COMPLIANCE TESTING PROTOCOL

FOR THREE SIEMENS 8000H COMBUSTION TURBINES

PREPARED FOR ZACHRY ENGINEERING CORPORATION AND FLORIDA POWER AND LIGHT

AT THE CAPE CANAVERAL ENERGY CENTER BREVARD COUNTY, FLORIDA

Florida Department of Environmental Protection
Permit No: 0090006-005-AC

February 13, 2013

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Broken Arrow, OK 74012

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Prepared By:

Danny Parr, QSTI, Director of Operations

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1.0 INTRODUCTION

1.1 General Facility Description

The Cape Canaveral Energy Center (CCEC) is owned and operated by Florida Power and Light Company (FPL) and is located at 6000 North U.S. Highway 1, Brevard County Florida. Florida is within the jurisdiction of USEPA Region 4. Two existing residual fuel and natural gas units (Unit 1 and Unit 2) have been shut down and dismantled and a new 1250 MW natural gas fired combined cycle unit has been constructed at the CCEC. The new unit is designated Unit 3 and is comprised of three 250 megawatt Model 8000H gas turbine-electrical generator sets with evaporative inlet cooling systems, three supplementary-fired heat recovery steam generators (HRSG's) with SCR reactors, one nominal 460 MMBtu/hr (LHV) gas fired duct burner located with-in each of the three HRSG's, three 149-foot exhaust stacks and a common 500-MW steam electrical generator. This "3-on-1" combined cycle technology yields a total generating capacity of approximately 1,250 MW.

Dry-low NOX combustion technology for gas firing and water injection during oil firing are utilized to reduce NOX emissions and selective catalytic reduction is employed to further reduce NOX emissions. The Florida Department of Environmental Protection issued permit allows each of the combustion turbines to operate 8,760 hours per year. The permit does limit the total heat input fired by the duct burners to provide additional steam-generated electrical power to 3,697,920 MMBtu divided between the three HRSG's during any consecutive 12-month period while combusting natural gas. Each CT will primarily combust pipeline natural gas with ultralow sulfur distillate (ULSD) fuel oil as a back-up fuel.

The nominal maximum heat input rating for each combustion turbine is 2,586 MMBtu/hr. With the duct burners, this number increases to 3,046 MMBtu/hr. According to the facility's air permit each CT is limited to a maximum heat input of 2,586 MMBtu/hr while firing natural gas and 2,440 MMBtu/hr while firing ultralow sulfur distillate (ULSD) fuel oil.

The 8000H stacks are circular and measure 21.95 feet (ft) (263.38 inches) in inner diameter at the test ports which are approximately 138 ft above grade level with an exit elevation of approximately 150 ft above grade level. The test ports are located 44.31 ft (531.75 inches) downstream and approximately 12 ft (144 inches) upstream from the nearest disturbances.

1.2 Reason for Testing

The units are subject to emission testing requirements set forth in the standards designated by the United States Environmental Protection Agency (EPA) Title 40, Code of Federal Regulations, Part 60 (40CFR60), 40 CFR 75, and the Florida Department of Environmental Protection (FDEQ) operating permit (0090006-005-AC). As such, the units will be tested for nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), ammonia slip (NH_3), carbon dioxide (CO_2), oxygen (O_2) and opacity. The units will be tested while operating on natural gas (NG) with duct burners (DB), NG without DB, and Fuel Oil.

2.0 SUMMARY

2.1 Owner Information

Company:	Florida Power & Light
Contact:	
Mailing Address:	6000 North U.S. Highway 1 Brevard County, Florida 33470
Office:	()
Cell:	()
Email:	@fpl.com

2.2 Site Information

Company:	Zachry Engineering Corporation
Contact Person:	Ronnie Stroble
Mailing Address:	5601 I-40 West Amarillo, TX 79106
Office:	806-676-7763
Fax:	806-359-2499
Email:	StrobleR@zhi.com

2.3 Test Contractor Information

Company:	Air Hygiene International, Inc.
Contact:	Danny Parr, Director of Operations
Mailing Address:	1600 West Tacoma Street Broken Arrow, Oklahoma 74012
Office:	(918) 994-4173
Cell:	(918) 809-8947
Fax:	(918) 307-9131
Email:	danny@airhygiene.com
Website:	www.airhygiene.com

2.4 Expected Test Start Date

Test dates are yet to be determined. Further notification will be provided by Zachry and/or FPL as a testing schedule is determined.

2.5 Testing Schedule

The following schedule indicates specific activities required to be done each day; however, the schedule may require flexibility and will be compacted or extended as necessary.

Pre-test Activities	**Due Date**
1. Prepare draft test protocol (Air Hygiene)	>30 days prior to testing
2. Submit final approved test plan to FDEQ (Zachry)	≥30 days prior to testing

On-site Activities	**Time**
Day 0 – Initial site mobilization, setup	
• Arrive at site and attend safety training	08:00 – 10:00
• Setup on Units 3A, 3B, and 3C for simultaneous testing	10:00 – 15:00
• Conduct preliminary testing of Air Hygiene equipment	15:00 – 17:00

Compliance Testing	**Time**
Day 1 – 3 Units, NG with DB and NG without DB; Fuel Oil	
• Daily setup and calibrations	05:00 – 07:00
• Conduct preliminary testing and stratification test	08:00 – 09:00
◦ Stratification testing for NOx and O_2	
• Conduct testing for NOx, CO, VOC, NH_3, CO_2, and O_2 (NG with DB)	09:00 – 15:00
◦ NOx, CO, VOC, CO_2, and O_2 testing: 3, 63-minute runs (combination of every three 21-minute RATA runs to support compliance)	
◦ Opacity observations	
• Conduct testing for NOx, CO, VOC, NH_3, CO_2, and O_2 (NG without DB)	15:00 – 19:00
◦ NOx, CO, VOC, CO_2, and O_2 testing: 3, 60-minute runs	
• Transition from NG to Fuel Oil	19:00 – 20:00
• Conduct testing for NOx, CO, VOC, NH_3, CO_2, and O_2 (Fuel Oil)	20:00 – 24:00
◦ NOx, CO, VOC, CO_2, and O_2 testing: 3, 60-minute runs	
Day 2 –Teardown and prepare to demobilize	08:00 – 10:00

Activities after Testing	
• Demobilization of Testing Crew (Air Hygiene)	Day 1
• Preparation of draft test report (Air Hygiene)	Days 2 – 9
• Submit for review to Zachry (Air Hygiene)	Day 10
• Review and comment on draft (Zachry)	Days 11 – 15
• Prepare final hard copy test reports (Air Hygiene)	Days 16 – 19
• Final reports delivered to Zachry (Air Hygiene)	Day 20

2.6 Test Report Content

The Test Reports for the units will meet the requirements of the FDEQ and the EPA for compliance and certification testing. The reports will include discussion of the following:

- Introduction
- Plant and Sampling Location Description
- Summary and Discussion of Test Results Relative to Acceptance Criteria
- Sampling and Analytical Procedures
- QA/QC Activities
- Test Results and Related Calculations
- Stack and Testing Equipment Drawings
- Raw Field Data and Calibration Data Sheets
- Sampling Log and Chain-of-Custody Records

- Audit Data Sheets

2.7 Equipment and Procedures

Test methods and parameters to satisfy 40 CFR 60 will include:

- 40 CFR 60, App A, EPA Method 1 for sample location
- 40 CFR 60, App A, EPA Method 2 for sample exhaust flow
- 40 CFR 60, App A, EPA Method 3a for oxygen (O_2) and carbon dioxide (CO_2)
- 40 CFR 60, App A, EPA Method 4 for stack exhaust moisture
- 40 CFR 60, App A, EPA Method 7e for nitrogen oxides (NOx)
- 40 CFR 60, App A, EPA Method 9 for visual emissions (VE – opacity)
- 40 CFR 60, App A, EPA Method 10 for carbon monoxide (CO)
- 40 CFR 60, App A, EPA Method 18 for gas chromatograph analysis of methane and ethane
- 40 CFR 60, App A, EPA Method 19 for stack exhaust FFactor
- 40 CFR 60, App A, EPA Method 25a for total hydrocarbons (THCs)
- 40 CFR 63, App A, EPA Method 320 for FTIR of moisture, methane, ethane, ammonia (NH_3),

2.8 Proposed Variations

All moisture tests will be approximately 35-minutes in duration if conducted utilizing Method 4 or 60-minutes in duration if conducted utilizing a FTIR. All moisture tests will be conducted from a single point near the center of the stack if Method 4 is utilized. If FTIR moisture readings are used, the samples will be taken from the points used by the gas probe.

A Relative Accuracy Test Audit will be performed. Therefore, in lieu of 40 CFR 60 criteria, after the successful completion of a stratification test for NOx and O_2 from 12 points in the stack, testing will be conducted from one point if the test passes under the appropriate 40 CFR 75 criteria for RATAs.

The NO_2 to NO converter check will be verified using the Emission Measurement Center's ALT-013 acceptable alternative procedure to section 8.2.4 of EPA Method 7e in Appendix A of 40 CFR Part 60 utilizing a NO_2 concentration around 50 parts per million.

No bias correction will be utilized for the EPA Method 25a sampling and all negative readings will be replaced with "zeroes" prior to determining final averages. Also, the VOC analyzer will be calibrated by running the certified gases through the sample probe, rather than directly to the back of the analyzer.

RM 19 stoichiometrically calculated stack exhaust flows will be used to convert all gaseous NH_3 concentrations to emission rates.

2.9 Compliance Sampling Strategy

Testing will be conducted on the three units simultaneously for nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), ammonia slip (NH_3), carbon dioxide (CO_2), oxygen (O_2) and opacity. Prior to testing, with units operating at base load with duct burners, a stratification test for NOx and O_2 will be performed to determine the sample point(s) for the remainder

of the gas tests. After the stratification test, testing will be conducted while the units are operating under three conditions; natural gas with duct burners, without duct burners, and Fuel Oil. Testing on the units will include:

- NOx – 3 test runs at 3 hours per run
- CO – 3 test runs at 3 hours per run
- VOCs – 3 test runs at 3 hours per run
- NH_3 – 3 test runs at 3 hours per run
- Moisture – 3 test runs at 3 hours per run
- O_2 and CO_2 3 test runs at 3

During testing Zachry or FPL personnel will track unit operating parameters including: load (megawatts), fuel flow (standard cubic feet per hour), combustor discharge pressure (millimeters of mercury), heat input rate (million British thermal units per hour), and ammonia flow rate. Air Hygiene personnel will monitor and record ambient temperature (^{o}F), relative humidity (%), and barometric pressure (in. Hg) at the start of each test run. In addition, a fuel analysis will be provided by Zachry personnel.

Method 3a, 7e, 10, 25a, and 320 – Oxygen, Carbon Dioxide, Nitrogen Oxide, Carbon Monoxide, Total Hydrocarbon/VOC, and NH_3 Testing

Appendix B contains details pertaining to sampling and quality control for these reference method tests.

Method 25a – Volatile Organic Compound Testing

VOC emission concentrations will be quantified in accordance with principles set forth in EPA Method 25a and 320. A flame ionization detector FID will be used for the Method 25a measurements for total hydrocarbons (THCs). This detector responds to all hydrocarbons in the sample. A Fourier transform infrared (FTIR) analyzer will be used for the Method 320 methane and ethane measurements. Methane and ethane results will be subtracted from the total hydrocarbon results to determine VOCs. All test results will be available in real-time, on-site, with summaries at the end of each test day.

Method 320 – FTIR Testing (NH_3, Methane, and Ethane)

A MKS Instruments - MultiGas™ Fourier transform infrared (FTIR) spectrometer, or equivalent, will be used for ammonia slip, moisture, methane, and ethane analysis per EPA Method 320. The FTIR spectrometer spectral resolution is 0.5 cm^{-1}. The system employs a silicon carbide infrared source at 1200 ºC, a helium neon reference laser, beam splitters, and potassium bromide (KBr) cell window, front-surface optical transfer mirrors, and multi-pass absorption cells. MCT detectors will be used and cooled with liquid nitrogen in order to maintain a constant temperature of 77 Kelvin. The approximately 5.11-meter multi-pass path cells incorporate aspheric, aberration-correcting mirrors to increase the optical throughput and the detection sensitivity. Transducers and thermocouples are connected directly to the insulated sample cells that provide the pressure and temperatures of the sample streams. During testing, the temperature of the absorption cells will be set at 191 ºC. Elevated temperature prevents gas condensation within the cell and minimizes analyte adhesion to the cell walls and mirrors. The volume of the absorption cell is 0.5 liters, so at a sample gas flow rate of 4.0 liters per minute, the sample gas in the cell is refreshed approximately four times each minute. Interferograms consisting of 56 co-added

scans will be recorded continuously during the test periods, and will provide approximately 60-second average concentrations. All test results will be available in real-time, on-site, with summaries at the end of each test day.

2.10 Additional Test Related Items

Power – Zachry/FPL will provide 480 volt welder's receptacle with pigtail connector.

Safety – Level D safety equipment is required in the form of hard hats, eye protection, hearing protection (if needed), steel-toed boots, and work gloves.

APPENDIX A

QA/QC PROGRAM

QA/QC PROGRAM

AIR HYGIENE ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA team and encompasses five major areas:

1. QA reviews of reports, laboratory work, and field testing;
2. Equipment calibration and maintenance;
3. Chain-of-custody;
4. Training; and
5. Knowledge of current test methods.

QA Reviews

AIR HYGIENE's review procedure includes a review of each source test report, along with laboratory and fieldwork by the QA Team.

The most important review is the one that takes place before a test program begins. The QA Team works closely with technical division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance

The equipment used to conduct the emission measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the Environmental Protection Agency. Quality control checks are also conducted in the field for each test program.

Chain-of-Custody

AIR HYGIENE maintains full chain-of-custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, AIR HYGIENE documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.). Samples are stored in a locked area to which only AIR HYGIENE personnel have access. Field data sheets are secured at AIR HYGIENE's offices upon return from the field.

Training

Personnel training is essential to ensure quality testing. AIR HYGIENE has formal and informal training programs, which include:

1. Attendance at EPA-sponsored training courses;
2. Enrollment in EPA correspondence courses;
3. A requirement for all technicians to read and understand Air Hygiene Incorporated's QA manual;
4. In-house training and QA meetings on a regular basis; and
5. Maintenance of training records.

Knowledge of Current Test Methods

With the constant updating of standard test methods and the wide variety of emerging test procedures, it is essential that any qualified source tester keep abreast of new developments. AIR HYGIENE subscribes to services, which provide updates on EPA reference methods, rules, and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences.

COMBUSTION TESTING QUALITY ASSURANCE ACTIVITIES

A number of quality assurance activities are undertaken before, during, and after each testing project. The following paragraphs detail the quality control techniques, which are rigorously followed during testing projects.

Each instrument's response is checked and adjusted in the field prior to the collection of data via multi-point calibration. The instrument's linearity is checked by first adjusting its zero and span responses to zero nitrogen and an upscale calibration gas in the range of the expected concentrations. The instrument response is then challenged with other calibration gases of known concentration and accepted as being linear if the response of the other calibration gases agreed within plus or minus 2 percent of range of the predicted values.

After each test run, the analyzers are checked for zero and span drift. This allowed each test run to be bracketed by calibrations and documents the precision of the data just collected. The criteria for acceptable data are that the instrument drift is no more than 3 percent of the full-scale response. Quality assurance worksheets are prepared to document the multipoint calibration checks and zero to span checks performed during the tests.

The sampling systems are leak checked by demonstrating that a vacuum greater than 10 in Hg could be held for at least 1 minute with a decline of less than 1 in. Hg. A leak test is conducted after the sample system is set up and before the system is dismantled. This test was conducted to ensure that ambient air had not diluted the sample. Any leakage detected prior to the tests would be repaired and another leak check conducted before testing commenced.

The absence of leaks in the sampling system is also verified by a sampling system bias check. The sampling system's integrity is tested by comparing the responses of the analyzers to the calibration gases introduced via two paths. The first path was directly into the analyzer and the second path via the sample system at the sample probe. Any difference in the instrument responses by these two methods is attributed to sampling system bias or leakage. The criteria for acceptance are agreement within 5 percent of the span of the analyzer.

The control gases used to calibrate the instruments are analyzed and certified by the compressed gas vendors to ± 1% accuracy for all gases. EPA Protocol No. 1 was used where applicable to assign the concentration values traceable to the National Institute of Standards and Technology (NIST), Standard Reference Materials.

