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# LAFARGE
# ALPENA, MICHIGAN

## TEST REPORT:

## EMISSIONS OF HYDROGEN CHLORIDE AND PARTICULATE MATTER

## FOR KILNS, WET GAS SCRUBBER, RAW MILLS AND CLINKER COOLERS

**PREPARED FOR:**

LAFARGE

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JULY 2016

# 1.0 SUMMARY

## 1.1 Introduction

Lafarge North America operates five dry process cement kilns (Kilns 19-23) at its plant in Alpena, Michigan (EPA Facility ID #MID005379607). Kilns Nos. 19, 20, and 21 are collectively known as Kiln Group 5 (KG5). Kiln Nos. 22 and 23 are collectively known as Kiln Group 6 (KG6). All five kilns operate with waste-heat boilers for energy recovery and fabric filter baghouses for control of particulate matter emissions.

Table 1-1 addresses the test program parameters and locations tested by AECOM on behalf of Lafarge in July 2016. Lafarge operates under the Renewable Operating Permit (ROP) MI-ROP-B1477-2012a which requires testing for hydrogen chloride (HCl) and particulate matter (PM) on multiple sources. Testing was performed to both confirm compliance with each kiln's HCl emission limits and to assess the current emission of particulate matter (PM) on Kilns 19-21 and the Wet Gas Scrubber (WGS), which is the emission point for Kiln 22 and Kiln 23.

Testing was also performed on the Raw Mill and Clinker Coolers to determine compliance with the National Emission Standards for Hazardous Air Pollutants for Source Categories; Portland Cement Manufacturing Industry; Final Rule (PC MACT Regulation 40 CFR 63, Subpart LLL).

**Table 1-1. Test Program Parameters and Locations (2016)**

| Parameter | Kiln 19 | Kiln 20 | Kiln 21 | Kiln 22 | Kiln 23 | WGS | Raw Mill 14 | Raw Mill 15 |
|---|---|---|---|---|---|---|---|---|
| Flow Rate | • | • | • | • | • | • | • | • |
| Moisture | • | • | • | • | • | • | • | • |
| HCl | • | • | • | | | • | | |
| PM | • | • | • | | | • | • | • |

An AECOM test team consisting of Bob Jongleux, Pat Turner, Sam Warnock, Fran Cobo, Willie Lea, Luke Turner, Charles Thompson, Megan Fish, Chris Hughes and David Marzec performed the emissions testing. Travis Weide of Lafarge provided oversight to the sampling. Mark Dziadosz, Kurt Childs and Jeremy Howe of MDEQ observed a portion of the field testing activities.

Section 2 includes a summary of the results, Section 3 includes a summary of the process operating conditions, Section 4 contains the source and process descriptions, Section 5 discusses sampling locations, Section 6 describes the sampling and analytical procedures, Section 7 discusses the test results in detail, and Section 8 discusses quality assurance and quality control practices. Questions regarding this test report should be directed to the following individuals:

| AECOM | MDEQ - Air Quality Division | Lafarge |
|---|---|---|
| 1. Bob Jongleux<br>Project Manager<br>Direct: 919.461.1242<br>bob.jongleux@aecom.com | 1. Karen Kajiya-Mills<br>Compliance Support Unit<br>517.335.4874<br>kajiya-millsk@michigan.gov | 1. Travis Weide<br>Area Environmental and Public Affairs Manager<br>989.358.3321<br>travis.weide@lafargeholcim.com |
| 2. David Marzec<br>Test Lead<br>Direct: 919.461.1241<br>david.marzec@aecom.com | 2. Mark Dziadosz<br>Air Quality Division<br>586.753.3745<br>dziadoszm@michigan.gov | |

# 2.0 HCL AND PARTICULATE MATTER RESULTS

## 2.1 KG5 and KG6 HCl and PM Results

Testing for HCl and PM was conducted by AECOM from July 11 through August 25, 2016. The objective was to sample HCl and PM concentrations from the kilns and WGS to determine compliance with the applicable standards.

Tables 2-1 and 2-2summarize the Kiln and WGS HCl and PM test results. Detailed HCl and PM test results for Kilns 19-21 and WGS can be found in Section 7 as well as in Appendix A of this report.

**Table 2-1. Summary of Kiln and WGS HCl Test Results (2016)**

| Source | $O_2$ (%) | HCl Concentration | | $Cl^-$ Concentration | | HCl Equivalent Emission (ppmvd, dry @ 7% $O_2$) | HCl Equivalent Permit Limit (ppmvd @7%$O_2$) | HCl Equivalent Emission Rate (lb/hr) | HCl[a] Equivalent Emission Permit Limit (lb/hr) |
|---|---|---|---|---|---|---|---|---|---|
| | | ppmvd | ppmvd @7%$O_2$ | ppmvd | ppmvd @7%$O_2$ | | | | |
| K19 | 7.2 | 36.69 | 37.29 | 0.12 | 0.12 | 37.53 | **65** | 12.87 | **36** |
| K20[b] | 8.7 | 19.32 | 22.08 | 0.13 | 0.15 | 22.38 | **65** | 10.23 | **36** |
| K21 | 10.6 | 8.08 | 10.94 | 0.08 | 0.10 | 11.14 | **65** | 3.84 | **36** |
| WGS | 7.3 | 1.06 | 1.08 | 0.08 | 0.08 | 1.24 | **170[a]** | 2.23 | **162[a]** |

[a] HCl + 2 x (Cl2) = HCl Equivalents

[b]Results from additional test runs conducted on 7/13/2016

**Table 2-2. Summary of Kiln and WGS Particulate Matter Results (2016)**

| Source | Average Test Result | Units of Measurement | PM Limit |
|---|---|---|---|
| K19 | 0.02 | lb/1000 lb exhaust dry gas | **0.25** |
| K20 | 0.02 | lb/1000 lb exhaust dry gas | **0.25** |
| K21 | 0.01 | lb/1000 lb exhaust dry gas | **0.25** |
| WGS | 0.003 | lb/1000 lb exhaust dry gas | **0.25** |

The oxygen concentrations used to correct the resultant emissions to 7% $O_2$ basis were obtained from plant data which is documented in Appendix D of this report. KG 5 and KG 6 were found to be in compliance with the required standards.

