



1.0 INTRODUCTION

CK Environmental Inc. (CK) was contracted by Great Lakes Water Authority (GLWA) to conduct the emission compliance test program at the Detroit Wastewater Resource Recovery Facility (WRRF). This test program was conducted to demonstrate that four (units 7, 8, 9 & 10) of the facility's multiple hearth incinerators (MHI) meet regulatory mandated emissions limitations while operating under the facility's full capacity.

The purpose of this source test program was to quantify the controlled emissions of nitrogen oxides (NO_x) from each unit. Volumetric flow rate measurements, consisting of exhaust gas velocity, oxygen (O₂) and carbon dioxide (CO₂) concentrations, and exhaust gas moisture content was made concurrently with the pollutant measurements. Results are reported in units of the standard in accordance with Tables 3-1 and 3-2. Unit 9 also underwent PM emissions testing.

Testing was conducted in accordance with the conditions and monitoring requirements for compliance testing as set forth in the State of Michigan Department of Environment, Great Lakes, and Energy (EGLE) and United States Environmental Protection Agency (USEPA) Part 60, Subpart M - Emission Guidelines for Existing Sewage Sludge Incineration Units (Model Rule).

Testing was completed the week of November 2, 2021. Michael Kelley, QSTI, is the CK Project Manager, responsible for all aspects of the emissions testing program. Assisting Michael Kelley with field testing activities was a group of CK engineers. Melvin Dacres served as the facility contact and be responsible for coordinating the facility operations and the facility's operations staff. Representatives of the EGLE (Jeremy Howe and Stephen Weiss) were present to observe on-site emissions testing activities.

Table 1-1
Project Contacts

Company Name	Role	Contact	Telephone/Email
CK Environmental	Testing Firm	Michael Kelley	(781) 828-5200 mkelley@cke.us
Great Lakes Water Authority	Facility	Melvin Dacres	(313) 297-0363 melvin.dacres@glwater.org
Michigan Department of Environment, Great Lakes & Energy	EGLE	Jeremy Howe	(231) 878-6687 Howej1@michigan.gov



2.0 PROCESS DESCRIPTION

GLWA operates eight (8) sewage sludge multiple hearth incinerators. All sewage sludge incinerators are subjected to the 40 CFR Part 60, Subpart M emissions guidelines through Rule 972. Four (4) MHIs are included in this group: EUINC07, EUINC08, EUINC09 and EUINC10.

Sludge is dewatered with belt filter presses and conveyed to the multiple hearth furnaces with belt conveyors. The sludge conveyors are equipped with weigh scales for continuous monitoring of the amount of sludge being incinerated. The dewatered sludge is introduced at the top hearth and rabbled down through successive hearths in a spiral path. The moisture in the sludge is evaporated in the upper hearths as hot combustion gases traveling concurrently from the middle hearths where combustion takes place. The maximum feed rate is 3.2 dry tons per hour at 25% solids and 75% volatiles condition. It is a continuous feed process. Under normal operating conditions each incinerator runs between 2.0 and 2.5 dry tons per hour with temperature of the solids between 50 and 80 °F. The furnace is equipped with auxiliary natural gas burners at hearths 2, 4, 6, 8, 10, and 12. The firing rate of the burners is modulated by a central control system to sustain the desired hearth temperatures.

Each air pollution control system is comprised of a Double Zero Hearth afterburner section of Hearths 1 and 2, a quench section, and EnviroCare® Venturi-Pak (venturi throat sections and mist eliminator) scrubber system. The total pressure drop across the wet scrubber ranges between 25 and 40 inches of water column (in. wc). The total scrubber water flow should be greater than 1330 gallons per minute (gpm). Exhaust gases pass through this MHI via an induced draft (ID) fan and exit the scrubber at 100-150 °F.

2.1 PROCESS MONITORING

Facility personnel recorded and monitored key process parameters. These process parameters were monitored and recorded during each test. At a minimum, the following were recorded:

- Biosolids Feed Rate (wet tons/hr)
- Biosolid Cake Solids (%)
- Biosolids Feed Rate (dry tons/hr)
- Afterburner Exit Temp (°F)
- Total Scrubber Water Flow (gal/min)
- Total Scrubber Pressure Drop (in. wc)
- Scrubber Water Outlet pH



3.0 TEST PROGRAM

Testing was conducted at the scrubber exhaust duct of each MHI details are described in section 4.0.

