



## 1.0 INTRODUCTION

CK Environmental was retained by NEFCO to perform compliance emission testing at the Great Lakes Water Authority (GLWA) Biosolids Drying Facility in Detroit, MI. Testing was conducted December 3-6, 2019.

The objective of the testing program was to determine the compliance status of two of the four dryers (B & C) operating at the drying facility per Michigan Department of Environment, Great Lakes, and Energy (EGLE), Air Quality Division, Renewable Operating Permit No. MI-ROP-B2103-2014d.

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 in the performance of this 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 Robert Ciriello, Michael O'Connor, and Kevin Kwedor, environmental engineers/technicians. Steve Miller of NEFCO coordinated facility operations with the emission testing. The EGLE was the regulatory authority mandating the emission test program. Mark Dziadosz was the agency's representative and witnessed much of the test program. Table 1-1 provides contact information of the primary parties involved with the test program. Table 1-2 summarizes the test schedule as performed.

**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

**Table 1-2**  
Test Schedule

Day	Activity
Monday-12/2/2019	Set-up
Tuesday-12/4/2019	EUDryerTrainB and Recycle Bin B
Wednesday-12/5/2019	EUDryerTrainC and Recycle Bin C



## 2.0 FACILITY DESCRIPTION

### 2.1 Process Description

CK tested two of the four dryer trains (designated as EUDryerTrainA, EUDryerTrainB, EUDryerTrainC, and EUDryerTrainD). This test program was conducted on dryer trains EUDryerTrainB & EUDryerTrainC and their respective Recycle Bins. The biosolids dryer trains consist of a triple-pass rotary natural gas-fired dryer equipped with a low-NO<sub>x</sub> burner and exhaust recirculation, a cyclone product collector, a vibrating screener, a recycle bin, and a crusher. Emissions from each dryer train's cyclone exhausts 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 dryer trains exhausts through two stacks, the main dryer train exhaust stack and the recycle bin/fabric filter exhaust stack.

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 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

### 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 program was to conduct compliance emission testing on (2) dryer trains in order to determine the compliance status of the sources with respect to the EGLE Renewable Operating Permit No. MI-ROP-B2103-2014d. Emission test results are reported in units of standard in accordance with Table 3-1, Emission limits.

The following are the main objectives for this test program:

- Measure O<sub>2</sub>/CO<sub>2</sub>, and moisture, for emission calculation purposes, at each exhaust stack
- Measure exhaust flow of each exhaust stack
- Conduct PM/CPM, NO<sub>x</sub> and CO testing at the dryer train exhaust stacks to determine emission compliance
- Conduct PM/CPM testing at the recycle bin/ fabric filter exhaust stack to determine emission compliance
- Obtain plant process and pollution control operational data for emission compliance test validation

#### **3.2 Test Matrix**

The following table outlines the test methodologies used, the pollutants measured and the allowable emission limits. Each parameter was measured and analyzed in accordance with EPA and/or EGLE-approved procedures as presented in the test protocol. Three test runs to determine each emission parameter were performed and the average of the three used to establish emission compliance.



**Table 3-1**  
 Test Matrix – Compliance Emission Limits  
 (Trains A & D)

<b>Pollutant</b>	<b>EPA Method(s)</b>	<b>Run Duration</b>	<b>Emission Limits (Dryer/ RTO Stack Only)</b>
<b><u>All Locations</u></b>			
Flow Rate	1-2	Concurrent with other testing	N/A
O <sub>2</sub> /CO <sub>2</sub>	3A	Concurrent with other testing	N/A
Moisture	4	Concurrent with other testing	N/A
<b><u>Dryer Train</u></b>			
PM/PM <sub>10</sub> /PM <sub>2.5</sub>	5/202	120 Minutes	PM: 1.22 lb/hr PM <sub>10</sub> : 1.63 lb/hr PM <sub>2.5</sub> : 1.14 lb/hr
NO <sub>x</sub>	7E	60 Minutes	3.95 lb/hr
CO	10	60 Minutes	3.67 lb/hr
<b><u>Recycle Bin</u></b>			
Recycle Bin PM/CPM	5/202	120	PM: 0.005 gr/dscf

### 3.3 Deviations from Approved Test Protocol

All test methods and procedures used during this test program were conducted in accordance with EPA and MDEQ-approved test methodology and the approved test protocol.

### 3.4 Summary of Result

The results of the dryer train and recycle bin emission test program are summarized in Tables 3-2 to 3-5. These tables show that the dryer trains and their respective recycle bins 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 summarized in the tables are presented in Appendices of this report.



