitors are also redundant backups to the primary system, identified as components F01 and F02 while the Unit 3 data acquisition and handling system (DAHS) assigns the monitors to channels BK1 and BK2.

Volumetric flowrate RA was determined at two distinct Unit 3 operating loads (high and mid) beginning with triplicate trial flow runs on August 5 and 6, 2019. The trial runs evaluated the need to optimize if necessary, the primary (average of BK1 and BK2) and both individual redundant backup flow CEMS, as allowed in 40 CFR 75, Appendix B §2.3.2(b)(2). The high and mid load trial flow run results differed by no more than ± 10% of the average RM value which met the trial run RA criterion in 40 CFR 75.20(b)(3)(vii)(E)(2), thereby allowing the trial runs to be incorporated into the 12-run flow RATA result at each operating load.

As summarized in Table 2-1, the volumetric flow CEMS met the ≤10.0% criterion in 40 CFR 75, Appendix A §3.3.4(a) and the annual test frequency incentive standard of ≤7.5% in 40 CFR 75, Appendix B §2.3.1.2(c).

**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 (F01 & F02) | F01 Monitor | F02 Monitor |
| Teledyne Monitor Labs Model 150 | Unit 3 F01 Monitor SN 1500470 | High Load | ≤ 10% of mean RM | 4.77% | 6.36% | 3.50% |
| | | Mid Load | | 3.77% | 3.98% | 3.82% |
| | F02 Monitor SN 1500471 | Bias | \|d\| ≤ \|CC\| = Pass | Fail 1.043 | Fail 1.058 | Fail 1.036 |

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

## 2.3 $SO_2$ GAS RATA

The $SO_2$ ppm CEMS did not meet the ≤10% RA specification in 40 CFR 75, Appendix A §3.3.1(a) or the reduced RATA test frequency incentive standard of ≤7.5% RA in 40 CFR 75, Appendix B §2.3.1.2(a). However, the average measured RM $SO_2$ value (14 ppm) was ≤250.0 ppm, thus the SO2 CEMS met the low emitting alternate RA specification of ± 15.0 ppm absolute difference specified in 40 CFR 75, Appendix A §3.3.1 and the alternate reduced test frequency incentive standard of ± 12 ppm absolute difference in 40 CFR 75, Appendix B §2.3.1.2(e).

The $SO_2$ lb/mmBtu CEMS did not meet the 20% RA criteria in 40 CFR Part 60, Appendix B, Performance Specification (PS) 2, § 13.2, however the average RM measured value (0.047 lb/mmBtu) was <50% of the applicable emissions standard of 1.2 lb/mmBtu, thus the SO2 lb/mmBtu CEMS RA met the ≤10% alternate applicable emissions standard RA criteria which uses the emission standard in the denominator of Equation 2-6, PS2. Table 2-2 summarizes the $SO_2$ RATA results.

**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 3 SN 0706120983 | ppm | ≤10% of mean RM (or) | 43.33% |
| | | | ±15.0 ppm RM/CEMS difference | -5.87 ppm |
| | | lb/mmBtu[1] | ≤20% of mean RM (or) | 44.53% |
| | | | ≤10% of emission limit[2] | 1.31% |
| | | 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 EGLE 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]The average Unit 3 RM $SO_2$ lb/mmBtu emission rate was <50% of the 1.2 lb/mmBtu emission limit; therefore, percent RA was calculated using the emission limit as the denominator in the RA equation as specified in 40 CFR Part 60, Appendix B, Performance Specification 2, §13.2. JH Campbell Unit 3 is also subject to Federal Consent Decree (CD) 30-day (0.085 lb/mmBtu) and 365-day (0.070 lb/mmBtu) $SO_2$ emission limits, however compliance with these limits is assessed by calculating the lb/mmBtu rate as CEMS derived $SO_2$ mass divided by CEMS derived heat input (as opposed to averaging CEMS derived $SO_2$ lb/mmBtu emission rates). The 1.2 lb/mmBtu $SO_2$ emission limit RA approach is therefore more appropriate than CD derived $SO_2$ limits for assessing lb/mmBtu RA.