AIR HYGIENE maintains a large variety of calibration gases to allow the flexibility to accurately test emissions over a wide range of concentrations.

APPENDIX B

TEST EQUIPMENT CONFIGURATION AND DESCRIPTION

INSTRUMENT CONFIGURATION AND OPERATIONS FOR GAS ANALYSIS

The sampling and analysis procedures to be used conform in principle with the methods outlined in the Code of Federal Regulations, Title 40, Part 60, Appendix A, Methods 1, 3a, 7e, 10, 25a; 40 CFR 63, Appendix A, Method 320.

The sample system to be used for the NOx, CO, VOC, NH_3, moisture, methane, ethane, CO_2, and O_2 tests is configured per the following description. A stainless steel probe will be inserted near the center of the stack. The gas sample will be continuously pulled through the probe and transported via 3/8 inch heat-traced Teflon® tubing to a stainless steel, minimum-contact condenser designed to dry the sample and then through Teflon® tubing via a stainless steel/Teflon® diaphragm pump and into the sample manifold within the mobile laboratory. From the manifold, the sample is partitioned to the NOx, CO, CO_2, and O_2 analyzer through rotameters that control the flow rate of the sample. VOC, NH_3, moisture, methane, and ethane samples are routed to the analyzer prior to gas conditioning.

The schematic (Figure 1) shows that the sample system is also equipped with a separate path through which a calibration gas could be delivered to the probe and back through the entire sampling system. This allows for convenient performance of system bias checks as required by the testing methods.

All instruments are housed in an air-conditioned, trailer-mounted mobile laboratory. Gaseous calibration standards are provided in aluminum cylinders with the concentrations certified by the vendor according to EPA Protocol No. 1.

This general schematic also illustrates the analyzers to be used for the tests (i.e., O_2, CO). All data from the Reference Method continuous monitoring instruments are recorded on a Logic Beach Hyperlogger. The Hyperlogger retrieves calibrated emissions data from each instrument every second. An average value is recorded every 30 seconds.

The stack gas analysis for O_2 and CO_2 concentrations will be performed in accordance with procedures set forth in EPA Method 3a. The O_2 analyzer uses a paramagnetic cell detector and the CO_2 analyzer uses a continuous nondispersive infrared analyzer.

EPA Method 7e will be used to determine concentrations of NOx. A chemiluminescence analyzer will be used to provide the analysis. NO_2 conversion efficiency will be verified following EPA's Approved Alternative Method ALT-013 for NO_2 conversion efficiency. A NO_2 in nitrogen certified gas cylinder will be used to verify at least a 90 percent NO_2 conversion on the day of the test.

CO emission concentrations will be quantified in accordance with procedures set forth in EPA Method 10. A continuous nondispersive infrared (NDIR) analyzer will be used for this purpose.

NH_3 emission concentrations will be quantified in accordance with principles set forth in EPA Method 320. A FTIR will be used for the analysis.

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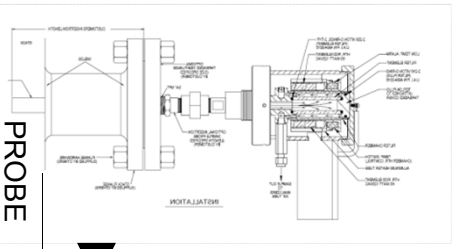
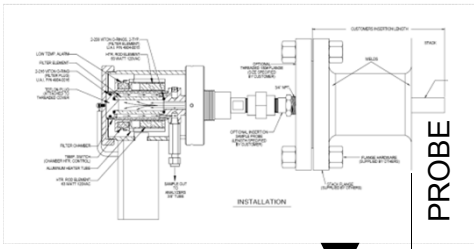


LEGEND
- Heated Teflon Tubing (pre-conditioned sample)
- Unheated Teflon Tubing (conditioned sample)
- Diluted Calibration Gas
- Calibration Gas
- Electronic Input/Output



PROCESS INLET OR 2ND STACK

dual line heated sample umbilical

STACK EXHAUST

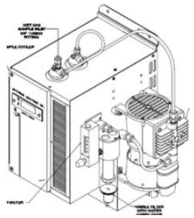
TEST TRAILER EXTERIOR

TEST TRAILER INTERIOR

DATA RECORDER

COMPUTER

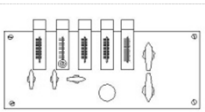
GAS CONDITIONER



dual line heated sample umbilical

MOBILE SECONDARY ANALYZERS

MANIFOLD



GAS DILUTER

THC, VOC

O_2, CO_2, NOx, CO, SO_2

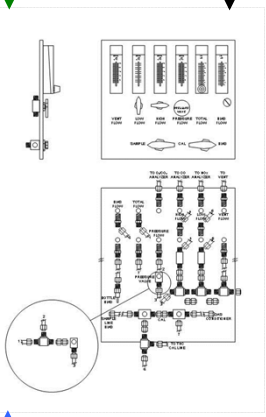
HOT/WET ANALYZERS

COLD/DRY ANALYZERS

COLD/DRY ANALYZERS HOT/WET

O_2, CO_2, NOx, CO, SO_2

FLOW CONTROL MANIFOLD



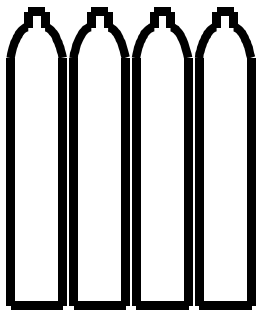
FTIR

THC, VOC

CONDITIONER

VENT

CALIBRATION/ BIAS GAS BOTTLES



VENT

FIXED PRIMARY ANALYZERS

Shown fully equipped. Some labs may not contain these features and others may contain additional features specific to certain scopes.

AIR HYGIENE

Figure 1
EMISSIONS TESTING LAB

1600 W Tacoma Street
Broken Arrow, Oklahoma 74012
www.airhygiene.com
(888) 461-8778

TABLE 1: TESTING MATRIX

Target	EPA Test Method	Locations/Unit Test Load(s)	Test Length
O_2	3a	NG/NGDB/FO	1 hour
CO_2	3a	NG/NGDB/FO	1 hour
Moisture	320	NG/NGDB/FO	1 hour
NOx	7e	NG/NGDB/FO	1 hour
Opacity	9	NG/NGDB/FO	1 hour
CO	10	NG/NGDB/FO	1 hour
VOC	18/25a or 320	NG/NGDB/FO	1 hour
NH_3	320	NG/NGDB/FO	1 hour

TABLE 2: ANALYTICAL INSTRUMENTATION

Parameter	Model and Manufacturer	Common Use Ranges	Sensitivity	Detection Principle
O_2	Servomex or equivalent	0-25%	0.1%	Oxygen - Paramagnetic cell
CO_2	FUJI 3300 or equivalent	0-20%	0.1%	Nondispersive infrared
NOx	TECO 42C or equivalent	0-10,000 ppm	0.1 ppm	Thermal reduction of NO_2 to NO. Chemiluminescence of reaction of NO with O_3. Detection by PMT. Inherently linear for listed ranges.
CO	TECO 48C or equivalent	0-10,000 ppm	0.1 ppm	Infrared absorption, gas filter correlation detector, microprocessor based linearization.
VOC	TECO 51 or equivalent	User may select up to 3,000 ppm	0.1 ppm	Flame Ionization Detector
NH_3, H_2O, Methane, Ethane	MKS Multigas 2030 or equivalent	User may select up to 1,100 ppm	0.04 ppm	Fourier Transform Infrared Spectroscopy

TABLE 3: ANALYTICAL INSTRUMENTATION TESTING CONFIGURATION

Parameter	Sample Methodology	Example Range	Calibration Gases (based on example range)
O_2	3a	0-21%	Zero = 0 ppm nitrogen Mid = 8.4 – 12.6% High = 21%
CO_2	3a	0-20%	Zero = 0 ppm nitrogen Mid = 8 – 12% High = 20%
NOx	7e	0-1000 ppm	Zero = 0 ppm nitrogen Mid = 400 – 600 ppm High = 1000 ppm
CO	10	0-1000 ppm	Zero = 0 ppm nitrogen Mid = 400 – 600 ppm High = 1000 ppm
THC/VOC (as methane)	18	0-10 ppm	Zero = 0 ppm nitrogen Low = 2.5 – 3.5 ppm Mid = 4.5 – 5.5 ppm High = 8 – 9 ppm

TABLE 4: NATURAL GAS FIRED PERMIT LIMITS

Component	Limit
CO Combined Cycle Normal Operation (No Duct Burners Operating)	29.0 lb/hr 5.0 ppmvd@15% O2 : 90 to 100% CT load 8.0 ppmvd@15% O2 : 60 to 90% CT load
CO Combined Cycle Normal Operation (Duct Burners Operating) at 100% CT load	52.7 lb/hr 7.6 ppmvd@15% O2
NOx Combined Cycle with SCR (Duct Burners Operating)	22.8 lb/hr 2.0 ppmvd@15% O2
NOx Combined Cycle with SCR (Duct Burners Not Operating)	19.3 lb/hr 2.0 ppm@15% O2
Ammonia Combined Cycle All Modes	5 ppmvd@15% O2
Opacity All Modes	10 percent
VOC's Normal Combined Cycle (No Duct Burners)	1.5 ppmvd @15% O2, 4.8 lb/hr
VOC's Combined Cycle (Duct Burners Operating)	1.9 ppmvd @ 15% O2 7.2 lb/hr

TABLE 4: FUEL OIL FIRED PERMIT LIMITS

Component	Limit
CO Combined Cycle Normal Operation (No Duct Burners Operating)	61.0 lb/hr : 100% Load 10.0 ppmvd@15% O2 : 70 to 100% CT load
NOx Combined Cycle with SCR (Duct Burners Not Operating 3x1 operation)	80.0 lb/hr 8.0 ppm@15% O2
Ammonia Combined Cycle All Modes	5 ppmvd@15% O2
Opacity All Modes	10 percent
VOC's Combined Cycle (No Duct Burners)	6.0 ppmvd @15% O2 18.9 lb/hr

APPENDIX C

STACK DRAWINGS

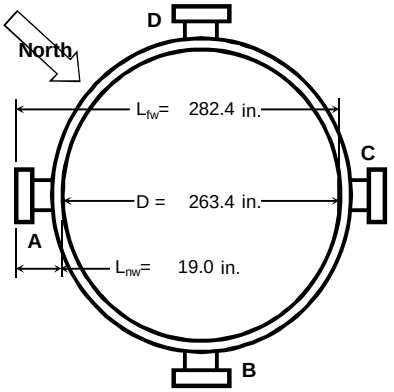
METHOD 1 - STRATIFICATION TEST FOR A CIRCULAR SOURCE

Company	Zachry	**Date**	2013
Plant Name	Cape Canaveral Energy Center	**Project #**	zac-13-capecanaveral.fl-comp#1
Equipment	Mitsubishi 501G	**# of Ports Available**	4
Location	Brevard County, Florida	**# of Ports Used**	4

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})	282.38	in.
Distance to Near Wall of Stack	(L_{nw})	19.00	in.*
Diameter of Stack	(D)	263.38	in.
Area of Stack	(A_s)	378.35	ft^2

*assume 19 in. reference (must be measured and verified in field)

Distance from Disturbances to Port			
Distance Upstream	(A)	144.00	in.
Diameters Upstream	(A_D)	0.55	diameters
Distance Downstream	(B)	531.75	in.
Diameters Downstream	(B_D)	2.02	diameters



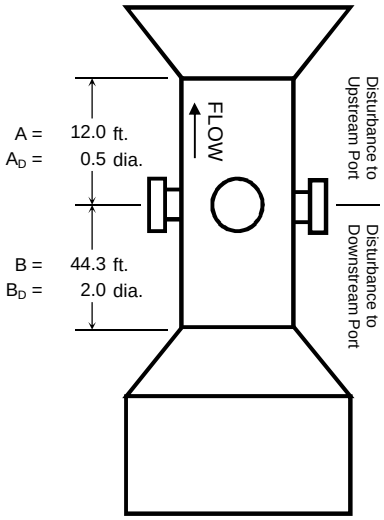
Number of Traverse Points Required

Diameters to Flow Disturbance		Minimum Number of[1] Traverse Points		Minimum Number of Traverse Points
Down (B_D)	Up (A_D)	Particulate	Velocity	Comp Stratification
Stream	Stream	Points	Points	Criteria / Points
2.00-4.99	0.50-1.24	24	16	○ RM 7E 8.1.2 — 12 RM1 pts
5.00-5.99	1.25-1.49	20	16	○ Alt 7E 8.1.2 — 3 points
6.00-6.99	1.50-1.74	16	12	
7.00-7.99	1.75-1.99	12	12	
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]	**Minimum Number of Traverse Points RATA Stratification**
Upstream Spec		24	16	
Downstream Spec		24	16	
Traverse Pts Required		24	16	

Criteria	**Points**
◉ Part75/60	12 RM1 pts
○ 75 abrv (a)	3 points
○ 75 abrv (b)	6 points
12 points	

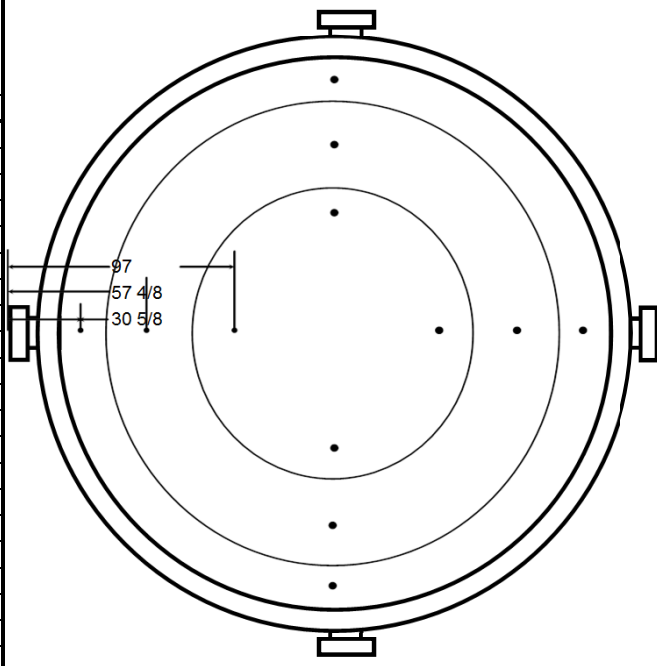
[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches



Number of Traverse Points Used				
4	**Ports by**	3	**Pts / port**	**Stratification Traverse (RATA)**
12	**Pts Used**	12	**Required**	

Traverse Point Locations			
Traverse Point Number	**Percent of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
	%	in.	in.
1	4.4%	11 5/8	30 5/8
2	14.6%	38 4/8	57 4/8
3	29.6%	78	97
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			



APPENDIX D

EXAMPLE TEMPLATES AND CALCULATIONS

Air Permit # :	
Plant Name or Location:	
Date:	
Project Number:	
Manufacturer & Equipment:	
Model:	
Serial Number:	
Unit Number:	
Test Load:	
Tester(s) / Test Unit(s):	

		RUN																
	UNITS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Start Time	hh:mm:ss																		
End Time	hh:mm:ss																		
Bar. Pressure	in. Hg																		
Amb. Temp.	°F																		
Rel. Humidity	%																		
Spec. Humidity	lb water / lb air																		
Comb. Inlet Pres.	psig																		
NOx Water Inj.	gpm																		
Total Fuel Flow	SCFH																		
Heat Input	MMBtu/hr																		
Power Output	megawatts																		
Steam Rate	lb/hr																		

NOx Converter Efficiency

Date:

Analyzer:

RM 7E, (08-15-06), 8.2.4.1 Introduce a concentration of 40 to 60 ppmv NO_2 to the analyzer in direct calibration mode and record the NOx concentration displayed by the analyzer. ... Calculate the converter efficiency using Equation 7E-7 in Section 12.7. The specification for converter efficiency in Section 13.5 must be met. ... The NO_2 must be prepared according to the EPA Traceability Protocol and have an accuracy within 2.0 percent.

Audit Gas: NO_2 Concentration (C_V), ppmvd

Converter Efficiency Calculations:

Analyzer Reading, NO Channel, ppmvd

Analyzer Reading, NOx Channel, ppmvd

Analyzer Reading, NO_2 Channel ($C_{Dir(NO2)}$), ppmvd

Converter Efficiency, %

RM 7E, (08-15-06), 13.5 NO2 to NO Conversion Efficiency Test (as applicable). The NO2 to NO conversion efficiency, calculated according to Equation 7E-7 or Equation 7E-9, must be greater than or equal to 90 percent.