**Table 3-2**  
**Summary of Results**  
**GLWA Biosolids Drying Facility – EUDryerTrainB**

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		
<b>Sample Conditions</b>						
Volume	dscf <sup>a</sup>	74.203	75.431	74.709	74.781	
Volume	dscm <sup>b</sup>	2.101	2.136	2.116	2.118	
Isokinetics	%	90	100	102	97	
<b>Stack Conditions</b>						
Flow Rate	dscfm <sup>c</sup>	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	
Oxides of Nitrogen	PPM	17.0	18.6	18.8	18.1	
Oxides of Nitrogen	lb/hr	1.12	1.18	1.16	1.16	3.95
Carbon Monoxide	PPM	10.9	11.6	11.4	11.3	
Carbon Monoxide	lb/hr	0.44	0.45	0.43	0.44	3.67
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	mg	5.3	12.5	4.4	7.4	
	Grains/dscf	0.001	0.003	0.001	0.002	
	lb/hr	0.09	0.19	0.07	0.12	
Emission Rate - Back Half	tons/yr	0.38	0.85	0.29	0.51	
	mg	17.3	26.3	20.6	21.4	
	Grains/dscf	0.004	0.005	0.004	0.004	
Emission Rate - Front & Back Half	lb/hr	0.28	0.41	0.31	0.34	1.14
	mg	22.6	38.8	25.0	28.8	
	Grains/dscf	0.005	0.008	0.005	0.006	
	lb/hr	0.37	0.60	0.38	0.45	1.14

a) dry standard cubic feet  
b) dry standard cubic meters  
c) dry standard cubic feet per minute



**Table 3-3**  
**Summary of Results**  
**GLWA Biosolids Drying Facility – EUDryerTrainC**

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		
<b>Sample Conditions</b>						
Volume	dscf <sup>a</sup>	82.656	73.737	95.664	84.019	
Volume	dscm <sup>b</sup>	2.341	2.088	2.709	2.379	
Isokinetics	%	94	92	105	97	
<b>Stack Conditions</b>						
Flow Rate	dscfm <sup>c</sup>	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	
Oxides of Nitrogen	PPM	19.7	20.5	19.0	19.7	
Oxides of Nitrogen	lb/hr	1.46	1.39	1.40	1.42	<b>3.95</b>
Carbon Monoxide	PPM	7.5	7.0	6.4	7.0	
Carbon Monoxide	lb/hr	0.34	0.29	0.29	0.31	<b>3.67</b>
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	mg	10.3	10.2	6.5	9.0	
	Grains/dscf	0.002	0.002	0.001	0.002	
	lb/hr	0.17	0.17	0.09	0.15	
	tons/yr	0.75	0.76	0.41	0.64	
Emission Rate - Back Half	mg	20.5	13.1	13.8	15.8	
	Grains/dscf	0.004	0.003	0.002	0.003	
	lb/hr	0.34	0.22	0.20	0.25	<b>1.14</b>
Emission Rate - Front & Back Half	mg	30.8	23.3	20.3	24.8	
	Grains/dscf	0.006	0.005	0.003	0.005	
	lb/hr	0.51	0.39	0.29	0.40	<b>1.14</b>

a) dry standard cubic feet  
b) dry standard cubic meters  
c) dry standard cubic feet per minute



**Table 3-4**  
**Summary of Results**  
**GLWA Biosolids Drying Facility - Recycle Bin B**

Test Run No.		Recycle Bin 2, Run 1	Recycle Bin 2, Run 2	Recycle Bin 3, Run 3	Average	Facility Permit Limit
Date		12/04/19	12/04/19	12/04/19		
Time	Start	8:50	11:33	14:15		
	Stop	10:50	13:40	16:16		
<b>Sample Conditions</b>						
Volume	(dscf) <sup>a</sup>	70.859	76.462	88.055	78.459	
Volume	(dscm) <sup>b</sup>	2.007	2.165	2.494	2.222	
Isokinetics	(%)	108.0	96.4	100.8	101.7	
<b>Stack Conditions</b>						
Flow Rate	(dscfm) <sup>c</sup>	515	678	747	647	
Temperature	(°F)	100	148	107	118	
Oxygen	(%)	20.9	20.9	20.9	20.9	
Carbon Dioxide	(%)	0.0	0.0	0.0	0.0	
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	(mg)	44.5	12.5	5.9	21.0	
	(Grains/dscf)	0.010	0.003	0.001	0.004	
Emission Rate - Back Half	(mg)	28.1	15.0	25.0	22.7	
	(Grains/dscf)	0.006	0.003	0.004	0.005	
Emission Rate - Front & Back Half	(mg)	72.6	27.5	30.9	43.667	
	(Grains/dscf)	0.016	0.006	0.005	0.009	0.005

- a) dry standard cubic feet
- b) dry standard cubic meters
- c) dry standard cubic feet per minute

Test Run No.		Recycle Bin B, Run 2	Recycle Bin B, Run 3	Recycle Bin B, Run 4	Average	Facility Permit Limit
Date		02/26/20	02/26/20	02/26/20		
Time	Start	11:05	13:25	15:35		
	Stop	13:05	15:25	17:35		
<b>Sample Conditions</b>						
Volume	(dscf) <sup>a</sup>	88.252	91.943	92.457	90.884	
Volume	(dscm) <sup>b</sup>	2.499	2.604	2.618	2.574	
Isokinetics	(%)	97.4	90.5	90.9		
<b>Stack Conditions</b>						
Flow Rate	(dscfm) <sup>c</sup>	722	803	811	779	
Temperature	(°F)	106	106	101	104	
Oxygen	(%)	20.9	20.9	20.9	20.9	
Carbon Dioxide	(%)	0.0	0.0	0.0	0.0	
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	(mg)	5.5	5.9	4.4	5.3	
	(Grains/dscf)	0.001	0.001	0.001	0.001	
Emission Rate - Back Half	(mg)	8.3	13.4	6.9	9.5	
	(Grains/dscf)	0.001	0.002	0.001	0.002	
Emission Rate - Front & Back Half	(mg)	13.8	19.3	11.3	14.800	
	(Grains/dscf)	0.002	0.003	0.002	0.003	0.005

