



1.0 INTRODUCTION

CK Environmental was retained by NEFCO to perform compliance emission testing at the Great Lakes Water Authority Biosolids Drying facility, 9125 W. Jefferson Avenue, Detroit, MI. The purpose of this test program was to document the performance of four Dryer Trains with respect to sulfur dioxide (SO₂) emissions. The determination SO₂ emissions from each of the four Dryer Trains was required by a Consent Order (AQD No. 7-2017) issued by the Michigan Department of Environment, Great Lakes, and Energy, Air Quality Division (EGLE). This SO₂ emission test program was conducted during the performance of an additional emission compliance test program that was performed on two of the four Dryer Trains. The EGLE ordered an emission test program be performed on the (2) Dryer Trains which included the measurement of the emissions of Filterable Particulate Matter, Condensable Particulate Matter, Oxides of Nitrogen and Carbon Monoxide. This test program was defined and presented in a separate Protocol Report that was submitted to the EGLE on November 1, 2019. The SO₂ emission test program documented in this report occurred December 3, 4 and 5, 2019.

The objective of this emission testing program was to determine the compliance status of four Dryer Trains operating at the Biosolids Drying Facility with respect to emissions of sulfur dioxide (SO₂). This program was conducted in order to comply with a Consent Order issued by the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Air Quality Division, which required testing each Dryer Train for SO₂ emissions only.

All testing and analysis was conducted in accordance with the applicable procedures as found in 40 CFR 60, Appendix A. The EPA Quality Assurance Handbook and the approved pretest protocol were adhered to as well. A detailed explanation of the methodology, procedures and equipment used to conduct the emission test program can be found in Section 5 of this report.

Michael Kelley of CK Environmental was responsible for the emissions compliance test program. He was assisted by Kevin Kwedor and Michael O'Connor, environmental engineers/technicians. Steve Miller of NEFCO coordinated facility operations with the emissions testing. The EGLE was the regulatory authority mandating the SO₂ emission test program. Mark Dziadosz was the agency's representative and witnessed the test program. Table 1-1 provides contact information of pertinent parties.



Table 1-1
Key Personnel

Contact	Company Name	Telephone
Michael Kelley, Project Manager	CK Environmental, Inc.	(781) 828-5200
Manuel Irujo, Vice President of Operations	NEFCO	(617) 851-6297
Steve Miller, Plant Manager	NEFCO	(313) 551-5278
Mark Dziadosz Environmental Quality Analyst	EGLE Air Quality Division	(586) 753-3745



2.0 FACILITY DESCRIPTION

2.1 Process Description

CK tested four dryer trains designated as EUDryerTrainA, EUDryerTrainB, EUDryerTrainC, and EUDryerTrainD. The biosolids dryer trains consist of a triple-pass rotary natural gas-fired dryer equipped with a low-NO_x burner and exhaust gas recirculation, a cyclone collector, a vibrating screener, a recycle bin, and a crusher. Emissions from each dryer train's cyclone exhaust through a three-stage impingement tray scrubber followed by a regenerative thermal oxidizer (RTO) followed by a packed tower liquid counterflow scrubber. Emissions from the recycle bin are controlled with a fabric filter collector. Each of the four dryer trains exhausts through two stacks (two stacks per dryer train).

The equipment used to prepare the feed to the dryer trains consists of eight sludge grinders (two per dryer train), eight electrically-powered dewatering centrifuges (two per dryer train), a cake bin and an enclosed pug mill from each dryer train, and conveyors to transfer materials. The facility also has a hot water heater, an air handling unit, and make-up air units for the building, all natural-gas fired.

The facility processes a blend of primary and waste activated sludge from the GLWA Water Resource Recovery Facility. Normal rated capacity of each dryer train is 105.4 dry tons per day with maximum capacity 10-15% higher.

A EGLE consent order required Dryer Train/RTO stack testing for SO₂ emissions only.

2.2 Process Parameters

The following process and pollution control device operating parameters were monitored and recorded during the test program:

- feed rate of centrifuge cake as measured by liquid sludge flowmeters and % solids samples
- temperature in the RTO combustion chamber
- liquid flow rate to the impingement tray scrubber
- pressure drop across the impingement tray scrubber
- the pH of the impingement tray scrubber liquid effluent samples
- pressure drop across the recycle bin fabric filter collector
- liquid flow rate to the packed tower liquid scrubber, measured by magmeter
- the pH of the scrubber liquid in the packed tower liquid scrubber, measured by online pH probe

Appendix D contains the process data sheets recorded during the test program.