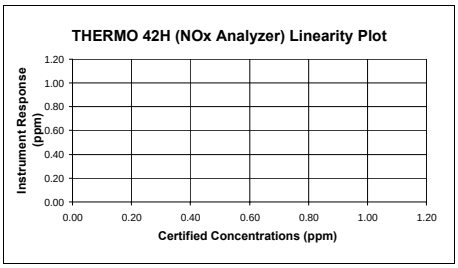
$$Eff_{NO2} = \left(\frac{C_{Dir}}{C_V} \right) \times 100$$ Eq. 7E-7 = $\frac{\text{ppmvd}}{\text{ppmvd}}$ x 100 =

Date/Time	Elapsed Time	NOx	NO
mm/dd/yy hh:mm:ss	Seconds	ppmvd	ppmvd

Calibration Date:
Client:

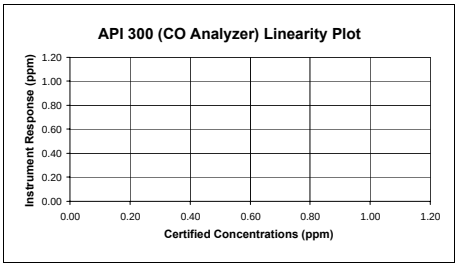
NOx Span (ppm) =

THERMO 42H (NOx Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Absolute Conc. (ppm)	Pass or Fail (±2%, ≤0.5ppm)
Linearity =				



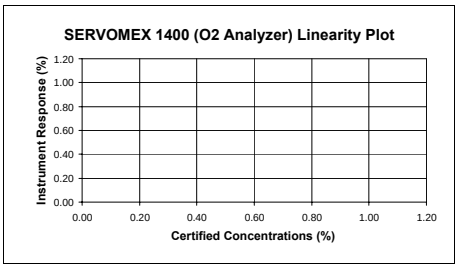
CO Span (ppm) =

API 300 (CO Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Absolute Conc. (ppm)	Pass or Fail (±2%, ≤0.5ppm)
Linearity =				



O2 Span (%) =

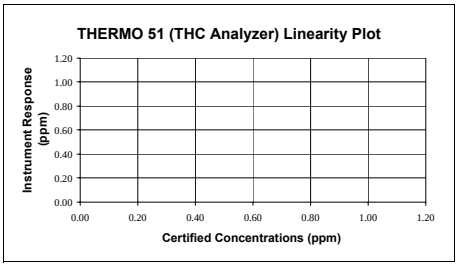
SERVOMEX 1400 (O_2 Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Absolute Conc. (ppm)	Pass or Fail (±2%, ≤0.5%)
Linearity =				



THC Range (ppm) =

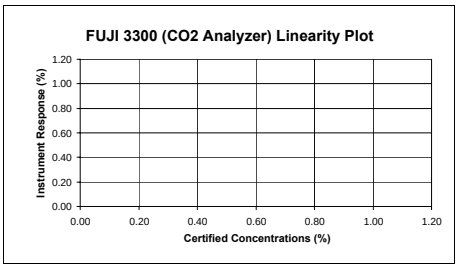
THERMO 51 (THC Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Estimated Point (ppm)	Pass or Fail (±2,5%)[1]
Linearity =				

[1]-zero/high based on 2% of spanlow/mid based on 5% of concentration



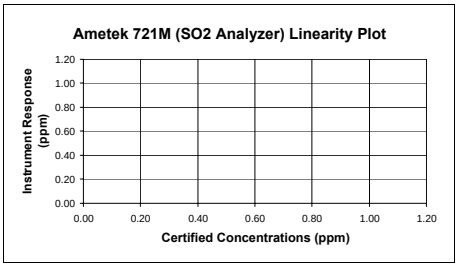
CO2 Span (%) =

FUJI 3300 (CO_2 Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Absolute Conc. (ppm)	Pass or Fail (±2%, ≤0.5%)
Linearity =				



SO2 Span (ppm) =

Ametek 721M (SO_2 Analyzer)				
Certified Concentration (ppm)	Instrument Response (ppm)	Calibration Error (%)	Absolute Conc. (ppm)	Pass or Fail (±2%, ≤0.5ppm)
Linearity =				



Client:
Location:
Date:
Project #:

Fuel Oil - Fuel Analysis

Characteristics of Fuel Gas		
Molecular Weight of oil =		lb/lb-mole
Btu per lb. of oil =		gross (HHV)
Btu per lb. of oiil =		net (LHV)
Density of fuel oil[2] =		lb/cu. ft
Density of fuel oil[2] =		lb/gal
Specific Gravity =		@ 68 deg F

Standardized to 68 deg F and 14.696 psia

Component	Wt%
carbon	
oxygen	
hydrogen	
nitrogen	
helium	
sulfur	
Total	

Fuel Oil HHV Conv.	
HHV (Btu/lb)	
HHV (Btu/SCF)	

Fuel Oil LHV Conv.	
LHV (Btu/lb)	
LHV (Btu/SCF)	

F-Factor (SCF dry exhaust per MMBtu [HHV]) =
(Based on EPA RM-19) at 68 deg F and 14.696 psia

F-Factor Calculation:

F-Factor = 1,000,000*((3.64*%H)+(1.53*%C)+(0.57*%S)+(0.14*%N)-(0.46*%O))/GCV

GCV = Gross Btu per lb. of gas (HHV)

%H, %C, %S, %N, & %O are percent weight values calculated from fuel analysis and have units of (scf/lb)/%

Density of fuel oil based on lab analysis or specific gravity multiplied by density of water at 68 deg F and 14.696 psia.

References:

[1] ASTM D 3588

[2] Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg

[3] Mark's Standard Handbook for Mechanical Engineers, 10th ed. - Eugene A. Avallone, Theodore Baumeister III

[4] Introduction to Fluid Mechanics, 3rd ed. - William S. Janna

[5] GPA Reference Bulletin 181-86, revised 1986, reprinted 1995

Client:
Location:
Date:
Project #:

Natural Gas - Fuel Analysis

Standardized to 68 deg F and 14.696 psia - EPA Standards

Gas Component		Mole (%)	Molecular[1] Weight (lb/lb-mole)	Lbs Component per Lb-Mole of Gas	Wt. % of Component	Ideal Gross[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [HHV] (Btu/SCF)	Ideal Net[1,3] Heating Value (Btu/ft^3)	Fuel Heat Value [LHV] (Btu/SCF)
Methane	CH_4								
Ethane	C_2H_6								
Propane	C_3H_8								
iso-Butane	iC_4H_{10}								
n-Butane	nC_4H_{10}								
Iso-Pentane	iC_5H_{12}								
n-Pentane	nC_5H_{12}								
Hexanes	C_6H_{14}								
Heptanes	C_7H_{16}								
Octanes	C_8H_{18}								
Carbon Dioxide	CO_2								
Nitrogen	N_2								
Hydrogen Sulfide	H_2S								
Oxygen	O_2								
Helium	He								
Hydrogen	H_2								
Totals						**dry**		**dry**	
						wet[2,5]		**wet[2,5]**	

Characteristics of Fuel Gas		
Molecular Weight of gas =		lb/lb-mole
Btu per lb. of gas[4] =		gross (HHV)
Btu per lb. of gas[4] =		net (LHV)
Density of fuel gas[2] =		lb/cu. ft
Wt % VOC in fuel gas =		%
Specific Gravity[1] =		

Component	Wt%
carbon	
oxygen	
hydrogen	
nitrogen	
helium	
sulfur	
Total	

F-Factor (SCF dry exhaust per MMBtu [HHV]) =
(Based on EPA RM-19) at 68 deg F and 14.696 psia

F-Factor Calculation:

F-Factor = 1,000,000*((3.64*%H)+(1.53*%C)+(0.57*%S)+(0.14*%N)-(0.46*%O))/GCV

GCV = Gross Btu per lb. of gas (HHV)

%H, %C, %S, %N, & %O are percent weight values calculated from fuel analysis and have units of (scf/lb)/%

Density of natural gas based on specific gravity multiplied by density of air at 68 deg F and 14.696 psia.

References:

[1] ASTM D 3588

[2] Civil Engineering Reference Manual, 7th ed. - Michael R. Lindeburg

[3] Mark's Standard Handbook for Mechanical Engineers, 10th ed. - Eugene A. Avallone, Theodore Baumeister III

[4] Introduction to Fluid Mechanics, 3rd ed. - William S. Janna

[5] GPA Reference Bulletin 181-86, revised 1986, reprinted 1995

DRIFT AND BIAS CHECK		
Strat Test Pre and Post QA/QC Check	**Diluent 1**	**Pollutant 1**
Initial Zero		
Final Zero		
Avg. Zero		
Initial UpScale		
Final UpScale		
Avg. UpScale		
Sys Resp (Zero)		
Sys Resp (Upscale)		
Upscale Cal Gas		
Initial Zero Bias		
Final Zero Bias		
Zero Drift		
Initial Upscale Bias		
Final Upscale Bias		
Upscale Drift		
Alternative Specification Abs Diff **Initial Zero**		
Final Zero		
Initial Upscale		
Final Upscale		
Calibration Span		
3% of Range (drift)		
5% of Range (bias)		

Respone Time (min)		
Sys. Response (min)		

Date/Time mm/dd/yy hh:mm:ss	z	s	z	s	**INJECTIONS** x

Source Information	
Company	
Plant Name	
Equipment	
Location	

Test Information	
Date	
Project #	
Unit Number	
Load	
Number of Ports Available	
Number of Ports Used	

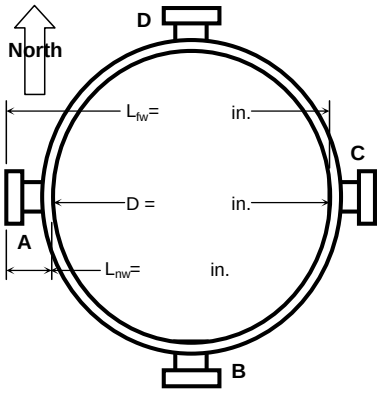
Stack and Test Type				
○	Isokinetic Traverse (Wet Chemistry Testing)			**Circular Stack**
○	Velocity Traverse (Flow and Flow RATA Test)			
○	Stratification Traverse (Compliance Test)		☐ RM 20	
◉	**Stratification Traverse (RATA)**	☐ Part 60	☑ Part 75	

METHOD 1 - STRATIFICATION TEST FOR A CIRCULAR SOURCE

Company		**Date**	
Plant Name		**Project #**	
Equipment		**# of Ports Available**	
Location		**# of Ports Used**	

Circular Stack or Duct Diameter			
Distance to Far Wall of Stack	(L_{fw})		in.
Distance to Near Wall of Stack	(L_{nw})		in.
Diameter of Stack	(D)		in.
Area of Stack	(A_s)		ft^2

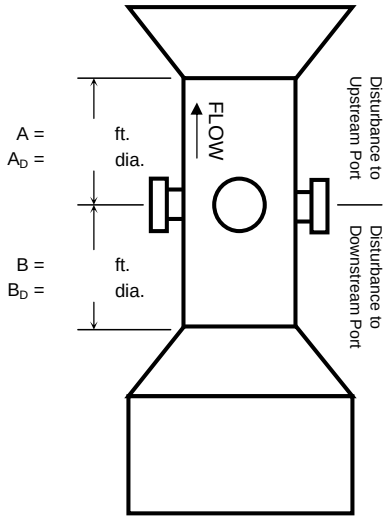
Distance from Disturbances to Port			
Distance Upstream	(A)		in.
Diameters Upstream	(A_D)		diameters
Distance Downstream	(B)		in.
Diameters Downstream	(B_D)		diameters



Number of Traverse Points Required					
Diameters to Flow Disturbance		Minimum Number of[1] Traverse Points		Minimum Number of Traverse Points Comp Stratification	
Down (B_D) Stream	Up (A_D) Stream	Particulate Points	Velocity Points	Criteria	Points
2.00-4.99	0.50-1.24	24	16	○ RM 7E 8.1.2	12 RM1 pts
5.00-5.99	1.25-1.49	20	16	○ Alt 7E 8.1.2	3 points
6.00-6.99	1.50-1.74	16	12		
7.00-7.99	1.75-1.99	12	12		
>= 8.00	>=2.00	8 or 12[2]	8 or 12[2]	**Minimum Number of**	
Upstream Spec				**Traverse Points**	
Downstream Spec				**RATA Stratification**	
Traverse Pts Required				**Criteria**	**Points**
				○ Part75/60	12 RM1 pts
				○ 75 abrv (a)	3 points
				○ 75 abrv (b)	6 points

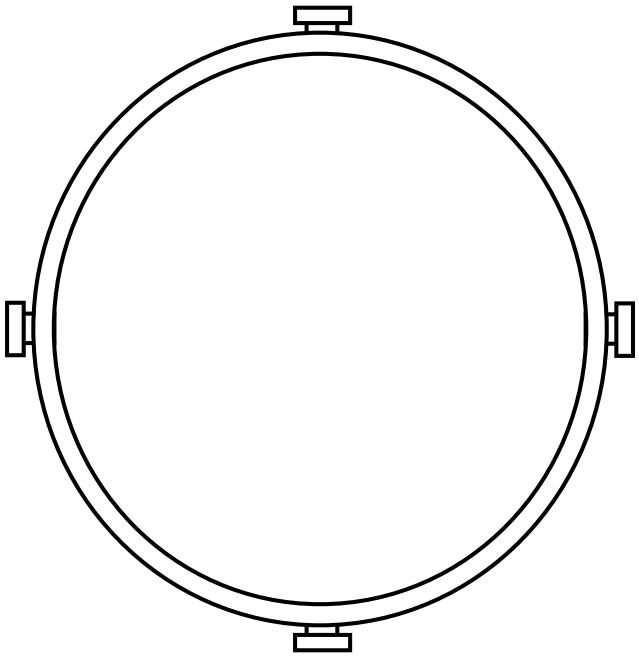
[1] Check Minimum Number of Points for the Upstream and Downstream conditions, then use the largest.

[2] 8 for Circular Stacks 12 to 24 inches
12 for Circular Stacks over 24 inches



Number of Traverse Points Used				
	Ports by		**Pts / port**	**Stratification Traverse (RATA)**
	Pts Used		**Required**	

Traverse Point Locations			
Traverse Point Number	**Percent of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
	%	in.	in.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			



STRATIFICATION TRAVERSE (RATA) RESULTS

Company		**Date**	
Plant Name		**Project #**	
Equipment		**# of Ports Available**	
Location		**# of Ports Used**	

Stack Dimensions				**Traverse Data**			
Diameter or Length of Stack	(D)		in.		**Ports by**		**Pts / port**
Width of Stack	(W)		in.		**Pts Used**		**Required**
Area of Stack	(A_s)		ft^2	**Run Start**		**Run End**	

Traverse Point	**Time Per Point**	**Point Start Time**	**Point Stop Time (Reading)**	**Diluent 1**	**Percent Difference**	**Pollutant 1**	**Percent Difference**
	min.	hh:mm:ss	hh:mm:ss	%	%	ppm	%

RATA SAMPLE POINTS FOR CIRCULAR STACK

Company		**Date**	
Plant Name		**Project #**	
Equipment		**# of Ports Available**	
Location		**# of Ports Used**	

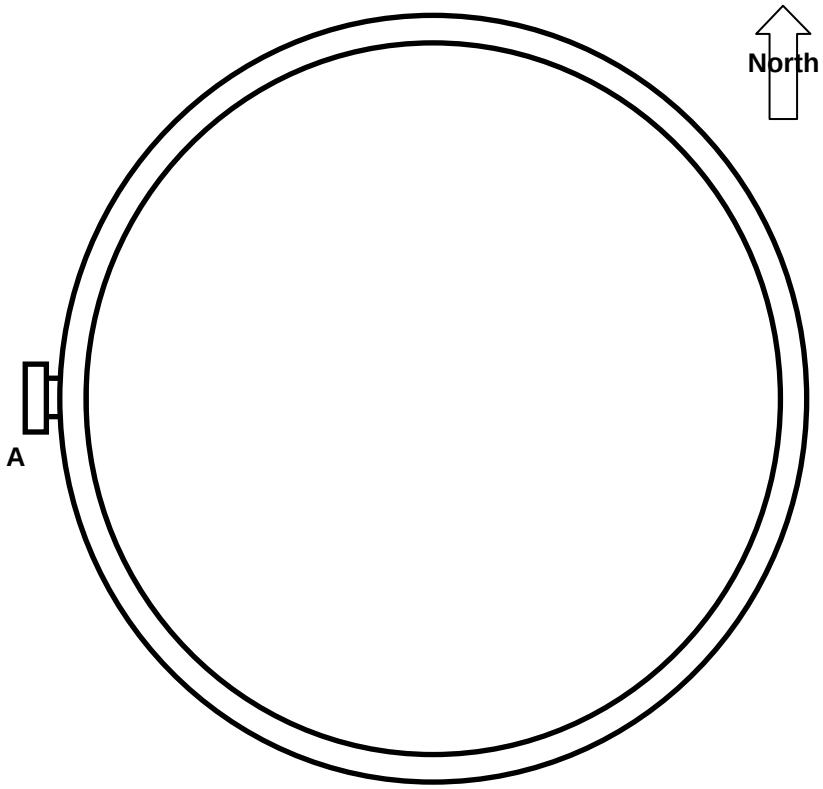
Stack Dimensions				**Traverse Data**			
Diameter or Length of Stack	(D)		in.		**Ports by**		**Pts / port**
Width of Stack	(W)		in.		**Pts Used**		**Required**
Area of Stack	(A_s)		ft^2	**Run Start**		**Run End**	

40 CFR 75 Criteria

Stratification Results	
Maximum Percent Difference	No Test
Maximum Pollutant Conc. Diff.	No Test
Maximum Diluent Conc. Diff.	No Test
Stack Diameter	in.
Stratification Conclusions	
Maximum % Diff.	No Stratification Anticipated
Maximum Conc. Diff.	No Stratification Anticipated
Stack Diameter	D > 93.6 in.
Use Short RM Measurement Line	

Traverse Point Number	**Percent of Stack Diameter**	**Distance from Inside Wall**	**Distance Including Reference Length**
	%	in.	in.
1			
2			
3			

Test Type
- ☐ Moisture, for MW
- ☐ Moisture, for wet-to-dry
- ☑ Gas
- ☐ 6.5.6(b)(2) alt. points could apply



Calculations, Formulas, and Constants

The following information supports the spreadsheets for this testing project.