- a) dry standard cubic feet
- b) dry standard cubic meters
- c) dry standard cubic feet per minute



**Table 3-5**  
**Summary of Results**  
**GLWA Biosolids Drying Facility - Recycle Bin C**

Test Run No.		Recycle Bin 3, Run 4	Recycle Bin 3, Run 5	Recycle Bin 3, Run 6	Average	Facility Permit Limit
Date		12/04/19	12/04/19	12/04/19		
Time	Start	16:58	7:48	10:45		
	Stop	19:05	9:53	12:47		
<b>Sample Conditions</b>						
Volume	(dscf) <sup>a</sup>	102.858	104.434	117.082	108.125	
Volume	(dscm) <sup>b</sup>	2.913	2.958	3.316	3.062	
Isokinetics	(%)	94.6	92.8	100.5	95.9	
<b>Stack Conditions</b>						
Flow Rate	(dscfm) <sup>c</sup>	931	963	943	946	
Temperature	(°F)	106	100	104	103	
Oxygen	(%)	20.9	20.9	20.9	20.9	
Carbon Dioxide	(%)	0.0	0.0	0.0	0.0	
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	(mg)	6.1	72.1	64.7	47.6	
	(Grains/dscf)	0.001	0.011	0.009	0.007	
Emission Rate - Back Half	(mg)	8.5	13.1	13.8	11.8	
	(Grains/dscf)	0.001	0.002	0.002	0.002	
Emission Rate - Front & Back Half	(mg)	14.6	85.2	78.5	59.427	
	(Grains/dscf)	0.002	0.013	0.010	0.008	0.005

- a) dry standard cubic feet  
b) dry standard cubic meters  
c) dry standard cubic feet per minute

Test Run No.		Recycle Bin C, Run 1	Recycle Bin C, Run 2	Recycle Bin C, Run 3	Average	Facility Permit Limit
Date		02/27/20	02/27/20	02/27/20		
Time	Start	7:50	10:00	12:10		
	Stop	9:50	12:00	14:10		
<b>Sample Conditions</b>						
Volume	(dscf) <sup>a</sup>	125.821	133.343	126.653	128.606	
Volume	(dscm) <sup>b</sup>	3.563	3.776	3.587	3.642	
Isokinetics	(%)	96.7	92.3	90.4		
<b>Stack Conditions</b>						
Flow Rate	(dscfm) <sup>c</sup>	1,038	1,142	1,117	1,099	
Temperature	(°F)	87	88	96	90	
Oxygen	(%)	20.9	20.9	20.9	20.9	
Carbon Dioxide	(%)	0.0	0.0	0.0	0.0	
<b>Particulate Matter Emissions</b>						
Emission Rate - Front Half	(mg)	17.6	10.5	1.7	9.9	
	(Grains/dscf)	0.002	0.001	0.000	0.001	
Emission Rate - Back Half	(mg)	13.7	9.4	8.8	10.6	
	(Grains/dscf)	0.002	0.001	0.001	0.001	
Emission Rate - Front & Back Half	(mg)	31.3	19.9	10.5	20.6	
	(Grains/dscf)	0.004	0.002	0.001	0.002	0.005

- a) dry standard cubic feet  
b) dry standard cubic meters  
c) dry standard cubic feet per minute





#### 4.0 SAMPLING LOCATIONS

The dryer trains exhaust through two stacks. The Dryer Train stack height is 130 feet with an internal diameter of 30 inches. The Recycle Bin/Fabric Filter Stack height is 130 feet with an internal diameter of 8 inches. The upstream and downstream disturbance distances were verified by test personnel while onsite to determine the appropriate number of sampling points. The test port on the Recycle Bin/Fabric Filter stack is located 16 inches from the outlet flange on the last elbow before the vertical stack. The sampling locations are accessed from the roof. Appendix D contains a picture of the sampling location.

A gaseous stratification check was conducted by CK personnel. Instrumental sampling was conducted at a minimum of twice the system response time at each of the 12 traverse point. Figures 4-1 and 4-2 present stack diagrams and Tables 4-1 and 4-2 present the stack dimensions.

