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**Source Test Report for
2023 Subpart YYYY Formaldehyde Testing
Combined Heat and Power Unit
(EUCPP-CHPHRSG)**

**The University of Michigan-Central Power Plant
(State Registration Number: M0675)
Ann Arbor, Michigan**

Prepared For:

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For Submission To:

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**U.S Environmental Protection Agency, Region 5
Air Enforcement & Compliance Assurance Branch (AECAB)
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Document Number: MW049AS-029439-RT-1-40

Test Dates: October 31, 2023

Submittal Date: December 20, 2023



Review and Certification

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature:



Date: December 18, 2023

Name: John Nestor

Title: District Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature:



Date:

December 19, 2023

Name:

Blake Ericson

Title:

Business Development Manager

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1.0 Introduction

1.1 Summary of Test Program

The University of Michigan contracted Montrose Air Quality Services, LLC (Montrose) to perform a compliance test program on the Combined Heat and Power Unit (EUCPP-CHPHRSG) at the University of Michigan-Central Power Plant facility (Facility ID: M0675) located in Ann Arbor, Michigan. Testing was performed on October 31, 2023 to satisfy the emission testing requirements pursuant to Michigan Department of Environment, Great Lakes, and Energy (EGLE) Renewable Operation Permit No. MI-ROP-M0675-2021b and 40 CFR Part 63 Subpart YYYYY.

The specific objectives were to:

- Verify the emissions of CH₂O from EUCPP-CHPHRSG Exhaust Stack while burning NG at 90-110% load (High Load)
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

Table 1-1
Summary of Test Program

Test Date(s)	Unit ID/ Source Name	Activity/Parameters	Test Methods	No. of Runs	Duration (Minutes)
10/31/2023	EUCPP-CHPHRSG (High Load)	O ₂	EPA 3A	3	60
10/31/2023	EUCPP-CHPHRSG (High Load)	Moisture, CH ₂ O	EPA 320	3	60

To simplify this report, a list of Units and Abbreviations is included in Appendix D.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized and compared to their respective permit limits in Table 1-2. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The testing was conducted by the Montrose personnel listed in Table 1-4. The tests were conducted according to the test plan (protocol) dated August 25, 2023 that was submitted to EGLE and USEPA EPA and approved by EPA via email dated 9/1/2023.

Table 1-2
Summary of Average Compliance Results – EUCPP-CHPHRSG (High Load)
October 31, 2023

Parameter/Units	Average Results	Emission Limits
Formaldehyde (CH₂O)*		
ppbvd @ 15% O ₂	<24	91

* The "<" symbol indicates that the compound was below the Minimum Detection Limit (MDL) of the analytical method. See Section 4.2 for details.

1.2 Key Personnel

A list of project participants is included below:

Facility Information

Source Location: The University of Michigan – Central Power Plant
 1239 Kipke Drive
 Ann Arbor, MI 48109

Project Contact: Brandi Campbell - Environment, Health and Safety Department
 Role: Sr. Environmental Specialist
 Company: The University of Michigan
 Telephone: 734-647-9017
 Email: campbelb@umich.edu

Agency Information

Regulatory Agency:	EGLE-AQD	USEPA, Region 5
Agency Contact:	Andrew Riley	Jacob Herbers, AECAB
Telephone:	586-565-7379	312-886-0405
Email:	RileyA8@michigan.gov	Herbers.Jacob@epa.gov

Testing Company Information

Testing Firm: Montrose Air Quality Services, LLC
 Contact: John Nestor
 Title: District Manager
 Telephone: 248-765-5032
 Email: jonestor@montrose-env.com

Test personnel and observers are summarized in Table 1-4.

Table 1-4

Test Personnel and Observers

Name	Affiliation	Role/Responsibility
John Nestor	Montrose	Field Technician, QI
Roy Zimmer	Montrose	Field Technician
Brandi Campbell	University of Michigan	Test Coordinator

2.0 Plant and Sampling Location Descriptions

2.1 Process Description, Operation, and Control Equipment

The combined heat and power unit (CHP) with heat recovery steam generator (HRSG) (EUCPP-CHPHRSG) produces a nominal 15.8 MW of electricity. The primary fuel for the turbine is natural gas, but it is also capable of firing ultra-low sulfur diesel (ULSD) as a back-up fuel. The combustion gas turbine (CTG) is a Solar Titan 130E with a rating of 190.1 MMBtu/hr (HHV) when firing natural gas and 173.4 MMBtu/hr (HHV) when firing ULSD. The HRSG is equipped with a natural gas-fired duct burner rated at 112 MMBtu/hr (HHV) to provide heat for additional steam production. The HRSG is not capable of operating independently from the CTG. The natural gas duct burner is not operated when ULSD is being fired in the turbine. The CTG/HRSG is equipped with dry low NO_x combustion technology, selective catalytic reduction (SCR) and an oxidation catalyst. The oxidation catalyst was recently installed to meet Subpart YYYYY and assist in the control of formaldehyde emissions.