## 2.2 Raw Mill and Clinker Cooler PM Results

The raw mills and clinker coolers were sampled using EPA Method 5 to determine emissions of particulate matter during the July 2016 test program. A retest on Raw Mill 14 was completed on August 25, 2016. Table 2-3 summarizes the raw mill PM results and Table 2-4 summarizes the clinker cooler PM Results. Detailed test run results can be found in Section 7 and Appendix A-2 of this report.

## Table 2-3. Raw Mill PM Results (2016)

| Source | Average PM Result | Units of Measurement | Permit Limit |
|---|---|---|---|
| RM 14[a] | 0.01 | lb/1000 lb dry exhaust gas | **0.15** |
| | 2.14 | lb/hr | **27.51** |
| RM 15 | 0.01 | lb/1000 lb dry exhaust gas | **0.15** |
| | 1.77 | lb/hr | **27.51** |

[a]RM14 PM results are from the retest on 8/25/2016.

## Table 2-4. Clinker Cooler PM Results (2016)

| Source | Average PM Result | Units of Measurement | Permit Limit |
|---|---|---|---|
| CC 22 | 0.01 | lb/ton of dry feed | **0.10** |
| | 0.01 | lb/1000 lb dry exhaust gas | **0.04** |
| | 1.11 | lb/hr | **24.8** |
| CC 23 | 0.03 | lb/ton of dry feed | **0.10** |
| | 0.01 | lb/1000 lb dry exhaust gas | **0.04** |
| | 2.06 | lb/hr | **24.8** |
| CC 92 | 0.02 | lb/ton of dry feed | **0.10** |
| | 0.01 | lb/1000 lb dry exhaust gas | **0.04** |
| | 1.39 | lb/hr | **24.8** |
| CC 93 | 0.01 | lb/ton of dry feed | **0.10** |
| | 0.01 | lb/1000 lb dry exhaust gas | **0.04** |
| | 2.09 | lb/hr | **24.8** |

The raw mills and clinker coolers complied with the mandated standards noted in section 1 of this report.

## 2.3 Clinker Cooler CPMS Results

The clinker coolers are subject to compliance with PC MACT Regulation 40 CFR 63, Subpart LLL. This regulation requires each clinker cooler to be tested annually to determine a site-specific limit. The required PC MACT operating limits ($O_l$) are determined from a CPMS correlation with the PM emissions determined during from the Method 5 test results. Equation 5 in PC MACT Regulation 40 CFR 63, Subpart LLL Section 63.1439 (b)(1)(iii) details the calculation used to determine the PM CPMS limit:

$$O_1 = z + \frac{0.75(L)}{R} \qquad \text{(Eq. 5)}$$

- $O_l$ = The operating limit for your PM CPMS on a 30-day rolling average, in milliamps or the digital equivalent.
- L = Your source emission limit expressed in lb/ton clinker.
- z = Your instrument zero in milliamps, or digital equivalent, determined from (b)(1)(iii)(A).
- R = The relative lb/ton-clinker per milliamp, or digital equivalent, for your PM CPMS, from Equation 4.

Table 2-5 summarizes the PM-CPMS limits determined for each clinker cooler.

**Table 2-5. Clinker Cooler PM-CPMS Operating Limits (2016)**

| Source | PM Emissions (lb/ton clinker) | PM Limit (lb/ton clinker) | PM-CPMS Operating Limit (mA) |
|---|---|---|---|
| CC 22 | 0.01 | 0.07 | 4.41 |
| CC 23 | 0.05 | | 4.35 |
| CC 92 | 0.01 | | 6.56 |
| CC 93 | 0.01 | | 4.80 |

# 3.0 PROCESS OPERATING CONDITIONS

## 3.1 Kiln and WGS Operating Conditions

Process operating data was recorded by plant monitors for the kilns and WGS by the plant's Data Acquisition System (DAS). The process operating data was reduced and reported by AECOM personnel. Detailed plant operating data for the test runs reported on a minute by minute basis are located in Appendix D-1.Tables 3-1 and 3-2 summarize the plant operating data during the kiln HCl and PM testing during the July 2016 deployment. Detailed production data can be found in Section 7 and Appendix D-2 as provided by Lafarge.

**Table 3-1. Summary of Kiln and WGS Production Data during HCl–PM Testing**

| Kiln | Date | Fuel Used[b] | Raw Material Feed Rate (tons/hr) | Clinker Production Rate (tons/hr) |
|---|---|---|---|---|
| K19 | 7/13/2016 | coal/coke/shingles | 78.16 | 47.28 |
| K20[a] | 7/13/2016 | coal/coke/plastics/shingles | 66.92 | 41.45 |
| K21 | 7/11/2016 | coal/coke/plastics/shingles | 74.23 | 44.91 |
| WGS – K22 | 7/16/2016 | coal/coke/plastics/shingles | 120.72 | 72.24 |
| WGS – K23 | 7/16/2016 | coal/coke/plastics/shingles | 120.51 | 72.90 |

[a]Data is from additional test runs conducted on 7/13/2016.

