LAFARGE
NORTH AMERICA
ALPENA, MICHIGAN

TEST REPORT

METALS EMISSIONS
FROM KILN 23 EXHAUST
DURING ASPHALT SHINGLES FIRING

PREPARED FOR:

LAFARGE NORTH AMERICA
1435 FORD AVENUE
ALPENA, MICHIGAN 49707

PREPARED BY:

URS
1600 PERIMETER PARK, SUITE 400
MORRISVILLE, NORTH CAROLINA 27560

TABLE OF CONENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

URS Corporation (URS) conducted emissions testing July 19, 2013 at the Lafarge Alpena facility (Lafarge) on emission unit ID Kiln 23 (K23) in Flexible Group 6 (FG6). Testing was conducted to confirm compliance under MDEQ Air Permit No. 167-12, issued March 22, 2013. The permit specifies special conditions for metals testing during Lafarge's 180 day trial period when the fuel feed to the Kiln 23 are supplemented with asphalt shingle material.

A URS test team consisting of Vaughn Kashuba, Willie Lea, Anne Marie Wells, Robert Raymond, Erik Riegel and Kevin White performed metals emission testing. 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 methods performed, and Section 5.0 describes the QA/QC procedures followed during this test program.

Questions regarding this test report should be directed to the following individuals:

Bob Jongleux
Project Manager
URS Corporation
1600 Perimeter Park, Suite 100
Morrisville, NC 27560
(919) 461-1242
bob.jongleux@urs.com

Bob Budnik
Environmental Manager
Lafarge North America
1435 Ford Avenue
Alpena, MI 49707
(989) 358-3321
bob.budnik@lafarge.com

Gloria Torello
Environmental Quality Analyst
Air Quality Division
P.O Box 1830
2100 West M-32
Gaylord, MI 49734-5830
989-705-3410
TorelloG@michigan.gov

2.0 SUMMARY OF RESULTS

The test program consisted of three runs sampling the Kiln 23 exhaust gas for As, Ca, Total Cr, Cu, Pb, Mn, Hg, Ni, and Zn per EPA Method 29. Test Run 1 was 144 minutes in duration and, Runs 2 and 3 were each 162 minutes in duration. EPA Methods 3 and 4 were used to determine stack gas molecular weight and moisture, respectively, in conjunction with Method 29. Table 2-1 provides a summary of the trial burn test emissions in pounds per hour as requested in the permit. Test results are based on the average emission rate results obtained for each parameter over the course of the 3 test runs.

Table 2-1. Summary of Kiln 23 Metalsa Emission Results Dduring Asphalt Shingles Trial Burn (July 2013)

Analyte	Flue Gas Concentration (mg/dscm)	Trial Burn Emissions (lb/hr)
Arsenic	4.27×10^{-4}	2.63×10^{-4}
Cadmium	6.30 x 10-^{5}	3.92×10^{-5}
Total Chromium	1.44×10^{-3}	8.93×10^{-4}
Copper	1.19×10^{-3}	7.36×10^{-4}
Lead	5.05×10^{-4}	3.13×10^{-4}
Manganese	1.45×10^{-3}	8.81×10^{-4}
Mercury	3.00×10^{-2}	1.83×10^{-2}
Nickel	1.46×10^{-3}	9.09×10^{-4}
Zinc	1.33×10^{-2}	8.22×10^{-3}

[a] EPA Method 29

3.0 PROCESS DESCRIPTION

Lafarge's Alpena, Michigan plant operates five rotary kilns, which manufacture Portland cement clinker using the dry process. A mixture of pulverized bituminous coal and petroleum coke serves as the primary fuel fed to the kilns.

Coal and coke are fed to a Raymond bowl mill and ground to a fineness of approximately 95% passing a 200-mesh sieve.

Kiln Group 6 at the Lafarge Alpena plant consists of two rotary kilns (#22 and #23). Specific components of Kiln Group 6 are:

- Coal/petroleum coke, plastics and combustion air delivery; Shingles – specifically to K23
- 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.

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 Kiln Group 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.

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 Wheelbrator-Frye, consists of two parallel sets of five chambers and has design airflow of 285,000 cfm at 400°F. Figure 3-1 provides a process flow diagram of Kiln Group 6, which depicts the process flow of K23.

3.1 Kiln Process Instrumentation

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

parameters. These parameters were recorded during each emissions test run to document the kiln and baghouse operation. In addition to these operating parameters, volumetric flow and flue gas oxygen concentrations were recorded during each test run by the plant's certified flow monitors. All process parameters normally monitored during typical operation were recorded during the trial burn period (including coal/coke and asphalt shingles feed rate in tons per hour).