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

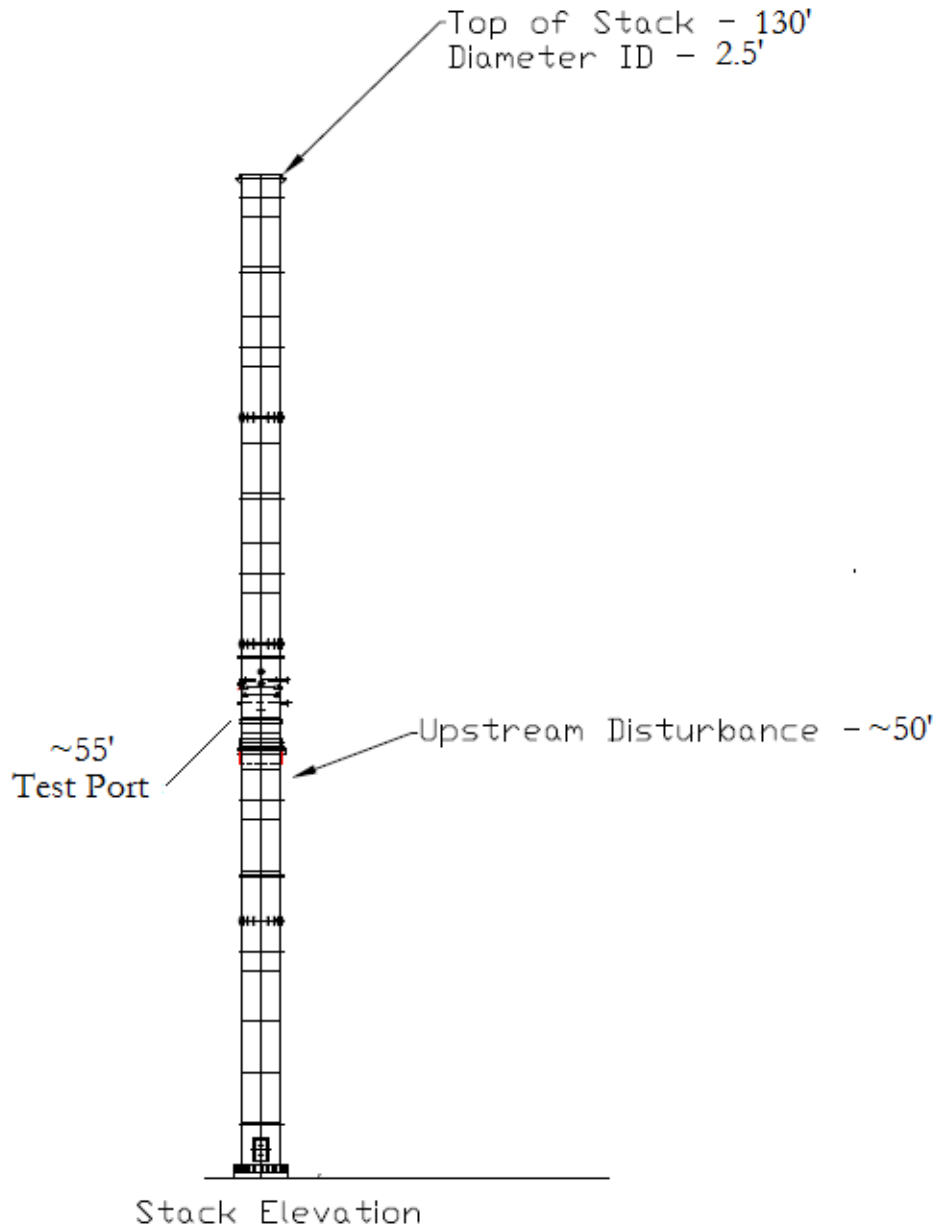
Description	Dimension
Sample Port To Downstream Distance	~75'
Upstream Distance To Sample Port	5'
Duct Diameter	2.5'
Stack Height	130' above grade
Number of Ports	2
Number of Points	24

**Table 4-2**  
Recycle Bin Filter Exhaust  
Stack Dimensions

Description	Dimension
Sample Port To Downstream Distance	~75'
Upstream Distance To Sample Port	16"
Duct Diameter	8"
Stack Height	130' above grade
Number of Ports	1
Number of Points	1 point, center