[b]Fuel Usage is based on plant production estimates

**Table 3-2. Summary of Kiln and WGS Operating Conditions during HCl – PM Testing**

| Kiln | Date | Differential Pressure (kPa) | Plastics Feed[a] (tons/hr) | Scrubber Liquid (pH) | Scrubber Pressure Drop (hPa) | Spray Pump Pressure (kPa) |
|---|---|---|---|---|---|---|
| K19 | 7/13/2016 | 1.09 | 34.34 | -- | -- | -- |
| K20 | 7/13/2016 | 0.62 | 41.63 | -- | -- | -- |
| K21 | 7/11/2016 | 0.46 | 38.55 | -- | -- | -- |
| WGS – K22 | 7/16/2016 | 1.03 | 33.07 | 5.14 | -0.0003 | 85.04 |
| WGS – K23 | 7/16/2016 | 0.97 | 33.07 | 5.14 | -0.0003 | 85.04 |

[a]Plant provided feed estimates that plastics were split evenly between K22 and K23

## 3.2 Raw Mill and Clinker Cooler Operating Conditions

The Raw Mill and Clinker Cooler production was recorded by the plant DAS during the PM testing. Table 3-3 and 3-4 summarize the operating conditions during the test runs. Detailed operating conditions can be found in Section 7 and Appendix D-1.

**Table 3-3. Summary of Raw Mill Operating Data during PM Testing**

| Source | Date | Raw Feed Rate (tons/hr) | Baghouse Differential Pressure (kPa) | Baghouse Inlet Temp. (°C) |
|---|---|---|---|---|
| RG14 | 8/25/2016 | 306.6 | 1.35 | 85.0 |
| RG15 | 7/18/2016 | 277.2 | 1.04 | 87.6 |

**Table 3-4. Summary of Clinker Cooler Production Data during PM Testing**

| Source | Date | Raw Feed Rate (tons/hr) | Clinker Produced (tons/hr) | PM CPMS (mA) |
|---|---|---|---|---|
| CC 22 | 7/14/2016 | 133.14 | 79.54 | 4.11 |
| CC23 | 7/15-7/16/2016 | 69.08 | 42.79 | 4.32 |
| CC 92[a] | 7/19/2016 | 88.17 | 53.34 | 4.86 |
| CC93[a] | 7/19/2016 | 160.04 | 96.82 | 4.49 |

[a]CC92-93 production is expressed as a ratio of the total volumetric flow for KG5 kilns

# 4.0 SOURCE AND PROCESS DESCRIPTIONS

Lafarge's Alpena, Michigan plant operates five rotary kilns, which manufacture Portland cement clinker using a dry manufacturing 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. Coal and coke were fed to a Raymond bowl mill and ground to a fineness of approximately 95% passing a 200-mesh sieve.

## 4.1 Kiln Group 5

Kiln Group 5 at the Lafarge Alpena plant consists of three rotary kilns (19, 20, and 21). Specific components of Kiln Group 5 are:

- Coal/petroleum coke and combustion air delivery
- Raw mix preparation and delivery
- Three rotary kilns
- Kiln burners
- Waste heat recovery boilers
- Air pollution control system, consisting of the following components:
  - Multiclone dust collectors
  - Baghouses
  - DAA (hydrated lime) injection
  - SNCR
  - Induced draft (ID) fans
  - Exhaust stacks.

Allis Chalmers manufactured rotary kilns 19, 20, and 21. 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. These kilns rotate at speeds of greater than 40 revolutions per hour and are driven by an electric motor.

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 baghouses for kilns 20 and 21, manufactured by Wheelabrator-Frye, are identical in construction to the Dracco unit, 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 for all baghouses is 550°F.

## 4.2 Kiln Group 6

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 and combustion air delivery
- Raw mix preparation and delivery
- Two rotary kilns
- Kiln burners
- Waste heat recovery boiler
- Air pollution control system, consisting of the following components:
  - SNCR (mid-kiln)
  - Multiclone dust collectors
  - Baghouses
  - Induced draft (ID) fans
  - Wet Gas Scrubber (WGS)
  - 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 the Fuller Company and are identical in design and operation. The kilns are 500 feet long and have a 19.6-foot inner diameter and 17 feet for the remainder. The kilns were 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 drop out chamber, a boiler and then a set of multiclones before entering a fabric filter baghouse. After exiting the baghouse, the gases are routed through a breaching duct that connects the baghouse to a common reinforced concrete stack. This stack has a wet gas scrubber (WGS) before it is exhausts to atmosphere.

The kilns rotate up to a rate of 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.

## 4.3 Kiln Process Instrumentation

Instruments used to monitor kiln operating parameters were located throughout the kiln system. Parameters that were recorded during testing were the baghouse inlet temperature, production rate, and baghouse change in pressure (delta P). 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.

Figure 4-1 is a detailed diagram of the process flow indicating where the air quality control equipment is located for KG5 and KG6 as well as the emission point identification numbers of each device. Figure 4-2 is a schematic of the plant's SNCR system. Figure 4-3 is an example diagram of the raw mill process.