## 2.4 $NO_x$ GAS RATA

The $NO_x$ CEMS RA met the ≤10% RA specification in 40 CFR 75, Appendix A §3.3.2(a) but not the reduced RATA test frequency incentive criterion of ≤7.5% in 40 CFR 75, Appendix B §2.3.1.2(a). However, the average RM measured $NO_x$ emission rate was ≤0.200 lb/mmBtu, thus the $NO_x$ CEMS met the alternate ±0.015 lb/mmBtu RM/CEMS difference criteria in 40 CFR 75, Appendix B §2.3.1.2(f). 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 NOx Model 42i | Unit 3 SN 0801820985 | lb/mmBtu | ≤10% of mean RM | 9.48% |
| | | lb/mmBtu | ±0.015 RM/CEMS Difference | -0.004 |
| | | Bias | \|d\|≤\|CC\|=Pass | Pass |

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

## 2.5 $CO_2$ Gas RATA

The $CO_2$ CEMS met the ≤10% RA and mean difference criteria ≤±1.0% $CO_2$ in 40 CFR 75, Appendix A §3.3.3, and the ≤7.5% RA and mean difference within ±0.7% $CO_2$ reduced RATA frequency incentives in 40 CFR 75, Appendix B §2.3.1.2(a) and (h). Table 2-4 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 3 SN 0801820987 | ≤10% of mean RM | 1.23% |

# 3.0 SOURCE AND MONITOR DESCRIPTION

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 various applicable federal regulations, including 40 CFR Part 75, and includes requirements for monitoring gas flow, SO2, CO2, and NOx emissions using CEMS installed, maintained, and operated in accordance with 40 CFR 75 provisions. EUBOILER3 is identified as a designated emission unit in the permit.

EUBOILER3 is a pulverized coal-fired 8,240 mmBtu per hour dry bottom, wall-fired boiler with fuel oil startup capability. High pressure steam from the boiler turns a turbine connected to a generator to produce electricity. The boiler is fired with low sulfur western sub-bituminous pulverized coal and is rated to produce an electricity output of approximately 830 megawatts (MW) net and 900 MW gross.

Unit 3 emissions are minimized or controlled through the use of low-NOx burners (LNB), over-fire air (OFA), and selective catalytic reduction (SCR) for NOx, activated carbon injection (ACI) for mercury (Hg), spray dry absorbers (SDAs) for acid gases [e.g., sulfur oxides (SOx), HCl], and a low pressure/high volume pulse jet fabric filter (PJFF) system baghouse for particulate matter control.

Thermo Environmental dilution-extractive CO2, SO2, NOx, and Teledyne ultrasonic air flow CEMS are installed in the common exhaust duct, upstream of the discharge stack, to measure exhaust gas concentrations and velocity on a wet basis. Mercury (Hg) and particulate matter (PM) CEMS are also installed in this proximity. The CEMS are designed to 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, mass emissions, and unit operating parameters.

Figures 1 and 2 (flow) and 3 (gas) illustrates the in-duct RM test port locations. Although not presented via diagram, the upstream flow disturbance relative to the RM test ports consist of a silencer/change in duct size, while the downstream disturbance consists of a 90 degree duct bend /change in duct size entering the base of the exhaust stack.

Prior to performing the RATA, an Operating Load Analysis (OLA) identified the normal load level(s) based on the number of operating hours at each of three load levels, low-, mid-, and high- over a minimum of four representative operating quarters and ensured the RATAs were performed at load levels separated by no less than 25.0 percent of the range of operation (i.e., 132.5 MW). The monitoring plan and historical EUBOILER3 operating data in the OLA dated April 1, 2018 through June 30, 2019 revealed a 380 to 910 MW range of operation. The most frequently used load level, normal load, was high (>60 percent of the range of operation), while Mid-load was identified as the 2nd most frequently used level. The OLA is presented in Appendix C.

# 4.0 SAMPLING AND ANALYTICAL PROCEDURES

Specific test procedures detailed in 40 CFR Part 60, Appendix B, Reference Methods 1, 2, 3, 3A, 4, ALT-008, 6C, 7E, and 19 were used to conduct a minimum of nine runs on Unit 3 to calculate gas and flow CEMS RA. During each gas RATA run, $CO_2$, $SO_2$ and $NO_x$ concentrations were measured for 21-minutes in the central test port for 7-minutes from each of three traverse points located 15.7 (0.4 m), 47.2 (1.2 m) and 78.7 (2.0 m) inches from the duct wall. Volumetric air flow measurements utilized traverse points specific to USEPA Method 1 requirements and were performed for a minimum of 5-minutes per test.

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 used.

## 4.1 Traverse Points (USEPA Method 1)

The number and location of traverse points used to determine exhaust gas velocity and Flow RA was determined in accordance with USEPA Method 1, *Sample and Velocity Traverses for Stationary Sources*. The equivalent diameter of the duct is 28.54 feet, and the flow and gas test ports are located approximately 107.5 feet downstream and 23.1 feet upstream of a flow disturbance. Thus, the test ports are located approximately 3.8 duct diameters upstream and 0.8 duct diameters downstream from flow disturbances.

