

Air Emissions Test Report

Completed for:

***Gainesville Renewable Energy Center
Woody Biomass Power Plant
Biomass-fueled BFB Boiler (EU-002)***

Test Report Number: 20-6132-01-001

Test Completed: November 20 - 23, 2013



Air Emissions Test Report

**Gainesville Renewable Energy Center
Woody Biomass Power Plant
Woody Biomass-fueled BFB Boiler (EU-002)
Gainesville, Florida**

C.E.M. Solutions Project No.: 6132
Fagen PO No: 573552

Testing Completed: November 20 - 23, 2013

C.E.M. Solutions, Inc. Report Number: 20-6132-01-001

C.E.M. Solutions, Inc.
1183 E. Overdrive Circle
Hernando, Florida 34442
Phone: 352-489-4337

**Declaration of Conformance to ASTM D 7036-04:
Standard Practice for Competence of Air Emission
Testing Bodies**

C.E.M. Solutions operates in conformance with the requirements of ASTM D 7036-04: Standard Practice for Competence of Air Emission Testing Bodies through the use of a quality system which incorporates a quality manual, internal audit system, systematic training of personnel and rigorous review of test methods and operating procedures.



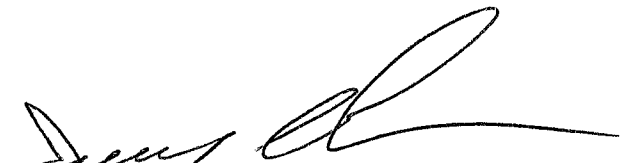
Joe Conti
Quality Assurance Manager
C.E.M. Solutions

Statement of Validity

I hereby certify the information and data provided in this emissions test report for tests performed at the Gainesville Renewable Energy Center's Woody Biomass Power Plant conducted on November 20 through 23, 2013 are complete and accurate to the best of my knowledge.



Joe Conti
Quality Assurance Manager,
C.E.M. Solutions, Inc.



Jeremy Johnson
President,
C.E.M. Solutions, Inc.

Project Background

Name of Source Owner: Gainesville Renewable Energy Center

Address of Owner: 11201 NW Hwy 441
Gainesville, FL 32653

Source Identification: Facility ID: 0010131
Woody Biomass-fueled BFB Boiler
Emissions Unit: 002

Location of Source: Alachua County, Florida

Type of Operation: SIC Code 4911

Tests Performed: Method 1 – Traverse Points
Method 2 – Stack Gas Volumetric Flow and Velocity
Method 3A – Determination of Molecular Weight
Method 4 – Stack Gas Moisture Content
Method 5 – Particulate Matter
USEPA Method 6C - Determination of Sulfur Dioxide
USEPA Method 7E - Determination of Nitrogen Oxides
NCASI Method 8A – Sulfuric Acid Mist
USEPA Method 10 - Determination of Carbon Monoxide
Method 9 – Determination of Opacity of Emissions
Method 19 – Determination of Emission Rates
Method 25A - Determination of VOC
Method 26A - Determination of HCl and HF
Conditional Test Method 027 –Ammonia Slip Determination
Method 29 – Determination of Metals
Method 202 – Determination of Condensable Particulate Matter
Method 316 – Determination of Formaldehyde
SW-846, Method 0010 – Determination of PAH/POM
SW-846, Method 0030 – Volatile Organic Sampling Train

Test Supervisor (QSTI): Mr. Charles Horton

Test Technicians: Mr. Joe Conti
Mr. Josh Cooper
Mr. William Harris
Mr. Alex Houseal
Mr. Derek Kopera
Mr. Michael McDonald
Mr. Matthew Savin

Date(s) Tests Conducted: Nov. 20, 2013: Run 1 for Methods 5, 202, 29, 0010, 0030, 316
Nov. 21, 2013: Run 2 for Methods 5, 202, 29, 0010, 0030, 316
Nov. 22, 2013: Run 3 for Methods 5, 202, 29, 0010, 0030, 316
November 23, 2013: Runs 1 – 4 for Methods 3A, 6C, 7E, 10,
25A 8A, 26A, CTM027

Site Test Coordinator: Eric Johnson, Fagen, Inc. Project Manager

State Regulatory Observers: William Basta of AMEC and Justin Knoll for Alachua City

Table of Contents

1.0	Introduction.....	1
1.1	Errors and Omissions	1
2.0	Facility Description	4
2.1	Process Equipment	4
2.2	Regulatory Requirements.....	4
3.0	Test Program/Operating Conditions.....	6
4.0	Test Methods.....	7
4.1	Sample and Velocity Traverse Points	7
4.1.1	Gaseous Traverse Points and Run Durations	8
4.1.2	Wet Chemistry Traverse Points and Run Durations	8
4.2	Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tubes)	8
4.2.1	Method 2 Quality Assurance/Quality Control Procedures	9
4.3	Moisture Content Determination.....	9
4.3.1	Method 4 Quality Assurance/Quality Control Procedures	9
4.4	Particulate Matter Determination.....	10
4.4.1	Sample Recovery and Analysis.....	10
4.4.2	Quality Assurance/Quality Control Procedures	10
4.5	Condensable Particulate Matter (CPM) Determination	11
4.5.1	Sample Recovery and Analysis.....	11
4.5.2	Quality Assurance/Quality Control Procedures	11
4.6	Sulfuric Acid Mist (NCASI Method 8A).....	12
4.6.1	Sample Recovery and Analysis.....	12
4.6.2	Quality Assurance/Quality Control Procedures	12
4.7	Hydrogen chloride (HCl) and Hydrogen Fluoride (HF)	13
4.7.1	Quality Assurance/Quality Control Procedures	13
4.8	Ammonia Slip Test	14
4.8.1	Quality Assurance/Quality Control Procedures	14
4.9	Mercury and Metals Determination	15
4.9.1	Sample Recovery and Analysis.....	15
4.9.2	Quality Assurance/Quality Control Procedures	16
4.10	Semi-Volatile Organic Compounds Determination.....	16
4.10.1	Method 0010 Quality Assurance/Quality Control Procedures	17
4.11	Volatile Organic Compound Determination	18
4.11.1	Method 0030 Quality Assurance/Quality Control Procedures	18
4.12	NO _x , SO ₂ , CO, O ₂ , CO ₂ and VOC Determination.....	19
4.13	Visible Emission Determination.....	21
5.0	Test Results	22
5.1	Nitrogen Oxides(NO _x)	22
5.2	Sulfur Dioxide (SO ₂)	22
5.3	Sulfuric Acid Mist (SAM).....	22
5.4	Carbon Monoxide (CO)	22
5.5	Hydrogen Chloride (HCl) & Hydrogen Fluoride (HF).....	22
5.6	Particulate Matter	22
5.7	Visible Emissions	23
5.8	Volatile Organic Compounds (THC).....	23
5.9	Ammonia Slip (NH ₃)	23
5.10	Mercury(Hg)	23
5.11	Sum of HCl, HF, Organic HAP and Metal HAP	23