K23 is equipped with a differential pressure indicator system, with measurement points located in the duct entering and exiting the baghouse. The differential pressure devices were used to monitor the pressure drop across the baghouse.

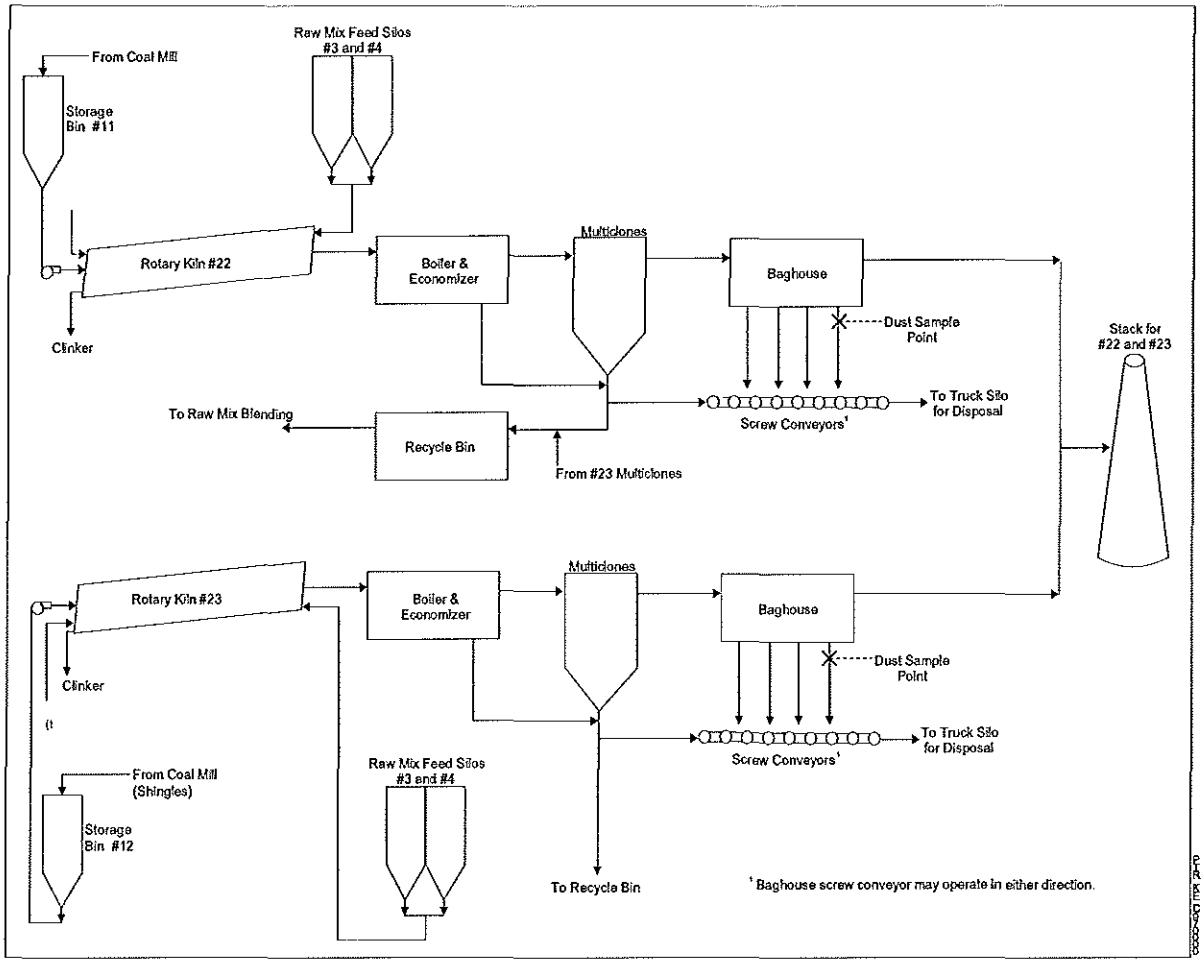

Figure 3-1. Process Flow Diagram for Kiln Group 6

Table 3-1. Kiln Process Monitoring Instruments for Emissions Testing

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

3.2 Kiln Operating Conditions

Each kiln at the Alpena plant functions to produce clinker, which is the major intermediate constituent of Portland cement. Kiln 23 was operated at or near normal production capacity during the trial burn testing with asphalt shingles. The asphalt shingle material was mixed with the normal coal/coke fuel feed and did not exceed 10 % of the fuel by weight. The asphalt shingles were fed to the kiln with the coal/coke fuel mixture. Table 3-2 lists K23 measured average fuel and production feed rates, (in metric tons per hour) during the trial burn emission test runs. The kiln was operated within the required permit limitations during the trial burn emissions testing.