The area of the Unit 3 exhaust duct was determined and the cross-section divided into a number of equal areas based on the location of existing air flow disturbances. Twenty (20) RM traverse points (4 traverse points in each of the 5 test ports) were selected as illustrated in Figure 2.

## 4.2 Velocity and Volumetric Flow (USEPA Method 2 and CTM-041)

The exhaust gas velocity and temperature RA measurements were conducted in accordance with USEPA Method 2, *Determination of Stack Gas Velocity and Volumetric Flow Rate*. The exhaust stack pressure differential was measured using an S-type Pitot tube connected to a pressure transducer in place of an inclined manometer as illustrated in Figure 4.

Please note that the RM flow data incorporates a wall effect adjustment factor (WAF) of 0.9740, derived from August 2016 measurements using USEPA CTM-041*, Determination of Volumetric Gas Flow in Rectangular Ducts or Stacks Taking into Account Velocity Decay near the Stack or Duct Walls* while Unit 3 operated at high-load. The CTM-041 results are shown in Appendix B1.

## 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)*.

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 absorbed. Each sample concentration was read on the instrument scale, and the resulting 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 Method 4 and ALT-008)

The gas RATA moisture content was determined in accordance with USEPA Method 4, *Determination of Moisture Content in Stack Gases*. Flue gas is extracted from the stack at a constant rate through a stainless steel probe, flexible line, 4 impingers assembled in an ice bath container, and a metering console/pump. Moisture in the gas stream condenses in the impingers and is determined gravimetrically.

The flow RATA moisture content was determined using 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, incorporated into Method 6A of 40 CFR Part 60, 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 is configured following general guidelines in Figure 4-2 and § 8.2 of USEPA Method 4*,* and ALT-008 Figure 1 or 2. Flue gas is extracted from the stack at a constant rate through a heated sample probe and filter, umbilical, 4 midget impingers and a metering console/pump. Moisture condenses in the impingers and is determined gravimetrically. Figure 5 depicts the Method 4 and ALT-008 Moisture Sample Apparatus.

## 4.5 Sulfur Dioxide (USEPA Method 6C)

$SO_2$ concentrations were measured using an ultraviolet photometric analyzer following the guidelines of USEPA Reference Method 6C, *Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)*.

## 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)*.

The gaseous measurements (diluent, sulfur dioxide and nitrogen oxides) for each method use the same sample system described in USEPA Method 7E, but differ in analytical principles.

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

Data collected from the RM analyzers are averaged for each run with $SO_2$ and $NO_x$ concentrations measured in parts per million by volume (ppmv) and $CO_2$ concentrations as percent. Since the extractive RM analyzers and dilution CEMS operate on different principles (dry vs. wet measurement), flue gas moisture content is measured concurrently with each gas RATA run to convert RM concentrations from dry to a wet basis. Conversely, 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 air flow RATA consistent with 40 CFR Part 75, Appendix A, Section 6.5.7(a).

## 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

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

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 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 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 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. Employing these requirements in conjunction with the RM precision and accuracy standards provides a consistent basis for achieving 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 volumetric flow were 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 and magnehelic gauge (employed to obtain static pressure only) used with Method 2 were calibrated in accordance with §6.2.1 of the method. Refer to Appendix C for the moisture instrumentation, magnehelic gauge, Pitot tube and thermocouple inspection and calibration sheets.

## 5.2 Dry Gas Metering Console

The ALT-008 dry gas meter and pump used to measure moisture content for the flow RATA was calibrated against a dry gas meter calibration standard as described in Method 5, §16.1, using the procedures in Method 5, §10.3.2. The RM4 dry gas meter and pump used during the gas RATA to measure moisture content was calibrated using Approved Alternative Method ALT-009, *Alternative Method 5 Post-Test Calibration*, which is based on the principles of the optional pretest orifice meter coefficient check in 9.2.1.1 in Method 5. Refer to Appendix C for the 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 applicable reference methods based in part on the quality assurance and quality control requirements contained in USEPA Method 7E.

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.

A $NO_x$ analyzer nitrogen dioxide ($NO_2$) to nitric oxide (NO) conversion efficiency (CE) test was then conducted to verify the analyzer's ability to convert $NO_2$ to NO in order to accurately measure $NO_x$ by chemiluminescence. Refer to Appendix C for this CE documentation.

After each gaseous 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 Appendices B4 and C.

## 6.0 DISCUSSION OF TEST RESULTS

The RATA results in Appendix B indicate the CEMS operating at J.H. Campbell EUBOILER3 meet the performance specifications in 40 CFR 75, Appendix A, and the annual reduced test frequency incentives in 40 CFR 75, Appendix B. The results also indicate compliance with MI-ROP-B2835-2013b CEMS monitoring and recordkeeping requirements.