List of Tables

Table 1: Summary of Test Results.....	3
Table 2: Emissions Limitations and Standards	5
Table 3: Test Dates and Unit Load	6
Table 4: Summary of EPA Reference Methods	7
Table 5: Isokinetics Summary	19
Table 6: Summary of Instrumental Reference Methods and Instrumentation	19
Table 7: Reference Method Instrument Ranges and Calibration Gases	21
Table 8: Compliance Test Summary	24
Table 9: Compliance Test Summary	24
Table 10: Sum of HAP Compliance Test Summary	25

Appendices

Appendix A: Facility Operating Data	
Appendix B: Mathematical Equations	
Appendix C: Sample Location Diagram/Traverse Points	
Appendix D: Reference Method QA/QC	
Appendix E: Reference Method Data	
Appendix E-1: Instrumental Methods Test Data	
Appendix E-2: Particulate Matter Test Data	
Appendix E-3: Sulfuric Acid Mist Test Data	
Appendix E-4: Ammonia Slip Test Data	
Appendix E-5: HCl and HF Test Data	
Appendix E-7: Metals Test Data	
Appendix E-8: Volatile Organics Test Data	
Appendix E-9: Semi Volatile Organics Test Data	
Appendix E-10: Formaldehyde Test Data	
Appendix E-11 Method 9	
Appendix F: Laboratory Reports	
Appendix G: Accreditations and Certifications	

1.0 Introduction

Fagen, Inc. retained C.E.M. Solutions, Inc. to conduct air emissions tests at the Gainesville Renewable Energy Center's (GREC) Woody Biomass-fueled BFB Boiler (EU-002) located in Gainesville, Florida.

The test program was used to determine the compliance status of Woody Biomass-fueled BFB Boiler in regards to its emissions limitations and standards outlined in Air Construction Permit 0010131-001-AC and (IB MACT standards, 40CFR63, Subpart DDDDD).

The test program and results are presented and discussed in this report. Table 1 summarizes the target pollutants, test methods used and the permit and/or performance criteria for each pollutant. Test results are detailed and discussed in Section 5.0 of this report.

Eric Johnson of Fagen, Inc. coordinated plant operations throughout the test program. Mr. Knoll of the City of Alachua was present during portions of the test program. All testing was conducted in accordance with test methods promulgated by the USEPA and approved by the Florida Department of Environmental Protection. With approval from the FDEP, the organics were determined using alternate test methods with lower detection limits.

A Stationary Source Audit Sample (SSAS) was ordered from the ERA laboratory and included with the samples delivered to Enthalpy Analytical for analysis. Results of the audit were within the SSAS criteria and the audit sample report is included in Appendix E with the HCl/HF laboratory analysis results report.

Precautions were made, during this test project, to minimize the possibility of contamination. Gloves were worn during train preparation, assembly and recovery. Methods 5/202, 26A, and M0010 were recovered in a separate location from the Methods 0030 and 316 recovery area to avoid background contamination. Efforts were made to keep recovery personnel from entering each trailer (recovery area) during the test program.

1.1 Errors and Omissions

Four (4) compliance runs for gases, HCl/HF, SAM and Ammonia Slip were conducted on December 23, 2013. Run 1 was not used for HCl/HF and SAM due to sample train failures. Run 2 was not used for Ammonia Slip due to sample train failure as well. The remaining three good runs for each of these parameters were used for compliance determination.

Method 3A was used for determining CO₂ and O₂ concentrations for calculation of molecular weight and lb/mmBtu values.

Due to the low level of analytes encountered during the test program, a universal protocol was developed for reporting laboratory analysis values. If the laboratory reported a value to be under the minimum detection level (MDL) or as a “non detect”, the value was reported at the MDL for calculations of emissions. When a value is reported to be above the MDL but below the Limit of Quantification (LOQ, which means the presence of the compound is detected but it could not be accurately determined) the LOQ or reporting limit of the analytical method was used for calculation of emissions. Reported emissions impacted by this reporting protocol include the HCl and HF (Method 26A), SAM (Method 8A), Acetaldehyde (Method 316) and organic compounds (Methods 0010 and 0030). Analytical reports provided by the laboratories detail which analytes were not detected and those below the LOQ.

**Table 1: Summary of Test Results
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Parameter	3 Run Average Emission	Permitted Emissions Rate
Nitrogen oxides	0.052 lb/mmBtu	0.070 lb/mmBtu
Sulfur dioxide	0.000 lb/mmBtu	0.029 lb/mmBtu
Sulfuric acid mist	0.1 lb/hr	1.4 lb/hr
Carbon monoxide	0.02 lb/mmBtu	0.08 lb/mmBtu
HCl and HF	0.04 lb/hr 0.04 lb/hr	2.22 lb/hr
Total Filterable Particulate Matter	0.001 lb/mmBtu	0.015 lb/mmBtu
Condensable Particulate Matter	0.001 lb/mmBtu	No set limit.
Visible Emissions	0.0 %	10% Opacity
Total Hydrocarbons (VOC)	0.003 lb/mmBtu	0.009 lb/mmBtu
Ammonia slip	0.7 ppmvd @ 7% O ₂	10 ppmvd @ 7% O ₂
Mercury	3.2 x10 ⁻⁷ lb/mmBtu	8.0 X 10 ⁻⁷ lb/mmBtu (40CFR63, Subpart DDDDD for Hg)
Chromium, Lead, Manganese and Phosphorus	3.87 TPY	Sum of HCl, HF, Organic HAP and Metal HAP shall not exceed 24.7 tons per year (TPY)
acrolein, benzene, xylene isomers plus ethyl benzene, methylene chloride, methyl chloroform and toluene		
formaldehyde and acetaldehyde		
PAH/POM		

2.0 Facility Description

The Biomass-fueled Bubbling Fluidized Bed Boiler (EU-002) consists of a 100 MW steam turbine electric power generator. The Woody Biomass-fueled BFB Boiler burns clean wood and is rated for a maximum heat input of 1,358 mmbtu/hr.