3.0 TEST PROGRAM

3.1 Objectives

The objective of the testing program is to conduct sulfur dioxide emission testing from the four dryer trains utilized at the Detroit Biosolids Drying Facility (BDF) per the EGLE Consent Order requirements. Emissions are reported in units of standard in accordance with emission limits presented in Table 3-1.

The following are the main objectives of this test program:

- Measure stack gas O₂/CO₂, and moisture content for emission calculation purposes
- Measure exhaust gas flow rate
- Conduct SO₂ testing at the exhaust stacks to determine compliance with SO₂ emission limits
- Obtain plant operational parameters for emission data reduction and validation

3.2 Test Matrix

The following table summarizes the pollutants monitored, the test methodologies used and the allowable emission limits. Each emission parameter was measured and analyzed in accordance with EPA and/or EGLE-approved procedures as presented in the test protocol submitted to the EGLE. A total of three test runs were performed on each dryer train and the average mass emission rate was used to determine the compliance status of the dryer trains.

Table 3-1
Test Matrix – Compliance Emission Limits

Pollutant	EPA Method(s)	Run Duration	SO₂ Emission Limits Dryer/RTO Stack
Flow Rate	1-2	Concurrent with other testing	N/A
O ₂ /CO ₂	3A	Concurrent with other testing	N/A
Moisture	4	Concurrent with other testing	N/A
SO ₂	6C	60 Minutes	0.82 lb/hr



3.3 Summary of Result

The results of the sulfur dioxide emission test program are summarized in Tables 3-2 to 3-5. These tables show that the Dryer Trains are in compliance with the emission limits imposed by the EGLE in their Air Quality Division issued permit to operate. The tables also summarize the exhaust gas parameters measured from each Dryer Train. All data pertinent to arriving at the final results are presented in Appendices of this report.

Table 3-2
Summary of Results
EUDryerTrainA
Sulfur Dioxide Emissions

Test Run No.		Dryer Train 1 - Run 1	Dryer Train 1 - Run 2	Dryer Train 1 - Run 3	Average	Facility Permit Limit
Date		12/03/19	12/03/19	12/03/19		
Time		08:30 - 09:30	09:43 - 10:43	10:57 - 11:57		
Sample Conditions						
Volume	dscf ^a	22.675	25.546	26.621	24.947	
Volume	dscm ^b	0.642	0.723	0.754	0.707	
Stack Conditions						
Flow Rate	dscfm ^c	9,196	9,066	9,454	9,239	
Temperature	°F	136	135	135	136	
Moisture	%	19.1	18.7	17.0	18.3	
Oxygen	%	8.8	9.3	9.4	9.2	
Carbon Dioxide	%	7.4	7.1	7.0	7.2	
Sulfur Dioxide	PPM	0.0	-0.1	0.1	0.0	
Sulfur Dioxide	PPM@15% O ₂	0.0	-0.1	0.1	0.0	
Sulfur Dioxide	lb/hr	0.00	-0.01	0.01	0.00	0.82



Table 3-3
Summary of Results
EUDryerTrainB
Sulfur Dioxide Emissions

Test Run No.		Dryer Train 2 - Run 7	Dryer Train 2 - Run 8	Dryer Train 2 - Run 9	Average	Facility Permit Limit
Date		12/04/19	12/04/19	12/04/19		
Time	Start	8:07	11:33	14:15		
	Stop	10:24	13:40	16:18		
Stack Conditions						
Flow Rate	dscfm ^c	9,184	8,886	8,644	8,905	
Temperature	°F	133	134	134	134	
Moisture	%	17.1	16.4	19.8	17.8	
Oxygen	%	8.9	8.4	9.1	8.8	
Carbon Dioxide	%	7.2	7.4	6.9	7.2	
Sulfur Dioxide	PPM	0.4	0.0	0.0	0.1	
Sulfur Dioxide	PPM@15% O ₂	0.2	0.0	0.0	0.1	
Sulfur Dioxide	lb/hr	0.04	0.00	0.00	0.01	0.82