Given Data:

Ideal Gas Conversion Factor = 385.23 SCF/lb-mol at 68 deg F & 14.696 psia

Fuel Heating Value is based upon Air Hygiene's fuel gas calculation sheet. All calculations are based upon a correction to 68 deg F & 14.696 psia

High Heating Values (HHV) are used for the Fuel Heating Value, F-Factor, and Fuel Flow Data per EPA requirements.

ASTM D 3588

Molecular Weight of NOx (lb/lb-mole) =	46.01
Molecular Weight of CO (lb/lb-mole) =	28.00
Molecular Weight of SO2 (lb/lb-mole) =	64.00
Molecular Weight of THC (propane) (lb/lb-mole) =	44.00
Molecular Weight of VOC (methane) (lb/lb-mole) =	16.00
Molecular Weight of NH3 (lb/lb-mole) =	17.03
Molecular Weight of HCHO (lb/lb-mole) =	30.03

40CFR60, App. A., RM 19, Table 19-1

Conversion Constant for NOx =	0.0000001194351
Conversion Constant for CO =	0.0000000726839
Conversion Constant for SO2 =	0.0000001661345
Conversion Constant for THC =	0.0000001142175
Conversion Constant for VOC (methane) =	0.0000000415336
Conversion Constant for NH_3 =	0.0000000442074
Conversion Constant for HCHO =	0.0000000779534

NOTE: units are lb/ppm*ft^3

Formulas:

1. Corrected Raw Average (C_{Gas}), 40CFR60, App. A, RM 7E, Eq. 7E-5 (08/15/06)

$$C_{Gas} = \left(C_{Avg} - C_O\right) \times \left(\frac{C_{MA}}{C_M - C_O}\right)$$

2. Correction to % O_2, 40CFR60, App. A, RM 20, Eq. 20-5 (11/26/02)

$$C_{adj} = C_{Gas(T\,\arg et)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}}\right)$$

3. Emission Rate in lb/hr

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

4. Emission Concentration in lb/MMBtu (O_2 based)

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 20.9\%}{20.9\% - C_{Gas(O2)}}$$

5. Emission Concentration in lb/MMBtu (CO_2 based)

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 100\%}{C_{Gas(CO2)}}$$

RATA SHEET CALCULATIONS

d = Reference Method Data - CEMS Data

S_d = Standard Deviation

CC = Confident Coefficient

n = number of runs

$t_{0.025}$ = 2.5 percent confidence coefficent T-values

RA = relative accuracy

ARA = alternative relative accuracy

BAF = Bias adjustment factor

n	t	n	t	n	t
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

1. Difference

$$d = \sum_{i=1}^{n} d_i$$

2. Standard Deviation

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \left[\frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}\right]}{n-1}}$$

3. Confident Coefficient

$$CC = t_{0.025} \times \frac{S_d}{\sqrt{n}}$$

4. Relative Accuracy

$$RA = \frac{\left|d_{AVG}\right| + \left|CC\right|}{RM_{AVG}} \times 100$$

5. Alternative Relative Accuracy

$$ARA = \frac{\left|d_{AVG}\right| + \left|CC\right|}{AS} \times 100$$

5. Bias Adjustment Factor

$$BAF = 1 + \left(\frac{\left|d_{AVG}\right|}{CEM_{AVG}}\right)$$

RM 7E, (08-15-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

ACE = Analyzer calibration error, percent of calibration span.
B_{WS} = Moisture content of sample gas as measured by Method 4 or other approved method, percent/100.
C_{Avg} = Average unadjusted gas concentration indicated by data recorder for the test run.
C_D = Pollutant concentration adjusted to dry conditions.
C_{Dir} = Measured concentration of a calibration gas (low, mid, or high) when introduced in direct calibration mode.
C_{Gas} = Average effluent gas concentration adjusted for bias.
C_M = Average of initial and final system calibration bias (or 2-point system calibration error) check responses for the upscale calibration gas.
C_{MA} = Actual concentration of the upscale calibration gas, ppmv.
C_O = Average of the initial and final system calibration bias (or 2-point system calibration error) check responses from the low-level (or zero) calibration gas.
C_S = Measured concentration of a calibration gas (low, mid, or high) when introduced in system calibration mode.
C_{SS} = Concentration of NOx measured in the spiked sample.
C_{Spike} = Concentration of NOx in the undiluted spike gas.
C_{Calc} = Calculated concentration of NOx in the spike gas diluted in the sample.
C_V = Manufacturer certified concentration of a calibration gas (low, mid, or high).
C_W = Pollutant concentration measured under moist sample conditions, wet basis.
CS = Calibration span.
D = Drift assessment, percent of calibration span.
E_p = The predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level response.
Eff_{NO2} = NO_2 to NO converter efficiency, percent.
H = High calibration gas, designator.
L = Low calibration gas, designator.
M = Mid calibration gas, designator.
NOFinal = The average NO concentration observed with the analyzer in the NO mode during the converter efficiency test in Section 16.2.2.
NOxCorr = The NOx concentration corrected for the converter efficiency.
NOxFinal = The final NOx concentration observed during the converter efficiency test in Section 16.2.2.
NOxPeak = The highest NOx concentration observed during the converter efficiency test in Section 16.2.2.
Q_{Spike} = Flow rate of spike gas introduced in system calibration mode, L/min.
Q_{Total} = Total sample flow rate during the spike test, L/min.
R = Spike recovery, percent.
SB = System bias, percent of calibration span.
SB_i = Pre-run system bias, percent of calibration span.
SB_f = Post-run system bias, percent of calibration span.
SB / D_{Alt} = Alternative absolute difference criteria to pass bias and/or drift checks.
SCE = System calibration error, percent of calibration span.
SCE_i = Pre-run system calibration error, percent of calibration span.
SCE_{final} = Post-run system calibration error, percent of calibration span.
Z = Zero calibration gas, designator.

40CFR60.355(b)(1), (09-20-06), Nomenclature. The terms used in the equations are defined as follows:

P_r = reference combustor inlet absolute pressure at 101.3 kilopascals ambient pressure, mm Hg
P_o = observed combustor inlet absolute pressure at test, mm Hg
H_o = observed humidity of ambient air, g H_2O/g air
e = transcendental constant, 2.718
T_a = ambient temperature, K

Small Engine and FTIR Nomenclature. The terms used in the equations are defined as follows:

bhp = brake horsepower
hp = horsepower
Q_{sys} = system flow (lpm)
Q_m = matrix spike flow (lpm)

RM 19, (07-29-06), 12.1 Nomenclature. The terms used in the equations are defined as follows:

AdjFactor = percent oxygen or carbon dioxide adjustment applied to a target polltant
B_{wa} = Moisture fraction of ambient air, percent.
Btu = British thermal unit
$\%_C$ = Concentration of carbon from an ultimate analysis of fuel, weight percent.
$\%_{CO2d}$,$\%_{CO2w}$ = Concentration of carbon dioxide on a dry and wet basis, respectively, percent.
CIP / CDP = Combustor inlet pressure / compressor discharge pressure (mm Hg); note, some manufactures reference as PCD.
E = Pollutant emission rate, ng/J (lb/million Btu).
E_a = Average pollutant rate for the specified performance test period, ng/J (lb/million Btu).
E_{ao}, E_{ai} = Average pollutant rate of the control device, outlet and inlet, respectively, for the performance test period, ng/J (lb/million Btu).
E_{bi} = Pollutant rate from the steam generating unit, ng/J (lb/million Btu).
E_{bo} = Pollutant emission rate from the steam generating unit, ng/J (lb/million Btu).
E_{ci} = Pollutant rate in combined effluent, ng/J (lb/million Btu).
E_{co} = Pollutant emission rate in combined effluent, ng/J (lb/million Btu).
E_d = Average pollutant rate for each sampling period (e.g.,24-hr Method 6B sample or 24-hr fuel sample) or for each fuel lot (e.g., amount of fuel bunkered), ng/J (lb/million Btu).
E_{di} = Average inlet SO_2 rate for each sampling period d, ng/J (lb/million Btu).
E_g = Pollutant rate from gas turbine, ng/J (lb/million Btu).
E_{ga} = Daily geometric average pollutant rate, ng/J (lbs/million Btu) or ppm corrected to 7 percent O_2.
E_{jo},E_{ji} = Matched pair hourly arithmetic average pollutant rate, outlet and inlet, respectively, ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
E_h = Hourly average pollutant, ng/J (lb/million Btu).
E_{hj} = Hourly arithmetic average pollutant rate for hour "j," ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.
EXP = Natural logarithmic base (2.718) raised to the value enclosed by brackets.
Fc = Ratio of the volume of carbon dioxide produced to the gross calorific value of the fuel from Method 19
F_d, F_w, F_c = Volumes of combustion components per unit of heat content, scm/J (scf/million Btu).
ft^3 = cubic feet
G = ideal gas conversion factor
(385.23 SCF/lb-mol at 68 deg F & 14.696 psia)
GCM = gross Btu per SCF (constant, compound based)
GCV = Gross calorific value of the fuel consistent with the ultimate analysis, kJ/kg (Btu/lb).
GCV_p, GCV_r = Gross calorific value for the product and raw fuel lots, respectively, dry basis, kJ/kg (Btu/lb).
$\%_H$ = Concentration of hydrogen from an ultimate analysis of fuel, weight percent.
H_b = Heat input rate to the steam generating unit from fuels fired in the steam generating unit, J/hr (million Btu/hr).
H_g = Heat input rate to gas turbine from all fuels fired in the gas turbine, J/hr (million Btu/hr).
$\%_{H2O}$ = Concentration of water from an ultimate analysis of fuel, weight percent.
H_r = Total numbers of hours in the performance test period (e.g., 720 hours for 30-day performance test period).
K = volume of combustion component per pound of component (constant)
K = Conversion factor, 10^{-5} (kJ/J)/(%) [10^6 Btu/million Btu].
K_c = (9.57 scm/kg)/% [(1.53 scf/lb)/%].
K_{cc} = (2.0 scm/kg)/% [(0.321 scf/lb)/%].
K_{hd} = (22.7 scm/kg)/% [(3.64 scf/lb)/%].
K_{hw} = (34.74 scm/kg)/% [(5.57 scf/lb)/%].
K_n = (0.86 scm/kg)/% [(0.14 scf/lb)/%].
K_o = (2.85 scm/kg)/% [(0.46 scf/lb)/%].
K_s = (3.54 scm/kg)/% [(0.57 scf/lb)/%].
K_{sulfur} = $2x10^4$ Btu/wt%-MMBtu
K_w = (1.30 scm/kg)/% [(0.21 scf/lb)/%].
lb = pound
ln = Natural log of indicated value.
L_p,L_r = Weight of the product and raw fuel lots, respectively, metric ton (ton).
$\%_N$ = Concentration of nitrogen from an ultimate analysis of fuel, weight percent.
$M_\%$ = mole percent
mol = mole
MW = molecular weight (lb/lb-mol)
MW_{AIR} = molecular weight of air (28.9625 lb/lb-mole)[1]
NCM = net Btu per SCF (constant based on compound)
$\%_O$ = Concentration of oxygen from an ultimate analysis of fuel, weight percent.
$\%_{O2d}$, $\%_{O2w}$ = Concentration of oxygen on a dry and wet basis, respectively, percent.
P_B = barometirc pressure, in Hg
P_s = Potential SO2 emissions, percent.
$\%_S$ = Sulfur content of as-fired fuel lot, dry basis, weight percent.
S_e = Standard deviation of the hourly average pollutant rates for each performance test period, ng/J (lb/million Btu).
$\%_{Sf}$ = Concentration of sulfur from an ultimate analysis of fuel, weight percent.
S(wt%) = weight percent of sulfur, per lab analysis by appropriate ASTM standard
S_i = Standard deviation of the hourly average inlet pollutant rates for each performance test period, ng/J (lb/million Btu).
S_o = Standard deviation of the hourly average emission rates for each performance test period, ng/J (lb/million Btu).
$\%S_p$, $\%S_r$ = Sulfur content of the product and raw fuel lots respectively, dry basis, weight percent.
SCF = standard cubic feet
SH = specific humidity, pounds of water per pound of air
$t_{0.95}$ = Values shown in Table 19-3 for the indicated number of data points n.
T_{amb} = ambient temperature, ^oF
W/D Factor = 1.0236 = conv. at 14.696 psia and
68 deg F (ref. Civil Eng. Ref. Manual, 7th Ed.)
X_{CO2}=CO_2 Correction factor, percent.
X_k = Fraction of total heat input from each type of fuel k.