2.1 Process Equipment

Emission controls consist of the following:

- Nitrogen oxides (NO_x) emissions are controlled by a selective catalytic reduction (SCR) system (via injection of ammonia solution into combustion flue gas).
- Sulfur dioxide (SO₂), acid gases (HCl and HF) and organic compound emissions from the Woody Biomass-fueled BFB Boiler are controlled by an in-duct sorbent injection system.
- PM, NO_x, CO and VOC emissions are controlled by efficient combustion
- Particulate matter (PM/PM10) emissions are controlled by a fabric filter (baghouse).

2.2 Regulatory Requirements

The facility was required to conduct emissions testing to determine compliance with Florida Air Permit No. 0010131-001-AC (PSD-FL-411) and 40CFR63, Subpart DDDDD - NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS FOR MAJOR SOURCES: INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS AND PROCESS HEATERS. The source of each parameter's emissions limitations and standards are summarized in Table 2.

**Table 2: Emissions Limitations and Standards
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Parameter	Performance/Emissions Limit	Performance or Permit condition
NOX	0.070 lb/MMBtu	Subsection B, PC 9
CO	0.080 lb/MMBtu 230 ppmvd @ 3% O ₂	Subsection B, PC 9 40CFR63, Subpart DDDDD
SO ₂	0.029 lb/MMBtu	Subsection B, PC 9
VOC	0.009 lb/MMBtu	Subsection B, PC 9
HCl	2.22 lb/hr 2.2 X 10 ⁻² lb/MMBtu	Subsection B, PC 9 40CFR63, Subpart DDDDD
∑ HCl, Hf, organic HAPs and Metal HAPs	24.7 TPY	Subsection B, PC 9
PM (total filterable) via M5	0.015 lb/MMBtu 0.0098 lb/MMBtu	Subsection B, PC 9 40CFR63, Subpart DDDDD
CPM	No required limit	Subsection B, PC 9
SAM/flow M8A/M2	1.4 lb/hr	Subsection B, PC 9
VE (Boiler)	Boiler: 10%/20% once/hr	Subsection B, PC 9
NH ₃ Slip, O ₂	10 ppmvd @ 7% O ₂	Subsection B, PC 9
Mercury	8.0 X 10 ⁻⁷ lb/MMBtu	40CFR63, Subpart DDDDD

3.0 Test Program/Operating Conditions

Air emissions testing to determine the compliance status of the Woody Biomass-fueled BFB Boiler was conducted on November 20 through November 23, 2013.

Table 3 summarizes the dates on which portions of the compliance test were conducted and the average heat input at which the unit was operating during each day.

**Table 3: Test Dates and Unit Load
Gainesville Renewable Energy Center
Woody Biomass-fueled BFB Boiler**

Date	Test Conducted	Unit Heat Input (mmBtu/hr)
November 20, 2013	Methods 5/202, 29, 316, M0010 & 0030 (run 1)	1345.7 mmBtu/hr
November 21, 2013	Methods 5/202, 29, 316, M0010 & 0030 (run 2)	1286.3 mmBtu/hr
November 22, 2013	Methods 5/202, 29, 316, M0010 & 0030 (run 3)	11257.9 mmBtu/hr
November 23, 2013	Methods 8A, 26A, CTM 027 and Gases (runs 1 – 4)	1260.9 mmBtu/hr

During the compliance test program, the Woody Biomass-fueled BFB Boiler heat input averaged 1287.7 mmBtu/hr while operating on 100 percent solid fuel, which correlates to 94.8 percent of the maximum heat input (1358 mmBtu/hr).

As specified in permit condition B.17, the Woody Biomass-fueled BFB Boiler heat input was calculated in accordance with 40CFR75 using fuel factors.

4.0 Test Methods

All testing was performed in accordance with methods approved by the USEPA and FDEP. The following discusses the methods, as well as quality assurance and sample handling procedures.

Table 4 summarizes the EPA test methods utilized to complete the test program.

**Table 4: Summary of EPA Reference Methods
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

EPA Method	Description
1	Sample and Velocity Traverses for Stationary Sources
2	Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot)
3A	Determination of Oxygen and Carbon Dioxide
4	Moisture Content in Stack Gases
5	Particulate Emissions from Stationary Sources
6C	Determination of Sulfur Dioxide
7E	Determination of Nitrogen Oxides
NCASI 8A	Determination of Sulfuric Acid Mist
9	Opacity (Visible Emissions)
10	Determination of Carbon Monoxide
19	Determination of Emission Rates
25A	Determination of VOC
26A	Determination of HCl and HF
CTM-027	Determination of Ammonia Slip
29	Determination of Metals
M0010	Determination of PAH/POM
M0030	Determination of Volatile Organics
202	Determination of Condensable PM
316	Determination of Organic HAP

4.1 Sample and Velocity Traverse Points

Sample and velocity traverse points were determined utilizing EPA Method 1. The circular boiler exhaust stack has an inner diameter of 143.5 inches at the sample location. The Sample location is approximately 110.5 feet (1326 inches) downstream from the nearest flow disturbance and 68.5 feet (822 inches) upstream from the stack exit. The sample location is approximately 9.24 diameters downstream from the nearest disturbance and approximately 5.73 diameters upstream for the exhaust exit.

The stack contains four (4) 6 inch diameter test ports, located at 20°, 110°, 200° and 290°. An additional single test port is located at 315°. A diagram of the sample location can be viewed in Appendix C.