Table 3-2. Kiln 23 Production and Fuel Data During Asphalt Shingles Trial Burn Testing (July 2013)

Run	Clinker Production (MT/h)	Shingles (MT/h)	Coal/Coke (MT/h)	Total Fuel Feed Ratea (MT/h)	Asphalt Shingles (% of Fuel by weight)
1	345.34	0.494	7.09	7.59	6.5
2	562.65	0.486	7.13	7.62	6.4
3	739.34	0.481	7.21	7.70	6.3
Average	**549.11**	**0.49**	**7.15**	**7.63**	**6.38**

[a] Total Fuel Feed based on sum of Shingles and Coal/Coke mixture

The fuel feed rates were obtained from Lafarge's Aspen data system during the K23 metals test runs. The feed (coal/coke/shingles mix) heat value was calculated as 24.88 MMBTU/ton with shingles having a heat value of 0.009 MMBTU/ton. Documentation on the verification of BTU

value, % Chlorine, % Sulfur, % Ash, and % Moisture in the asphalt shingles roofing material can be found in Appendix D. Analysis of Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Hexavalent Chromium, Lead, Manganese, Mercury, Nickel, Selenium, Silver, and Zinc in the asphalt shingle roofing material was performed by RTI Laboratories and data was supplied to Lafarge to complete permit testing requirements. The feedstock metals verification lab report completed by RTI can be found in Appendix D.

3.3 Kiln Sampling Locations

The baghouse breeching duct (normal emission testing location) was used to conduct the metals testing on Kiln 23. Figure 3-2 depicts the breeching ducts on K23. A complete description of the KG6 kiln sampling location is provided in Section 3 of the main test protocol which can be found in Appendix A.