Tables 3-1 through 3-2 present the test methodologies, pollutants tested, and allowable limits for this program. Each parameter was measured and analyzed in accordance with EPA or EGLE-approved procedures as presented in this test protocol. Table 3-3 presents the proposed test schedule.

Table 3-1
Test Matrix – EUINC07, EUINC08, EUINC09 and EUINC10

EPA Method	Pollutant	# of Runs	Length of Run	Emission Limit
1-2 & 4	Flow Rate & Moisture	3	60 mins	N/A
3A	Oxygen/Carbon Dioxide (O ₂ /CO ₂)	3	60 mins	N/A
7E	Nitrogen Oxides (NO _x)	3	60 mins	220 ppmvd @ 7% O ₂

Table 3-2
Test Matrix – EUINC09

EPA Method	Pollutant	# of Runs	Length of Run	Emission Limit
1-5	Filterable Particulate Matter	3	72 min	80 mg/dscm @ 7% O ₂

3.1 DEVIATIONS FROM APPROVED PROTOCOL

Testing was performed in accordance with the approved test protocol without deviations.

3.2 SUMMARY OF RESULTS

The results of the emission test programs are summarized below. Tables 3-3 through 3-6 provide the individual test run results for each unit. Test results demonstrate compliance with all permitted emission limits. Supporting documentation is in Appendices.

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Table 3-3
EUINC 7
CEMS Summary

Test Run No.	Run 7	Run 8	Run 9	Averages	Facility Permit Limits
Date	11/03/21	11/03/21	11/03/21		
Time	07:50 - 08:50	09:05 - 10:05	10:18 - 11:18		
<u>Continuous Emissions Monitoring Systems</u>					
Oxygen %	9.7	10.1	9.9	9.9	
Carbon Dioxide %	8.3	8.3	8.4	8.3	
Oxides of Nitrogen PPM	124.7	153.0	157.1	144.9	
PPM@7% O ₂	154.76	196.92	198.52	183.40	220

Table 3-4
EUINC 8
CEMS Summary

Test Run No.	Run 10	Run 11	Run 12	Averages	Facility Permit Limits
Date	11/03/21	11/03/21	11/03/21		
Time	11:50 - 12:50	13:05 - 14:05	14:27 - 15:27		
<u>Continuous Emissions Monitoring Systems</u>					
Oxygen %	10.0	9.2	9.4	9.5	
Carbon Dioxide %	8.3	9.0	8.8	8.7	
Oxides of Nitrogen PPM	157.3	150.0	135.1	147.5	
PPM@7% O ₂	200.59	178.21	163.29	180.70	220



Table 3-5
EUINC 9
CEMS and PM Emissions Summary

Test Run No.		Run 1	Run 2	Run 3	Average	Facility Permit Limits
Date		11/02/21	11/02/21	11/02/21		
Time	Start	8:35	10:40	13:35		
	Stop	9:59	11:59	15:01		
Stack Conditions						
Flow Rate	dscfm ^c	14,086	15,575	15,451	15,037	
Temperature	°F	74	74	71	73	
Moisture	%	1.9	2.9	2.7	2.5	
Continuous Emissions Monitoring Systems						
Oxygen	%	10.3	10.3	11.2	10.6	
Carbon Dioxide	%	8.0	8.0	7.3	7.8	
Oxides of Nitrogen	PPM	128.8	143.7	124.9	132.5	
	PPM@7% O ₂	168.90	188.44	178.98	178.77	220
	lb/hr	13.0054	16.0437	13.8337	14.29	
Particulate Matter Emissions						
	<i>Sample Conditions</i>					
Volume	(dscf) ^a	49.1	40.6	40.6	43.5	
Volume	(dscm) ^b	1.4	1.2	1.2	1.2	
Isokinetics	(%)	103	108	110		
Total PM Catch	Front Half (mg)	17.3	16.9	10.6	14.9	
Total PM Emission Rate	(mg/dscf)	0.4	0.4	0.3	0.3	
	(mg/dscm@7% O ₂)	16.3	19.3	13.2	16.3	80
	(lb/hr)	0.7	0.9	0.5	0.7	

