HCl and Hg Test Report
Lafarge North America
Alpena, Michigan
July 2013

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1.0 INTRODUCTION

URS Corporation (URS) conducted testing July 16-20, 2013 at the Lafarge Alpena facility (Lafarge). Lafarge operates 5 dry process cement kilns and 2 raw grind stacks at its plant in Alpena, Michigan. Kiln Nos. 19, 20, and 21 are collectively known as Kiln Group 5 (KG5), while Kiln Nos. 22 and 23 are collectively known as Kiln Group 6 (KG6). The KG5 kilns are smaller than the KG6 kilns but are of similar overall design. The raw grind mill vents 20-269 and 21-269 are known as Raw Grind stack 14 (RG 14) and Raw Grind stack 15 (RG 15).

Testing was conducted to confirm compliance with Lafarge's Michigan Department of Environmental Quality (MDEQ) issued air permit MI-ROP-B1477-2012 Hydrogen Chloride (HCl) and Chloride (Cl^-, based on equivalents) for all 7 locations and for Mercury (Hg) on the kilns.

A URS test team consisting of Vaughn Kashuba, Willie Lea, Anne Marie Wells, Robert Raymond, Erik Riegel and Kevin White performed HCl emission sampling. Josh Strapec of Lafarge provided oversight to the sampling. Rob Dickman of MDEQ observed the testing activities.

Section 2.0 includes a summary of the results, section 3.0 contains the source descriptions, section 4.0 describes the sampling and analytical procedures, section 5.0 discusses the test results in detail and section 6.0 describes the QA/QC procedures followed during this test program.

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2.0 SUMMARY OF RESULTS

EPA Method 26A was used to sample the kiln exhaust gases for HCl and Cl^-. EPA Methods 3 and 4 were used to determine stack gas molecular weight and moisture, respectively. Volumetric flow rate was determined using stack gas velocity data from the plant CEMS. The mercury testing was conducted with EPA Method 30B using paired sorbent tubes. The testing was performed in accordance with the emissions test plan that MDEQ approved in a letter dated June 27, 2013.

Table 2-1 represents KG5 and KG6 average results for HCl both as-measured and corrected to 7% oxygen. Table 2-2 represents the average results for the Cl^- as measured and corrected to 7% O_2. Michigan Rule 1003 (R 336.2003) Section 2, states: "for purposes of determining compliance with an applicable emission limit, rule, or permit condition, the arithmetic mean of results of the three samples shall apply." Table 2-1 demonstrates that the results indicate from both the kilns and raw grinds met the concentration and mass emission limits for HCl and Hg as specified in Lafarge's air permit. Results from the individual test runs are provided in Section 5.0. Both KG5 and KG6 were tested for HCl and Hg while operating with plastics in the fuel mix.

Mercury emissions from the 7 sources are summarized in Table 2-2. The average mercury concentration at each source was determined by 3 sets of pair runs. Emission rate in pounds per hour is based on 8760 hours of operation and a constant stack gas volumetric flow rate as measured during the test period. Stack flow rate for the Mercury emission testing was based on the average flow rate from the CERMS testing runs that were taken in the same time period.

Table 2-3 summarizes the average operating conditions of the kilns for each test run. Additional operating data are provided in Section 5, and in the appendices of this report.

Table 2-1. Summary of Kiln Hydrogen Chloride Results

Source	O_2 Conc (%)	Cl^- Concentration		HCl Concentration		HCl Equivalent Permit Limit (ppmvd @7%O_2)	Cl- Emission Rate (lb/hr)	HCl Emission Rate (lb/hr)	HCl Emission Equivalent Permit Limit (lb/hr)
		Uncorrected (ppmvd)	Corrected (ppmvd @7%O_2)	Uncorrected (ppmvd)	Corrected (ppmvd @7%O_2)				
K19	7.7	0.05	0.05	2.9	3.04	**65**	0.02	1.1	**36**
K20	9.5	0.06	0.07	14.6	17.8	**65**	0.03	7.1	**36**
K21	9.4	0.04	0.05	7.7	9.3	**65**	0.02	3.9	**36**
K22	7.8	0.05	0.05	67.8	71.8	**170**	0.03	47.0	**162**
K23	7.2	0.04	0.04	63.3	64.4	**170**	0.03	52.3	**162**