2.2 Flue Gas Sampling Location

Information regarding the sampling location is presented in Table 2-1.

**Table 2-1
Sampling Location**

Sampling Location	Stack Inside Diameter (in.)	Distance from Nearest Disturbance		Number of Traverse Points
		Downstream EPA "B" (in./dia.)	Upstream EPA "A" (in./dia.)	
EUCPP-CHPHRSG Exhaust Stack	168.0	>336.0 / >2.0	>84.0 / >0.5	Gaseous: 1

See Appendix A.1 for more information.

2.3 Operating Conditions and Process Data

Emission tests were performed while the EUCPP-CHPHRSG and air pollution control devices were operating at the conditions required by the permit. EUCPP-CHPHRSG was tested during High Load Range (90-110% load). The duct burners of the EUCPP-CHPHRSG were off during the test event.

Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B. Data collected includes the following parameters:

- CT6 Temperature and Ambient Temperature, °F
- Gas Fuel Flow, kscfh
- Output, kW

3.0 Sampling and Analytical Procedures

3.1 Test Methods

The test methods for this test program have been presented in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 3A, Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)

EPA Method 3A is an instrumental test method used to measure the concentration of O₂ and CO₂ in stack gas. The effluent gas is continuously or intermittently sampled and conveyed to analyzers that measure the concentration of O₂ and CO₂. The performance requirements of the method must be met to validate data.

The typical sampling system is detailed in Figure 3-1.

3.1.2 EPA Method 320, Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive FTIR Spectroscopy

FTIR data were collected using an MKS MultiGas 2030 FTIR spectrometer configured with a StarBoost system. The StarBoost technology consists of a 5-micron infrared detector, optical filtration and signal amplification. It is designed to optimize signal response and limit instrument noise for low detection limit applications. The FTIR was equipped with a temperature-controlled, 5.11-meter multipass gas cell maintained at 191°C. All data were collected in differential mode with 2 cm⁻¹ resolution sample data and 8 cm⁻¹ resolution background. Each FTIR spectrum was derived from the coaddition of 220 scans, with a new data point generated approximately every 60 seconds.

Sample gas continuously flew through the FTIR gas cell via heated head sampling pump. Total sample flow was approximately eight liters per minute. Gas flow and sampling system pressure were monitored using a rotameter and pressure transducer. See Table 1 below for sampling system details. The typical sampling system is detailed in Figure 3-1.