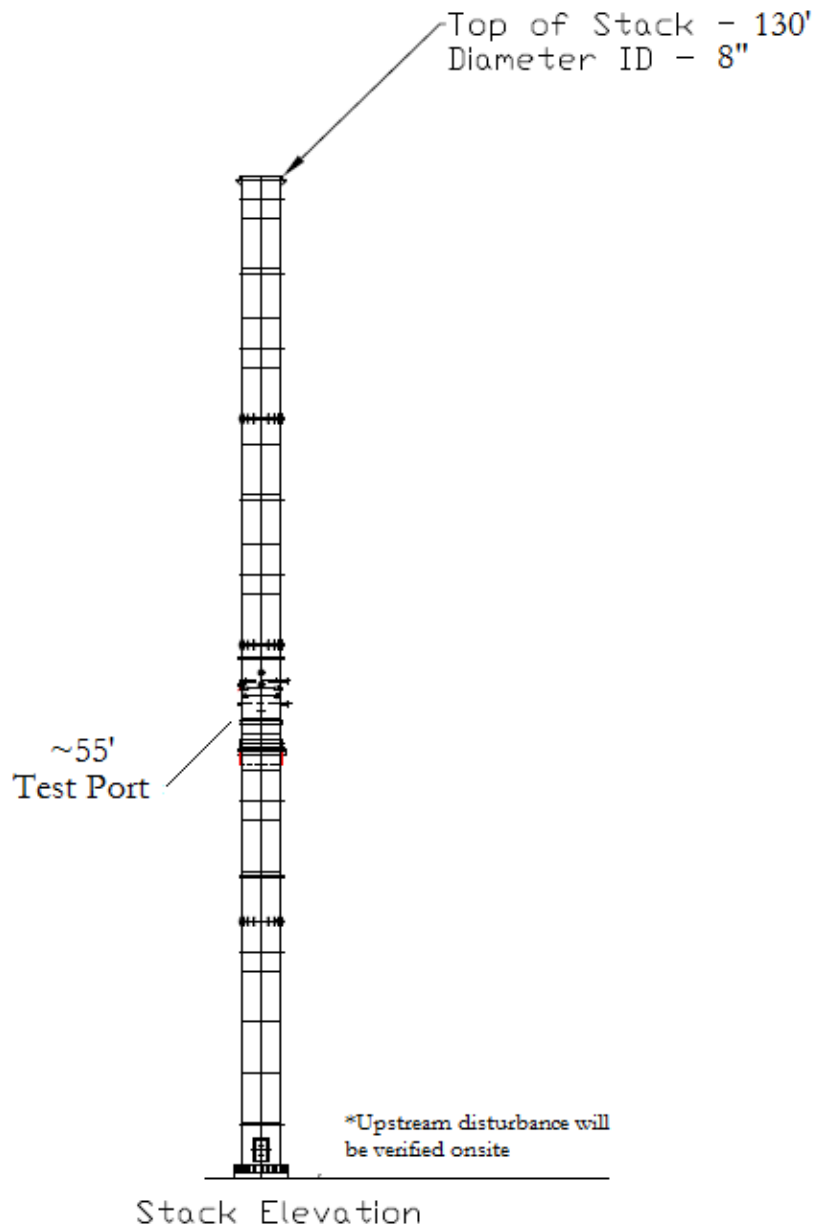


**Figure 4-1**  
Dryer/RTO Stack Train Exhaust  
Stack Diagram





**Figure 4-2**  
Recycle Bin Filter 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 4-2**  
Exhaust Gas Flow Traverse Point Locations

<b>Traverse Point</b>	<b>Diameter (%)</b>	<b>Distance from inside wall (inches)*</b>
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 emissions compliance:

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 5	Determination of Particulate Emissions from Stationary Sources
US EPA Method 7E	Determination of Nitrogen Oxides Emissions from Station Sources (Instrumental Analyzer Procedure)
US EPA Method 10	Determination of Carbon Monoxide Emissions from Stationary Sources
US EPA Method 202	Determination of Condensable Particulate Emissions from Stationary Sources

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 locations detailed in Section 4. All isokinetic trains were directly connected from the hot filter to the first impinger or condenser. No flexible lines from the hot filter to the first impinger or condenser were used. Three test runs for each pollutant constituted an emission compliance test.



### **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 included the determination of the proper number of traverse points and their locations in the stack (RM1), stack velocity and volumetric flow rate (RM2), stack gas molecular weight (RM3) and stack gas moisture content (RM4).

A 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 points in the exhaust stack.

The moisture content was determined in conjunction with the Method 5 and 202 sampling trains. The trains consisted of a series of impingers and applicable sampling reagents. The impingers were housed in an impinger bucket filled with water and ice to assure that the moisture in the stack gas condenses out. The impingers and their contents were weighed before and after testing. The last impinger contained a known quantity of silica gel to capture the remaining moisture from the gas stream. The resultant net weight gain of the impinger train was used to calculate the moisture content of 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 used a Teledyne Model 326A oxygen analyzer with a range of 0-25% oxygen and a California Analytical Instruments Model ZRH non-dispersive infrared carbon dioxide analyzer with a range of 0-20% carbon dioxide. The instruments meet all of the performance specifications of the Method. They were calibrated before and after each test period using low, mid or high calibration gases prepared according to EPA Protocol. Sampling occurred simultaneously with flow measurements in order to obtain volumetric flow data for mass emission calculations.