Table 2-2. Summary of Mercury Results

Source	Stack Flow Rate (dscfm)	Hg Mass Emission Rate (lb/hr)	Hg Concentration (ug/m^3)
RG 14	53,928	3.54E-06	0.02
RG 15	45,853	2.81E-06	0.02
K19	69,714	7.00E-03	26.80
K20	85,255	7.01E-03	21.94
K21	88,360	8.05E-03	24.33
K22	122,092	1.83E-02	39.92
K23	145,637	1.75E-02	32.06

Table 2-3. Summary of Kiln Operating Conditions

Kiln	Date of Testing	Fuel Used	Burning Zone Temperature (°C)	Raw Material Feed Rate (Metric tons/hr)	Kiln Dust Recycle Rate (Metric tons/hr)
19	07/18/13	Coal/coke/plastic	1398	68.9	5.7
20	07/18/13	Coal/coke/plastic	1425	80.6	8.9
21	07/19/13	Coal/coke/plastic	1337	78.7	7.1
22	07/16/13	Coal/coke/plastic	1356	118.5	4.6
23	7/20/2013	Coal/coke/plastic	1357	97.1	12.0

3.0 SOURCE DESCRIPTIONS

Lafarge's Alpena, Michigan plant operates five rotary kilns and two raw grind mills which manufacture Portland cement clinker using the dry process. A mixture of pulverized bituminous coal and petroleum coke, with a heating value of approximately 11,750 Btu per pound, serves as the primary fuel fed to the kilns. During this round of testing the plant also manually fed plastics to the kilns in addition to the coal/coke mixture. The coal/coke and plastics mixture are fed to a Raymond bowl mill and ground to a fineness of approximately 95% passing a 200-mesh sieve. The following sections describe the equipment tested at Lafarge in detail.

3.1 Kiln Group 5

Kiln Group 5 at the Lafarge Alpena plant consists of three rotary kilns: #19, #20, and #21. Kiln Group 5 consists of:

- Coal/petroleum coke, plastics and combustion air delivery;
- Raw mix preparation and delivery;
- Three rotary kilns
- Kiln burners; and
- Air pollution control system, consisting of the following components:
  - Boiler;
  - Multiclone dust collectors;
  - Baghouses;
  - Induced draft (ID) fans; and
  - Exhaust stacks.

Allis Chalmers manufactured the KG5 kilns. Each kiln is 460.5 feet long. Each kiln shell has an inside diameter of 15 feet at the feed end and 13 feet at the firing end. The kilns in KG5 rotate at speeds of greater than 40 revolutions per hour and are driven by an electric motor. An induced draft fan pulls combustion gases from each kiln. After exiting the kiln, the gases pass through a set of multiclones and then enter a fabric filter baghouse. After exiting the baghouse, the gases are routed through a breeching duct that connects the baghouse to a dedicated reinforced concrete stack.

Dracco manufactured the baghouse for Kiln 19. The baghouse has two parallel sets of six chambers and design airflow of 175,000 cubic feet per minute (cfm) at 400°F. The maximum operating temperature is 550°F. The baghouses for Kilns 20 and 21, manufactured by Wheelabrator-Frye are identical in design and construction, with two parallel sets of six chambers. Each baghouse has a design air flow of 166,000 cfm at 400°F. The maximum operating temperature is 550°F. Figure 3-1 provides a process flow diagram of Kiln Group 5.