EXAMPLE CALCULATIONS (FTIR SPIKE)

Concentration to dilute by 90% (ppmvw)

$$AVG_d = \frac{AVG_r}{2}$$

AVG_d = $\frac{\text{ppmvw}}{2}$ = ppmvw

Ideal matrix spike yield (ppmvw)

$$Y_{ideal} = AVG_d \times \left(\frac{Q_m}{Q_{sys}}\right) + AVG_r \times \left(1 - \frac{Q_m}{Q_{sys}}\right)$$

Y_{ideal} = ppmvw x $\left(\frac{\text{lpm}}{\text{lpm}}\right)$ + ppmvw x $\left(1 - \frac{\text{lpm}}{\text{lpm}}\right)$ = ppmvw

Minimum matrix spike yield (ppmvw)

$$Y_{min} = Y_{ideal} \times 0.7$$

Y_{ideal} = ppmvw x 0.7 = ppmvw

Maximum matrix spike yield (ppmvw)

$$Y_{max} = Y_{ideal} \times 1.3$$

Y_{ideal} = ppmvw x 1.3 = ppmvw

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (RUNS)

Stack Exhaust Flow (Q_S) - RM19

$$Q_S = \left(\frac{FFactor \times Q_f \times HHV}{1{,}000{,}000}\right) \times \left(\frac{20.9\%}{20.9\% - C_{Gas(O2)}}\right)$$

Q_S = SCF/MMBtu x SCF/hr x Btu/SCF x MMBtu/10^6 Btu x [20.90% / (20.9% - %)] = SCFH

NO_2 Conversion Efficiency Correction

RM 7E, (08-15-06), 12.8 NO2 - NO Conversion Efficiency Correction. If desired, calculate the total NOX concentration with a correction for converter efficiency using Equations 7E-8. (calc for non-bias corrected (raw) NOx gas, Run 1, if applicable)

$$NOx_{Corr} = NO + \frac{NOx - NO}{Eff_{NO2}} \times 100$$ Eq. 7E-8

NOx_{Corr} = ppm + (ppm - ppm) / % x 100 = ppm

Moisture Correction

RM 7E, (08-15-06), RM7E, (08-15-06), 12.10 Moisture Correction. Use Equation 7E-10 if your measurements need to be corrected to a dry basis. (calc for THC analyzer, Run 1, if applicable) Note: Calculations may not match as Run 1 results are typically also bias adjusted

$$C_D = \frac{C_W}{1 - B_{WS}}$$ Eq. 7E-10

C_D = ppmvw / (1 -) = ppmvd

Diluent-Corrected Polutant Concentration, O_2 Based

RM 20, (11-26-02), 7.3.1 Correction of Pollutant Concentration Using O2 Concentration. Calculate the O2 corrected pollutant concentration, as follows: (calc for gas, Run 1, if applicable)

$$C_{adj} = C_{Gas(T\,arget)} \times \left(\frac{20.9\% - AdjFactor}{20.9\% - C_{Gas(O2)}}\right)$$ Eq. 20-4

C_{adj} = ppm x [20.9% - % / 20.9% - %] = ppm@%O_2

Diluent-Corrected Polutant Concentration, CO_2 Based

RM 20, (11-26-02), 7.3.2 Correction of Pollutant Concentration Using CO2 Concentration. Calculate the CO2 corrected pollutant concentration, as follows: (calc for gas, Run 1, if applicable)

$$C_{adj} = C_{Gas(T\,arget)} \times \frac{X_{CO2}}{C_{Gas(CO2)}}$$ Eq. 20-5

C_{adj} = ppm x % / % =

7.2 CO_2 Correction Factor. If pollutant concentrations are to be corrected to percent O_2 and CO_2 concentration is measured in lieu of O_2 concentration measurement, a CO_2 correction factor is needed. Calculate the CO_2 correction factor as follows: 7.2.1 Calculate the fuel specific F_o, as follows:

$$F_0 = \frac{0.209\,F_d}{F_c}$$ Eq. 20-2

F_0 = 0.209 x SCF/MMBtu / SCF/MMBtu =

7.2.2. Calculate the CO_2 correction factor for correcting measurement data to percent oxygen, as follows:

$$X_{CO2} = \frac{20.9\% - AdjFactor}{F_0}$$ Eq. 20-3

X_{CO2} = 20.9% - % = %

Diluent-Corrected Polutant Concentration Corrected to ISO Conditions

40CFR60.335(b)(1), Conversion for conc. at ISO Conditions (68°F, 1 atm). Calculate, as follows: (calc for @% with Run 1 data, if applicable)

$$C_{ISO} = C_{Adj} \times \sqrt{\frac{P_r}{P_o}} \times e^{(19 \times (H_O - 0.00633))} \times \left(\frac{288}{T_a}\right)^{1.53}$$

C_{ISO} = ppm@%O_2 x $\sqrt{(\text{psig} + 14.69232\ \text{psi}) / (0.01933677\ \text{psi/mm Hg.})}$ / $\sqrt{(\text{psig} + \text{psi}) / (0.01933677\ \text{psi/mm Hg.})}$ x 2.718 (19x(lb/lb-0.00633)) x (288 K / K)$^{1.53}$ = ppm@% and ISO

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (RUNS)

Emissions Rate (lb/hr)

Calculation for pound per hour emission rate. Calculate, as follows: (calc for gas Run 1, if applicable)

$$E_{lb/hr} = \frac{C_{Gas}}{10^6} \times \frac{Q_S \times MW}{G}$$

$$E_{lb/hr} = \frac{\text{ppm}}{10^6 \text{ ppm/part}} \text{ x } \frac{\text{SCFH x lb/lb-mol}}{\text{SCF/lb-mol}} = \frac{\text{lb}}{\text{hr}}$$

Emissions Rate (ton/year)

Calculation for tons per year emission rate based on 8760 hours per year. Calculate, as follows: (calc for gas Run 1, if applicable)

$$E_{ton/yr} = \frac{E_{lb/hr} \times hr_{year}}{2000}$$

$$E_{ton/yr} = \frac{\text{lb}}{\text{hr}} \text{ x } \frac{\text{hr}}{\text{year}} \text{ x } \frac{\text{ton}}{\text{2000 lb}} = \frac{\text{ton}}{\text{year}}$$

Emissions Rate (lb/MMBtu)

RM 19, (07-19-06), 12.2 Emission Rates of PM, SO2, and NOx. Select from the following sections the applicable procedure to compute the PM, SO2, or NOx emission rate (E) in ng/J (lb/million Btu). (calc for gas Run 1, if applicable)

Oxygen Based

12.2.1 Oxygen-Based F Factor, Dry Basis. When measurements are on a dry basis for both O_2 (%O_2d) and pollutant (Cd) concentrations, use the following equation:

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 20.9\%}{20.9\% - C_{Gas(O2)}}$$ Eq. 19-1

$$E_{lb/MMBtu} = \frac{\text{ppm x SCF/MMBtu x lb/ppm*ft}^3 \text{ x 20.9\%}}{\text{20.9\% - \%}} = \frac{\text{lb}}{\text{MMBtu}}$$

Carbon Dioxide Based

12.2.4 Carbon Dioxide-Based F Factor, Dry Basis. When measurements are on a dry basis for both CO_2 (%CO_2d) and pollutant (Cd) concentrations, use the following equation:

$$E_{lb/MMBtu} = \frac{C_{Gas} \times F_d Factor \times Conv_C \times 100\%}{C_{Gas(CO2)}}$$ Eq. 19-6

$$E_{lb/MMBtu} = \frac{\text{ppm x SCF/MMBtu x lb/ppm*ft}^3 \text{ x 100\%}}{\text{\%}} = \frac{\text{lb}}{\text{MMBtu}}$$

Conversion Constant

Convc for

$$Conv_c(lb/ppm \cdot ft^3) = \frac{\frac{MW}{G}}{10^6}$$

$$Conv_c = \frac{\text{lb}}{\text{lb•mole}} \text{ x } \frac{\text{lb•mole}}{\text{SCF}} = \frac{\text{lb}}{\text{ppm-ft}^3}$$

Sulfur Dioxide Rate (lb/MMBtu), 40CFR60, App. A, RM 19, Eq. 19-25 (11/20/03)

$$SO_2(lb/MMBtu) = 0.97 \times K \times \frac{S(wt\%)}{GCV}$$

$$SO_2 = 0.97 \text{ x } \frac{\text{2x10}^4 \text{ Btu}}{\text{wt\%•MMBtu}} \text{ x } \frac{\text{wt\%}}{\text{Btu/lb}} = \frac{\text{lb}}{\text{MMBtu}}$$

Emissions Rate (g/hp-hr)

Calculation for grams per horsepower-hour. Calculate, as follows: (calc for gas Run 1, if applicable)

$$E_{g/hp \cdot hr} = \frac{E_{lb/hr} \times 453.6}{mw \times 1314.022} \text{ or } \frac{E_{lb/hr} \times 453.6}{hp}$$

$$E_{g/hp-hr} = \frac{\text{lb}}{\text{hr}} \text{ x } \frac{\text{453.6 g}}{\text{lb}} \text{ x } \frac{\text{1}}{\text{mw}} \text{ x } \frac{\text{mw}}{\text{1314.022 hp}} = \frac{\text{g}}{\text{hp*hr}}$$

$$E_{g/hp-hr} = \frac{\text{lb}}{\text{hr}} \text{ x } \frac{\text{453.6 g}}{\text{lb}} \text{ x } \frac{\text{1}}{\text{hp}} = \frac{\text{g}}{\text{hp*hr}}$$

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (INFORMATION)

Specific Humidity (RH_{sp})

Note: RHsp (gr/lb) calculated using temperature, relative humidity, and barometric pressure with psychrometric chart, psychrometric calculator, or built in psychrometric algorithm.

$$RH_{sp}(lb/lb) = \left[\left(\frac{gr}{lb}\right) \times \frac{lb}{7000\ gr}\right]$$

RH_{sp}= $\frac{gr}{lb}$ x $\frac{1\ lb}{7000\ gr}$ = $\frac{lb\ H_2O}{lb\ Air}$

Fuel Flow Conversion (Q_f)

Note: Qf(lb/min) is a value uptained from the source operator.

$$Q_f = \left[Q_f \times G \times \left(\frac{1}{MW_{Fuel}}\right)\right]$$

Q_f = $\frac{lb}{min}$ x $\frac{60\ min}{hr}$ x $\frac{ft^3}{lb\text{-}mol}$ x $\frac{lb\text{-}mol}{lb}$ = SCFH

Combustor Inlet Pressure / Compressor Discharge Pressure (CIP / CDP)

(corrected from gauge to atmospheric pres. and conv. to mm Hg.)

Note: CIP / CDP (psig) is a value obtained from the source operator.

$$CIP/CDP = \left[(psig + P) \times \frac{51.71493\ mmHg}{1\ psi}\right]$$

CIP / CDP = (psig +) x $\frac{51.71493\ mmHg}{1\ psia}$ = mmHg (abs)

Heat Rate (MMBtu/hr)

$$HR = \frac{HHV_{DRY} \times Q_f}{1{,}000{,}000}$$

Heat Rate = $\frac{Btu}{SCF}$ x $\frac{SCF}{hr}$ x $\frac{MMBtu}{10^6\ Btu}$ = $\frac{MMBtu}{hr}$

Estimated Stack Gas Moisture Content (B_{ws})

$$B_{ws}(\%) = \frac{2 \times Q_f}{Q_s} \times 100$$

B_{ws} = 2 x $\frac{SCF}{hr}$ x $\frac{hr}{SCF}$ x 100 = %

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (CALIBRATION)

Analyzer Calibration Error

RM 7E, (08-15-06), 12.2 Analyzer Calibration Error. For non-dilution systems, use Equation 7E-1 to calculate the analyzer calibration error for the low-, mid-, and high-level calibration gases. (calc for analyzer mid gas, if applicable)

$$ACE = \left(\frac{C_{Dir} - C_V}{CS}\right) \times 100$$ Eq. 7E-1

ACE = $\frac{ppm\ -\ ppm}{ppm}$ x 100 = %

Calibration Error and Estimated Point, RM 25A, THC Analyzer

RM 25A, (07-19-06), 8.4 Calibration Error Test. Immediately prior to the test series (within 2 hours of the start of the test), introduce zero gas and high-level calibration gas at the calibration valve assembly. Adjust the analyzer output to the appropriate levels, if necessary. Calculate the predicted response for the low-level and mid-level gases based on a linear response line between the zero and high-level response. Then introduce low-level and mid-level calibration gases successively to the measurement system. ... These differences must be less than 5 percent of the respective calibration gas value. (calc for THC analyzer mid gas, if applicable)

$$E_P = \frac{C_{Dir(H)} - C_{Dir(Z)}}{C_{V(H)} - C_{V(Z)}} \times C_{Dir(M)} + C_{Dir(Z)}$$

Eq. of a line y=mx+b

E_p = $\frac{ppm\ -\ ppm}{ppm\ -\ ppm}$ x ppm + = ppm

$$ACE = \left(\frac{C_{Dir} - C_V}{CS}\right) \times 100$$ Eq. 7E-1

ACE_{THC} = $\frac{ppm\ -\ ppm}{ppm}$ x 100 = %

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (BIAS, DRIFT, AND CORRECTED RAW AVERAGE)

System Bias

RM 7E, (08-15-06), 12.3 System Bias. For non-dilution systems, use Equation 7E-2 to calculate the system bias separately for the low-level and upscale calibration gases. (calc for analyzer upscale gas, Run 1 initial bias, if applicable)

$$SB = \left(\frac{C_S - C_{Dir}}{CS}\right) \times 100$$ Eq. 7E-2

SB = (ppm - ppm) / ppm x 100 = %

Drift Assessment

RM 7E, (08-15-06), 12.5 Drift Assessment. Use Equation 7E-4 to separately calculate the low-level and upscale drift over each test run. (calc for analyzer upscale drift, Run 1, if applicable)

$$D = \left|SB_{final} - SB_i\right|$$ Eq. 7E-4

D = | % - % | = %

Alternative Drift and Bias

RM 7E, (08-15-06), 13.2 / 13.3 System Bias and Drift. Alternatively, the results are acceptable if |Cs – Cdir| is≤ 0.5 ppmv or if |Cs – Cv| is ≤ 0.5 ppmv (as applicable). (calc for analyzer initial upscale, Run 1, if applicable)

$$SB / D_{Alt} = \left|C_S - C_{Dir}\right|$$ Eq. Section 13.2 and 13.3

SB / D_{Alt} = | ppm - ppm | = ppm

Bias Adjusted Average

RM 7E, (08-15-06), 12.6 Effluent Gas Concentration. For each test run, calculate Cavg, the arithmetic average of all valid concentration values (e.g., 1-minute averages). Then adjust the value of Cavg for bias, using Equation 7E-5. (calc for analyzer, Run 1, if applicable)

$$C_{Gas} = \left(C_{Avg} - C_O\right) \times \left(\frac{C_{MA}}{C_M - C_O}\right)$$ Eq. 7E-5

C_{Gas} = (ppm - ppm) x (ppm / (ppm - ppm)) = ppm

EXAMPLE CALCULATIONS (BSFC)

Using LHV with Q_f (Btu/hp*hr)

$$BSFC\ (Btu / hp \cdot hr) = Q_f$$

BSFC = Btu / hp*hr = Btu / hp*hr

Using HHV with Q_f (SCFH)

$$BSFC\ (Btu / hp \cdot hr) = \frac{HHV \times Q_f}{bhp}$$

BSFC = Btu / SCF x SCF / hr x 1 / hp = Btu / hp*hr

Using LHV with Q_f (SCFH)

$$BSFC\ (Btu / hp \cdot hr) = \frac{LHV \times Q_f}{bhp}$$

BSFC = Btu / SCF x SCF / hr x 1 / hp = Btu / hp*hr

Using HHV with Q_f (Btu/hp*hr)

$$BSFC\ (Btu / hp \cdot hr) = \frac{Q_f \times HHV}{LHV}$$

BSFC = N/A Btu / hp*hr x Btu / SCF x scf / Btu = Btu / hp*hr

EXAMPLE CALCULATIONS (Emissions based on Table 29 values)

Emission Rate (lb/hr)
Q_f (Btu/hp*hr))

$$E(lb / hr) = \frac{E_{g / hp \cdot hr} \times bhp}{453.6}$$

E (lb/hr) = g / hp*hr x lb / 453.6 g x hp = lb / hr

Emission Rate (g/hp-hr)
Q_f (Btu/hp*hr))

$$E\ (g / hp \cdot hr) = CRA \times Q_f \times FFactor \times MW \times \frac{1}{10^6} \times \frac{1}{10^6} \times \frac{453.6}{G} \times \frac{20.9\%}{20.9\% - CRA_{O_2}}$$

E (g/hp-hr) = ppm x Btu / hp*hr x SCF / MMBtu x lb / lb-mol x 1 parts / 10^6 ppm x 1 MMBtu / 10^6 Btu x 453.6 g / lb x lb-mol / SCF x 20.9% / (20.9% - %) = g / hp*hr

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

EXAMPLE CALCULATIONS (FFACTOR)

RM 19, (07-19-06),
2.0 Summary of Method,
2.1 Emission Rates. Oxygen (O_2) or carbon dioxide (CO_2) concentrations and appropriate F factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant co

RM 19, (07-19-06),
12.2 Emission Rates of PM, SO2, and NOx. Select from the following sections the applicable procedure to compute the PM, SO2, or NOx emission rate (E) in lb/MMBtu. The pollutant concentration must be in lb/scf and the F factor must be in scf/MMBtu. If the pollutant concentration (C) is not in the appropriate units, use Table 19–1 in Section 17.0 to make the proper conversion. An F factor is the ratio of the gas volume of the products of combustion to the heat content of the fuel. The dry F factor (F_d) includes all components of combustion less water, the wet F factor (F_w) includes all components of combustion, and the carbon F factor (F_c) includes only carbon dioxide.