### **5.1.3 Nitrogen Oxides - EPA Method 7E**

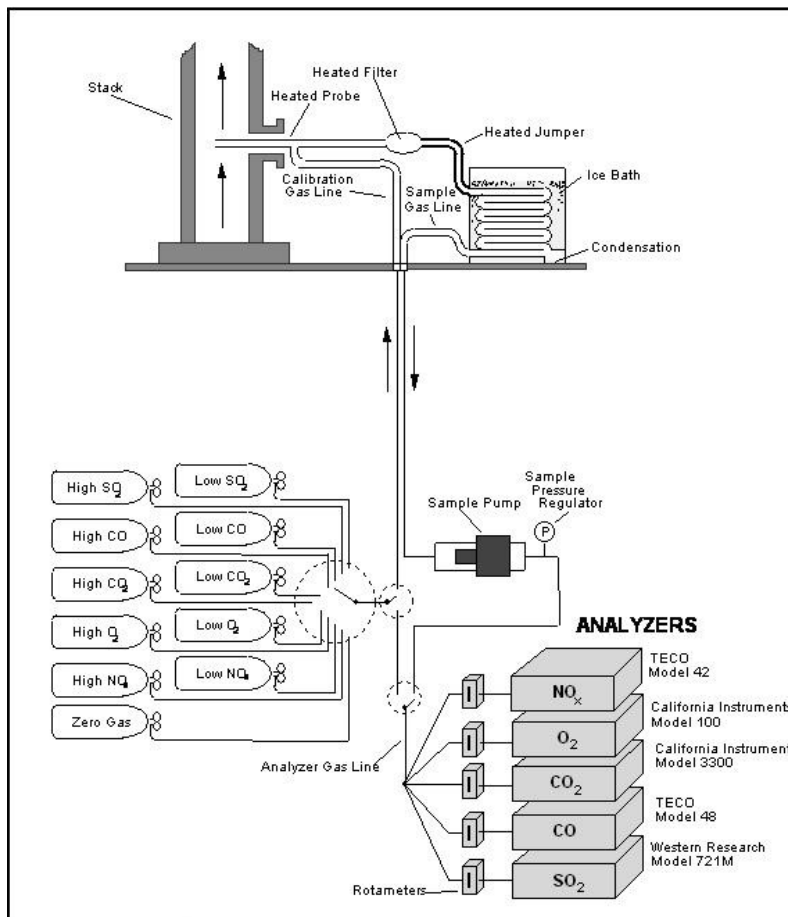
Nitrogen oxides were measured in accordance with EPA Method 7E. This Method utilizes continuous emissions monitoring instrumentation. CK Environmental used a Thermo Electron Model 42C, or equivalent NO<sub>x</sub> chemiluminescent monitor with 8 ranges from 0-10,000 ppm. The instrument meets all of the performance specifications of the Method. It was calibrated before and after each test period using low, mid or high calibration gases prepared according to EPA Protocol. The analyzer was calibrated in the 0-25 ppm operating range. Sampling occurred simultaneously with flow measurements in order to obtain volumetric flow data for mass emission calculations. A NO<sub>2</sub> to NO conversion efficiency test was conducted on-site before the test program. The analyzer must show a 90% conversion efficiency to be used for NO<sub>x</sub> measurement. The conversion efficiency data can be found in Appendix F.



### 5.1.4 Carbon Monoxide – EPA Method 10

EPA Method 10 was used to measure carbon monoxide. This Method utilizes continuous emissions monitoring instrumentation. A TECO Model 48 CO analyzer was utilized for the emissions testing. Radiation from an infrared source is chopped and then passes through a gas filter that alternates between CO and N<sub>2</sub> due to a rotation of a filter wheel. The radiation then passes through a narrow band-pass filter and a multiple optical pass sample cell where absorption by the sample gas occurs. The IR radiation exits the sample cell and falls on a solid state IR detector. The instrument meets all of the performance specifications of the Method. It was calibrated before and after each test period using low, mid or high calibration gases prepared according to EPA Protocol. The analyzer was calibrated in the 0-25 ppm operating range. Sampling occurred simultaneously with flow measurements in order to obtain volumetric flow data for mass emission calculations.

CO<sub>2</sub> interference was mitigated using gas filter correlation wheel technology. The TECO Model 48 CO Analyzer has this capability.



**Figure 5-1 Schematic of a Typical RM CEM System**



### 5.1.5 Particulate Matter – EPA Method 5/202

Filterable Particulate Matter (PM) is measured using EPA Methods 1 through 5, including the determination of the proper number of sampling points and their locations in the stack (RM1), stack velocity and volumetric flow rate (RM2), stack gas molecular weight (RM3A) and stack gas moisture content (RM4). For this testing program, the EPA Method 5 sampling train is combined with a condensable particulate Method 202 sampling train (see Figure 5-3). Sampling is conducted isokinetically for a period of 120 minutes per run, collecting a minimum of 60 dry standard cubic feet.

The front-half of the sampling train consists of a stainless steel or borosilicate glass nozzle, heated glass lined probe, and heated quartz glass filter.

All filters are prepared and analyzed by Maxxam Analytical. Each filter is weighed before and after sampling in accordance with the Method and the procedures outlined in the EPA Quality Assurance Handbook. They are desiccated for at least 24 hours, and then weighed at six-hour intervals until two consecutive weights demonstrate a constant weight,  $\pm 0.5$  milligrams.

Prior to sampling, the isokinetic correlation is established, the train is carefully assembled and leak checked. After the probe and filter compartment reach the desired operating temperature ( $248^{\circ}\text{F} \pm 25^{\circ}$ ), the probe is placed in the stack and isokinetic sampling takes place.

At the completion of isokinetic sampling, the train is leak checked for leaks, disassembled, and sealed. All train recovery procedures are conducted in accordance with EPA Method 5. The filter is carefully removed from the filter holder and placed in a sample label identified petri dish. The nozzle, probe and the front portion of the filter holder are thoroughly brushed and rinsed with acetone and collected in a container labeled for sample identification. Sample volumes are noted and liquid levels marked.

The samples are analyzed gravimetrically by Maxxam Analytical in accordance with the method. The acetone rinses are evaporated to dryness in tared beakers. All filters and beakers are desiccated before and after sampling for 24 hours, and weighed at 6-hour intervals until two consecutive weights are within  $\pm 0.5$  mg.

Condensable Particulate Matter (CPM) is quantified in accordance with the sample train operation and back end recovery and analysis procedures of EPA Method 202. The following is a description of the CPM sampling train and the procedures used to quantify CPM during the compliance testing. This includes the determination of the proper number of sampling points and their locations in the stack (RM1), stack velocity and volumetric flow rate (RM2), stack gas molecular weight (RM3) and stack gas moisture content (RM4).