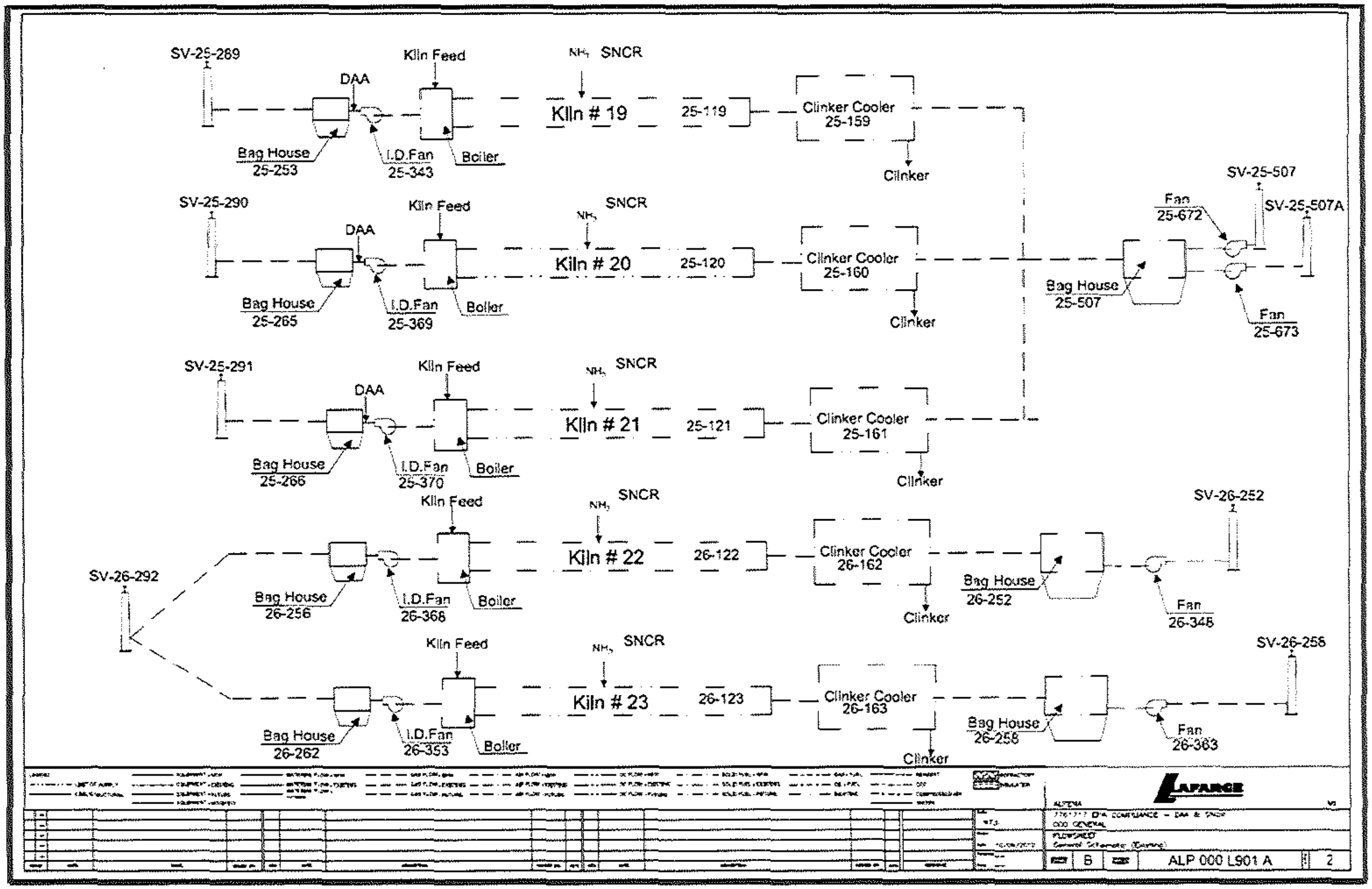


**Figure 4-1. Detailed Process Flow Diagram for Kiln Group 5 and Kiln Group 6**

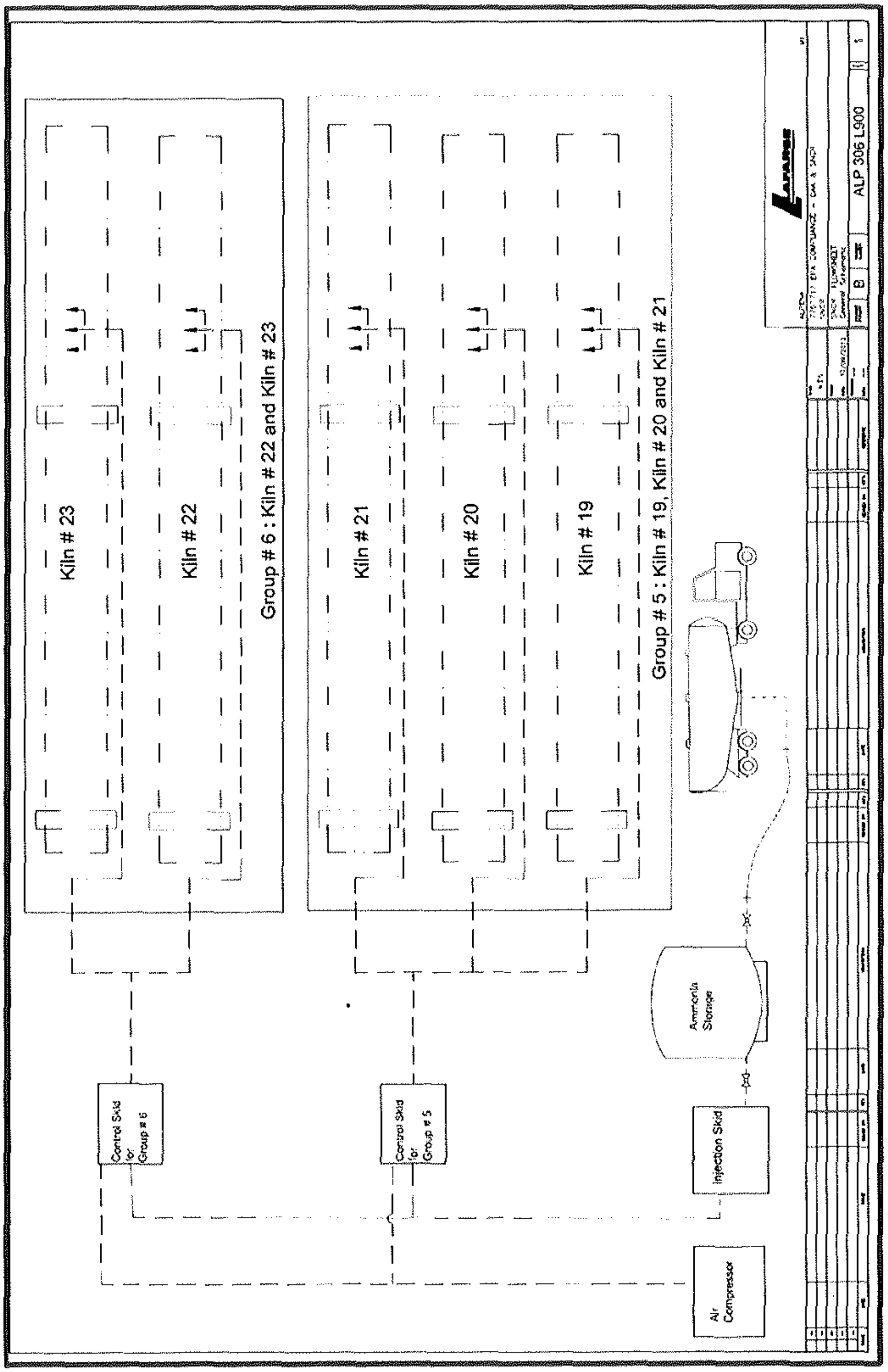


**Figure 4-2. Schematic of Kiln Group 5 and Kiln Group 6 SNCR System**

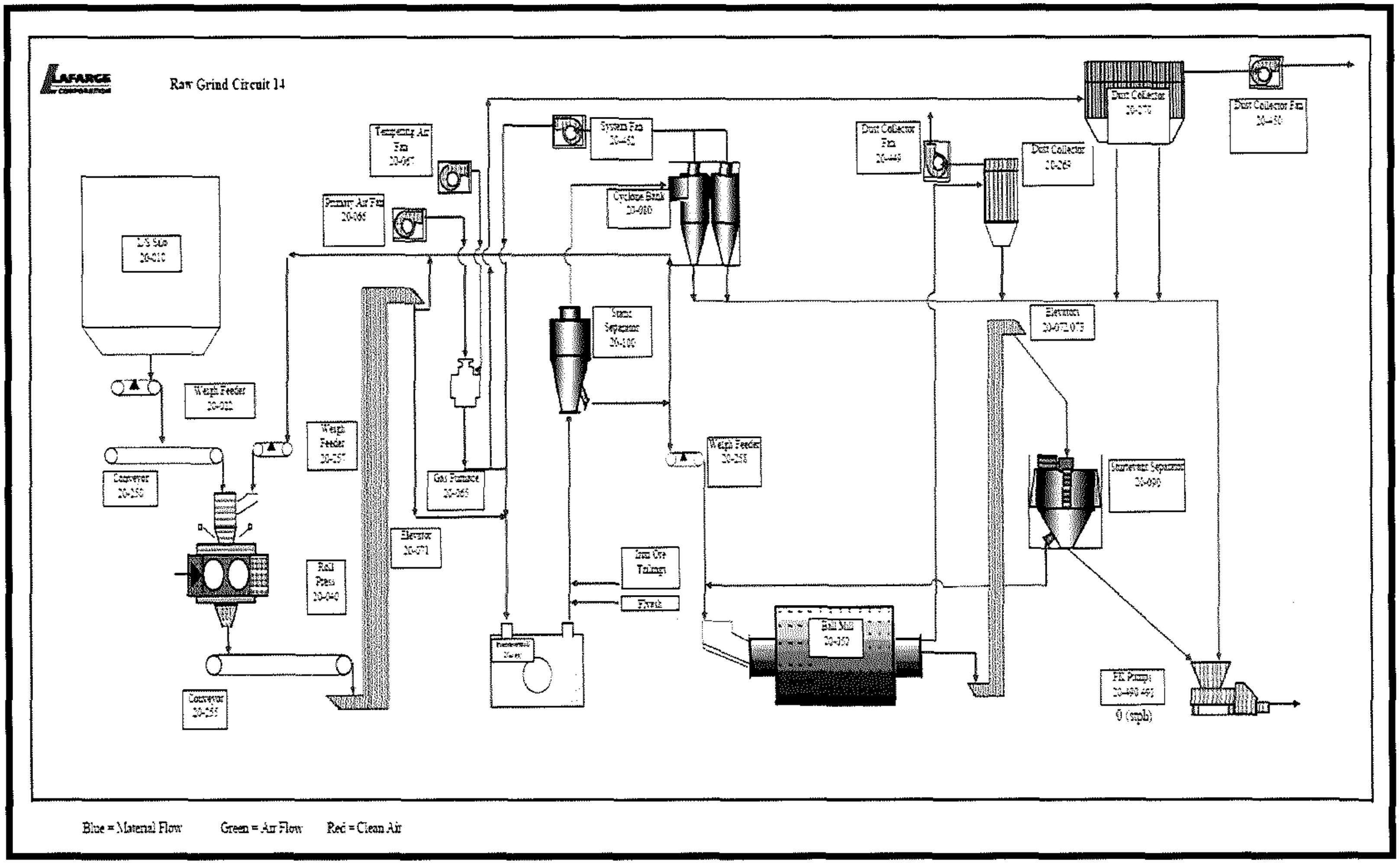


**Figure 4-3. Raw Mill Process Diagram**

## 5.0 SAMPLING LOCATIONS

### 5.1 KG5 and KG6 Sample Locations

For KG5, the sampling location was the breeching duct between each kiln's baghouse and discharge stack. The sampling platforms are each located approximately sixty feet above grade elevation. Kiln 19 has a duct inner length of 96 inches by 118 inches in width. Kilns 20 and 21 are identical with an inner length of 96 inches by 104 inches in width. Kilns 19 and 20 have three emission sampling ports and Kiln 21 has 5 sampling ports.

The emission point for KG6 is downstream of the WGS for Kilns 22 and 23. The sample platform for WGS is located approximately two hundred feet above grade elevation. The stack has several sample ports located on the sampling platform. A single point isokinetic sample point was utilized for HCl and PM testing due to the interference the platform beams pose when traversing the stack. This sample point was the average point of flow velocity taken from a preliminary EPA Method 2 traverse conducted by AECOM staff and discussed with MDEQ in the test planning process.

The sampling locations for the Kilns and WGS are illustrated in Figure5-1 through Figure 5-5.