During the test event, no deviations were observed by the QI's in attendance, the agency-approved Test Protocol was followed and all RM criteria met. 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 RM quality measures were met.

Please note that the gas RATA schedule was delayed due to an apparent measurement difference between the RM and CEMS $SO_2$ values. The preliminary RM $SO_2$ values observed on Tuesday, August 6, 2019 (the initially scheduled day of the CEMS audits) were abnormally low in comparison to associated CEMS values, which after performing significant RM instrument and measurement system trouble shooting, appeared to be caused by either condensed moisture in the sample system, the non-dispersive infrared (NDIR) instrument measurement sensitivity, or a combination of both. Therefore, RCTS requested and received agency approval to re-schedule the gas RATA from August 6, 2019, to Thursday, August 8, 2019, thus allowing time to resolve these issues. As noted in report Section 4.5

above, the RM $SO_2$ concentrations were ultimately measured satisfactorily using an ultraviolet photometric analyzer.

Also note that an apparent connection compatibility issue exists between the RCTS CompactRIO programmable logic controller (PLC) LabVIEW software application and Microsoft Windows 10 operating platform. This issue caused the RCTS DAS computer to disconnect from the PLC numerous times during the gas RATA on August 8, particularly during gas run 9. Therefore, while run 9 is included in Appendix B4, the run was not used to determine CEMS accuracy. Also note that RCTS is investigating this compatibility issue, and until resolved, a DAS computer equipped with a Microsoft Windows 7 operating platform (no apparent compatibility issues) will be used.

Finally, gaseous Run 3 was conducted from 9:33-9:53; however the associated moisture Run 3 was conducted from 9:14-9:34. This 1-minute time offset is permissible, since Part 75, Appendix A, § 6.5.7(a) states that for a gaseous RATA run, all pollutant, diluent and moisture data should be collected in the same 60-minute period.

Quality Assurance data in Appendix C includes the EUBOILER3 Operating Load Analysis, 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. Flow and gas RATA moisture data are provided in Appendix B3. Gas RATA instrument calibration and system bias/drift data are contained in Appendix B4. AETB certification and field test signature forms are provided in Appendix D.

## 6.1 Clock Time Synchronization

The electronic timestamps recorded for RM flow traverses, gas RATA runs and associated moisture runs are on military time basis and synchronized to the CEMS DAHS, which is in Eastern Standard Time (EST). However, the times recorded for the flow RATA moisture data in Appendix B3 are in local time (Eastern Daylight Time, or EDT), which was one hour ahead of EST. It is important to note however, that the recorded clock time for each run are also on a minute-end basis, e.g. a test run starting at 08:00:00 and ending at 08:20:00 a.m. encompasses *21-minutes* of run data. With that said, the RM4 moisture data in Appendix B3 collected during each gas RATA run appears to have an additional recorded minute beyond each associated gas RATA run timestamp; however the run durations are the same. Any observed inconsistency is due to moisture operator interpretation of clock-time vs. automatically recorded electronic timestamps.