Table 3-6
EUINC 10
CEMS Summary

Test Run No.		Run 4	Run 5	Run 6	Averages	Facility Permit Limits
Date		11/02/21	11/02/21	11/02/21		
Time		15:35 - 16:35	16:50 - 17:50	18:05 - 19:05		
Continuous Emissions Monitoring Systems						
Oxygen	%	11.1	9.7	9.3	10.0	
Carbon Dioxide	%	7.3	8.7	8.9	8.3	
Oxides of Nitrogen	PPM	135.6	142.2	147.2	141.7	
	PPM@7% O ₂	192.33	176.48	176.39	181.73	220



4.0 SAMPLING LOCATION

All MHI sampling locations are identical. Outlet flue gas sampling occurred at a location that is between the scrubber exhaust and induced draft fan. The inside diameter of the exhaust duct is 54 inches. Two test ports, spaced 90° apart, are located 120 inches (2.2 duct diameters) to the nearest upstream disturbance and 108 inches (2.0 duct diameters) to the nearest downstream disturbance. In accordance with EPA Method 1, twenty-four (24) traverse points (12 per port) were used for isokinetic sampling and volumetric flowrate determinations. Continuous emissions monitoring (CEM) took place through a single port that is located adjacent to the GLWA total hydrocarbons (THC) sampling probe (same elevation). Prior to the start of the continuous emissions monitoring (CEM) a three-point stratification check was performed at the following traverse points (9", 27", and 45").

All measurements were verified on-site.



5.0 TESTING METHODOLOGY

The following US EPA Reference Test Methods from Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), “Standards of Performance for New Stationary Sources” Appendix A – Test Methods.

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 Filterable Particulate Emissions from Stationary Sources
US EPA Method 7E	Determination of Nitrogen Oxides Emissions from Station Sources (Instrumental Analyzer Procedure)

The following sections describe the sampling and analytical methodologies utilized during the emissions compliance testing.

5.1 TEST METHODS

5.1.1 Volumetric Flow Rate and Moisture – EPA Method 1, 2 & 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 was 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. A calibration check with certified weight was performed on the field balance and was noted on the first moisture run.



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 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 the performance specifications of the Method. They were calibrated before and after each test period in accordance with the method requirements.

5.1.3 Oxides of Nitrogen -- EPA Method 7E

Oxides of Nitrogen (NO_x) were measured in accordance with US EPA Method 7E. This method utilizes continuous emissions monitoring instrumentation. CK used a Thermo Electron Model 42C NO_x chemiluminescent analyzer with ranges from 0-5,000 ppm. During this program the instrument was operated in the 0-500 ppm range. This instrument meets all the performance specifications of the utilized method. The instrument was calibrated before and after each test period using calibration gases prepared according to US EPA protocol specifications.

5.1.4 US EPA Method 5 - Particulate Matter

Filterable Particulate Matter (PM) was 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. Sampling was conducted isokinetically for a period of 60 minutes per run, collecting approximately 30 dry standard cubic feet.

The front-half of the sampling train consists of a glass button hook nozzle, a heated glass lined sample probe, a tared glass fiber filter in a holder in an oven box, a set of four tared glass impingers connected in series in an ice bath, and a control module consisting of a leak free sampling pump, a calibrated orifice, an inclined manometer, and a calibrated dry gas meter. A system leak check was performed per section 8.4.1 of Method 5. A calibration check with certified weight was performed on the field balance and was noted on the first moisture run. A glass cyclone bypass connected the sampling probe to the filter holder.

All filters are prepared and analyzed by Bureau Veritas. 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, + 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°F + 25°), the probe is placed in the stack and isokinetic sampling takes place.

At the completion of isokinetic sampling, the train was leak checked, disassembled, and sealed. All train recovery procedures were conducted in accordance with EPA Method 5. The filter was 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 were thoroughly brushed and rinsed with acetone and collected in a container labeled for sample identification. Sample volumes were noted, and liquid levels marked. An acetone field blank was also taken for analysis along with the samples.