4.1.1 Gaseous Traverse Points and Run Durations

An initial stratification test was conducted in accordance with Section 6.5.6.1 of 40CFR75, Appendix A on November 14, 2013. A total of 12 traverse points (three points per port), located 4.4% (6.25"), 14.6% (21.0") and 29.6% (42.5") from the inside wall of the stack, were used to conduct the SO₂, NO_x, CO₂ and O₂ stratification test while the unit was operating at a steady state. Each traverse point was measured for a minimum of two (2) minutes. The sample location was determined to be unstratified and the short reference method measurement line described in section 8.1.3 of PS No. 2 (0.4, 1.2 and 2.0 meters from the inner wall of the stack) was used. The test port located at 315° was utilized for gas sampling.

Each point was sampled for 20 minutes, equaling a total of 60 minutes per test run. A total of four test runs were completed.

4.1.2 Wet Chemistry Traverse Points and Run Durations

Isokinetic, wet chemistry method traverse points were determined in accordance with EPA Method 1. A total of 12 traverse points (3 points per port, 4 ports were used) were used to complete each test run. Points were located at 6.31, 20.95 and 42.48 inches from the inner wall of the stack. Each method varied in sample run duration.

Method 0030 and Method 8A were sampled at a constant rate and were located at a single point greater than 1 meter from the inner stack wall.

4.2 Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tubes)

Method 2 was used to determine the volumetric flow rate of the stack effluent gas and was used on each isokinetic test method train.

Differential pressure and stack temperature readings were taken with an S type pitot tube and Type K temperature sensor at each sample traverse point.

4.2.1 Method 2 Quality Assurance/Quality Control Procedures

The S type pitot tube was inspected visually and measured to meet the design specifications of EPA Method 2, for a pitot coefficient of 0.84.

The incline manometer and each leg of the pitot tube was leak checked before and immediately after each test run. The incline manometer was leveled and zeroed before each test run.

Thermocouple sensors were calibrated prior to the test program and a post test check was performed after testing completion.

Appendix D contains the completed QA/QC forms.

4.3 Moisture Content Determination

Moisture content of the stack gas was determined by Method 4 with each wet chemistry method.

Stack gas was sampled at each traverse point, passed through pre-weighed impingers and then through a calibrated dry gas meter. Moisture is removed from the sample gas in the pre-weighed impingers, which are submerged in an ice bath, and later analyzed for moisture weight gain. Moisture is determined based upon the amount of moisture weight gain and sample gas collected.

Field moisture data sheets are also located in Appendix E.

4.3.1 Method 4 Quality Assurance/Quality Control Procedures

The moisture sampling train was leak checked prior to each test run at approximately 15" Hg and immediately after each run at a vacuum higher than the highest vacuum recorded during the respective test run. Results are recorded on the moisture field data sheets.

Weighing to determine moisture content was conducted with a balance having an accuracy of 0.1 grams.

Gas temperature at the exit of the impingers was maintained at less than 68 degrees Fahrenheit.

4.4 Particulate Matter Determination

USEPA Method 5 was used to determine filterable particulate emissions. Stack gas was extracted isokinetically from the gas stream; particulate emissions are measured gravimetrically by determining the amount of particulate matter collected on the glass nozzle and quartz fiber filter. The probe liner and filter holder were maintained above 248°F during each run.

Sample volume was measured by passing the gas through a set of weighed impingers used for moisture content, then passed through a calibrated dry gas meter. An S type pitot tube is attached to the probe to measure stack gas velocity and to maintain sampling conditions between 90% and 110% isokinetics. A type K temperature sensor is also attached to the probe to measure the stack gas temperature.

Isokinetic conditions were maintained throughout each test run of the test program as demonstrated in Table 5. A minimum of 120 dscf of sample was taken each test run over a sampling period of approximately 240 minutes. Method 5/202 field data sheets are located in Appendix E.

4.4.1 Sample Recovery and Analysis

After each sample run, the nozzle and filter holder ahead of the filter were brushed and rinsed with acetone. Contents were stored in a leak free container for transport to the laboratory. The impingers were weighed for increase, to the nearest 0.1 gram, to determine moisture gain.

Particulate matter was determined by drying each filter to a constant weight and recorded to the nearest 0.1 mg. Sample from the probe nozzle and filter holder were evaporated in a tared beaker at ambient temperature and dried further in a desiccator then weighed to a constant weight, and recorded to the nearest 0.1 mg.

Appendix E contains the analytical results for each run.

4.4.2 Quality Assurance/Quality Control Procedures

The probe nozzles were inspected and measured across three different diameters to determine the appropriate nozzle diameter.

Before and after each test run, the manometer was leveled and zeroed. Leak checks of the sampling train were conducted before and immediately after each test run.

The dry gas meter was fully calibrated within six months prior to the test program using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i . Reagent and sample train blanks were collected and analyzed. Completed Method 5/202 QA/QC forms are located in Appendix D.

4.5 Condensable Particulate Matter (CPM) Determination

USEPA Method 202, combined with the Method 5 sample train, was used to determine condensable particulate matter emissions. Stack gas was extracted isokinetically from the gas stream. Condensable particulate emissions are collected in water dropout impingers and on a Teflon filter, after filterable particulate matter has been removed on a method 5 glass fiber filter.

A minimum of 120 dscf of sample was taken each test run over a sampling period of approximately 240 minutes.

4.5.1 Sample Recovery and Analysis

The impingers were weighed for increase, to the nearest 0.1 gram, to determine moisture gain, then the sample train was reassembled for a 1 hour, post run, nitrogen purge.

The liquid from the dropout impingers was collected and analyzed to determine the aqueous fraction of condensable particulate matter (CPM). The glassware in the sample train between the filterable PM filter and the CPM filter was rinsed with acetone and then hexane. These rinses were analyzed to determine the organic fraction of CPM. Both aqueous and organic CPM was extracted from the CPM filter in the laboratory. Fractions were evaporated and desiccated to a constant weight and recorded to the nearest 0.1 mg. Appendix E contains the analytical results for each run.

4.5.2 Quality Assurance/Quality Control Procedures

The probe nozzles were inspected and measured across three different diameters to determine the appropriate nozzle diameter.

Before and after each test run, the manometer was leveled and zeroed. Leak checks of the sampling train were conducted before and immediately after each test run.