# Figures

**Figure 1 – J.H. Campbell Unit 3 Test Port Location**

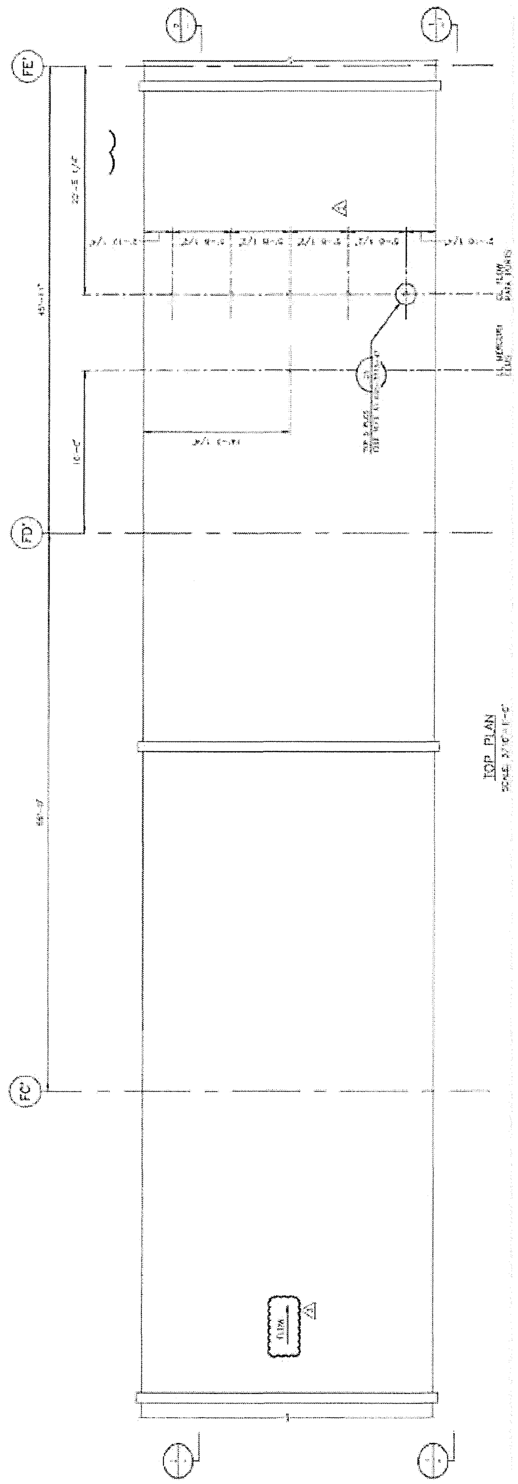


**Figure 2 – J.H. Campbell Unit 3 Duct