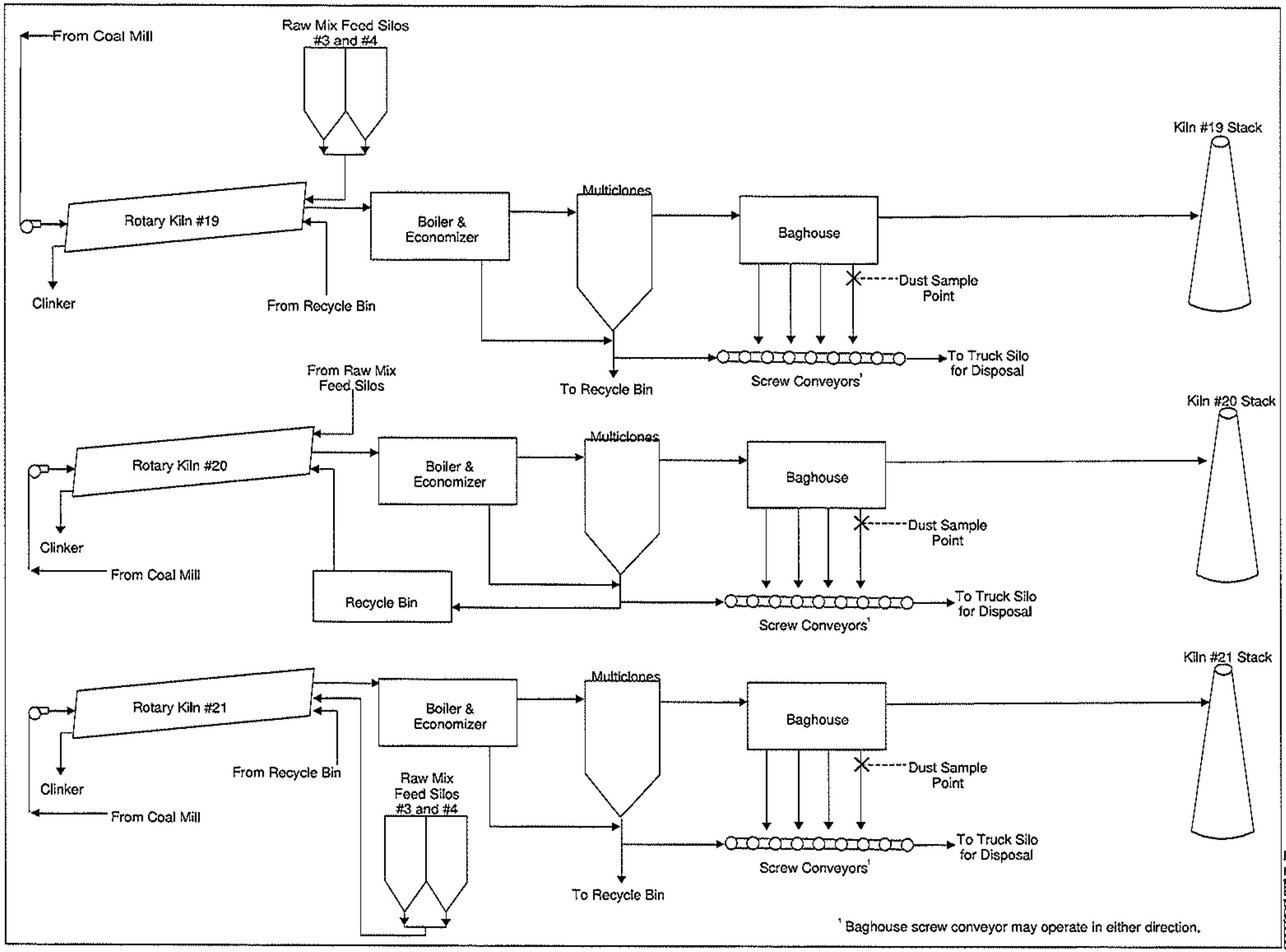

Figure 3-1. Process Flow Diagram for KG 5

3.2 Kiln Group 6

Kiln Group 6 at the Lafarge Alpena plant consists of two rotary kilns: #22 and #23. The other components of KG 6 consist of:

- Coal/petroleum coke, plastics and combustion air delivery;
- Raw mix preparation and delivery;
- Two rotary kilns
- Kiln burners; and
- Air pollution control system, consisting of the following components:
  - Boiler;
  - Multiclone dust collectors;
  - Baghouses;
  - Induced draft (ID) fans; and
  - Common exhaust stack.

Figure 3-2 provides a process flow diagram of Kiln Group 6.

The pulverized coal/coke is pneumatically conveyed by heated air, recycled from the clinker cooler, through the outer ring of a concentric burner torch. Both rotary kilns in KG 6 were manufactured by Fuller Co. and are identical in design and operation. The kilns are 500 feet long and have a 19.5-foot outer diameter. The kilns are lined with high-temperature refractory brick. The kiln design is based on a throughput of 4.8 million Btu per ton of clinker.

An induced draft fan pulls combustion gases from each kiln. After exiting the kiln, the gases pass through a set of multiclones and then enter a fabric filter baghouse. After exiting the baghouse, the gases are routed through a breeching duct that connects the baghouse to a common reinforced concrete stack.