Mark's Std Hdbk, 10th ed.,pg 4-26
High Heat Value Dry (HHV_{dry}), calc for Methane (single component for the fuel gas)

$$HHV_{dry}\left(Btu / SCF\right) = \left[\left(\frac{M_{\%}}{100}\right) \times GCM\right]$$

HHV_{dry} = % / 100.00 x Btu / SCF = Btu / SCF

Mark's Std Hdbk, 10th ed., pg 4-26
Low Heat Value Dry (LHV_{dry}), calc for Methane (single component for the fuel gas)

$$LHV_{dry}\left(Btu / SCF\right) = \left[\left(\frac{M_{\%}}{100}\right) \times NCM\right]$$

LHV_{dry} = % / 100.00 x Btu / SCF = Btu / SCF

Civil Eng. Ref. Man.,7th Ed.,pg 14-9/GPA Ref. Bulletin 181-86, App. C
High Heat Value Wet (HHV_{wet}), calc for entire sample (all components of the fuel gas)

$$HHV_{wet}\left(Btu / SCF\right) = \frac{HHV_{dry}}{W / D.\,factor}$$

HHV_{wet} = Btu/SCF = Btu/SCF

Civil Eng. Ref. Man.,7th Ed.,pg 14-9/GPA Ref. Bulletin 181-86, App. C
Low Heat Value Wet (LHV_{wet}), calc for entire sample (all components of the fuel gas)

$$LHV_{wet}\left(Btu / SCF\right) = \frac{LHV_{dry}}{W / D.\,factor}$$

LHV_{wet} = Btu/SCF = Btu/SCF

Lbs Component per Lb-Mol of Gas (CM), calc for Methane (single component for the fuel gas)

$$CM\left(lb / lb - mol\right) = \left[\left(\frac{M_{\%}}{100}\right) \times MW\right]$$

CM = % / 100.00 x lb / lb-mol = _____ lb/lb-mol

ASTM D 3588
Fuel Molecular Weight (MW_{Fuel})

$$MW_{Fuel}\left(lb / lb \cdot mol\right) = \left[\sum\left(CM\right)\right]$$

MW_{Fuel} = lb/lb-mol
\+ lb/lb-mol
+ etc. = lb/lb-mol

Btu per Lb of Gas Gross (**GCV**)

$$GCV\left(Btu / lb\right) = \left[\frac{HHV_{dry} \times G}{MW_{Fuel}}\right]$$

GCV = Btu/SCF x ft^3/lbmol / lb/lb-mol = Btu/lb

ASTM D 3588 (SG)
Specific Gravity

$$SG = \left[\frac{MW_{Fuel}}{MW_{AIR}}\right]$$

SG = lb/lb-mol / 28.96 lb/lb-mol =

Btu per Lb of Gas Net (**NCV**)

$$NCV\left(Btu / lb\right) = \left[\frac{LHV_{dry} \times G}{MW_{Fuel}}\right]$$

NCV = Btu/SCF x ft^3/lbmol / lb/lb-mol = Btu/lb

Weight Percent of Component ($C_{\%}$), methane

$$C_{\%}\left(\%\right) = \left[\left(\frac{CM}{MW_{Fuel}}\right) \times 100\right]$$

$C_{\%}$ = lb/lb-mol / lb/lb-mol x 100 = %

RM 19, (07-19-06), **Weight Percent of Volatile Organic Compounds** ($VOC_{\%}$)

$$VOC_{\%}\left(\%\right) = \left[\sum_{C_3H_8}^{C_8H_{18}} M_{\%}\right]$$

$VOC_{\%}$ = % + % + % + etc. = %

RM 19, (07-19-06), 12.3.2 Determined **F Factors**. If the fuel burned is not listed in Table 19–2 or if the owner or operator chooses to determine an F factor rather than use the values in Table 19–2, use the procedure below: 12.3.2.1 Equations. Use the eq

RM 19, (07-19-6),
12.1 Nomenclature

K (scf/lb)/%	
H	3.64
C	1.53
S	0.57
N_2	0.14
O_2	0.46

$$F_d = \frac{K\left(K_{hd}\%H + K_c\%C + K_s\%S + K_n\%N - K_o\%O\right)}{GCV} \qquad \text{Eq. 19-13}$$

F_d = 10^6Btu/MMBtu x [3.64 SCF / lb · % x % + 1.53 SCF / lb · % x % + 0.57 SCF / lb · % x % +
0.14 SCF / lb · % x % - 0.46 SCF / lb · % x %] x lb / Btu = SCF / MMBtu

Note: Lack of significant figures may cause rounding errors between actual calculations and example calculations.

TABLE A.2
LOAD 1 DATA SUMMARY

Parameter	Run - 1	Run - 2	Run - 3	Average
Start Time (hh:mm:ss)				
End Time (hh:mm:ss)				
Run Duration (min)				
Bar. Pressure (in. Hg)				
Amb. Temp. (°F)				
Rel. Humidity (%)				
Spec. Humidity (lb water / lb air)				
Turbine Fuel Flow (SCFH)				
Stack Flow (RM19) (SCFH)				
Power Output (megawatts)				
NOx (ppmvd)				
NOx (lb/hr)				
NOx (lb/MMBtu)				
NOx (g/hp*hr)				
CO (ppmvd)				
CO (lb/hr)				
CO (lb/MMBtu)				
CO (g/hp*hr)				
O_2 (%)				

TABLE A.3
LOAD 2 DATA SUMMARY

Parameter	Run - 4	Run - 5	Run - 6	Average
Start Time (hh:mm:ss)				
End Time (hh:mm:ss)				
Run Duration (min)				
Bar. Pressure (in. Hg)				
Amb. Temp. (°F)				
Rel. Humidity (%)				
Spec. Humidity (lb water / lb air)				
Turbine Fuel Flow (SCFH)				
Stack Flow (RM19) (SCFH)				
Power Output (megawatts)				
NOx (ppmvd)				
NOx (lb/hr)				
NOx (lb/MMBtu)				
NOx (g/hp*hr)				
CO (ppmvd)				
CO (lb/hr)				
CO (lb/MMBtu)				
CO (g/hp*hr)				
O_2 (%)				

DRIFT AND BIAS CHECK			
Run - 1	**O2**	**NOx**	**CO**
Raw Average			
Corrected Average			
Initial Zero			
Final Zero			
Avg. Zero			
Initial UpScale			
Final UpScale			
Avg. UpScale			
Sys Resp (Zero)			
Sys Resp (Upscale)			
Upscale Cal Gas			
Initial Zero Bias			
Final Zero Bias			
Zero Drift			
Initial Upscale Bias			
Final Upscale Bias			
Upscale Drift			
Alternative Specification Abs Diff **Initial Zero**			
Final Zero			
Initial Upscale			
Final Upscale			
Calibration Span			
3% of Range (drift)			
5% of Range (bias)			

DRIFT AND BIAS CHECK			
Run - 2	**O2**	**NOx**	**CO**
Raw Average			
Corrected Average			
Initial Zero			
Final Zero			
Avg. Zero			
Initial UpScale			
Final UpScale			
Avg. UpScale			
Sys Resp (Zero)			
Sys Resp (Upscale)			
Upscale Cal Gas			
Initial Zero Bias			
Final Zero Bias			
Zero Drift			
Initial Upscale Bias			
Final Upscale Bias			
Upscale Drift			
Alternative Specification Abs Diff **Initial Zero**			
Final Zero			
Initial Upscale			
Final Upscale			
Calibration Span			
3% of Range (drift)			
5% of Range (bias)			

Fuel Data

Fuel F_d factor		SCF/MMBtu
Fuel Heating Value (HHV)		Btu/SCF

Weather Data

Barometric Pressure		in. Hg
Relative Humidity		%
Ambient Temperature		° F
Specific Humidity		lb H_2O / lb air

Unit Data

Unit Load		megawatts
Heat Input		lb/MMBtu
Steam Rate		Steam lb/hr
Combustor Inlet Pres.		psig
NOx Control Water Injection		gpm
Est. Stack Moisture		%
Stack Exhaust Flow (M2)		SCFH
Stack Exhaust Flow (M19)		SCFH

Run - 1

Date/Time (mm/dd/yy hh:mm:ss)	Elapsed Time (seconds)	O_2 (%)	NOx (ppmvd)	CO (ppmvd)

RAW AVERAGE

	Serial Number:	O_2 (%)	NOx (ppmvd)	CO (ppmvd)
Bias	Initial Zero			
	Final Zero			
	Avg. Zero			
	Initial UpScale			
	Final UpScale			
	Avg. UpScale			

Upscale Cal Gas

EMISSIONS DATA	O_2	NOx	CO
Corrected Raw Average (ppm/% dry basis)			
Corrected Raw Average (ppm/% wet basis)			
Concentration (ppm@ %O_2)			
Concentration (ppm@ %O_2 &ISO)			
Emission Rate (lb/hr)			
Emission Rate (tons/day) at 24 hr/day			
Emission Rate (tons/year) at 8760 hr/yr			
Emission Rate (lb/MMBtu)			
Emission Rate (g/hp*hr)			

APPENDIX E

STATEMENT OF QUALIFICATIONS

STATEMENT OF QUALIFICATIONS - 2012

AIR HYGIENE, INC.

Testing Solutions for a Better World

Corporate Headquarters:
1600 West Tacoma Street
Broken Arrow, OK 74012

(918) 307-8865
(888) 461-8778

Remote Office Locations:
Las Vegas, NV 89156
Ft. Worth, TX 76028
Humble, TX 77338
Shreveport, LA 71115
Philadelphia, PA 19136

AIR HYGIENE, INC.

WWW.AIRHYGIENE.COM

Follow us on Twitter @AirHygiene

STATEMENT OF QUALIFICATIONS

AIR HYGIENE

AIR EMISSION TESTING SERVICES

www.airhygiene.com

January, 2012

INTRODUCTION

AIR HYGIENE INTERNATIONAL, INC. (**AIR HYGIENE**) is a professional air emission testing services firm operating from corporate headquarters in Broken Arrow, Oklahoma for 15 years. Additional field offices with ready for field use testing labs are strategically located in Shreveport, Louisiana; Fort Worth and Houston, Texas; Las Vegas, Nevada; Atlanta, Georgia; and Philadelphia, Pennsylvania to serve all fifty (50) United States, Mexico, and Canada. **AIR HYGIENE** specializes in air emission testing services for combustion sources burning multiple fuels with multiple control devices and supporting equipment.

AIR HYGIENE has testing laboratories which serve all fifty (50) of the United States and North America. Each mobile laboratory can be equipped with the following equipment and capabilities:

1. State-of-the-Art air emission analyzers, computers, and datalogging software.
2. Dual racks for multiple source testing simultaneously or multiple points on a single source (in/out SCR, etc.)!
3. NIST traceable gases for the most accurate calibration. Ranges as low as five (5) ppm!
4. PM_{10}, NH_3, **mercury (Hg)**, sulfuric acid mist (H_2SO_4), SO_3, and formaldehyde sampling equipment!
5. VOC testing with on-board gas chromatograph to remove methane and ethane!
6. On-board printers to provide hard copies of testing information on-site!
7. Networking capabilities to provide real-time emission data directly into the control room!

AIR HYGIENE is known for providing professional services which include the following:

- Superior, cost saving services to our clients!
- High quality emission testing personnel with service oriented, friendly attitude!
- Meeting our client's needs whether it is 24 hour a day testing or short notice mobilization!
- Using great equipment that is maintained and dependable!
- Understanding the unique startup and operational needs associated with combustion sources!

MISSION STATEMENT

Our mission is to provide innovative, practical, top-quality services allowing our clients to increase operating efficiency, save money, and comply with federal/state requirements. We believe our first responsibility is to the client. In providing our unique services, the owners of **AIR HYGIENE** demand ethical conduct from each employee of the company. The character and integrity of **AIR HYGIENE** employees allows our clients to feel confidence in the air testing services of **AIR HYGIENE**. Through a long-term commitment to this mission, **AIR HYGIENE** is known as a company committed to improving our clients' operations.

AIR HYGIENE …
… Does work worth paying for every time!
… Is well known for our emission testing services and uncompromising efforts to serve our clients!
… Does work that matters!
… Is proud of our emission testing capabilities!
… Provides exciting growth opportunities for energetic individuals!

AIR HYGIENE, INC.

Testing Solutions for a Better World

AIR HYGIENE Testing Services Summary

AIR HYGIENE is a privately-held professional services firm headquartered in Broken Arrow, Oklahoma with additional field offices in Las Vegas, NV; Houston, TX; Ft. Worth, TX; Shreveport, LA; and Philadelphia, PA. AIR HYGIENE specializes in emission testing services for a variety of industries including solid, liquid, & gas fired utility plants, turbines, engines, refineries, printers, glass plants, chemical plants, various manufacturers and related industries.

AIR HYGIENE provides turn-key emission testing services with fast-turnaround which include:

1. Pre-test site visit
2. Consulting on port locations and setup
3. Preparation of test plan for state agency
4. Coordination with state agency for emission testing
5. On-site emission testing services
6. Preparation of draft and final reports

AIR HYGIENE has a recently expanded corporate headquarters, testing warehouse, and training center. A newly constructed 32,000 square foot facility was completed in 2011. It expands our testing services capabilities with a larger, upgraded laboratory space and it houses a one-of-a-kind indoor stack, in a climate controlled environment. This provides a full service training center, available to both employees and customers to further develop testing knowledge and skills. Lastly, our expanded facilities better meet our operational needs, expand our test lab production capabilities, and help build upon our reputation of having the very best stack testing lab in the world!

AIR HYGIENE has mobile laboratories that serve all 50 United States and North America. AIR HYGIENE has performed over 20,000 emission tests on a variety of sources. AIR HYGIENE has fifteen (15) QSTI certified project managers and has received interim accreditation from STAC per ASTM D7036.

AIR HYGIENE performs air emission certification compliance testing on combustion sources (natural gas, biomass, coal, fuel oil, jet fuel, etc), NSPS sources, ICR MACT testing, and Title V compliance sites. Our experience ranges from emission testing for new PSD facilities, ICR, MACT, and RACT required performance certification testing to Relative Accuracy Test Audits (RATA Tests) for Continuous Emission Monitoring Systems (CEMS) and Parametric Emission Monitoring Systems (PEMS).

AIR HYGIENE performs FTIR testing by EPA Method 320 321, & ASTM D-6348 for Hazardous Air Pollutants (HAPS) including formaldehyde, benzene, xylene, toluene, hexane, ammonia, hydrogen chloride, etc. This methodology provides real-time analysis of these critical pollutants.

AIR HYGIENE specializes in the following types of pollutants and EPA Reference Methods (RM):

- Exhaust Flow – RM 2 &/or 19
- Carbon Dioxide (CO_2) – RM 3a
- Oxygen (O_2) – RM 3a &/or 20
- Moisture – RM 4
- Particulates (PM) – RM 5(filterable) & 202/OTM-028
- PM < 10 microns (PM_{10}) – RM 201a
- PM < 2.5 microns ($PM_{2.5}$) – RM 201b
- PM sizing (elzone analysis)
- Sulfur Dioxide (SO_2) – RM 6c
- Nitrogen Oxides (NOx) – RM 7e &/or 20
- Sulfuric Acid Mist (SO3) – RM 8a (control condensate)
- Opacity – RM 9
- Carbon Monoxide (CO) – RM 10
- Hydrogen Sulfide (H_2S) – RM 11
- Lead – RM 12
- Dioxin & Furans – RM 23
- Total Hydrocarbons (THC) – RM 25a
- Volatile Organic Compounds (VOC) RM 25a & RM 18
- Metals – RM 29
- Chrome – RM 306
- Formaldehyde – RM 320 & ASTM D-6348 (FTIR)
- HAPS – FTIR – RM 320, 321, & ASTM D-6348 (FTIR)
- Ammonia – RM 320, CTM-027, or BAAQMD ST-1B
- Mercury – RM 30b-Sorbent Tubes (both with on-site analysis, Ontario-Hydro, and RM

AIR HYGIENE, INC.

1600 West Tacoma Street
Broken Arrow, OK 74012

(888) 461-8778
www.airhygiene.com

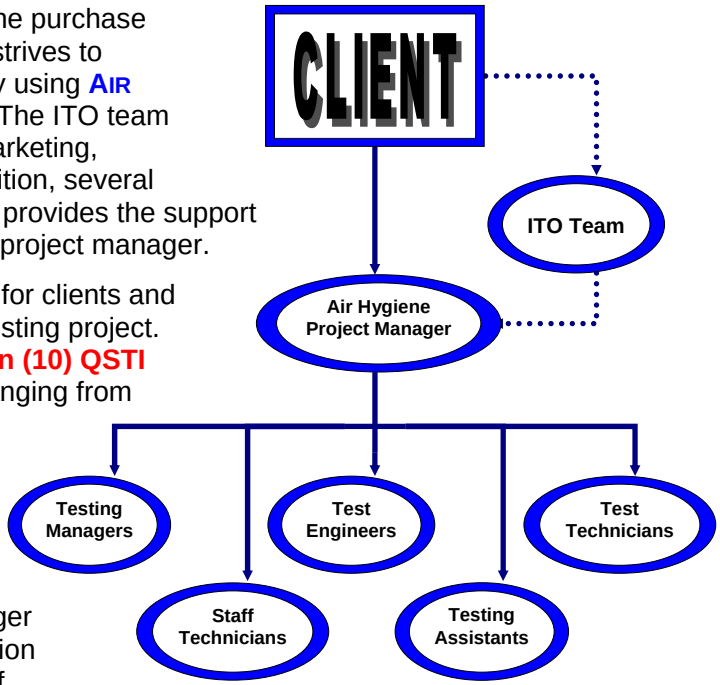
AIR HYGIENE, INC.