The dry gas meter was fully calibrated within six months prior to the test program using a set of EPA critical orifices. Post test program dry meter checks were

completed to verify the accuracy of the meter's Y_i . Reagent and sample train blanks were collected and analyzed. Completed QA/QC forms are located in Appendix D.

4.6 Sulfuric Acid Mist (NCASI Method 8A)

NCASI Method 8A was used to determine the volume of sulfuric acid mist (SAM) present in the flue gas. Each gas stream was sampled for one hour at a constant sample rate of approximately 10 lpm¹.

The Method 8A sample train consisting of a quartz glass probe, heated to 600°F \pm 25 °F, a heated quartz filter (600°F \pm 25 °F) used to filter particulate, a condenser (set to a temperature of 150°F \pm 10°F) used to condense and capture H₂SO₄, and a quartz fiber filter used to capture H₂SO₄. An impinger train, composed of the following impingers, following the condenser. The first two impingers contained 100 ml of deionized water, the third impinger was empty and the final impinger contained a pre-weighed amount of indicating silica gel.

4.6.1 Sample Recovery and Analysis

A 15 minute post-run purge with clean dry ambient air was conducted at the average sampling rate used during the sample run. After the purge, the H₂SO₄ condenser was rinsed multiple times with deionized water. The condenser wash was collected in a laboratory prepared polyethylene sample bottle. The probe and the quartz filter holder were rinsed with DI water and the rinse was discarded.

Appendix E contains the analytical results for each run.

4.6.2 Quality Assurance/Quality Control Procedures

Before and after each test run, the manometer was leveled and zeroed. Leak checks of the sampling train were conducted before and immediately after each test run.

¹Method 8A testing cannot be performed isokinetically since the sample flow rates are too high. This will not allow for enough time for the thermal drop in the sample gas through the condenser.

GREC Biomass Power Plant	Page 12 of 25	C.E.M. Solutions, Inc.
Biomass-fueled BFB Boiler		Report 20-6132-01-001
Compliance Test		Last Updated: 12/18/2013
November 20 - 23, 2013		

The dry gas meter was fully calibrated within six months prior to the test program using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i . Reagent and sample train blanks were collected and analyzed.

Completed QA/QC forms are located in Appendix D.

4.7 Hydrogen chloride (HCl) and Hydrogen Fluoride (HF)

Hydrogen chloride (HCl) and Hydrogen Fluoride (HF) was determined utilizing a USEPA Method 26A sample train.

Gaseous samples were withdrawn isokinetically from the duct and collected in absorbing solutions. The particulate matter collected on the filter is recovered to determine the amount of particulate collected during the test run. Acidic absorbing solutions collect the gaseous hydrogen halides (HCl). The hydrogen halides are solubilized in the acidic solution and form chloride. The halide solutions are measured by ion chromatography.

The optional cyclone was not utilized during the test program because liquid droplets in the flue gas stream are not expected.

The sample train consisted of 4 impingers. Impinger 1 and 2 contained 100ml of 0.1N sulfuric acid (H_2SO_4) solution, impingers 3 was empty and impinger 4 contained a pre-weighed amount of silica gel.

The entire sampling train was glass. Temperature requirements of Method 26A were met. Sample analysis was performed by Enthalpy Analytical of Wilmington, North Carolina. Laboratory results are located in Appendix F.

4.7.1 Quality Assurance/Quality Control Procedures

The probe nozzles were inspected and measured across three different diameters to determine the appropriate nozzle diameter.

Before and after each test run, the manometer was leveled and zeroed. Leak checks of the sampling train were conducted before and immediately after each test run.

The dry gas meter was fully calibrated within six months prior to the test program using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i . Reagent and sample train blanks were collected and analyzed. Completed QA/QC forms are located in Appendix D.

4.8 Ammonia Slip Test

Ammonia concentrations were determined using EPA Conditional Test Method 27 (CTM-027).

Stack gas-samples were extracted isokinetically, for a period of 60 minutes. Gas samples were pulled from the stack through a glass nozzle and glass lined probe into a heated filter box containing a quartz filter. The gas was then transported, via an unheated Teflon line, to an impinger train. The impinger train consisted of two Greenburg-Smith (G-S) impingers (impingers 1 and 2) and two modified G-S impingers with the tips removed (impingers 3 and 4) all connected in series in an ice bath. Impingers 1 and 2 were charged with 100ml of 0.1N sulfuric acid (H_2SO_4) solution. The third was left empty and the fourth impinger was loaded with a pre-weighed amount of silica gel.

The volume of the liquid (catch) in each of the first three impingers was recorded for future use. Each impinger catch was transferred into individual, clean 500-ml HDPE containers. Each container was then labeled and stored on ice for shipment to the laboratory, where the samples were analyzed within 2 weeks after their collection.

An ion chromatograph equipped with a conductivity detector was used for ammonium ion separation and quantitation to analyze the samples. At a minimum, the first two impingers were analyzed for ammonia breakthrough.

Pre and post impinger weights, field data collection, and lab analysis results are presented in Appendix D.

4.8.1 Quality Assurance/Quality Control Procedures

The sample train was leak checked prior to and following each test run at or above the highest vacuum recorded during the test run in accordance with the test method.

Prior to conducting each test run, the impinger train was chilled in ice for at least 10 minutes as specified in the test method.

All sample train glassware was cleaned prior to each test run with deionized (DI) water.

Following each test run, the back half of the filter housing was rinsed with DI water and stored in the same storage container as the catch from impinger 1. Impingers 1 and 2 were rinsed with DI water after recovery and stored with the impinger catch from its respective impinger as well. Reagent and sample train blanks were collected and analyzed. QA/QC forms can be viewed in Appendix D.

4.9 Mercury and Metals Determination

Mercury (Hg), Chromium (Cr), Lead (Pb), Manganese (Mn) and Phosphorus (P) concentrations were determined using EPA Test Method 29 as described in 40CFR60, Appendix A.

Stack gas-samples were extracted isokinetically. Gas samples were pulled from the stack through a glass nozzle, heated glass lined probe and heated filter to an impinger train. The impinger train consisted of seven impingers. Impinger 1 was left empty, impingers 2 and 3 were filled with 100 ml of 5% HNO₃/10% H₂O₂ solution, impinger 4 was left empty, impingers 5 and 6 were filled with 100 ml of acidified KMnO₄ and impinger 7 was loaded with a pre-weighed amount of silica gel with silica gel.