Table 3-4
Summary of Results
EUDryerTrainC
Sulfur Dioxide Emissions

Test Run No.		Dryer Train 3 - Run 4	Dryer Train 3 - Run 5	Dryer Train 3 - Run 6	Average	Facility Permit Limit
Date		12/04/19	12/05/19	12/05/19		
Time	Start	16:58	7:48	10:45		
	Stop	19:04	9:53	12:47		
Stack Conditions						
Flow Rate	dscfm ^c	10,355	9,445	10,315	10,038	
Temperature	°F	134	133	132	133	
Moisture	%	14.3	16.3	13.3	14.6	
Oxygen	%	9.5	8.4	8.8	8.9	
Carbon Dioxide	%	6.7	7.5	7.2	7.1	
Sulfur Dioxide	PPM	0.0	-0.1	0.2	0.0	
Sulfur Dioxide	PPM@15% O ₂	0.0	0.0	0.1	0.0	
Sulfur Dioxide	lb/hr	0.00	-0.01	0.02	0.00	0.82



Table 3-5
Summary of Results
EUDryerTrainD
Sulfur Dioxide Emissions

Test Run No. Date Time		Dryer Train 4 - Run 4 12/03/19 12:43 - 13:43	Dryer Train 4 - Run 5 12/03/19 13:54 - 14:54	Dryer Train 4 - Run 6 12/03/19 15:05 - 16:05	Average	Facility Permit Limit
Sample Conditions						
Volume	dscf ^a	27.978	24.325	27.244	26.516	
Volume	dscm ^b	0.792	0.689	0.772	0.751	
Stack Conditions						
Flow Rate	dscfm ^c	9,171	9,453	9,284	9,303	
Temperature	°F	132	134	135	134	
Moisture	%	17.2	16.8	18.5	17.5	
Oxygen	%	8.8	10.7	10.4	10.0	
Carbon Dioxide	%	7.4	6.3	6.4	6.7	
Sulfur Dioxide	PPM	0.0	0.0	0.0	0.0	
Sulfur Dioxide	PPM@15% O ₂	0.0	0.0	0.0	0.0	
Sulfur Dioxide	lb/hr	0.00	0.00	0.00	0.00	0.82



4.0 SAMPLING LOCATIONS

The dryer trains exhaust through two stacks. One stack exhausts the Dryer and ancillary RTO and one stack exhausts a Recycle Bin. The Dryer/RTO stack height is 130 feet and has an internal diameter of 30 inches. The Recycle Bin stack height is 130 feet and has an internal diameter of 8.0 inches. Testing was conducted from (2) four inch sample access ports installed in the Dryer/RTO stack. The upstream and downstream disturbance distances were verified by test personnel while onsite to determine the appropriate number of sampling points. The sampling location is accessed from the roof. Appendix F contains pictures of the sampling locations typical of the Dryer Train exhaust stacks.