The kilns rotate at a rate up to 80 revolutions per hour using two 350-hp motors. The kilns' associated air pollution control systems (APCS) are identical in all aspects of design, operation, and maintenance. The APCS for Kilns 22 and 23 are identical ten-compartment baghouses. Each baghouse, manufactured by Wheelabrator-Frye, consists of two parallel sets of five chambers and has design airflow of 285,000 cfm at 400°F.

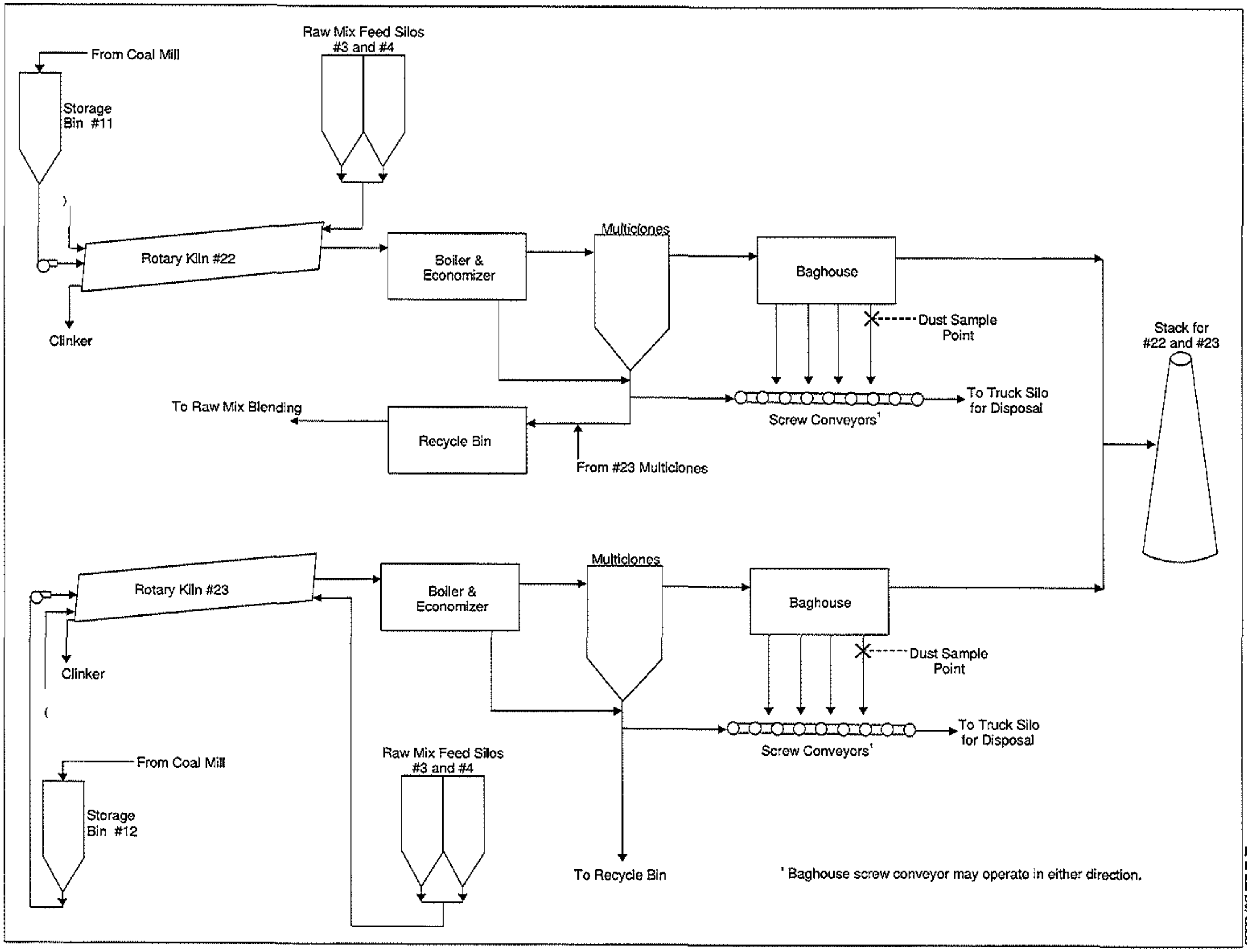

Figure 3-2. Process Flow Diagram for KG 6

3.3 Raw Mill 14 and 15 (RG-14 and RG-15)

The raw grind mill vents numbered 20-269 and 21-269 (RG-14 and RG-15, respectively) are each square ducts 12 inches by 24 inches and are similar in design. There is no straight run of ducting that meets EPA Method 1 criteria. A single port was installed on the side of the duct for testing. There was no combustion in these processes. Figure 3-3 provides a process flow diagram for Raw Grind Circuit 14. Each stack is a round, ~65 inch diameter duct with a straight run of approximately 4 duct diameters in length. Two test ports, 90 degrees apart are located near the middle of the straight run. EPA Methods 2 and 4 was used to determine volumetric flow rates.