The recovered samples were digested and analyzed using cold vapor atomic absorption spectroscopy.

4.9.1 Sample Recovery and Analysis

After each sample run, the nozzle, probe liner and filter holder ahead of the filter were brushed and rinsed with acetone. Contents were stored in a leak free container for transport to the laboratory. The impingers were weighed or measured for increase, to the nearest 0.1 gram or 1.0 ml, to determine moisture gain.

The catch from the sample train was transferred into 7 containers. The filter was carefully removed from the housing and placed in Container 1. The acetone rinse from the probe nozzle, probe liner and front half of the filter housing was transferred into Container 2. The HNO₃ rinse from the probe nozzle, probe liner and front half of the filter housing was transferred to Container 3. The contents of Impinger 1, 2 and 3 along with their HNO₃ rinse was transferred to Container 4. The contents of Impinger 4 and its HNO₃ rinse was transferred to Container 5A. The contents of Impinger 5 and 6, their Acidified KMnO₄ rinse and the DI Water rinse was transferred to Container 5B. If visible Manganese deposits remained in Impinger 5 and 6, they were rinsed with 8N HCl, which was transferred to Container 5C. Appendix E contains the analytical results for each run.

4.9.2 Quality Assurance/Quality Control Procedures

The probe nozzles were inspected and measured across three different diameters to determine the appropriate nozzle diameter. Before and after each test run, the manometer was leveled and zeroed. Leak checks of the sampling train were conducted before and immediately after each test run. The sample train was leak checked prior to and following each test run at or above the highest vacuum recorded during the test run in accordance with the test method.

The dry gas meter was fully calibrated within six months prior to the test program using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i .

Prior to conducting each test run, the impinger train was chilled in ice for at least 10 minutes as specified in the test method.

Isokinetic conditions were maintained throughout each test run of the test program as demonstrated in Table 5.

All sample train glassware was cleaned prior to the field test with deionized (DI) water, 10% nitric acid, and acetone.

Filter and Reagent blanks were taken for each lot used.

Container 7 – 100ml Acetone

Container 8A – 300ml 0.1N HNO₃

Container 8B – 100ml DI Water

Container 9 – 200ml 5% HNO₃/10% H₂O₂ solution

Container 10 – 100ml Acidified KMnO₄ solution

Container 11 – 25ml 8N HCl

Container 12 – 3 unused filters

Reagent and sample train blanks were collected and analyzed. Completed QA/QC forms are located in Appendix D.

4.10 Semi-Volatile Organic Compounds Determination

Method 0010 was used to determine semi-volatile organic compound concentrations. Stack gas was extracted isokinetically from the gas stream and collected in the glass nozzle, glass probe liner, glass fiber filter, and on a packed column of absorbent XAD-2 material. The semi-volatile organic compounds are extracted from the sample, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry.

The probe liner and filter heater box temperatures were maintained at 248 ± 25 degrees Fahrenheit throughout each test run. The XAD-2 absorbent module and

upstream condenser coil was cooled to below 20°C (68°F) to ensure efficient capture of the semi-volatile organic compounds during each test run by a water recirculating pump.

Sample volume was measured by passing the gas through a set of pre-weighed impingers used for moisture content, then passed through a calibrated dry gas meter. An S type pitot tube is attached to the probe to measure stack gas velocity and to maintain sampling conditions between 90% and 110% isokinetic. A type K temperature sensor is also attached to the probe to measure the stack gas temperature.

Appendix E contains completed Method 0010 field data sheets.

A minimum of 240 dscf of sample was taken each test run over a sampling period of 360 minutes.

After each sample run, the nozzle, probe liner, filter holder, and condenser ahead of the XAD absorbent trap were rinsed three times with a 1:1 solution of pesticide grade acetone and dichloromethane. The contents of the condensate trap were collected and the impinger was rinsed 3 times with the acetone/dichloromethane solution. Contents were stored in pre-treated amber leak free containers and environmentally controlled for transport to the laboratory. The impingers were weighed for increase, to the nearest 0.1 gram, to determine moisture gain.

Laboratory analysis was conducted by Enthalpy Analytics of Wilmington, North Carolina.

Appendix F contains the analytical results for each run.

4.10.1 Method 0010 Quality Assurance/Quality Control Procedures

All sample glassware in the sampling train upstream and including the XAD resin trap were soaked for several hours in an Alconox cleaning solution, soaked in Chemsolv, rinsed with hot tap water, rinsed 3 times with HPLC grade water, rinsed 3 times with acetone, and sealed with Teflon tape and high density hexane-rinsed aluminum foil.

The probe nozzles were inspected and measured across three different diameters to determine the appropriate nozzle diameter.

Before and after each test run, the manometer was leveled and zeroed.

Leak checks of the sampling train were conducted before and immediately after each test run.

The dry gas meter was fully calibrated, within six months prior to the test program, using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i .

Reagent and sample train blanks were collected and analyzed. Completed QA/QC forms are located in Appendix D.

4.11 Volatile Organic Compound Determination

Method 0030 was used to determine volatile organic compound concentrations. Stack gas was extracted at a constant rate from the gas stream and collected in Tenax traps. The volatile organic compounds are extracted from the traps, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry.

The probe liner and filter heater box temperatures were maintained at 130 ± 5 degrees Celsius throughout each test run. The exit of the first condenser was cooled to below 20°C (68°F) to ensure efficient capture of the volatile organic compounds during each test run by a water recirculating pump.

Sample volume was measured by passing the gas through a set of VOST traps and condensers, then passed through a calibrated dry gas meter. Appendix E contains completed Method 0030 field data sheets.

Sample was collected at 0.5 lpm over a sampling period of 120 minutes.

Traps were switched out at approximately 40 minute intervals and leak checks were conducted. The contents of the condensate trap were collected in a 40 ml VOA vial. HPLC water was added to the vial to eliminate headspace. Traps and condensate vials were stored on ice for transport to the laboratory.

Laboratory analysis was conducted by Test America of Knoxville, Tennessee. Appendix F contains the analytical results for each run.