Cross Section and Flow Traverse Point Detail**

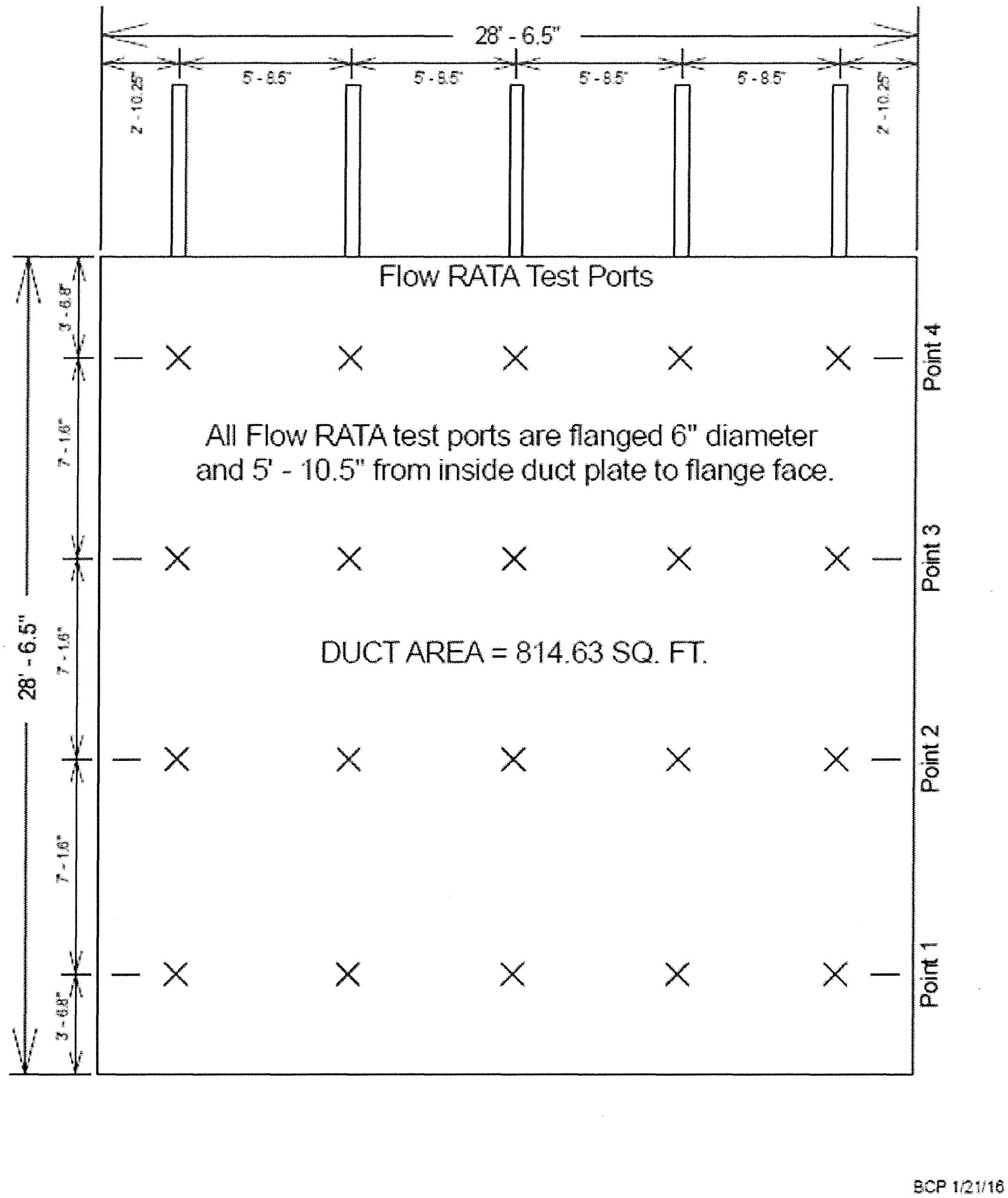


**Figure 3 – J.H. Campbell Unit 3 Duct Cross Section and