The raw mill systems mix, grind, and dry the raw materials then sends the materials to the kilns. Raw materials include limestone, sand, bauxite, Bell shale, gypsum as well as alternate materials such as slag, iron ore, fly ash and (cement kiln dust) CKD; limestone making up 90% of the mix.

Both systems are capable of producing about 305 metric tons per hour. The yearly throughput is approximately 4.2 million tons. The raw materials go through the process starting out at about 4 inches and end up reducing down by 82% passing 200 mesh sieve. The process of crushing the stone first starts in the roller press. After leaving the press it travels through a hammer mill and via suction up a riser duct. It is in the area of the hammer mill and riser duct that drying and addition of the other materials take place. When the combined material leaves the riser duct it passes through a static separator, here material that is fine enough to make product is scalped off, and the course material is conveyed to the ball mill for finish grinding. Finished product from the static separator and from the mill is then conveyed to the kiln feed silos. Both Raw mill 14 and 15 at the Lafarge Alpena plant consists of five dust collectors.

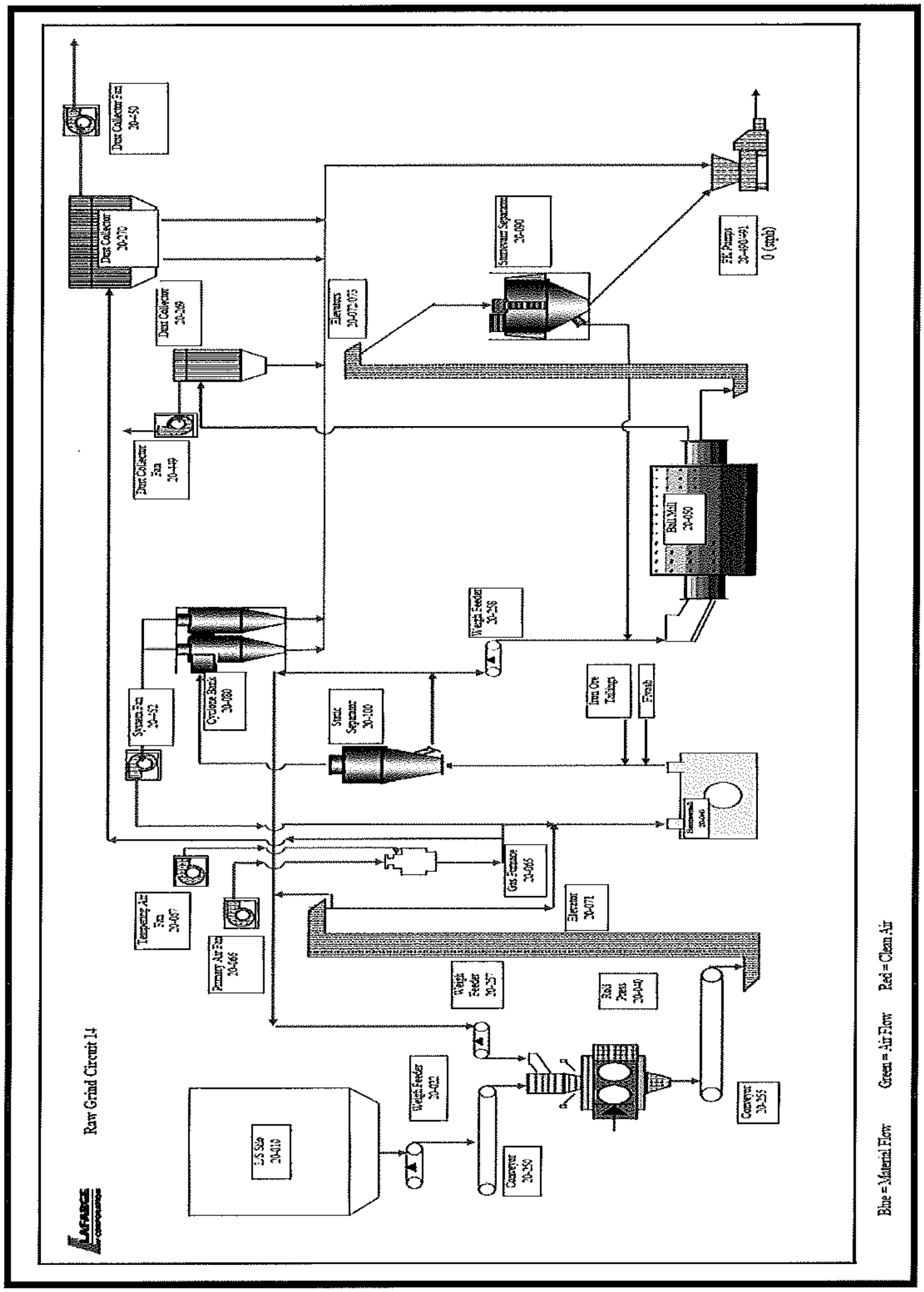

Figure 3-3. Process Flow Diagram for RG-14/15

3.4 Process Instrumentation

Instruments used to monitor kiln operating parameters are located throughout the kiln system. Table 3-1 lists the location and equipment used to monitor process operating parameters.

Each kiln system is equipped with a differential pressure indicator system, with measurement points located in the duct prior to and exiting the baghouse. The differential pressure devices are used to monitor the pressure drop across the baghouse.

Table 3-1. Process Monitoring Instruments

Parameter	Instrument	Location
Temperature Monitoring		
Baghouse Inlet	Thermocouple	Baghouse Inlet Duct
Additional Monitoring		
Production Rate	Raw Mix Feed Rate	In Kiln Feed Housing at Cold-End
Baghouse ΔP	Differential Pressure Indicator	Baghouse Inlet and Outlet Ducts

4.0 SAMPLING AND ANALYTICAL PROCEDURES