4.11.1 Method 0030 Quality Assurance/Quality Control Procedures

All sample glassware in the sampling train upstream and including the Tenax traps were soaked for several hours in an Alconox cleaning solution, rinsed with hot tap water, rinsed 3 times with HPLC grade water, oven dried at 110°C and sealed with Teflon tape and high density aluminum foil.

Leak checks of the sampling train were conducted before and immediately after each test run and each time the traps were switched out.

The dry gas meter was fully calibrated, within six months prior to the test program, using a set of EPA critical orifices. Post test program dry meter checks were completed to verify the accuracy of the meter's Y_i . Reagent and trap blanks were collected and analyzed. Completed QA/QC forms are located in Appendix D.

**Table 5: Isokinetic Summary
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Method	% Isokinetic				Tolerance
	Run 1	Run 2	Run 3	Run 4	
5/202	97.9	98.7	99.8	-	90 – 110%
26A	-	91.6	99.8	101.3	90 – 110%
CTM 027	103.8	-	105.4	105.9	90 – 110%
29	98.9	98.3	99.7	-	90 – 110%
316	98.6	99.0	98.4	-	90 – 110%
0010	96.3	101.3	94.1	-	90 – 110%

4.12 NO_x, SO₂, CO, O₂, CO₂ and VOC Determination

NO_x, SO₂, CO, O₂, CO₂ and VOC reference method (RM) data was determined using instrument analyzer procedures. Mathematical equations used to determine calculated emissions standards are located in Appendix B. Table 4 summarizes the EPA methods and instrumentation:

**Table 6: Summary of EPA Instrumental Reference Methods and Instrumentation
Gainesville Renewable Energy Center
Woody Biomass-fueled BFB Boiler**

Pollutant	EPA Method	Instrument	Serial Number
NO _x	7E	TEI Model 42i	1200951382
SO ₂	6C	TEI Model 43i	734726464
CO	10	TEI Model 48c	48C-68846-361
CO ₂ (dilution system)	3A	TEI Model 410i	903034509
CO ₂ (full extractive)	3A	TEI Model 410i	1009241630
O ₂	3A	TEI Model 410i	1009241630
VOC	25A	TEI Model 51i	C03326

All reference method analyzers used meet or exceed applicable performance specifications detailed in the appropriate method.

NO_x, SO₂, and CO₂ gas data was collected using an in stack dilution probe, operating at a dilution ratio of 20:1 (wet basis). The sample is then sent to the gas analyzers, located in the environmentally controlled test trailer for analysis by the reference method analyzers. CO, VOC and diluent (O₂ and CO₂) gas samples were continuously extracted from the stack by a full extractive gas sample probe (dry basis). Samples were then transported to a gas sample conditioner via a heated sample line operating at 250°F or above. The gas sample conditioner lowers the dew point of the sample gas to approximately 5°C through minimum interference heat exchangers. The dry, cool sample is then sent to the gas analyzers, located in the environmentally controlled test trailer for analysis by the reference method analyzers.

Instrument outputs were recorded continuously with a Windows compatible personal computer, compiled into 15 second averages, and stored in a database for future reference.

Instrument ranges and calibration gases were chosen in accordance with each pollutant's applicable EPA method. Calibration gas Certificates of Analysis can be found in Appendix B. Instrument ranges and calibration gases used are shown in Table 7:

**Table 7: Reference Method Instrument Ranges and Calibration Gases
Gainesville Renewable Energy Center
Woody Biomass-fueled BFB Boiler**

Pollutant	Test Location	Calibration Span/Instrument Range	Calibration Gases^a
NO _x	BFB Boiler Stack Wet System	96.79 ppm	0.0 ppm NO 45.94 ppm NO 96.79 ppm NO
SO ₂	BFB Boiler Stack Wet System	50.64 ppm	0.0 ppm SO ₂ 21.14 ppm SO ₂ 50.64 ppm SO ₂
CO	BFB Boiler Stack Dry System	97.52 ppm	0.0 ppm CO 45.96 ppm CO 97.52 ppm CO
CO ₂	BFB Boiler Stack Dry System	19.07%	0.0 % CO ₂ 9.62 % CO ₂ 19.07 % CO ₂
O ₂	BFB Boiler Stack Dry System	20.37%	0.0 % O ₂ 10.03 % O ₂ 20.37 % O ₂
THC	BFB Boiler Stack Dry System	30.0 ppm	0.0 ppm 8.47 ppm 15.20 ppm 25.90 ppm

^a Concentrations of NO, SO₂, CO, O₂ and CO₂ are in a balance of purified nitrogen (N₂). Analyzers were zeroed with ultra high purity N₂ (THC, with zero air). All calibration gases have been certified to NIST traceable standards.

4.12 Visible Emission Determination

USEPA Method 9 was utilized to determine visible emissions.

Visible emissions observations were performed by a FDEP certified visible emissions reader. Readings were taken at 15 second intervals and reduced into six minute averages as required by the applicable EPA standard. One-sixty minute visible emissions test run was performed while the unit was operating at maximum capacity.

Method 9 data summary, field data and VE reader's certification are located in Appendix E.

5.0 Test Results

The following presents the results of the test program. Supporting calculations and field data summaries are presented in Appendix B and E, respectively. Tables 8 and 10 summarize the results of the test program.

5.1 Nitrogen Oxides(NO_x)

During the BFB Boiler gas test, NO_x emissions for the three test runs averaged 0.052 lb/mmBtu, passing the 0.070 lb/mmBtu permit limitation.

5.2 Sulfur Dioxide (SO₂)

During the BFB Boiler gas test, SO₂ emissions for the three test runs averaged 0.000 lb/mmBtu, passing the 0.029 lb/mmBtu permit limitation.

5.3 Sulfuric Acid Mist (SAM)

The three-run average for SAM during the test program was 0.1 lb/hr passing the permit limitation of 1.4 lb/hr. Reference method SAM values were below the MDL for the analytical method. The in-stack detection limit based on the MDL and run 1 flow and standard volume of sample collected was determined to be 0.01 lb/hr.

5.4 Carbon Monoxide (CO)

During the BFB Boiler gas test, CO emissions for the three test runs averaged 0.02 lb/mmBtu, passing the 0.08 lb/mmBtu permit limitation.