Testing Solutions for a Better World

EMISSION TESTING TEAM

Air Hygiene International, Inc. (**AIR HYGIENE**) intends to exceed your expectations on every project. From project management to field-testing teams, we're committed to hard work on your behalf. The job descriptions and flowchart below outline **AIR HYGIENE**'s client management strategy for your testing services.

From the initial request through receipt of the purchase order, the Inquisition To Order (ITO) team strives to inform every client of the benefits gained by using **AIR HYGIENE** for their emission testing project. The ITO team includes representatives from the sales, marketing, operations, and contracts divisions. In addition, several support staff assist to ensure the ITO team provides the support for client needs as requested by a client or project manager.



Project Managers are the primary contact for clients and ultimately responsible for every emission testing project. **AIR HYGIENE**'s Project Managers include **ten (10) QSTI certified** testing experts with experience ranging from masters level, professional engineers to industry experts with over 10,000 testing projects completed. Each project is assigned a Project Manager based primarily upon geographic location, then industry experience, contact history, and availability. The Project Manager prepares the testing strategy and organization for the project. This includes preparation of testing protocol; coordination with state agencies, client representatives, and any interested third parties. The site testing and report preparation are executed under the direction of the Project Manager from start to finish.

Testing Managers have completed Air Hygiene's rigorous demonstration of capability training program and are capable of operating all testing equipment and performing all test methods required for your testing project. Testing Managers assist Project Managers by leading the field testing when required, preparing draft reports, calibrating equipment, and overseeing testing team on-site. **AIR HYGIENE**'s staff includes **three (3) QSTI certified** testing managers.

Test Engineers have significant background and understanding of emission testing or related services. Test Engineers prepare pre-test drawings for port location, ensure on-site logistics for electrical and mechanical/structural needs, and conduct on site testing as directed by the Project Manager and/or Testing Manager. Test Engineers often have special understanding of process and/or regulations applicable to specific testing jobs, which provide great value to both the client and Project Manager in testing strategies.

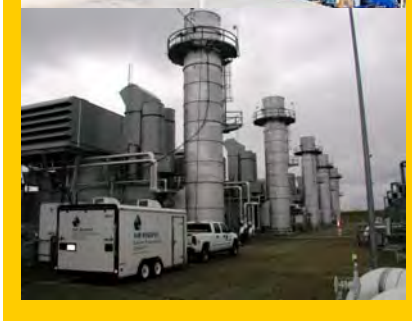
Test Technicians experience ranges from new hire with technical degree and experience to technicians who have performed 500 emission tests. All test technicians have a basic understanding of emission training and are involved in daily training and under supervision to continue to develop testing skills. Each have testing experience with **AIR HYGIENE** equipment along with a variety of industries and source equipment. Test Technicians may operate isokinetic sampling trains or gas analyzers on-site under the direction of the Project Manager and assist with preparation of field reports and quality assurance procedures.

Staff Technicians are entry-level personnel who have performed less than 500 emission tests. Staff Technicians perform pre-test equipment preparation, on-site test preparation, and testing assistance under the direction of Project Manager and/or Testing Manager. Staff Technicians connect sampling probes to ports, raise and lower equipment to and from sampling platform, and other support activities under the direction of the Project Manager and/or Testing Manager.

Testing Assistants are entry-level personnel who have performed less than 100 emission tests. Testing Assistants help with equipment set-up, teardown, and simple testing procedures (i.e. move probe, fill ice bath, clean impingers, etc.) as directed.

TESTING EXPERIENCE

AIR HYGIENE testing personnel include **fifteen (15) QSTI certified** test managers and account for more than one hundred fifty (150) years of combined testing experience and over 20,000 emission tests. Our testing services have involved interaction with all 50 state agencies and EPA regional offices. **AIR HYGIENE** testing personnel are rigorously trained on EPA reference test methods from 40 CFR Part 51, 60, 63, and 75 along with ASTM methods. All testing personnel are instructed and tested on test responsibilities and must complete a "Demonstration of Capability" test per the **AIR HYGIENE** Quality Assurance Manual and the **AIR HYGIENE** Emission Testing Standard Operating Procedures Handbook.



AIR HYGIENE has completed testing on over 500 power plants including in excess of 2,500 combustion turbines and 100 coal fired boilers 250,000 megawatts (MW). ***Let us add your project to our list of satisfied customers!***

TESTING SUCCESS STORIES

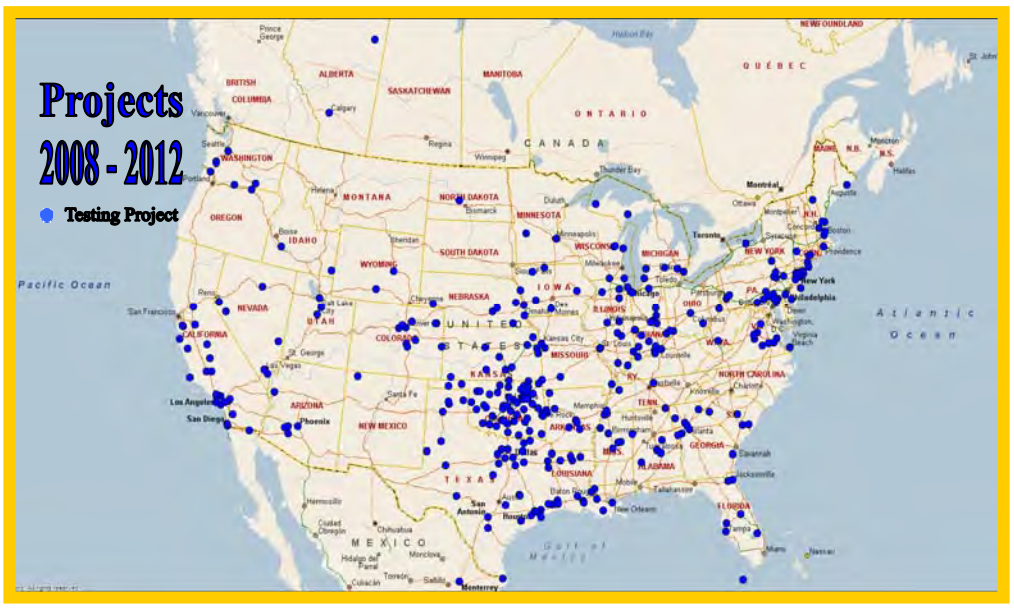
AIR HYGIENE personnel have performed thousands of testing projects which have yielded significant benefits for our clients. The following project descriptions briefly discuss some of these emission testing projects.

- Conducted **Mercury (Hg)**, PM, selected metals, HCl, Chlorine, and gas testing to verify status with the industrial boiler MACT on six coal fired units at three (3) locations.
- Conducted inlet/outlet baghouse emission testing for **Mercury (Hg)** to determine control efficiency using Ontario-Hyrdo testing methodology.
- Conducted numerous projects optimizing SCR performance by conducting inlet & outlet SCR analysis for NH_3, NOx, flow, and Oxygen. Used information to assist with flow optimization and AIG tuning.
- Conducted federal and state required compliance testing for NOx, CO, PM-10 (front & back-half), SO_2, VOC, Ammonia, Formaldehyde, Opacity, RATA testing (NOx and CO) for new and updated power plants with both simple and combined cycle turbines firing natural gas and fuel oil.
- Conducted dry low NOx burner tuning and performance testing for various models of GE, Siemens Westinghouse, Mitsubishi, Pratt & Whitney, and ABB combustion turbines to verify manufacturer's emission guarantees for clients in preparation for compliance testing.
- Performed power plant emission testing for natural gas & fuel oil fired combustion turbines. Tests included federal required testing per 40 CFR Part 75, state air permit requirements, RATA testing, and emission testing to verify manufacturer's guarantee's during electric/heat output performance testing.

TESTING LOCATIONS

AIR HYGIENE bases mobilization charges on the distance from your site to the closest of seven (7) regional starting points covering all 50 United States. These include Las Vegas, Tulsa, Houston, Fort Worth, Shreveport, Atlanta, and Philadelphia.

Each start point is located such that the **AIR HYGIENE** test teams can mobilize to your site within 24 hours at affordable costs to ensure we are price competitive to any U.S. location.



AIR HYGIENE, INC.

Testing Solutions for a Better World

COMBUSTION TESTING SERVICES SUMMARY

Thank you for your consideration of the combustion emission testing services of Air Hygiene International, Inc. (**AIR HYGIENE**). The following list details the testing services and extras **AIR HYGIENE** includes with each testing job.

Types of Air Testing Services for Combustion Sources:

- Boiler or Turbine tuning/mapping for NOx, CO, O2, CO2, flow, temperature, &/or NH_3 emissions
- Pollutant testing to verify EPC contractual emission guarantees
- Research and Development (R&D) emission data research and emissions optimization
- **Mercury (Hg) testing with on-site data**
- 40 CFR Part 60 Subpart GG or KKKK – Turbine Compliance Testing
- 40 CFR Part 75 – Acid Rain Classified Equipment Testing
- 40 CFR Part 75 Appendix E – Peaking Plant CEMS alternative NOx emissions versus Heat Input mapping
- RATA Testing on CEMS systems for NOx, CO, SO_2, CO_2 or O_2, Flow (3-D & Wall effects)
- QA/QC Plans, Monitoring Plans, Linearity Checks, Testing Protocols, etc. are provided with our high quality, service oriented emission testing services
- Initial permit compliance testing for PM, PM-10, PM-2.5, SO_2, NOx, CO, H2SO4, HCl, Hg, exhaust flow, moisture, O_2, CO_2, Ammonia, Formaldehyde, other HAPs

AIR HYGIENE will provide the following testing services:

- On-site, real-time test data
- Fuel F-Factor calculation data sheet
- Experienced emission testing personnel
- Flexible testing schedules to meet your needs
- Electronic reports provided on CD upon request
- Extensive experience with all 50 state agencies in the U.S., Mexico, & Canada
- EPA Protocol 1 Certified Gases (one percent accuracy) for precise calibration
- Low range (0-10 ppm) equipment calibration and measurement available
- Test protocol preparation, coordination with state agency, and site personnel
- Numerous mobile testing labs, which may be used for your projects across the U.S.
- State-of-the-art data logging technology to allow real-time examination of meaningful emission data
- Monitor your emissions data measured in our test lab from your control room via our datalogging network system and/or 4-20 mA output data directly fed to your DAHS!

AIR HYGIENE is committed to providing testing teams that will take the time to meet your needs. We ensure the job is completed on time with the least amount of interruption to your job and site operation as possible. Thank you for considering our services.

AIR HYGIENE, INC.

Testing Solutions for a Better World

SYNERGISTIC APPROACH TO POWER PLANT CONSTRUCTION PROJECT TESTING

Power plants continue to be built, modified, and improved across the United States. These new or modified facilities are at the forefront of clean energy. Emission rates and limits continue to decrease. These units are very efficient, environmentally friendly, and meet the stringent requirements set forth by the Environmental Protection Agency (EPA) and associated state agencies. **AIR HYGIENE** has developed a unique strategy to help owners demonstrate compliance with testing solutions for difficult sampling locations to meet complicated requirements.

Unique Testing Strategy

AIR HYGIENE has developed a synergistic approach to assisting the various groups involved in the completion of a commissioning/startup unit or modification project. **AIR HYGIENE** strives to combine the multiple testing aspects involved with bringing a combustion unit to commercial service. By conducting the various emission tests required for a new combustion unit using one test company, the following benefits are a given:

1. Save money by…
    a. Reduced mobilizations
    b. Combined tests yield reduced fuel usage and site time
    c. Bulk projects receive quantity discounts
2. Improve efficiency through familiarity with site needs
3. Site personnel and testing team are comfortable working together

These projects typically involve some or all of the following groups. There is not a defined set of responsibilities that will match every project. The table below simply suggests a typical list of testing responsibilities.

Responsible Party	**Testing Responsibilities**
Owner	Initial and on-going federal and state compliance testing (i.e. NSPS Sub GG, Part 75, Operating Air Permit, etc.)
Operator	Initial and on-going federal and state compliance testing (i.e. NSPS Sub GG, Part 75, Operating Air Permit, etc.)
Turbine/Boiler manufacturer	Contractual emission guarantees of unit (i.e. NOx, SO2, CO, VOC, PM-10, NH3, H2SO4)
EPC & Construction Company	Contractual emission guarantees including control devices (i.e. NOx, SO2, CO, VOC, PM-10, NH3, H2SO4)
CEMS Supplier	Initial RATA testing (i.e. NOx, CO, SO2, CO2, O2, flow)
Lending Party (i.e. bank)	No responsibility, but concerned with outcome of all tests
Environmental Consultant	Concerned with air permit and overall compliance; may select the test contractor and provide oversight for testing

Example Project:

A recent project provides a prime example of the synergistic benefits of using **AIR HYGIENE** to perform your commissioning/startup or remodification testing needs for performance and compliance. Eight GE Frame 7FA turbines were taken from performance testing through compliance testing in 20 days. The following tests were performed on each turbine:

- NOx tuning and mapping
- Contractual performance testing for NOx, CO, VOC, SO_2, NH_3, & PM_{10}
- 40 CFR Part 60 Subpart GG: testing for NOx and CO at max load
- 40 CFR Part 75: NOx & CO RATA certification on CEMS
- State required compliance testing for NOx, CO, VOC, NH_3(on-site analysis), formaldehyde (on-site analysis by FTIR), opacity and SO_2 burning natural gas

Test data was provided on-site for all tests, except PM-10. Electronic files were e-mailed for review to the turbine manufacturer, owner & operator, and environmental consultant within 24 hours following completion of site work. Complete reports including PM-10 were submitted to interested parties within 10 days following each blocks completion.

Power Plant Testing Experience

AIR HYGIENE personnel have over one hundred (100) years of testing experience on combustion turbines, coal fired boilers, gas fired boilers, landfill gas, wood fired, & diesel fired engines across the United States. **AIR HYGIENE** has 15 combustion labs serving all 50 states from one corporate office in Tulsa, OK and five (5) additional field offices (Houston, TX; Ft. Worth, TX; Shreveport, Louisiana; Las Vegas, NV; & Philadelphia, PA). **AIR HYGIENE** has tested plants ranging from 50 to 2,000 megawatts in both simple and combined cycle operation with controls including:

- Selective Catalytic Reduction - Ammonia injection
- Steam/Water injection
- Sprint injection
- Dry Low NOx burners (DLN)

AIR HYGIENE has completed testing at over 500 plants on 2,500 combustion turbines, 100 coal fired boilers, 100 gas fired boilers, and other sources representing 250,000 plus megawatts (MW). **AIR HYGIENE** has proven through our numerous projects that we can be relied upon for uncompromised quality, service flexibility, and loyalty to our clients no matter where the job nor what the situation may be. ***Let us add your upcoming project to our list of satisfied customers!***

Relative Accuracy Test Audit (RATA) Services

AIR HYGIENE, INC.

Why Air Hygiene is the Clear Choice for your next RATA:

- Interim Accredited AETB
- On-site Draft RATA Reports!
- Reviewed Draft Report in 5 Days!
- Ammonia RATAs On-site!
- Time Shared CEMS RATA Testing!
- RATAs on Dilution Systems!
- PM-10 and Hg RATA Testing!
- CEMS XML Reporting by ECMPS!
- Quarterly Linearity/CGA Testing!
- Rental of EPA Protocol Gases!
- CEMS XML Reporting by ECMPS!
- 3-D Flow RATA Testing!
- Hard working, Flexible Testing Team
- Over 5,000 Rata Tests Performed

Corporate Headquarters:
1600 West Tacoma Street
Broken Arrow, OK 74012

(918) 307-8865
(888) 461-8778

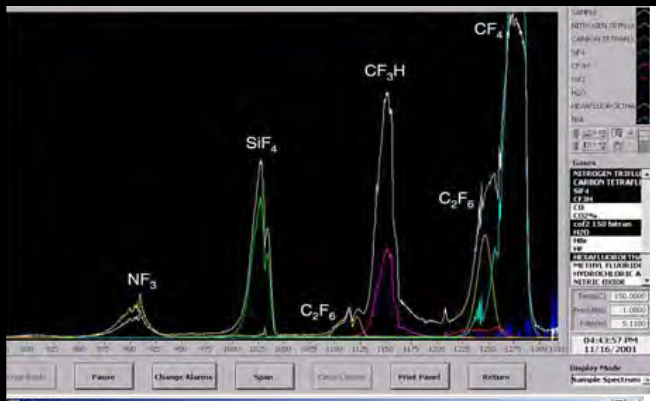
AIR HYGIENE, INC.