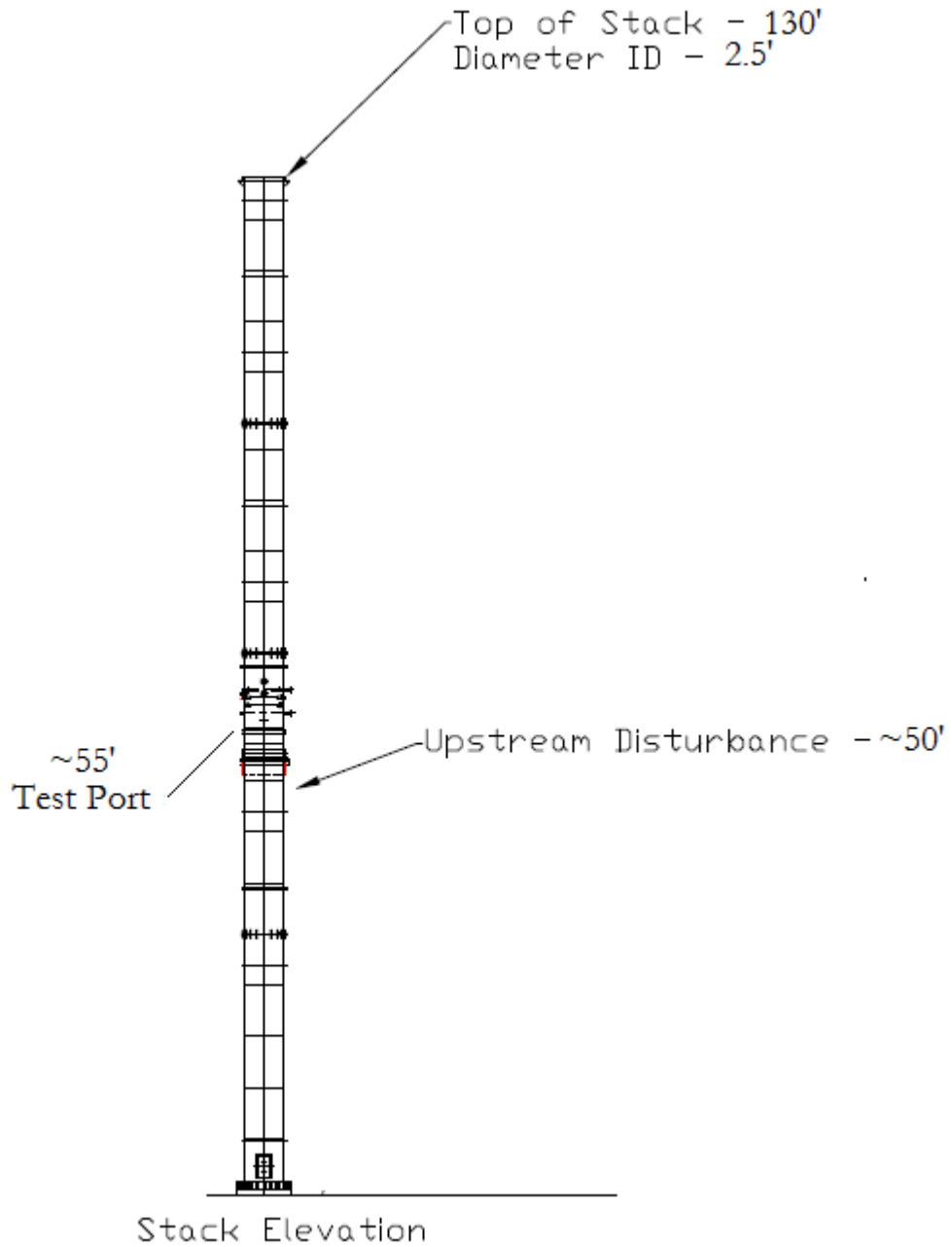
A cyclonic flow and gaseous stratification check was performed by CK personnel prior to testing. For the stratification test, instrumental sampling was conducted at a minimum of twice the response time. Table 4-1 summarizes the Dryer Train exhaust stack dimensions, system response time at each traverse point. Figure 4-1 presents a diagram typical of the Dryer Train exhaust

Table 4-1
Dryer Train Exhaust
Dryer/RTO Stack Dimensions

Description	Dimension
Sample Port To Downstream Distance	~75'-0"
Upstream Distance To Sample Port	5'-0"
Duct Diameter	2.5'
Stack Height	130' above grade



Figure 4-1
Dryer/RTO Stack Train Exhaust
Stack Diagram





4.1 Traverse Point Location

In accordance with EPA Method 1 a 24-point traverse (12 points per port) was used to make exhaust gas measurements in order to determine exhaust gas velocity, volumetric flow rate, temperature, pressure and moisture content. The traverse points within the stack were positioned in accordance with Table.4-2.

Table 4-3
Exhaust Gas Flow Traverse Point Locations

Traverse Point	Diameter (%)	Distance from inside wall (inches)*
1	2.1	7.5
2	6.7	8.5
3	11.8	10.0
4	17.7	11.75
5	25.0	14.0
6	35.6	17.25
7	64.4	25.75
8	75.0	29.0
9	82.3	31.25
10	88.2	33.0
11	93.3	34.5
12	97.9	35.5

*accounts for 6.5" port depth



5.0 SAMPLING AND ANALYTICAL PROCEDURES

5.1 Test Methods – Emissions Testing

The following US EPA Reference Test Methods contained in Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), “Standards of Performance for New Stationary Sources” Appendix A – Test Methods were used during the performance of the emission compliance test program:

US EPA Method 1	Sample and Velocity Traverses for Stationary Sources
US EPA Method 2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot tube)
US EPA Method 3A	Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)
US EPA Method 4	Determination of Moisture Content in Stack Gases
US EPA Method 6C	Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrumental Analyzer Procedure)

The following is a description of the test methodologies, equipment, and procedures used for this program. Each parameter was measured and analyzed in accordance with EPA and/or EGLE approved procedures as presented in the test protocol. All samples were collected at the sampling location detailed in Section 4. The average emission rate of three test runs was used to determine emission compliance status.