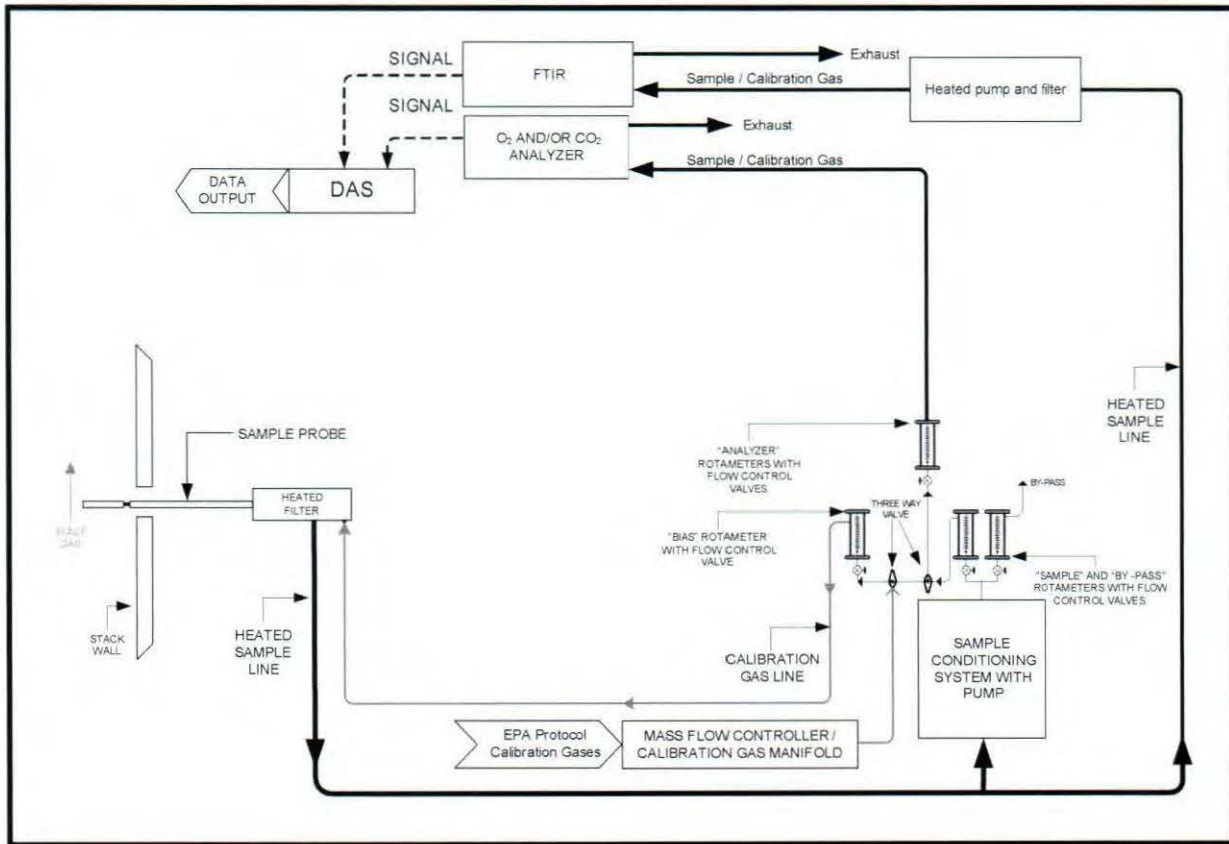
StarBoost™ FTIR QA/QC Methodology

QA/QC procedures followed US EPA Method 320. See Table 3-1 below for QA/QC procedure details and list of calibration gas standards. All calibration gases were introduced to the analyzer and sampling system using instrument grade stainless steel rotameters. All QA/QC procedures were within the acceptance criteria allowance of the EPA methodology. QA/QC calculations are presented in detail below. FTIR diagnostics were performed on the instrument daily to ensure signal intensity and line shape were acceptable to make low-level formaldehyde measurements. See the FTIR Diagnostics Appendix for results.

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Figure 3-1
EPA Method 3A and 320 Sampling Train



StarBoost™ FTIR QA/QC Methodology

QA/QC procedures followed US EPA Method 320. See Tables 3-1 below for QA/QC procedure details and list of calibration gas standards. All calibration gases were introduced to the analyzer and sampling system using instrument grade stainless steel rotameters. All QA/QC procedures were within the acceptance criteria allowance of the EPA methodology. QA/QC calculations are presented in detail below. FTIR diagnostics were performed on the instrument daily to ensure signal intensity and line shape were acceptable to make low-level formaldehyde measurements. See the FTIR Diagnostics Appendix for results.

**Table 3-1
Sampling Location**

QAQC Specification	Purpose	Calibration Gas Analyte	Delivery	Frequency	Acceptance Criteria	Result
M320: Zero	Verify that the FTIR is free of contaminants & zero the FTIR	Nitrogen (zero)	Direct to FTIR	Pre/post Test	<MDL or Noise	Pass
M320 Calibration Transfer Standard (CTS) Direct	Verify FTIR stability, confirm optical path length	Methane	Direct to FTIR	Pre-Test	+/- 5% cert. Value	Pass
M320 Analyte Direct	Verify FTIR calibration	Formaldehyde, N2O	Direct to FTIR	Pre-Test	Determine FTIR response to be used for analyte spike calcs	Pass
M320: CTS Response	Verify system stability, recovery, RT	Methane	Sampling System	Pre/post Test	+/-5% Direct Measurement	Pass
M320: Zero Response	Verify system is free of contaminants, system bias	Oxygen, Nitrogen (zero)	Sampling System	Pre/post Test	Bias correct data	Pass
M320: Analyte Spike	Verify system ability to deliver and quantify analyte of interest in the presence of other effluent gases	Formaldehyde, N2O	Dynamic Addition to Sampling System, 1:10 Effluent	Pre-Test	+/- 30% theoretical recovery	Pass

**StarBoost™ FTIR QA/QC Calculations
Method 320: Analyte Spiking**

Formaldehyde spiking was performed at each source prior to and following to testing to verify the ability of the sampling system to quantitatively deliver a sample containing formaldehyde from the base of the probe to the FTIR. The spike target dilution ratio was 1:10 or less. Analyte spiking assures the ability of the FTIR to quantify formaldehyde in the presence of effluent gas.