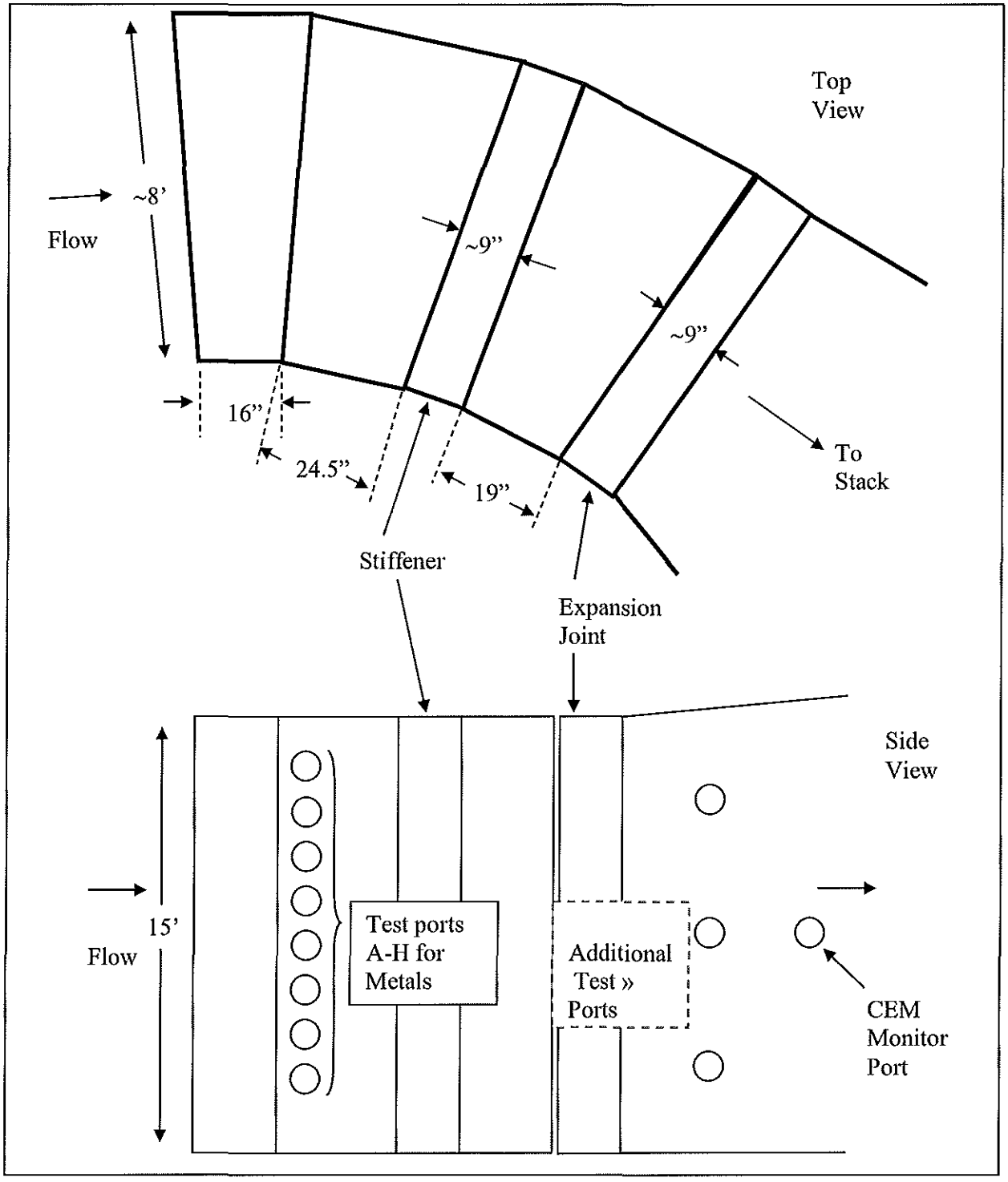

Figure 3-2. Kiln 23 Breeching Ducts

4.0 METHOD DESCRIPTIONS

4.1 EPA Method 29 - Metals

Metals emissions from Kiln 23 testing were determined by EPA Method 29. The sample was a multi- point isokinetic sample at the breeching ductwork, prior to each kiln stack. (Ports A-H). The probe and heated filter were maintained at ≥ 250 F. Each sampling run was about 2.5 hours in duration at a nominal sampling rate of 0.75 cubic feet per minute (cfm). The impinger fractions were recovered in the field and weighed gravimetrically to determine the moisture content of the flue gas. The recovered impinger fractions for each sample train were analyzed by Element One, following standard chain of custody procedures.

The heated quartz lined probe and filter box assembly was used to traverse the exhaust duct in horizontal orientation. Quartz fiber filters were used to minimize filter background contamination for metals. Filters were not weighed to determine particulate matter emissions. The recovered quartz filter was combined with the nitric acid rinses from the probe and glass nozzle. A Teflon®-lined jumper was used to connect the filter assembly to the impinger train. A seven-stage impinger train was maintained in an ice bath to reduce the exit temperature to below 68 °F and remove residual moisture prior to being measured by a dry gas metering console. The impinger train consisted of one empty moisture knockout impinger, one modified Greenberg-Smith and one Greenberg-Smith impinger each charged with 100 ml of an acidified hydrogen peroxide solution, one empty modified Greenberg-Smith style impinger, two modified Greenberg-Smith impingers each charged with 100 ml of an acidified potassium permanganate absorbing solution, and a final modified Greenberg-Smith impinger containing approximately 100 grams of silica gel. The empty impingers and those charged with the acidified hydrogen peroxide (high grade) solution were recovered with nitric acid and analyzed for all metals, including mercury. The impingers containing the acidified potassium permanganate were recovered with a fresh permanganate solution and deionized water and analyzed for mercury only. Figure 4-1 shows a schematic of the Method 29 train.

The analysis of the Method 29 field samples was conducted by Element One of Wilmington North Carolina per standard analytical operating procedures and established chain of custody. The Method 29 samples were digested, prepared and analyzed according to Method 29 protocols. The samples were analyzed for metals on a PerkinElmer ELAN 6100 ICP-MS. The detection limit was 1.0 ug/ml for the metals. Duplicate analyses relative percent difference (RPD), spike recovery, and second source calibration verification data are summarized in the Quality Control Section of the Laboratory Data Package (See Appendix C). The laboratory reported values were not corrected for blank values or spike recovery.