Gas Sample Port Detail**

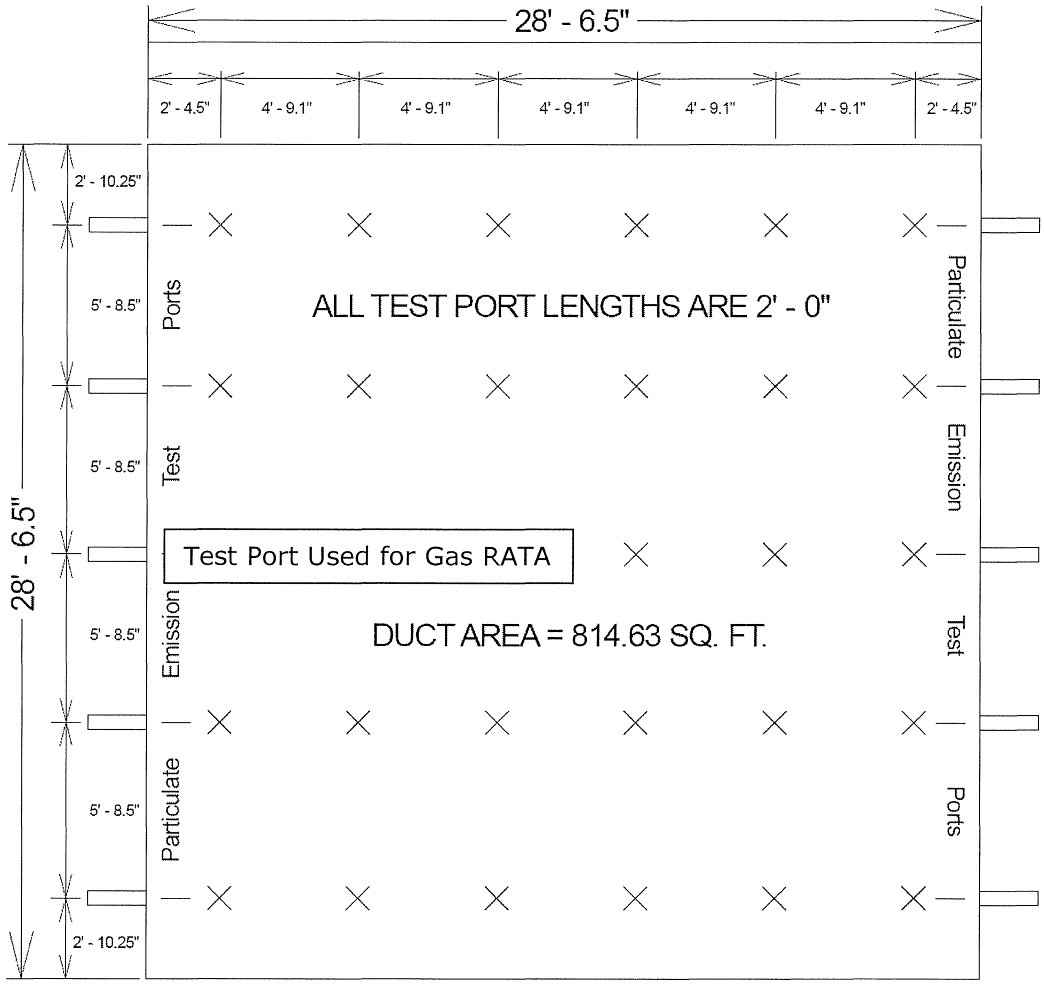
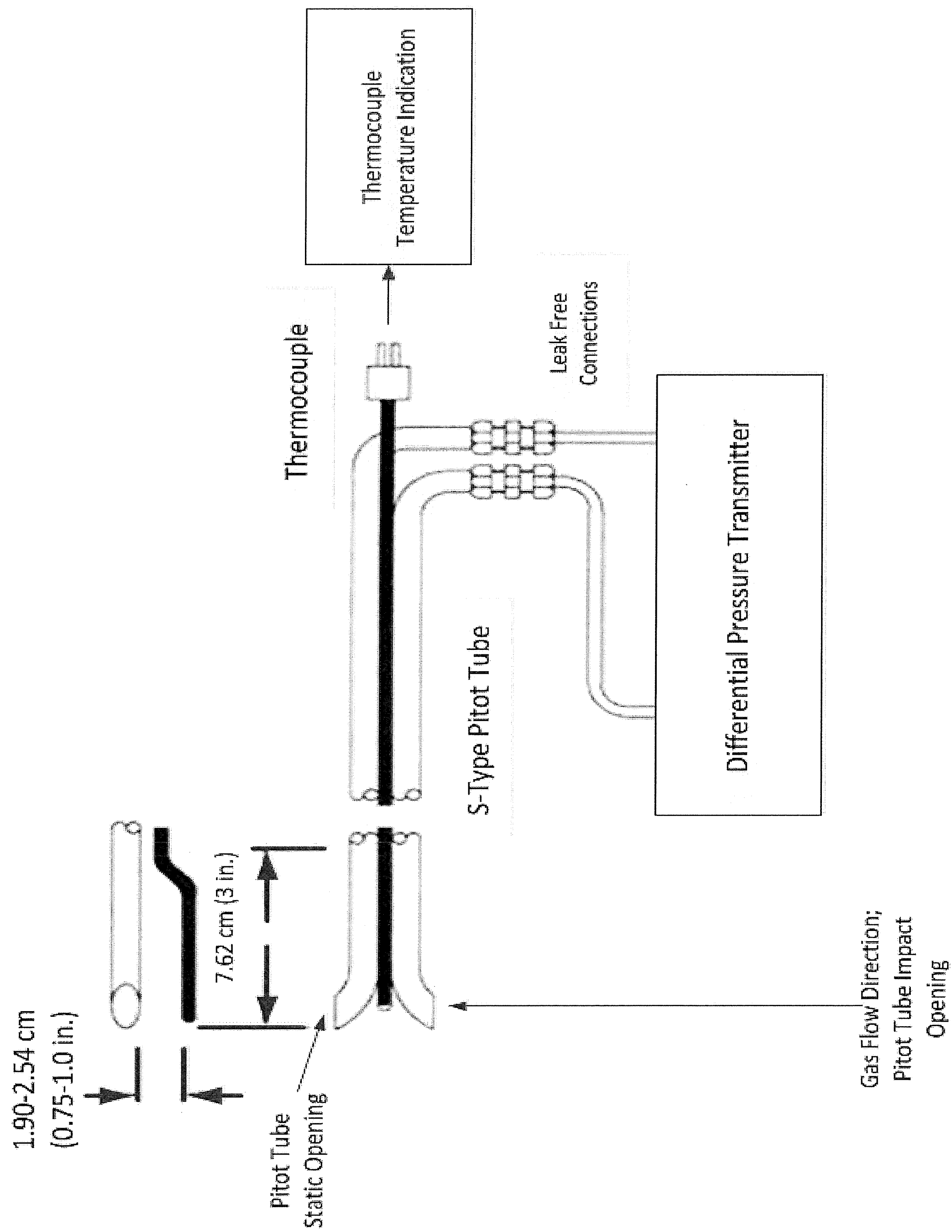
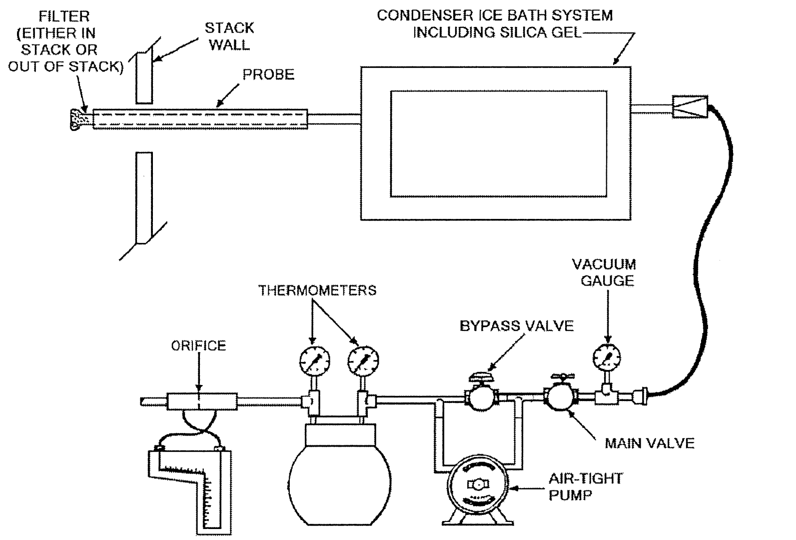