As part of the spiking procedure, samples from the source were measured before spiking to determine native concentrations to be used in the spike recovery calculations. The analyte spiking gas contained nitrous oxide (N2O). The determined N2O concentration in the spiked sample was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked formaldehyde.

$$DF = \frac{N2O(spik) - N2O(nat)}{N2O(Direct)}$$

$$CS = DF * Spike(dir) + unspike(1 - DF) \quad (\text{sec 9.3.1 (2) USEPA Method 320})$$

DF = Dilution factor of the spike gas

$N_2O_{(dir)}$ = N2O concentration measured directly in undiluted spike gas

$N_2O_{(nat)}$ = Native N2O concentration measured in unspiked samples

$N_2O_{(spk)}$ = Diluted N2O concentration measured in a spiked sample

$Spike_{dir}$ = Concentration of the analyte in the spike standard measure by the FTIR directly

CS = Expected concentration of the spiked samples

Unspike = Native concentration of analytes in unspiked samples

FTIR Post Collection Data Validation

As part of the data validation procedure, reference spectra are manually fit to that of the sample spectra and a concentration is determined. The reference spectra are scaled to match the peak amplitude of the sample, thus providing a scale factor. The scale factor multiplied by the reference spectra concentration is used to determine the concentration value for the sample spectra. Sample pressure and temperature corrections are then applied to compute the final sample concentration. The manually calculated results are then compared with the software generated results. The data is then validated if the two concentrations are within $\pm 20\%$ agreement. If there is a difference greater than $\pm 20\%$ the spectra are reviewed for possible spectra interferences or any other potential causes leading to misquantified data. See the Data Validation Appendix for results.

3.2 Process Test Methods

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

4.0 Test Discussion and Results

4.1 Field Test Deviations and Exceptions

No field deviations or exceptions from the test plan or test methods occurred during this test program.

4.2 Presentation of Results

The average results are compared to the limits in Tables 1-2 and 1-3. The results of individual compliance test runs performed are presented in Tables 4-1 and 4-2. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

Concentration values displayed in Tables 1-2 and 4-1 denoted with a '<' were measured to be below the minimum detection limit (MDL) of the applicable analytical method.

Concentrations denoted with a '<' in Tables 1-2, 1-3, 4-1, and 4-2 were calculated utilizing the applicable MDL concentration value instead of the "as measured" concentration value.

Table 4-1
Formaldehyde Emissions Results -
EUCPP-CHPHRSG (High Load)

Parameter/Units	Run 1	Run 2	Run 3	Average
Date	10/31/2023	10/31/2023	10/31/2023	--
Time	10:55-11:55	13:15-14:15	14:55-15:55	--
Process Data†				
Output, kW	16576	16421	16487	16487
Sampling & Flue Gas Parameters				
O ₂ , % volume dry	14.36	14.46	14.46	14.43
moisture content, % volume	6.49	6.49	6.52	6.50
Formaldehyde (CH₂O)*				
ppmvd	<0.025	<0.025	<0.025	<0.025
ppbvd	<27	<27	<27	<27
ppbvd @ 15% O ₂	<24	<24	<24	<24

* The "<" symbol indicates that the compound was below the Minimum Detection Limit (MDL) of the analytical method. See Section 4.2 for details.

† Testing was done with a T1 temperature averaging 39 °F. Percent load was based off of 16.5 MW.

5.0 Internal QA/QC Activities

5.1 QA/QC Audits

EPA Method 3A calibration audits were all within the measurement system performance specifications for the calibration drift checks, system calibration bias checks, and calibration error checks.

The EPA Method 320 performance parameters measured included signal to noise tests, noise equivalent absorbance (NEA), detector linearity, background spectra, potential interferences, and cell and system leakage. Quality assurance procedures included baseline measurement with ultra-high purity nitrogen, measurement of a calibration transfer standard, direct analyte calibration measurements, and measurements to determine baseline shift. SF₆ was also used as a tracer gas in the calibration gases to evaluate dilution ratios and verify the sample delivery system integrity. A dynamic matrix spike was performed using SF₆ as a tracer gas. The method QA/QC criteria were met.