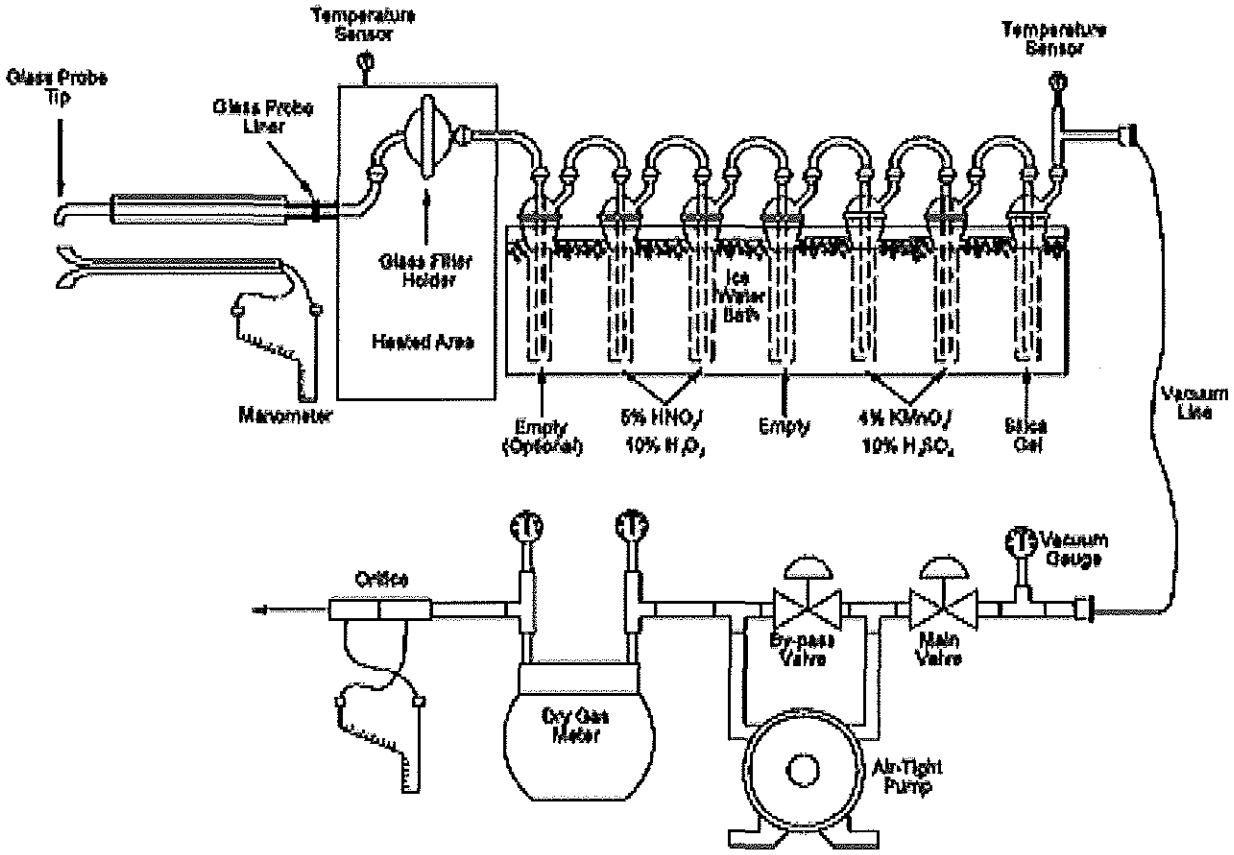

Figure 4-1. Method 29 – Multi-Metals Train Schematic

4.2 Methods 1, 2, 3A and 4

EPA Reference Methods 1, 2, and 4 was used to determine the sample traverse point locations, volumetric flow, dry gas molecular weight, and the gas moisture content.

The number of sampling points required to measure the average gas velocity and to collect stack gas samples is determined using EPA Method 1. The volumetric gas flow rates were determined using EPA Method 2. In this method, the flow rate is determined by measuring the average velocity of the gas and multiplying it by the cross-sectional area of the duct. The average gas velocity is calculated from the average square root of the Pitot tube pressure readings (ΔP), the average flue gas temperature, gas wet molecular weight, and the absolute static pressure. Temperatures, ΔP profile data, and fixed gas composition are determined during the isokinetic sampling traverses. Temperature and pressure profile data are measured using an S-type pitot tube/oil manometer and K-type thermocouple. Barometric pressure readings were recorded for

each run. The static gas pressure is measured by rotating the pitot so that it is perpendicular to the gas flow and comparing the pressure of one leg of the pitot to the ambient pressure.

EPA Method 3A (40 CFR Part 60, Appendix A) data was collected by the certified plant instrumentation to calculate concentrations of oxygen and carbon dioxide in the flue gas. The plant O_2 and CO_2 analyzers were also used to determine molecular weight. Stack gas velocity and volumetric flow rate was determined during the metals testing by EPA Method 2. In this method, a Type S pitot was used to traverse the duct using traverse points determined by EPA Method 1. The pitot pressures and temperature data collected during each sampling traverse were used to calculate the stack gas velocity. Kiln 23 is equipped with a custom designed flow monitor system which was used as back-up for comparison. The flow rate determined in conjunction with the Method 29 sampling train was used for the emission rate calculation.