The sampling and analytical procedures used for this testing episode are described in the test protocol, which is provided as Appendix A to this test report. The test methods used to perform the sampling and analysis are provided in Table 4-1. Additional details regarding the methods are described in the test protocol.

Table 4-1. Test Methods

Parameter Measured	Method	Method Description
Velocity	Plant Monitor	Determination of Stack Gas Velocity and Volumetric Flow Rate
Oxygen and Carbon Dioxide	40 CFR 60 Appendix A: Method 3A	Plant Oxygen and Carbon Dioxide Monitors
Moisture	40 CFR 60 Appendix A: Method 4	Determination of Moisture Content In Stack Gases
HCl and Cl^-	40 CFR 60 Appendix A: Method 26A	Determination of Hydrogen Chloride and Chloride Emissions From Stationary Sources

5.0 TEST RESULTS AND DISCUSSION

5.1 Emission Testing Results

The stack volumetric flow rate is a necessary component for the calculation of the constituent mass emission rates. A summary of the volumetric flow rate measurements from the plant monitors is presented in Table 5-1. Flow rates were given to URS in kscfm and were corrected for moisture using the HCl sampling train determined moisture obtained during each test period. Run 1 of Kiln 19 did not have plastics added to the process, therefore Kiln 19 required 4 test runs of 1-hour each to obtain 3 complete runs of HCl testing.

Table 5-1. Volumetric Flow Rates

Kiln	Run 1 (dscfm)	Run 2 (dscfm)	Run 3 (dscfm)	Average (dscfm)
19 (HCl / Cl-)	70,596	69,380	69,227	69,734
19 (Hg)	74,345	70,596	69,380	71,440
20	84,986	86,001	84,780	85,255
21	88,883	88,028	88,169	88,360
22	122,092	122,143	121,902	122,092
23	145,441	145,134	146,335	145,637

Table 5-2 summarizes the results of this emission testing program. Example calculations can be found in Appendix E. Both HCl and Cl- concentration were determined, and that HCl equivalent concentrations are reported using the following equation:

$$\text{HCl Equivalents } (Cl^-) = HCl + 2 \times Cl_2$$

The O_2 concentrations were used to correct the as-measured results to obtain 7% O_2 as specified in the Title V permit.