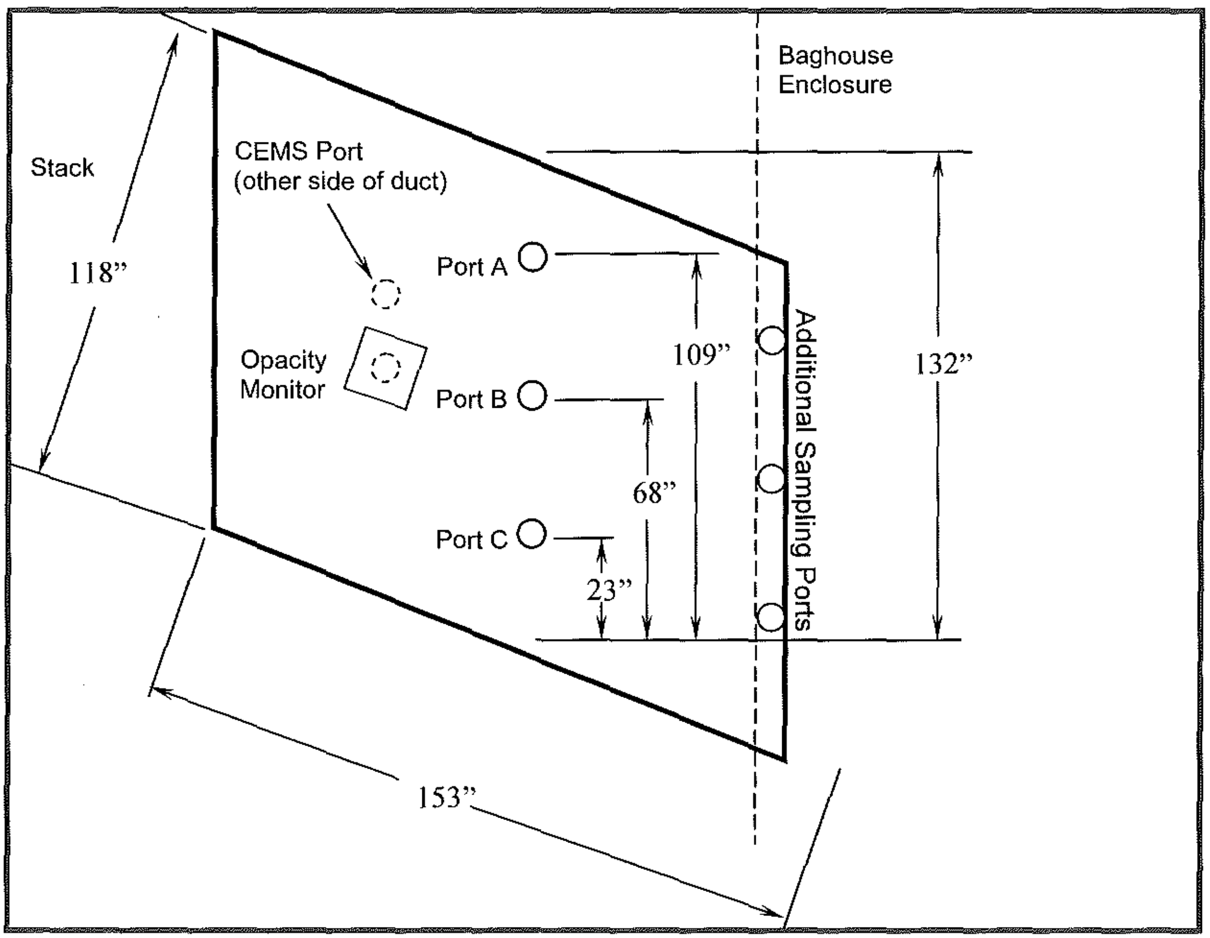


**Figure 5-1. Kiln 19 Test Port Locations (side view)**

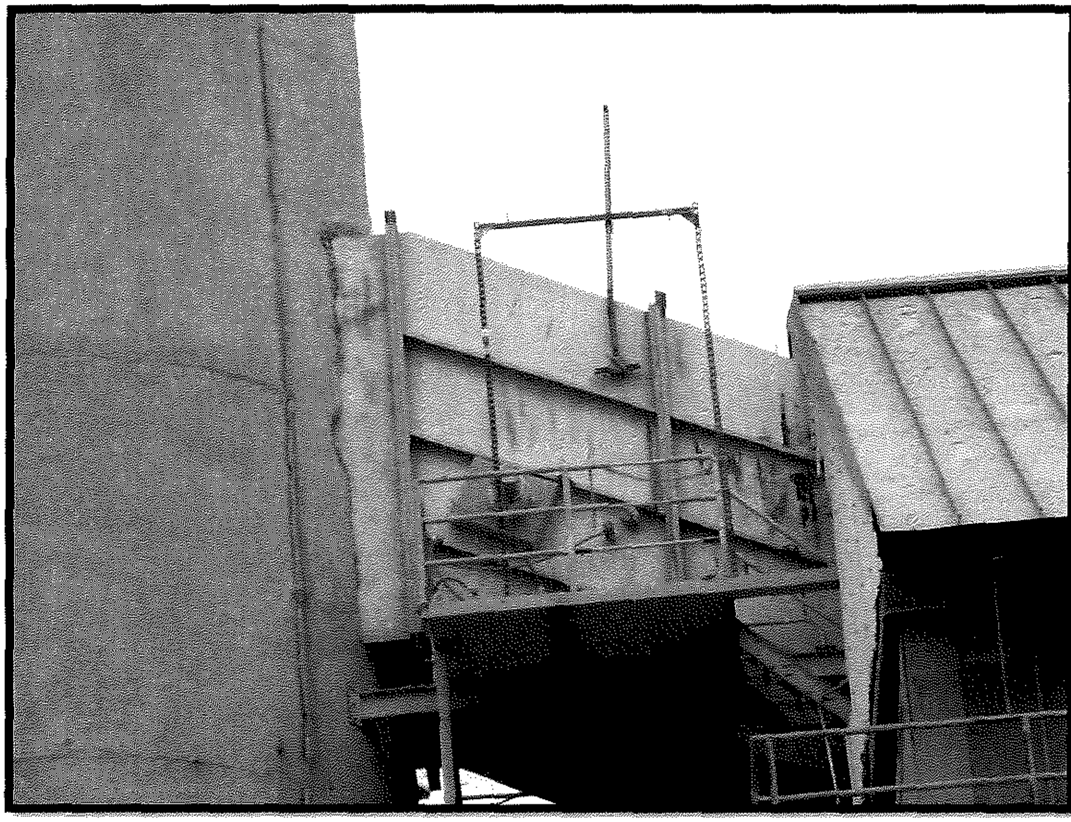

**Figure 5-2. Kiln 19 Breeching Duct**

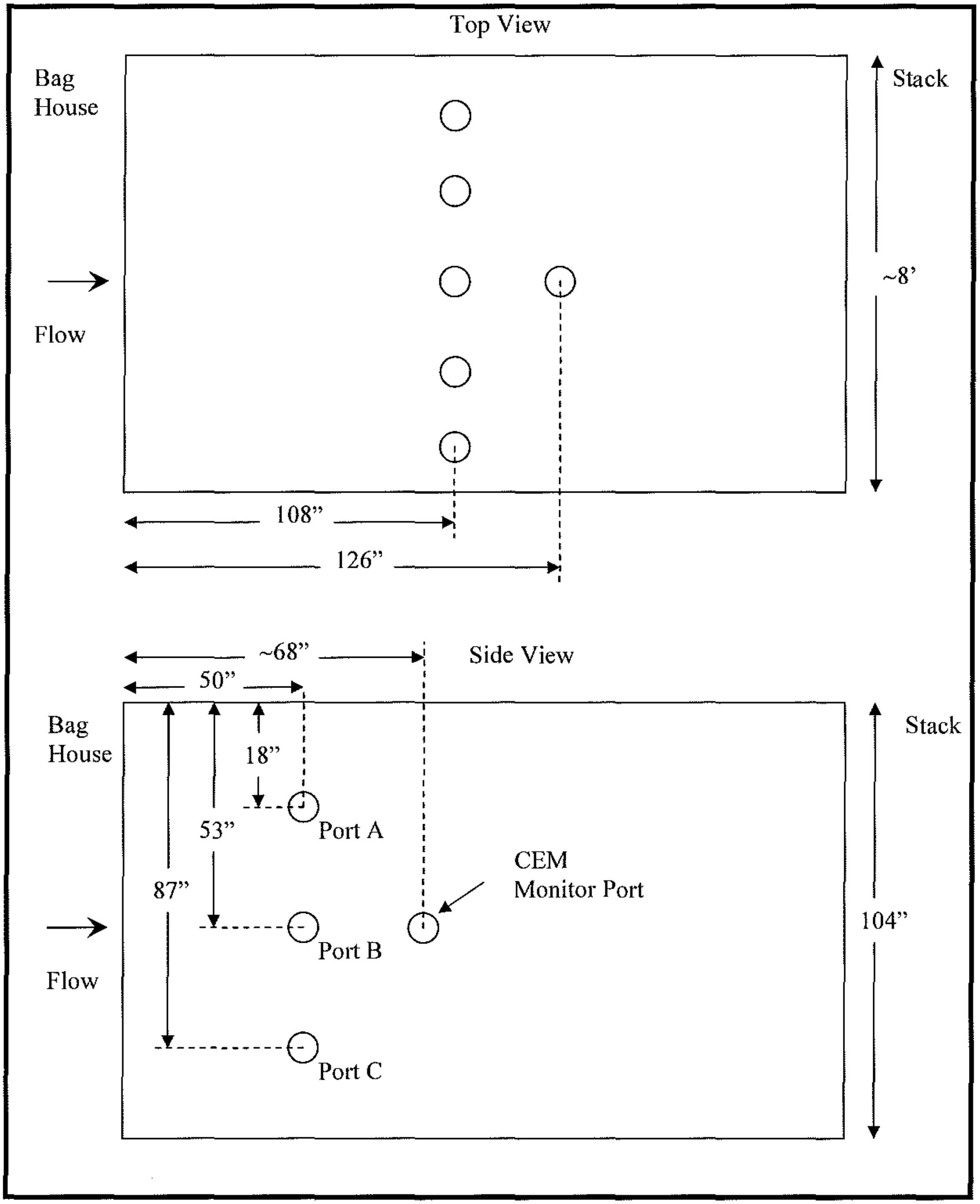