5.2 QA/QC Discussion

Montrose did not have a Qualified Individual (QI) for EPA Method 3A onsite during the test event as per ASTM D7036-04 requirements. However, upon data review, all EPA Method 3A data quality objectives were met.

5.3 Quality Statement

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043) and the EGLE AQD Document titled "Format for Submittal of Source Emission Test Plans and Reports" (November 2019).



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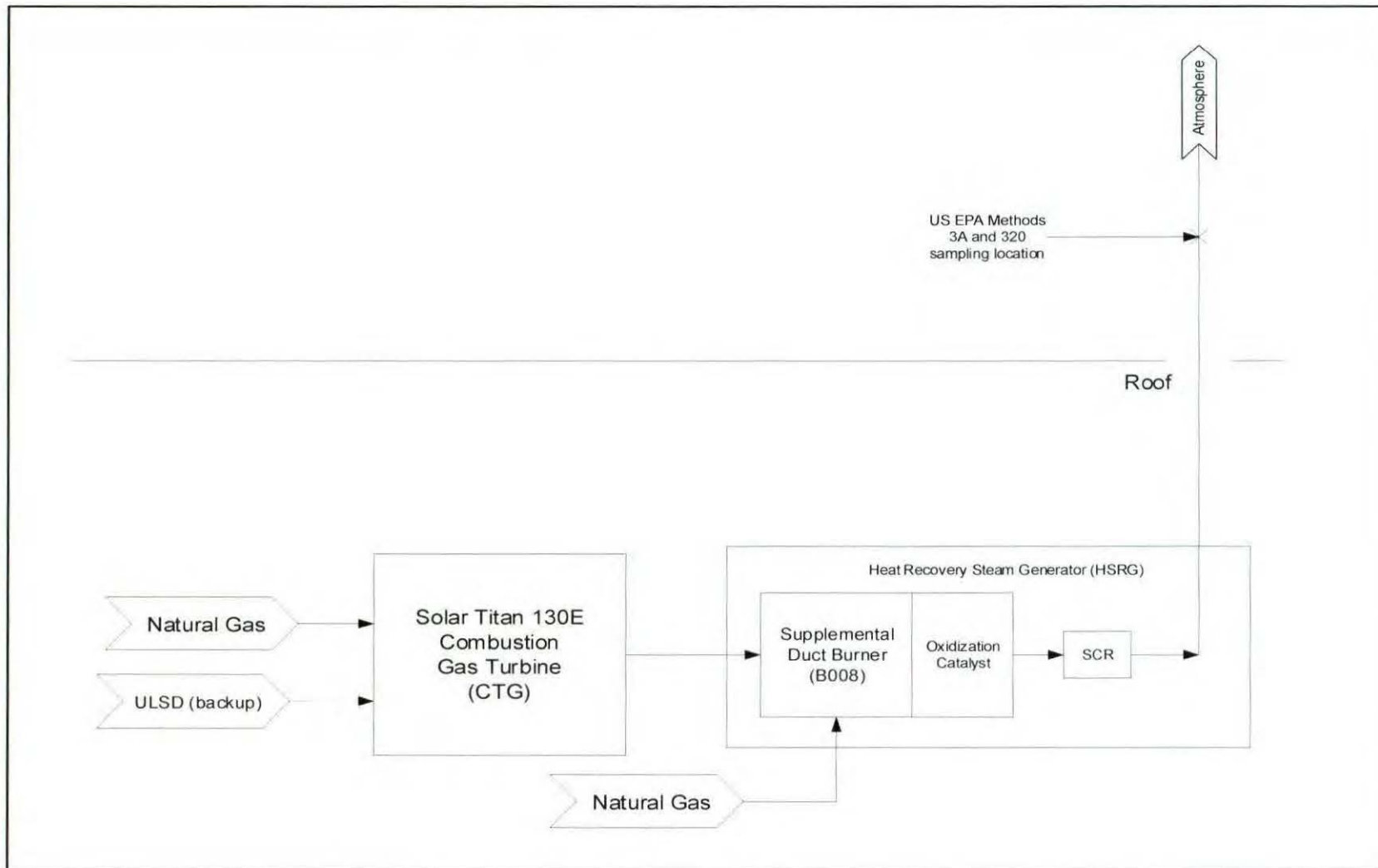
Appendix A

Field Data and Calculations

Appendix A.1

Sampling Locations

EUCPP-CHPHRSR SAMPLING LOCATION SCHEMATIC



Appendix A.2

EUCPP-CHPHSRG (high Load) Data Sheets