EPA Method 4 was used to determine the concentration of water vapor in the stack gas. This was done in conjunction with the Method 29 sampling train. A metered volume of stack gas was pulled through chilled impingers, where water vapor is condensed out of the gas stream. The gas then passed through an impinger filled with silica gel to trap residual moisture. At the end of each test run, the weight gain of the impinger train was used to calculate the amount of moisture contained in the measured volume of stack gas.

5.0 SAMPLING QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Specific quality assurance and quality control (QA/QC) procedures were followed during this test program to ensure the production of useful and valid data. The QA/QC checks and procedures described in this section are an integral part of the overall sampling.

Overall, the quality assurance objectives set forth in the test protocol were met. All planned test runs were completed, and every data point, both for emissions sampling and for process operating parameters, were collected. The following sections discuss specific procedures followed for emissions sampling and process monitoring.

5-1 URS Sampling Equipment

Method 29 Train

A standard Method 29 sampling train was used to collect the metal samples. All glassware was washed and soaked in concentrated nitric acid bath before rinsing with distilled, deionized water. All glassware used for metals sampling was freshly cleaned and not used prior to the metals sampling on this field deployment. Reagent and proof train (used glassware) samples as well as field blanks (after test run recovery) were employed for quality control purposes. A small hot box with a temperature controlled heated jumper (new Teflon) were employed for sample collection. The Method 29 sampling train had no metal surfaces in contact with flue gas. Quartz filters were used to reduce possible metals contamination. All reagents were ACS grade or better and screened for metals contamination.

All Method 29 sample runs met method established leak checks, and isokinetic rates. All test runs were collected with a minimum sample volume of 90 dscf as indicated in the test protocol.

All analytical data was within method specifications for duplicates, spike recovery and correlation coefficients.

The only quality concern was the third test run, which indicated an abnormally high value for manganese. The analytical value was an order of magnitude higher for this sampling run for manganese only. Cross contamination by potassium permanganate reagent from the impinger crossover connector is the suspected cause for the higher value. Therefore the third run for manganese was not included in the final average result.

5-2 Audit Samples

Audit samples through the newly instituted Source Sampling Audit Sample (SSAS) program were acquired from an Accredited Audit Sample Provider (AASP). Audit samples were requested specifically for this element of the test program (2013). The SSAS audits were analyzed in conjunction with the field samples in the laboratory. Tables 5-1 and 5-2 summarize the results from the SSAP. All SSAS results were "acceptable" by definition from the AASP.

Table 5-1. Summary of SSAP Metal Audit (Filter) Results for Lafarge Alpena

Analyte	Units	Laboratory Measured Result	Acceptable Range	Assigned Value
Arsenic	mg/L (ppm)	9.48	7.50 - 12.5	10.0
Cadmium	mg/L (ppm)	9.51	8.00 - 12.0	10.0
Chromium	mg/L (ppm)	10.4	8.00 - 12.0	10.0
Copper	mg/L (ppm)	9.58	7.50 - 12.5	10.0
Lead	mg/L (ppm)	9.66	8.00 - 12.0	10.0
Manganese	mg/L (ppm)	10.2	7.00 - 13.0	10.0
Nickel	mg/L (ppm)	9.91	7.00 - 13.0	10.0
Zinc	mg/L (ppm)	9.30	7.00 - 13.0	10.0

Table 5-2. Summary of SSAP Metal Audit (Liquid) Results for Lafarge Alpena

Analyte	Units	Laboratory Measured Result	Acceptable Range	Assigned Value
Arsenic	ug/ml	0.094	0.075 – 0.125	0.100
Cadmium	ug/ml	0.097	0.080 – 0.120	0.100
Chromium	ug/ml	0.098	0.080 – 0.120	0.100
Copper	ug/ml	0.095	0.075 – 0.125	0.100
Lead	ug/ml	0.097	0.075 – 0.125	0.100
Manganese	ug/ml	0.100	0.075 – 0.125	0.100
Nickel	ug/ml	0.095	0.080 – 0.120	0.100
Zinc	ug/ml	0.096	0.075 – 0.125	0.100
Mercury	ng/ml	51.0	37.5 - 62.5	50.0