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

5.2 EMISSIONS SAMPLING PROCEDURES

5.2.1 Isokinetic 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 occur prior to and during the actual test.

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

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

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

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

Barometric Pressure - Barometric pressure was obtained from the Weather Channel application

Sampling Train Set-Up -

- (a) The filter was placed in the filter holder and visually checked. Filter number and tare weights were recorded on the field data sheets.
- (b) The impingers were loaded with the appropriate solution and volumes were recorded on the field data sheets.
- (c) Approximately 200 grams of silica gel were placed in the final impinger. Exact weights were logged on the field data sheets.
- (d) Crushed ice was 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 was at the desired temperature for testing, the system was leak checked at fifteen inches of vacuum (15"Hg). A leak rate of less than 0.02 CFM was achieved prior to the start of sampling.

Final Check - When sampling was ready to commence, facility operations were checked to confirm that the process was operating at the desired capacity.

Sampling - Isokinetic sampling, per the Reference Method took place. Sample gas was extracted isokinetically at each traverse point. The sample rate was established according to the velocity pressure and temperature of measured at the sample point. Traverse points were 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 was leak checked at the highest vacuum recorded during that run. Leak checks less than 0.02 CFM were considered acceptable. If a leak check exceeded 0.02 cfm, the run was suspect and was to be repeated to get an exact leak rate.

Sample Recovery - All samples were recovered in accordance with EPA Reference Method 5 procedures.

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

5.2.2 CEMS Sampling System and Procedures (O₂, CO₂, & NO_x)

What follows is a description of the transportable continuous emissions monitor system used to quantify oxygen, carbon dioxide, carbon monoxide, sulfur dioxide, and oxides of nitrogen. The system meets all the specifications of Reference Methods 3A and 7E 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 was used to transport the sample gas from the probe to the emission monitoring analyzers. The sample line was heated to 248°F, ± 25°. The sample stream is passed through the sample conditioning system before being delivered to analyzers.

Sample Conditioning System-

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



Condenser - a Universal Analyzer Sample Cooler or ice cooled condenser system was located downstream from the pump to remove moisture from the gas stream.

Sample Pump - A diaphragm type vacuum pump was 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 allowed 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 allowed the operator to maintain constant flow and pressure conditions during sampling and calibration.

Gas Analyzers - capable of the continuous determination of O₂, CO₂, and NO_x 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 was used to record analyzer response to the sample and calibration gas streams. The data logger records at 30-second intervals and the data used to report test interval averages. The Monarch saves data to a compact flash drive that was downloaded to a computer. Separate files for each test run and associated calibrations were generated and saved. Data was loaded into a Microsoft Excel® spreadsheet for calculation of test interval average concentrations and emission rates.

All sampling and analytical procedures were conducted in accordance with EPA Reference Methods 3A and 7E (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 Method 7E.

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

Determination of Analyzer Calibration Error - Analyzer calibration error was determined immediately prior to testing in accordance with EPA Methods 3A and 7E.



Determination of Sampling System Bias - Sampling system bias was determined immediately prior to testing in accordance with EPA Methods 3A and 7E.