5.1.1 Flow Rate and Moisture – EPA Methods 1-4

The exhaust gas flow rate and moisture content were measured using EPA Methods 1 through 4. These measurements include the determination of the proper number of traverse points and their location in the stack (RM1), stack velocity, temperature, pressure and volumetric flow rate (RM2), stack gas molecular weight (RM3) and stack gas moisture content (RM4).

An S-type Pitot tube, inclined manometer and K-type thermocouple were used for the velocity pressure and temperature measurements. The Pitot tube meets the criteria of EPA Method 2 and was assigned a coefficient of 0.84. Velocity pressure and temperature readings were taken and recorded at each of the traverse point in the exhaust stack. A cyclonic flow check was conducted prior to the test in accordance with US EPA Test Method 1 to demonstrate the presence or absence of cyclonic flow.

The moisture content was determined using sample trains consisting of a series of four impingers connected to a metering system consisting of a monometer, temperature sensors, dry gas meter and vacuum pump. Impingers one and two contained known amounts of water, impinger three was empty (dry trap) and impinger four contained a known amount of silica gel. The impingers and their contents were weighed



before and after testing. These weights were recorded on a field data sheet. The impingers were housed in an impinger bucket filled with water and ice to assure the moisture condenses out from the sample exhaust gas. The net weight gain in the impinger train and sample volume, as recorded by the dry gas meter, was used to calculate the moisture content in the stack gas (%).

5.1.2 Oxygen/Carbon Dioxide - EPA Method 3A

Oxygen and carbon dioxide were measured in accordance with EPA Method 3A. This Method utilizes continuous emissions monitoring instrumentation. CK Environmental uses a Teledyne Model 326A oxygen analyzer with a range of 0-25%, and a California Analytical Instruments Model ZRH non-dispersive infrared carbon dioxide analyzer with a range of 0-20% to measure O₂ and CO₂ concentrations in the sample gas. The instruments meet all of the performance specifications of the Method. They were calibrated before and after each test period using calibration gases prepared according to EPA Protocol.

5.1.3 Sulfur Dioxide – EPA Method 6C

Method 6C utilizes continuous emissions monitoring instrumentation. CK Environmental uses a Western Research Model 721M ultraviolet (UV), non-dispersive infrared (NDIR) SO₂ gas analyzer. The instrument meets all of the performance specifications of the method. It was calibrated before and after each test period using calibration gases prepared according to EPA Protocol. The instrument was calibrated in the 0-50 ppm range. Stability test and interference test data sheets were on-site and can be found in an Appendix of this final report.