For this test program, the PM<sub>10</sub>/PM<sub>2.5</sub> emission rate is calculated as the sum of filterable PM emissions (M5) and CPM emissions (M202).





The CPM is collected in dry impingers after the filterable PM is collected on a heated, tared quartz fiber filter configured into the front-half of the sampling train. The potential CPM artifacts (sulfates) from the source's potential sulfur dioxide (SO<sub>2</sub>) emissions are reduced by using a condenser and dropout impinger to separate CPM from potential reactive gases. No water is added to the impingers prior to the start of sampling. To improve the collection efficiency of CPM, an additional Teflon® filter (the CPM filter) is placed between the second and third impingers.

The back-half of the Method 202 sampling train consists of a condenser and two condensate dropout impingers following the out-of-stack filterable PM heated filter assembly. These first two impingers are placed in an insulated "cold box" containing a water bath maintained at a temperature of less than 85°F which is recirculated through the condenser during sampling. The condenser is capable of cooling the stack gas to less than 85°F. At the start of testing, the water dropout and backup impingers are empty, without any water or reagent added.

A glass filter holder containing a nonreactive, non-disintegrating polymer filter, usually Teflon, (the CPM filter) and Teflon backer follow the first two impingers. The filter holder is fitted with a thermocouple measuring the temperature of the sample gas exiting the filter holder. The temperature of the sample gas is maintained at or below 85°F. A modified Greenburg Smith impinger containing 100 mL of water follows the CPM filter. This impinger is used as a moisture trap to collect any moisture that passes through the CPM filter. A fourth impinger contains a known quantity of color indicating silica gel for additional moisture collection. The temperature at the outlet of the fourth impinger is maintained below 68°F during sampling by use of an ice bath containing the third and fourth impingers. A vacuum line connects the outlet of the fourth impinger to a Method 5 control module consisting of a leak free sample pump, a calibrated critical orifice, an inclined manometer, a calibrated dry gas meter and inlet and outlet thermocouples.

Prior to mobilizing to the test site, the first two impingers, CPM filter holder, and their connecting glassware are cleaned with soap and water, rinsed using tap water, and further rinsed with deionized, distilled water, acetone, and finally, hexane. After cleaning, the glassware is baked at 300°C for six hours. Prior to each sampling run, the train glassware is rinsed thoroughly with deionized, distilled ultra-filtered water, acetone and hexane. Silicone grease is not used as a sealant in this sampling train.

Before and after each test the sampling train is leak checked to ensure a leakage rate of no greater than 0.02 cubic feet per minute (cfm) at a minimum of 15 inches of mercury (in. Hg) vacuum. The probe is then placed in the stack and stack gas is withdrawn isokinetically for an equal period of time at each traverse point. The velocity pressure, orifice differential pressure, dry gas meter volume, dry gas meter temperature, probe temperature, stack temperature, filter compartment temperature, CPM exit temperature, impinger outlet temperature, and sample vacuum are recorded at each traverse point during sampling. At the completion of each test, the sampling train is leak checked at the highest recorded sample vacuum to ensure a leakage rate of no greater than 0.02 cfm.



As soon as possible following the post-test leak check, the front-half of the sampling train is separated from the back-half, and the back half impingers re-weighed, for moisture determination. The front half of the train is recovered in accordance with Method 5 for the determination of filterable particulate matter. The back half of the train (CPM portion) is re-assembled and configured for the post-test nitrogen (N<sub>2</sub>) purge. Ice is left in the third and fourth impinger “cold box” to prevent removal of moisture during the purge. If necessary, additional ice is added during the purge cycle to maintain the gas temperature measured at the exit of the fourth impinger to below 68°F.

The short stem of the first impinger is replaced with a modified Greenberg Smith impinger insert with the impinger tip extending at least 1 centimeter below the surface of the collected condensate. The N<sub>2</sub> purge is performed by delivering N<sub>2</sub> through a Teflon line and inline membrane filter to the inlet of the CPM sampling train. The N<sub>2</sub> gas flow is slowly adjusted to a delivery rate 14 L/min and the purge conducted for 1 hour. After 1 hour the delivery system is turned off and the CPM train prepared for sample recovery.