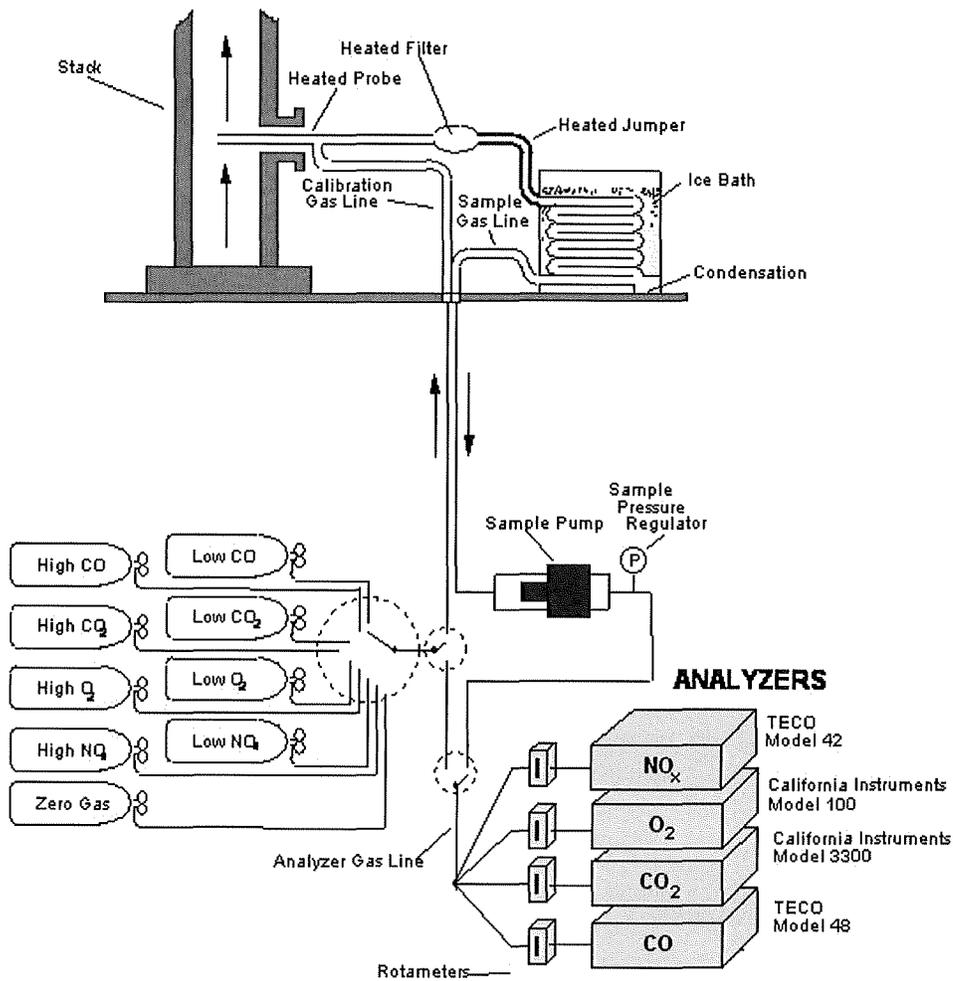
Determination of Zero and Calibration Drift - Before and after each test run, each analyzer's response to zero and mid- or hi-range calibration gases were determined. The pre-and post-test analyzer responses are compared to determine drift. The results were evaluated based upon specifications defined in EPA Methods 3A and 7E.

NO₂ to NO Converter Check- A NO₂ to NO converter check was conducted on the NO_x analyzer in accordance with Section 8.2.4 of Method 7E. A calibration gas of ≈ 50 ppm NO₂ was introduced into the analyzer in direct calibration mode. The NO_x concentration measured by the analyzer was recorded and the conversion efficiency calculated using equation 7E-7 in Method 7E. The converter check was acceptable if the calculated converter efficiency is between 90 and 110%.

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



Figure 5-1
Schematic of Reference Method CEMS





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

CK's emission testing teams are committed to providing high quality testing services. To meet this commitment, CK follows appropriate US EPA sampling procedures and implements applicable 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.

The CK QA 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).

6.1 SAMPLING

The CK measurement devices, thermocouples, and portable gas analyzers are uniquely identified and calibrated with documented procedures and acceptance criteria. Records of all equipment calibration data are maintained in CK's files. Copies of all calibration data pertinent to this test program were available on-site during testing and are included in the final Test Report.

Compressed gases used as calibration standards are always National Institute of Standards and Technology (NIST) traceable, either directly or indirectly. For this test program, US EPA Traceability Protocol certified calibration gas standards were used. The Certificates of Analysis for all Protocol standards were available on site during the testing. The Certificates of Analysis are presented in the final report

6.2 REPORTING

All Test Reports undergo a tiered review. The first review of the report and calculations is made by the report's author. A second review was then performed by another senior project scientist, or engineer. A Report Review Certification is included in the report to verify the review process was completed.