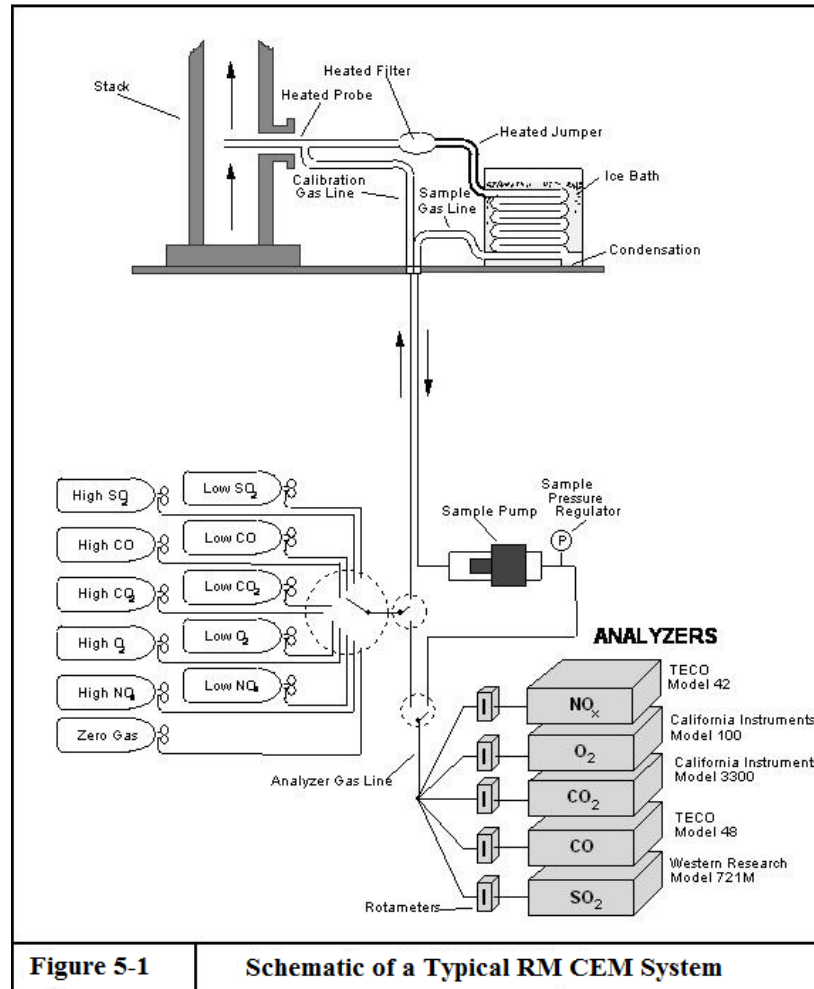


Figure 5-1

Schematic of a Typical RM CEM System



5.2 Emissions Sampling Procedures

5.2.1 Flow & Moisture Sampling Procedures

All sampling procedures were conducted in accordance with the Methods prescribed in the Code of Federal Regulations as found in 40 CFR 60 Appendix A and 40 CFR 61 Appendix B. The following is the sequence of events that occurred prior to and during the actual test.

Traverse Points - The traverse points are calculated in accordance with Method 1 and the probe marked accordingly.

Preliminary Traverse and Cyclonic Flow Check- A preliminary traverse is conducted. Readings include the velocity pressure, angle of flow, gas temperature and static pressure. The average angle of flow is used to determine whether the exhaust gas is considered “cyclonic” ($\geq 20^\circ$).

Stratification Check- Before any gaseous reference method test runs are performed, a stratification check is conducted to ensure that there is no stratification at the sampling location. Stratification is defined as a difference in excess of 10 percent between the average concentration of the stack and the concentration at any other point. Once the traverse is completed, each point is checked to see if it is less than or equal to 5% of the average of all the points, or ≤ 0.5 ppm.

Static Pressure - The static pressure of the stack is checked and recorded.

Nomograph - Once the above information is obtained, the nomograph for the actual test is set up to correlate the isokinetic relationships.

Barometric Pressure - Barometric pressure is obtained and recorded by use of a portable electronic barometer that gives 15-minute readings.

Sampling Train Set-Up -

- (a) The filter is placed in the filter holder and visually checked. Filter number and tare weights are recorded on the field data sheets.
- (b) The impingers are loaded with the appropriate solution and volumes are recorded on the field data sheets.
- (c) Approximately 200 grams of silica gel are placed in the final impinger. Exact weights are logged on the field data sheets.
- (d) Crushed ice is placed around the impingers.
- (e) Once the entire train is assembled, the probe and filter compartment heaters are turned on.

Pre-Test Leak Check - Once the filter compartment heater is at the desired temperature for testing, the system is leak checked at fifteen inches of vacuum (15"Hg). A leak rate of less than 0.02 CFM must be achieved prior to the start of sampling.



Final Check – When sampling is ready to commence, facility operations are checked to confirm that the process is operating at the desired capacity.

Sampling - Sample gas is extracted isokinetically at each traverse point. The sample rate is established according to the velocity pressure and temperature of measured at the sample point. Traverse points are sampled for equal periods over the course of the required test run time.

Post-Test Leak Check - Upon completion of each test run, the system is leak checked at the highest vacuum recorded during that run. Leak checks less than 0.02 CFM are considered acceptable. If a leak check exceeds 0.02 cfm the run is suspect and may be repeated.

5.2.2 CEMS Sampling System and Procedures (O₂, CO₂, SO₂)

What follows is a description of the transportable continuous emissions monitor system used to quantify oxygen, carbon dioxide and sulfur dioxide. The system meets all the specifications of Reference Methods 3A, 6C, and conforms to the requirements of The Measurement System Performance Tests as specified in 40 Code of Federal Regulations (CFR), Part 60, Appendix A.

Sample Probe - A heated stainless steel probe of sufficient length to sample the location specified in Section 2.0.

Sample Line - Approximately 200' of heated 3/8" Teflon tubing (1/16" wall) is used to transport the sample gas from the probe to the emission monitoring analyzers. The sample line is heated to 248°F, ± 25°. Prior to entering the sample gas conditioning system the gas stream is split. The sample stream is passed through a sample conditioning system before being delivered to the O₂, CO₂ and SO₂ analyzers.