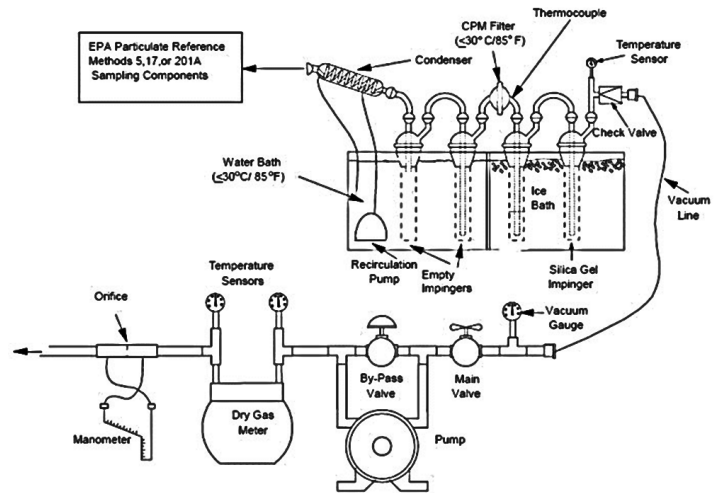
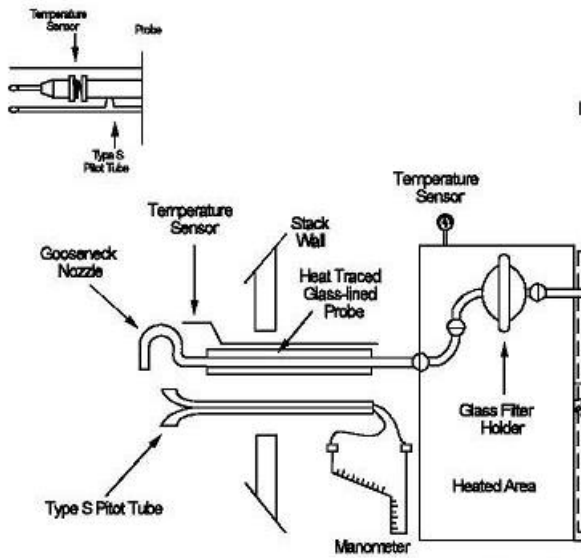
For sample recovery the CPM filter is carefully removed from the filter holder with tweezers / forceps and placed in a labeled plastic petri dish. Any particulate matter or filter fragments that adhere to the filter holder gasket are transferred to the petri dish using the forceps. The petri dish is then sealed for transport to the analytical laboratory.

The aqueous liquid impinger contents of impingers #1 and #2 (the dropout and backup dropout impingers) are quantitatively transferred into a clean glass sample container. The condenser, each impinger, connecting glassware and the front-half of the CPM filter holder are rinsed twice with deionized, distilled ultra-filtered water. The rinse water is recovered into the same bottle as the impinger contents and the liquid level marked. This sample container holds the water soluble (in organic) CPM captured in the sampling train.

Following the water rinses the sampling train components are rinsed with acetone, then twice with hexane. These solvent rinses are collected in a separate glass sample container and the liquid level marked. This sample container holds the organic CPM sample fraction captured in the sampling train.

The CPM sample fractions are maintained at or below 85°F during transport to the CK sub-contract analytical laboratory, Maxxam Analytics Inc., for analysis in accordance with Method 202 procedures. The resulting masses of organic and aqueous (inorganic) CPM collected are then determined using the drying and weighing procedures of EPA Method 202. A field blank was submitted for identical QA/QC analyses.

**Figure 5-2**  
Method 5 / 202 Sampling Train





## 5.2 Emissions Sampling Procedures

### 5.2.1 Isokinetic Sampling Procedures (Particulate Matter)

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 occur 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** - A preliminary traverse is conducted. Readings include the velocity pressure, gas temperature and static pressure.

**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** - Isokinetic sampling, per the Reference Method takes place. 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.

**Sample Recovery** - All samples are recovered in accordance with EPA Reference Methods 5 and 202 procedures.

**Isokinetics** - Once all sample recovery is completed (including moisture determination), calculations are conducted to determine the percent isokinetic of each test run.

### 5.2.2 CEMS Sampling System and Procedures (O<sub>2</sub>, CO<sub>2</sub>, NO<sub>x</sub>, CO)

What follows is a description of the transportable continuous emissions monitor system used to quantify oxygen, carbon dioxide, carbon monoxide and oxides of nitrogen. The system meets all the specifications of Reference Methods 3A 7E and 10 and conform 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 4.0.

**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°. The sample stream is passed through the sample conditioning system before being delivered to the O<sub>2</sub>, CO<sub>2</sub>, CO and NO<sub>x</sub> 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** - capable of the continuous determination of O<sub>2</sub>, CO<sub>2</sub>, CO and NO<sub>x</sub> 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, 7E and 10 (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 were determined prior to testing in accordance with EPA Methods 3A, 7E, 10.

**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, 7E, 10.

**Determination of Sampling System Bias** - Sampling system bias is determined immediately prior to testing in accordance with EPA Methods 3A, 7E, 10.

**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, 7E, 10.

**NO<sub>2</sub> to NO Converter Check**- A NO<sub>2</sub> to NO converter check is conducted on the NO<sub>x</sub> analyzer in accordance with Section 8.2.4 of Method 7E. A calibration gas of  $\approx 50$  ppm NO<sub>2</sub> is introduced into the analyzer in direct calibration mode. The NO<sub>x</sub> concentration measured by the analyzer is recorded and the



conversion efficiency calculated using equation 7E-7 in Method 7E. The converter check is acceptable if the calculated converter efficiency is between 90 and 110%.

**Stratification Check-** During Run 1 CK performed a stratification check at the test site to determine the appropriate number of sample traverse points. To test for stratification, CK used a probe of appropriate length to measure the diluent and pollutant concentration at twelve traverse points located according to Table 1-2 of Method 1. CK sampled for a minimum of twice the system response time at each traverse point. CK calculated the individual point and mean gas concentrations.

**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.