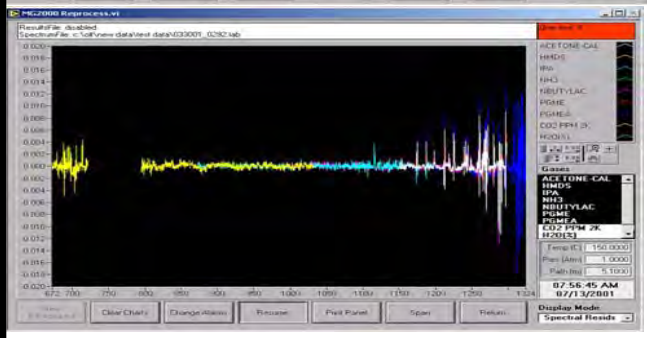
Remote Office Locations:
Las Vegas, NV 89156
Ft. Worth, TX 76028
Humble, TX 77338
Shreveport, LA 71115
Philadelphia, PA 19136

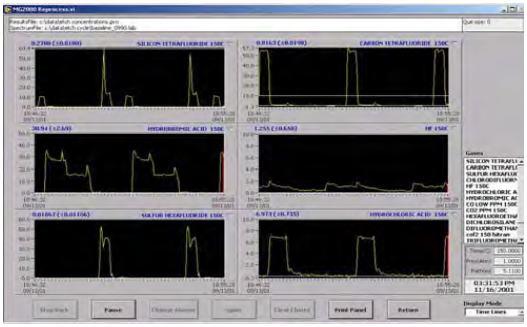
WWW.AIRHYGIENE.COM

Fourier Transform Infrared (FTIR) Spectroscopy

AIR HYGIENE, INC.







Why Air Hygiene FTIR Labs are the Solution for your Testing Needs!

- **Five (5) FTIR labs for formaldehyde, VOCs, & HAPS by EPA Method 320/321 & ASTM D-6348!**
- **Real-time data on-site for evaluation!**
- **On-site draft test reports & final report in 5 Days!**
- **Catalyst performance analysis (inlet & outlet testing) on-site with real-time data!**
- **Greenhouse Gases measured real-time, on-site (N2O, CO2, CH4)!**
- **SCR tuning with point-by-point data, real-time for NH3, NO, & NO2!**
- **Speciated VOC's on-site!**
- **Portable power by on-board generator!**
- **Hard Working, Flexible Testing Teams!**

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Combustion Engine Testing

AIR HYGIENE, INC.

Why Air Hygiene is the Solution for your Engine Testing!

- Five (5) FTIR Labs for formaldehyde, VOCs, & HAPS!
- Twenty (20) test labs providing testing anytime & anywhere!
- On-site draft test reports & final report in 10 Days!
- Catalyst performance analysis (in/out CO measurement on-site!
- Portable power by on-board generator!
- LDEQ, CARB, & SCAQMD Certified!
- MACT Floor testing for over 80 engines!
- VOC's by on-site GC for methane/ethane!
- Part 60 - JJJJ Testing (NOx, CO, VOC)!
- RICE MACT (Part 63 - ZZZZ) Testing!
- Hard Working, Flexible Testing Teams!
- Tests in all 50 states, Mexico, & Canada!

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Shreveport, LA 71115
Miami, FL 33101
Philadelphia, PA 19136

INSTRUMENT CONFIGURATION AND OPERATIONS FOR GAS ANALYSIS

The sampling and analysis procedures used by **AIR HYGIENE** during tests conform in principle with the methods outlined in the Code of Federal Regulations, Title 40, Part 60, Appendix A, Methods 3a, 6c, 7e, 10, 18, 19, 20, and 25a.

The flowchart on the next page depicts the sample system used by **AIR HYGIENE** for analysis of oxygen (O_2), carbon dioxide (CO_2), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC) tests. A heated stainless steel probe is inserted into the sample ports of the stack to extract gas measurements from the emission stream. The gas sample is continuously pulled through the probe and transported via 3/8 inch heat-traced Teflon® tubing to a stainless steel minimum-contact condenser designed to dry the sample through Teflon® tubing via a stainless steel/Teflon® diaphragm pump and into the sample manifold within the mobile laboratory. From the manifold, the sample is partitioned to the O_2, CO_2, SO_2, CO, and NOx analyzers through glass and stainless steel rotameters that control the flow rate of the sample. The VOC sample is measured as a wet gas.

The flowchart shows that the sample system is also equipped with a separate path through which a calibration gas can be delivered to the probe and back through the entire sampling system. This allows for convenient performance of system bias checks as required by the testing methods.

All instruments are housed in an air-conditioned trailer which serves as a mobile laboratory. Gaseous calibration standards are provided in aluminum cylinders with the concentrations certified by the vendor. EPA Protocol No. 1 is used to determine the cylinder concentrations where applicable (i.e. NO_x calibration gases).

All data from the continuous monitoring instruments are recorded on a Logic Beach Hyperlogger which retrieves calibrated electronic data from each instrument every second and reports an average of the collected data every 30 seconds and 10 seconds. The averaging time can be selected to meet the clients needs. **This data is available instantaneously for printout, statistical analysis, viewable by actual values, or examined by a trending graph!**

The number of test runs, test loads, and length of runs is based upon federal and state requirements for the facility. Typical run times associated with emission testing are as follows:

Type of Test	# of runs	Length of runs
O_2 Traverse (GG)	1 run @ low load (8 – 48 points)	2 minutes per point
NOx Stratification Test	1 run @ base load (12 points)	2 – 4 minutes per point
Subpart GG or KKKK	3 runs @ 4 loads (30%, 50%, 75%, & 100%)	15 – 60 minutes per run
RATA	9 – 12 runs @ normal load	21 minutes per run
State Permit Test (gases)	3 runs @ base load	1 hour per run
State Permit Test (particulates)	3 runs @ base load	2 – 4 hours per run

The stack gas analysis for O_2 and CO_2 concentrations are performed in accordance with procedures set forth in EPA Method 3a (EPA Method 20 for O_2 on combustion turbines). The O_2 analyzer uses a paramagnetic cell detector. The CO_2 analyzer uses an infrared detector.

CO emission concentrations are quantified in accordance with procedures set forth in EPA Method 10. A continuous nondispersive infrared (NDIR) analyzer is used for this purpose.

NOx emission concentrations are measured in accordance with procedures set fort in EPA Method 7e and/or 20. A chemiluminescence analyzer is used to determine the nitrogen oxides concentration in the gas stream.

Total hydrocarbons (THC), non-methane, non-ethane hydrocarbons also known as volatile organic compounds (VOC) are analyzed in accordance with procedures set forth in EPA Methods 18 & 25a. A flame ionization detector calibrated with methane is used to determine the THC concentration in the gas stream and VOCs analyzed by GC to determine methane, ethane, and remaining VOCs per EPA Method 18 determination with gas chromatograph using FID detector.

TESTING QUALITY ASSURANCE ACTIVITIES

A number of quality assurance activities are undertaken before, during, and after turbine testing projects. This section describes each of those activities.

Each instrument's response is checked and adjusted in the field prior to the collection of data via multi-point calibration. The instrument's linearity is checked by first adjusting its zero and span responses to zero nitrogen and an upscale calibration gas in the range of the expected concentrations. The instrument response is then challenged with other calibration gases of known concentration and accepted as being linear if the response of the other calibration gases agreed within ± two percent of range of the predicted values.

NO_2 to NO conversion is checked via direct connect with a EPA Protocol certified concentration of NO_2 in a balance of nitrogen. Conversion is verified to be above 90 percent.

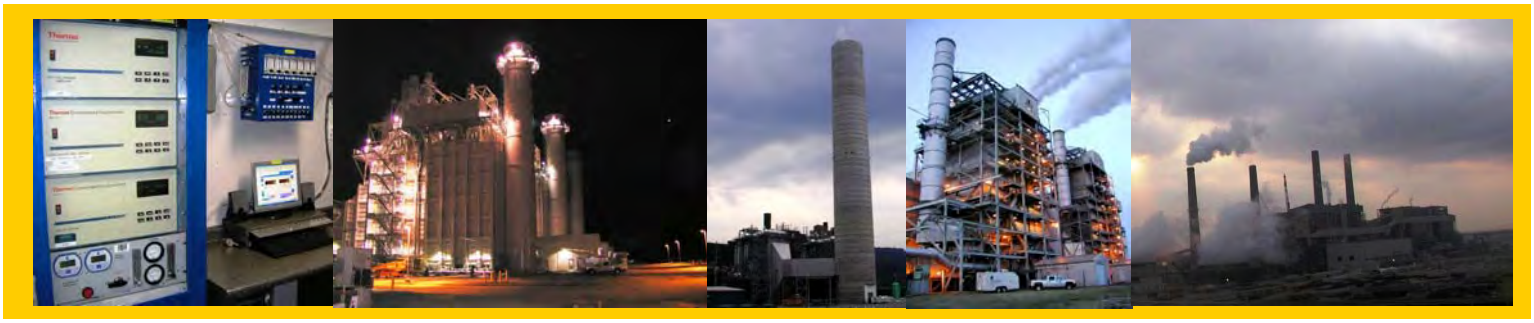
Instruments are both factory tested and periodically field challenged with interference gases to verify the instruments have less than a two percent interference from CO_2, SO_2, CO, NO, and O_2.

After each test run, the analyzers are checked for zero and span drift. This allows each test run to be bracketed by calibrations and documents the precision of the data collected. The criterion for acceptable data is that the instrument drift is no more than three percent of the full-scale response. Quality assurance worksheets summarize all multipoint calibration linearity checks and the zero to span checks performed during the tests are included in the test report.

The sampling systems is leak-checked by demonstrating that a vacuum greater than 10 in. Hg can be held for at least one minute with a decline of less than one in. Hg. A leak test is conducted after the sample system is set up and before the system is dismantled. This test is conducted to ensure that ambient air does not dilute the sample. Any leakage detected prior to the tests is repaired and another leak check conducted before testing will commence.

The absence of leaks in the sampling system is also verified by a sampling system bias check. The sampling system's integrity is tested by comparing the responses of the analyzers to the responses of the calibration gases introduced via two paths. The first path is directly into the analyzers and the second path includes the complete sample system with injection at the sample probe. Any difference in the instrument responses by these two methods is attributed to sampling system bias or leakage. The criterion for acceptance is agreement within five percent of the span of the analyzer.

The control gases used to calibrate the instruments are analyzed and certified by the compressed gas vendors to ± one percent accuracy for all gases. EPA Protocol No. 1 is used, where applicable, to assign the concentration values traceable to the National Institute of Standards and Technology (NIST), Standard Reference Materials (SRM). The gas calibration sheets as prepared by the vendor are included in the test report.



QUALITY ASSURANCE PROGRAM SUMMARY

AIR HYGIENE has received interim accreditation from the Source Testing Accreditation Council (STAC) per ASTM D7036 as an Air Emission Testing Body (AETB). Air Hygiene also maintains current accreditation from LDEQ, CARB, SCAQMD, and PADEP.

AIR HYGIENE has **fifteen (15) Qualified Stack Testing Individuals (QSTI)** on staff providing testing leadership for every testing project.

AIR HYGIENE ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA team and encompasses five major areas:

1. QA reviews of reports, laboratory work, and field testing;
2. Equipment calibration and maintenance;
3. Chain-of-custody;
4. Training; and
5. Knowledge of current test methods.

QA Reviews

AIR HYGIENE's review procedure includes review of each source test report, along with laboratory and fieldwork, by the QA Team.

The most important review is the one that takes place before a test program begins. The QA Team works closely with technical division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance

The equipment used to conduct the emission measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the Environmental Protection Agency. Quality control checks are also conducted in the field for each test program. Finally, **AIR HYGIENE** participates in a PT gas program by analyzing blind gases semi-annually to ensure continued quality.

Chain-of-Custody

AIR HYGIENE maintains full chain-of-custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, **AIR HYGIENE** documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.). Samples are stored in a locked area to which only **AIR HYGIENE** personnel have access. Field data sheets are secured at **AIR HYGIENE**'s offices upon return from the field.

Training

Personnel's training is essential to ensure quality testing. **AIR HYGIENE** has formal and informal training programs, which include:

1. A requirement for all technicians to read and understand Air Hygiene Incorporated's QA manual;
2. In-house training relating to 40 CFR Part 60 Appendix A methods and QA meetings on a regular basis;
3. OSHA 40 hour Hazwopper Training;
4. Visible Emission (Opacity) Training;
5. Maintenance of training records.

Knowledge of Current Test Methods

With the constant updating of standard test methods and the wide variety of emerging test procedures, it is essential that any qualified source tester keep abreast of new developments. **AIR HYGIENE** subscribes to services, which provide updates on EPA reference methods, rules, and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences. **AIR HYGIENE** personnel maintain membership in various relevant organizations associated with gas fired turbines.

February 5, 2011

To Whom It May Concern,

RE: Air Hygiene Accreditation

Air Hygiene is committed to the highest quality of emission testing services. In efforts to ensure continuous compliance with testing requirements provided with exceptional expertise to benefit the customer, Air Hygiene is committed to a rigorous training program as part of our QA/QC plan and participates in accreditation by 3rd party auditors and state/federal agency programs.

Air Hygiene ownership believes in training and demonstration of capabilities through testing and performance. Air Hygiene has fifteen (15) Qualified Stack Testing Individuals (QSTI) covering all four (4) group methods. These QSTI certified personnel lead all projects and oversee all testing. Air Hygiene has received interim accreditation from the Stack Testing Accreditation Council (STAC) for our ASTM D7036 application. This program is still in its startup phase and has not completed any field audits, but our plan is to be in the first group of field audited companies. Meanwhile, Air Hygiene has developed an ASTM specific QA/QC plan following ISO 17025 and it was approved in our initial company review allowing interim accreditation. Air Hygiene has also been accredited by state audit programs in Louisiana and California.

Finally, Air Hygiene continues to push for the highest quality in testing services and skills on the site for our customers. The planned development of the Air Hygiene Training Center at our new corporate headquarters will help further this goal. In addition, it will provide opportunities for our peers and respective observing agencies to receive training opportunities in a controlled setting representative of true field sites. Expected completion of the Air Hygiene Training Facility is schedule for April, 2011!

STACK TESTING ACCREDITATION COUNCIL
500 W. Wood Street, Palatine, IL, director@betterdata.org

June 9, 2010

Quinn Bierman
Air Hygiene International, Inc.
5634 South 122nd East Avenue, Suite F
Tulsa, Oklahoma 74146

Dear Mr. Bierman,

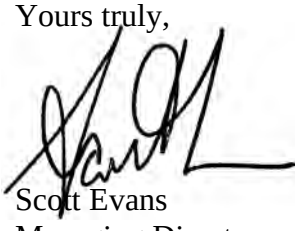
On behalf of the STAC Board of Directors, I am pleased to inform you that Air Hygiene International, Inc. has been granted interim accreditation by the Stack Testing Accreditation Council (STAC). After careful review of your Quality System documentation and procedures, STAC has determined that they are in conformance with ASTM D7036-04 "Standard Practice for the Competency of Air Emission Testing Bodies". Final accreditation is contingent upon successful completion of your field audit. Please see Module 3 of STAC policy documentation for scheduling requirements.

During this period of interim accreditation, Air Hygiene may not claim to be a STAC accredited organization. This requires evidence that your Quality System is effectively implemented in your organization as determined by the field assessment. You may claim, however, that your Quality System meets ASTM D7036 requirements.

Please note that the Attestation of Compliance you signed as part of your application for accreditation requires Air Hygiene to be in continuous compliance with the provisions of ASTM D7036. You are also required to comply with all relevant STAC policies and procedures. I encourage you to review this information.

If you have any questions, please feel free to contact me at 847-654-4569. Thank you for your participation in the STAC process and congratulations.

Yours truly,



Scott Evans
Managing Director

cc: Scott Swiggard, STAC Chair