Sample Conditioning System-

In-Stack Filter - A spun glass fiber filter is located at the probe tip to remove particulate from the gas stream.

Condenser (2) - a Universal Analyzer Sample Cooler or ice cooled condenser is located after the heated sample line for bulk moisture removal and a thermo-electric condenser system is located downstream from the pump to remove any remaining moisture from the gas stream.

Sample Pump - A diaphragm type vacuum pump is used to draw gas from the probe through the conditioning system and to the analyzers. The pump head is stainless steel, the valve disks are Viton and the diaphragm is Teflon coated.

Calibration Valve - A t-valve, located at the base of the probe allows the operator to select either the sample stream or introduce calibration gas to the system.

Sample Distribution System - A series of flow meters, valves and backpressure regulators allows the operator to maintain constant flow and pressure conditions during sampling and calibration.



Gas Analyzers – Analyzers capable of the continuous determination of O₂, CO₂ and SO₂ concentrations in a sample gas stream. They each meet or exceed the following specifications:

- Calibration Error** - Less than +2% of span for the zero, mid- and hi-range calibration gases.
- System Bias** - Less than $\pm 5\%$ of span for the zero, mid- or hi-range calibration gases.
- Zero Drift** - Less than +3% of span over the period of each test run.
- Calibration Drift** - Less than +3% of span over the period of each test run.

Data Acquisition System - A Monarch Model 4600, or equivalent, data logger system is used to record analyzer response to the sample and calibration gas streams. The data logger records at 15-second intervals and the data used to report test interval averages. The Monarch saves data to a compact flash drive that is downloaded to a computer. Separate files for each test run and associated calibrations are generated and saved. Data is loaded into a Microsoft Excel® spreadsheet for calculation of test interval average concentrations and emission rates.

All sampling and analytical procedures are conducted in accordance with EPA Reference Methods 3A and 6C (40CFR60, Appendix A). The following is the sequence of events leading up to and including the test:

Selection of Sampling Traverse Point Locations - Sampling point locations are determined prior to testing in accordance with EPA Methods 3A and 6C.

Determination of System Response Time - System response times are determined prior to testing. System response time is determined according to procedures delineated in each method, as required (40CFR60, Appendix A).

Determination of Analyzer Calibration Error - Analyzer calibration error is determined immediately prior to testing in accordance with EPA Methods 3A and 6C.

Determination of Sampling System Bias - Sampling system bias is determined immediately prior to testing in accordance with EPA Methods 3A and 6C.

Determination of Zero and Calibration Drift - Before and after each test run, each analyzer's response to zero and mid- or hi-range calibration gases are determined. The pre-and post-test analyzer responses are compared to determine drift. The results are evaluated based upon specifications defined in EPA Methods 3A and 6C.

Data Reduction - An average pollutant/diluent concentration for each test time interval is determined from the data acquisition system. This data is then reduced to determine relative pollutant concentrations in units of ppm and mass, lb/hr.



6.0 QUALITY ASSURANCE / QUALITY CONTROL PROCEDURES (QA/QC)

6.1 General

CK's emissions testing teams are committed to providing high quality testing services. To meet this commitment, CK follows applicable US EPA sampling procedures and implements applicable quality assurance/quality control (QA/QC) procedures with all test programs. These procedures ensure that all sampling is performed by competent, trained individuals and that all equipment used is operational and properly calibrated before and after use. Records of all CK's equipment calibrations are maintained in CK's files.

The CK quality assurance program generally follows the guidelines of the US EPA *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III Stationary Source Specific Methods* (EPA/600/R-94/038c – September 1994) and CK's in house QA/QC Manual.

6.1.1 Sampling

The CK measurement devices, thermocouples, and transportable gas analyzers are uniquely identified and calibrated with documented procedures and acceptance criteria. Records of all calibration data are maintained in CK's files. Copies of all pertinent calibration data were available on site during testing.

6.1.2 Analytical

All applicable compressed gas audit / calibration standards that were used are US EPA Traceability Protocol certified. Other gas standards and analytical laboratory support gases that were used are directly traceable to the National Institute of Standards and Technology (NIST). The certificates of analysis of the gas standards that were used during testing were available on site during testing and are contained in an Appendix of this report.

6.1.3 Reporting

All reports undergo a tiered review. The first review of the report and calculations are made by a project coordinator or engineer. A second, detailed review of the report and calculations are then performed by the project manager. Signatures on a Report Review Certification contained in each report are used to document the review process.