**Figure 4 – Volumetric Air Flow RATA Sample Apparatus**

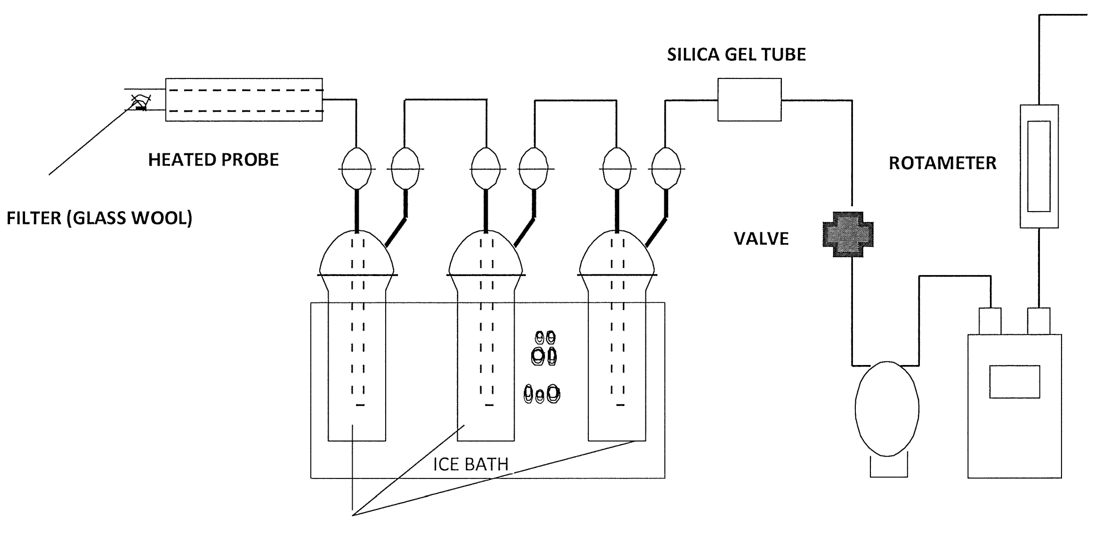


## Figure 5 – Method 4 and Alternative Method 008 Moisture Sample Apparatus

Method 4:

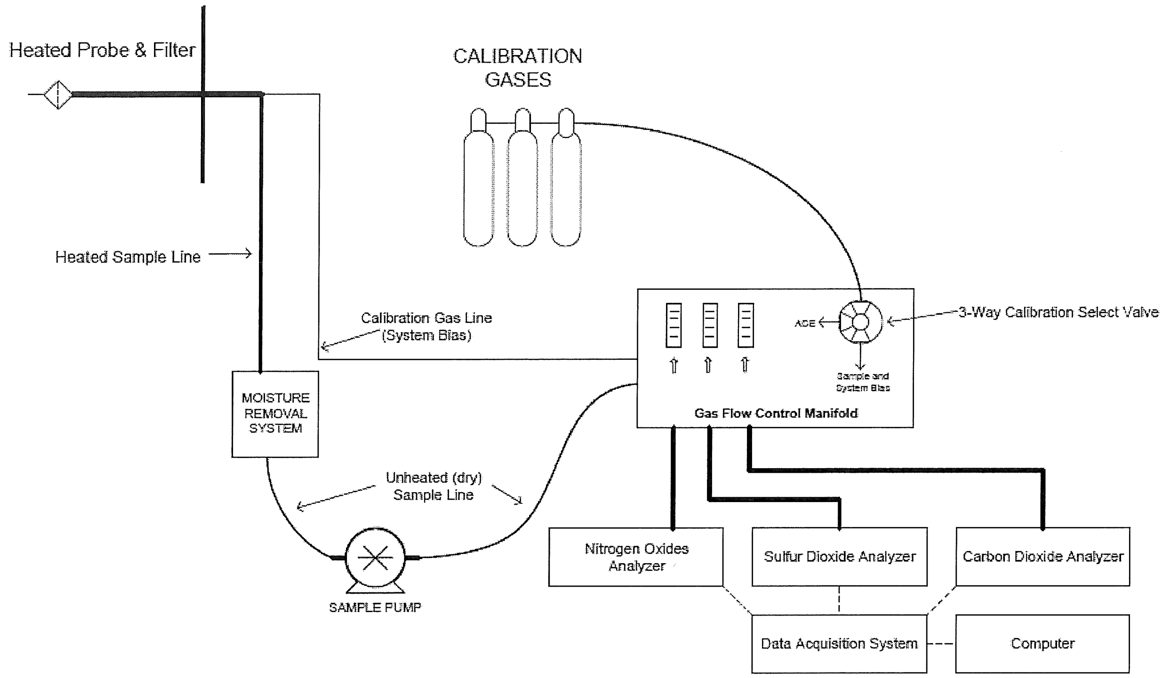



Method ALT-008:




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