5.5 Hydrogen Chloride (HCl) & Hydrogen Fluoride (HF)

HCl and HF, during the test program, averaged 0.04 lbs/hr over the three test runs, below the 2.22 lb/hr permit limit for both analytes. Reference method HCl and HF values were below the MDL for the analytical method. The in-stack detection limit based on the MDL and run 1 flow and standard volume of sample collected was determined to be 0.04 lb/hr.

5.6 Particulate Matter

The three-run average filterable particulate matter (FPM) emissions during the test program was 0.001 lb/mmBtu, passing the permitted emission limits of 0.015 lb/mmBtu. The three-run average condensable particulate matter (CPM)

emissions during the test program was 0.001 lb/mmBtu. The average total particulate matter (FPM + CPM) was calculated to be 0.002 lb/mmBtu.

5.7 Visible Emissions

The highest six-minute average visible emissions observed from the Woody Biomass-fueled BFB Boiler stack during the 60 minute visible emission observation was 0.0 percent opacity, passing the 10 percent emission limit.

5.8 Volatile Organic Compounds (THC)

The three-run average for VOC during the test program was 0.003 lb/mmBtu, below the 0.009 lb/mmBtu permit limit.

5.9 Ammonia Slip (NH₃)

The three-run average for ammonia slip during the test program was 0.7 ppmvd @ 7% O₂, passing the permitted emission limit of 10 ppmvd @ 7% O₂. The in-stack detection limit based on the MDL and run 1 stack flow and standard volume of sample collected was determined to be 0.006 ppmvd @ 7% O₂.

5.10 Mercury (Hg)

The three-run average for mercury during the test program was 3.2×10^{-7} lb/mmBtu, passing the permitted emission limit of 8.0×10^{-7} lb/mmBtu. The in-stack detection limit based on the MDL and run 1 stack flow and standard volume of sample collected was determined to be 1.7×10^{-9} lb/mmBtu.

5.11 Sum of HCl, HF, Organic HAP and Metal HAP

HCl, HF, Organic HAP and Metal HAP were calculated in lb/hr, summed, and then converted to tons per year (TPY). The three run average, during the test program, was calculated to be 3.87 TPY, below the 24.7 TPY permit limit. For many of the analytes making up the HAP sum (HCl, HF, acrolein, xylene isomers, ethyl benzene, methyl chloroform and PAH/POM), calculated lb/hr results were based on non-detected laboratory results. The MDLs for these parameters were used in emissions calculations. It should be noted that the resulting TPY values reported are biased high due to the use of MDL values in place of non detects.

**Table 8: Compliance Test Summary
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Parameter	Run 1	Run 2	Run 3	Average	Permitted Emissions Rate
FPM	0.001	0.001	0.001	0.001	0.015 lb/mmbtu (CPM and TPM for informational purposes only)
CPM	0.002	0.001	0.000	0.001	
TPM (FPM + CPM)	0.003	0.002	0.001	0.002	
VE	0.0	-	-	0.0	10% Opacity
Hg	3.5 x10 ⁻⁷	3.0 x10 ⁻⁷	3.2 x10 ⁻⁷	3.2 x10 ⁻⁷	8.0 X 10 ⁻⁷ lb/mmbtu

**Table 9: Compliance Test Summary
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Parameter	Run 1	Run 2	Run 3	Run 4	Average	Permitted Emissions Rate
NO _x	0.052	0.053	0.051	-	0.052	0.070 lb/mmbtu
SO ₂	0.000	0.000	0.000	-	0.000	0.029 lb/mmbtu
SAM	-	0.1*	0.1*	0.1*	0.1	1.4 lb/hr
CO	0.02	0.02	0.02	-	0.02	0.08 lb/mmbtu
HCl	-	0.04*	0.04*	0.04*	0.04	2.22 lb/hr
HF	-	0.04*	0.04*	0.04*	0.04	
VOC	0.000	0.010	0.000	-	0.003	0.009 lb/mmbtu
NH ₃	0.7	-	0.6	0.7	0.7	10 ppmvd @ 7% O ₂

* Value below MDL, reported at MDL

**Table 10: Sum of HAP Compliance Test Summary
Woody Biomass Power Plant Energy Complex
Woody Biomass-fueled BFB Boiler**

Parameter	Run 1 lb/hr	Run 2 lb/hr	Run 3 lb/hr	Average lb/hr	Permitted Emissions Rate
HCl	0.04*	0.04*	0.04*	0.04	Sum of HCl, HF, Organic HAP and Metal HAP shall not exceed 24.7 tons per year (TPY) as calculated from lb/hr
HF	0.04*	0.04*	0.04*	0.04	
Cr	2.9 x10 ⁻⁴	3.5 x10 ⁻⁴	3.0 x10 ⁻⁴	3.1 x10 ⁻⁴	
Pb	1.3 x10 ⁻⁴	1.3 x10 ⁻⁴	1.2 x10 ⁻⁴	1.3 x10 ⁻⁴	
Mn	2.0 x10 ⁻³	2.5 x10 ⁻³	1.9 x10 ⁻³	2.1 x10 ⁻³	
P	1.2 x10 ⁻²	1.6 x10 ⁻²	1.1 x10 ⁻²	1.3 x10 ⁻²	
Acrolein	0.535*	0.501*	0.535*	0.524	
Benzene	0.035	0.038	0.055	0.043	
xylene isomers plus ethyl benzene	0.001*	0.001*	0.002	0.001	
methyl chloride	0.003	0.002	0.003	0.003	
methyl chloroform	0.000*	0.000*	0.000*	0.000	
toluene	0.002	0.002	0.003	0.002	
Formaldehyde	0.051	0.029	0.038	0.039	
acetaldehyde	0.009	0.004*	0.007	0.007	
PAH/POM	0.168*	0.160*	0.179*	0.169	
SUM HCl, HF, Organic HAP, Metal HAP in lb/hr	0.90	0.84	0.92	0.88	
Results in Tons Per Year**					
SUM HCl, HF, Organic HAP, Metal HAP in TPY	3.94	3.66	4.01	3.87	24.7 TPY

* Value below MDL.

** TPY = lb/hr x 24 hours x 365 days x 1/2000 ton/pound