Only the kiln average results are compared to the permit limit in accordance with Michigan Rule 1003 (R 336.2003) Section 2, which states: "for purposes of determining compliance with an applicable emission limit, rule, or permit condition, the arithmetic mean of the results of the three samples shall apply. "The process operating data conditions during the entire emission testing program were recorded by Lafarge. Tables 5-3 and 5-4 present the kiln operating conditions during each test run.

Table 5-2. Hydrogen Chloride Annual Verification Test Results

Kiln	Run	O_2 Conc. (%)	Cl^- Concentrations [a] Uncorrected (ppmv, dry)	Corrected (ppmv,dry @7% O_2)	HCl Concentrations [a] Uncorrected (ppmv, dry)	Corrected (ppmv,dry @7% O_2)	HCl Equivalent Permit Limit (ppmv,dry @7% O_2)	Cl- Emission Rate (lb/hr)	HCl Emission Rate (lb/hr)	HCl Equivalent Emission Rate Permit Limit (lb/hr)
19	1	7.6	0.06	0.06	3.8	4.04		0.02	1.5	
	2	7.7	0.04	0.04	3.0	3.13		0.02	1.2	
	3	7.9	0.05	0.05	1.8	1.95		0.02	0.7	
	Avg	**7.7**	**0.05**	**0.05**	**2.9**	**3.04**	**65**	**0.02**	**1.1**	**36**
20	1	9.4	0.05	0.06	16.7	20.1		0.02	8.1	
	2	9.4	0.04	0.04	17.1	20.6		0.02	8.3	
	4	9.7	0.09	0.11	10.2	12.7		0.04	4.9	
	Avg	**9.5**	**0.06**	**0.07**	**14.6**	**17.8**	**65**	**0.03**	**7.1**	**36**
21	1	9.4	0.05	0.06	6.0	7.2		0.03	3.0	
	2	9.5	0.04	0.05	8.2	10.0		0.02	4.1	
	3	9.4	0.04	0.05	8.8	10.7		0.02	4.4	
	Avg	**9.4**	**0.04**	**0.05**	**7.7**	**9.3**	**65**	**0.02**	**3.9**	**36**
22	1	7.6	0.05	0.05	68.1	71.1		0.04	47.3	
	2	7.8	0.06	0.06	74.4	78.7		0.04	51.6	
	3	8.0	0.04	0.04	61.0	65.5		0.03	42.2	
	Avg	**7.8**	**0.05**	**0.05**	**67.8**	**71.8**	**170**	**0.03**	**47.0**	**162**
23	1	7.2	0.04	0.04	59.2	60.0		0.03	48.9	
	2	7.4	0.04	0.04	61.6	63.4		0.03	50.7	
	3	7.1	0.04	0.04	69.0	69.7		0.04	57.3	
	Avg	**7.2**	**0.04**	**0.04**	**63.3**	**64.4**	**170**	**0.03**	**52.3**	**162**

[a] As measured by EPA Method 26A (modified)

Table 5-3. Kiln Group 5 Operating Conditions

Kiln	Run #	Date	Run Start Time (EDT)	Run End Time (EDT)	Kiln BZT (°C)	Kiln Feed (Metric tons/hr)	Kiln Dust (Metric tons/hr)	Baghouse Inlet Temp (°C)	Baghouse Pressure Drop (kPa)	Opacity (%)
19	1	7/18/2013	0952	1052	1307	68.9	5.7	252	1.2	4.3
	2	7/18/2013	1125	1225	1441	68.9	5.7	248	1.2	2.9
	3	7/18/2013	1256	1356	1445	68.9	5.8	249	1.2	3.3
	Average				**1398**	**68.9**	**5.7**	**250**	**1.2**	**3.5**
20	1	7/18/2013	1629	1729	1414	80.5	8.9	251	0.4	4.7
	2	7/18/2013	1817	1917	1440	80.7	9.0	251	0.4	4.7
	3	7/18/2013	1955	2055	1421	80.5	9.0	250	0.4	4.6
	Average				**1425**	**80.6**	**8.9**	**251**	**0.4**	**4.7**
21	1	7/19/2013	0815	0915	1354	79.3	7.1	251	0.6	2.4
	2	7/19/2013	0951	1051	1327	78.9	7.2	253	0.5	2.4
	3	7/19/2013	1258	1358	1328	78.0	7.0	251	0.5	2.3
	Average				**1337**	**78.7**	**7.1**	**251**	**0.5**	**2.4**

Table 5-4. Kiln Group 6 Operating Conditions

Kiln	Run #	Date	Run Start Time (EDT)	Run End Time (EDT)	Kiln BZT (°C)	Kiln Feed (Metric tons/hr)	Kiln Dust (Metric tons/hr)	Baghouse Inlet Temp (°C)	Baghouse Pressure Drop (kPa)	Opacity (%)
22	1	7/16/2013	0730	0830	1360	117.6	4.6	259	0.8	4.8
	2	7/16/2013	0931	1031	1352	118.3	4.6	561	0.8	4.6
	3	7/16/2013	1130	1230	1356	119.4	4.8	260	0.8	4.4
	Average				**1356**	**118.5**	**4.6**	**260**	**0.8**	**4.6**
23	1	7/20/2013	0726	0826	1371	97.3	12.0	247	0.5	6.2
	2	7/20/2013	0836	0936	1355	96.9	12.0	245	0.5	6.2
	3	7/20/2013	0945	1045	1346	97.1	12.0	247	0.5	6.1
	Average				**1357**	**97.1**	**12.0**	**246**	**0.5**	**6.2**

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific quality assurance and quality control (QA/QC) procedures that were identified in the test plan were followed during this test episode to ensure collection of useful and valid data. Table 6-1 lists the acceptance criteria and control limits for the program, ion chromatography QC results for the test period.

Leak checks were performed on the sampling trains before and after every sample run. The measured leakage rate for all of the checks was within the allowable method rate for all reported samples.

6.1 Laboratory QC

Enthalpy Analytical of Durham North Carolina analyzed the acid and basic fractions of the Method 26A samples by ion chromatography (IC), following EPA Method 300.1 procedures. The caustic samples were collected and archived per agreement with MDEQ. Table 6-1 lists the results of all of the QC procedures that were conducted as part of the analysis. QC results were within the acceptance criteria. All samples were analyzed within their required hold times. Method blank results were less than the method detection limit.

The correlation coefficient is indicative of the linearity of the curve. An acceptable calibration curve has a correlation coefficient ≥ 0.995. The correlation curve for all analyses met this requirement. Also, the daily calibration verification results were all within the acceptance criteria.

All samples were analyzed in duplicate. RPD is then calculated for each duplicate pair of samples to indicate the precision of the analyses. RPD is calculated from the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

Where:

R1 and R2 represent initial and duplicate analytical results, respectively.

Table 6-1. Summary of QA/QC Procedures and Results for Chloride Analysis

Calibration and QC Analysis	Description	Frequency	Acceptance Criteria	Laboratory IC Result
Initial Calibration (ICAL)	5-point calibration proceeding from lowest to highest.	Daily, preceding and again following sample analysis.	Correlation coefficient ≥□0.995.	R^2 ≥□ 0.999
Duplicate Analyses	Duplicate analyses of all field samples.	Every sample and blank.	<10% RPD	≤ 0.35 % RPD
LCS/LCSD Duplicate	Extracted blank matrix samples spiked with second source standard.	One LCS per standard calibration preparation.	85 – 115% recovery.	97.6-98.5% recovery
Method Blank	Analysis of eluent used for dilutions and standards.	Daily.	Measured concentrations must be < MDL.	Method blank results were < reporting limit*

*Method blanks were less than the lowest level standard of the initial calibration.

LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
RPD	Relative Percent Difference
H_2S0_4	Sulfuric Acid
IC	Ion Chromatography
QC	Quality Control

6-2 Audit Samples

Audit samples through the newly instituted Source Sampling Audit Sample (SSAS) program were acquired from an Accredited Audit Sample Provider (AASP). Two audit samples were requested for this element of the test program (2013). Michigan DEQ requested a low level liquid audit sample for KG5 and a higher level liquid for KG6. The SSAS was analyzed in conjunction with the field samples in the laboratory. Table 6-2 summarizes the results from the SSAP. Both SSAS results were "acceptable" by definition from the AASP.

Table 6-2. Summary of SSAP Audit Results

Level	Units	Laboratory Result	Acceptable Range	Assigned Value
Low	mg/L (ppm)	9.24	9.0-11.0	10.0
High	mg/L (ppm)	138	115-141	128