**Figure 5-3. Kilns 20 and 21 Breeching - Test Port Locations**

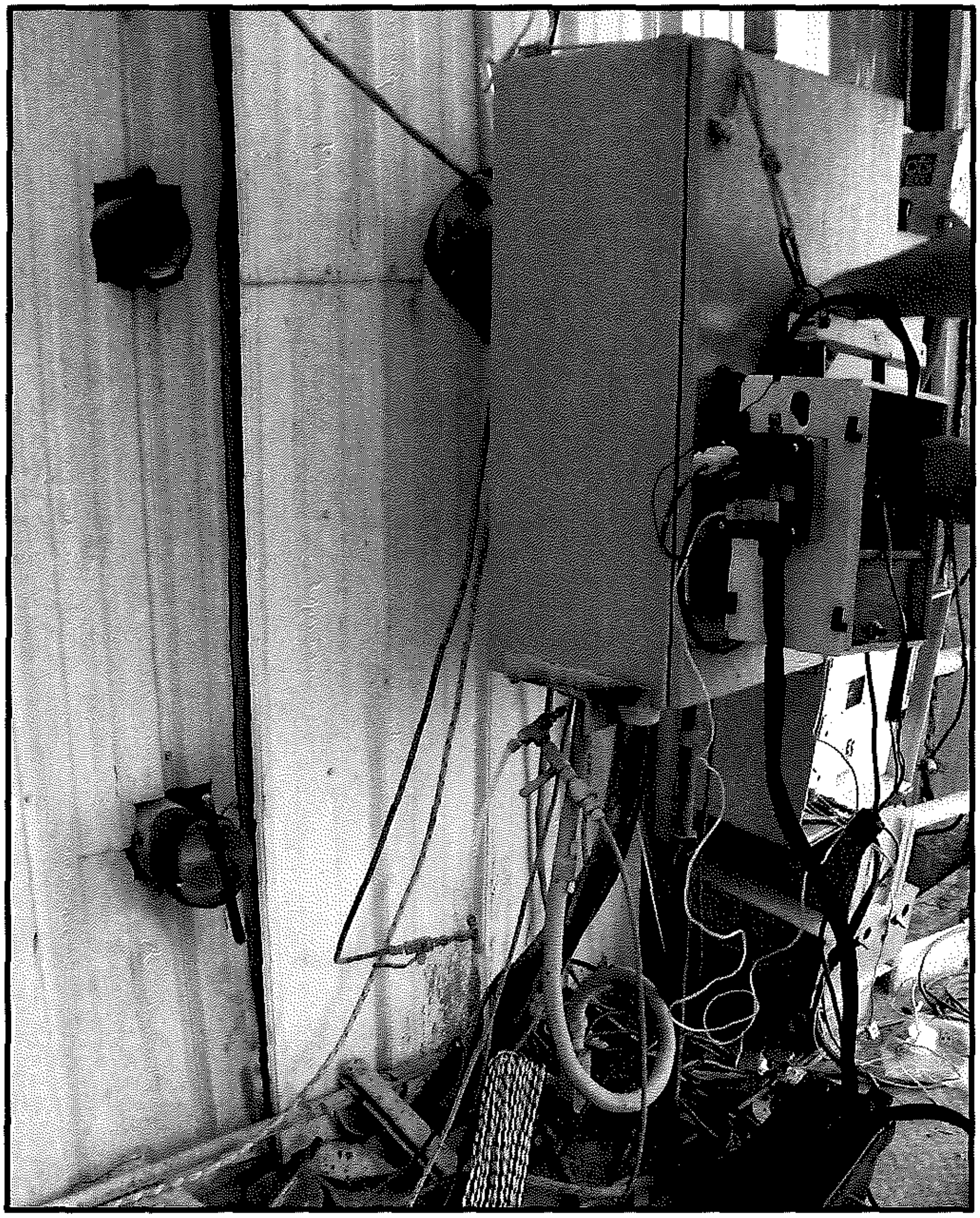

**Figure 5-4. Kiln 21 Breaching Duct – Lower Test Ports**

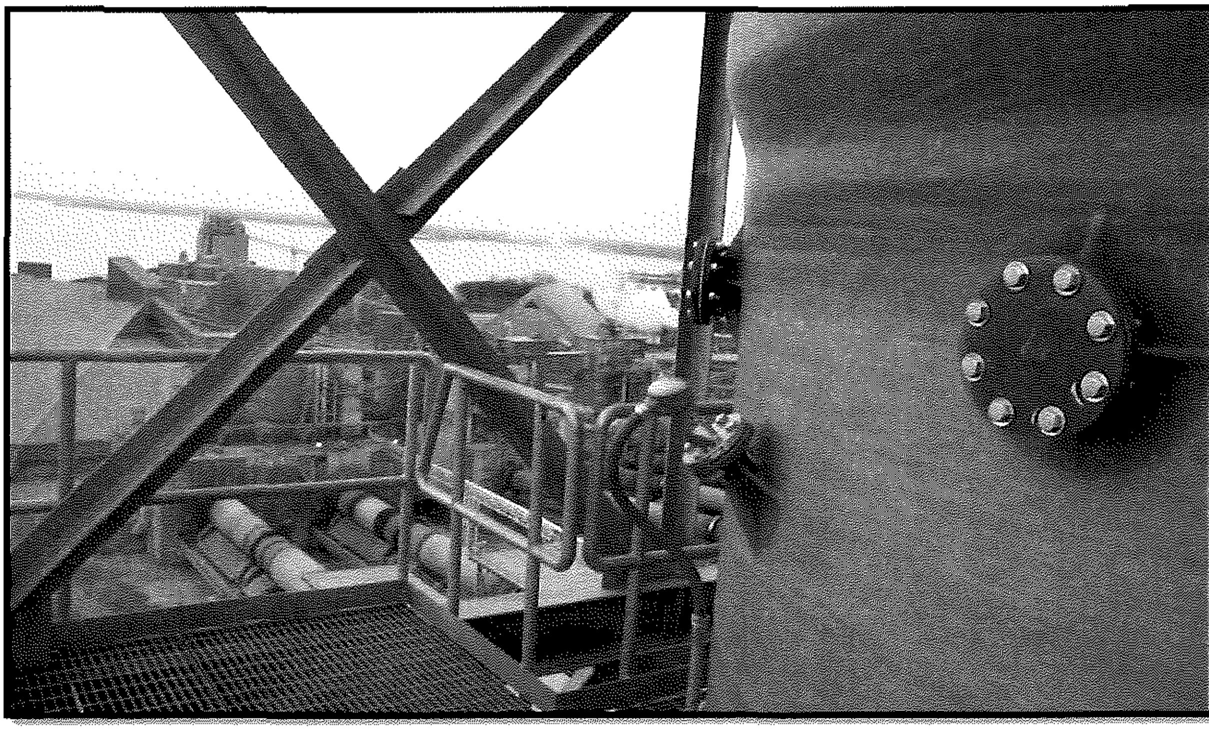

**Figure 5-5. WGS Sample Ports on Platform**

## 5.2 Raw Mill Sample Location

The sample ports for Raw Mill 14 and 15 are both located approximately 80 feet above grade elevation on the roof of the Raw Mill. Both stacks are identical with each having an inner diameter of 65.5 inches. Figure 5-6 illustrates the sample locations for the Raw Mill stacks.

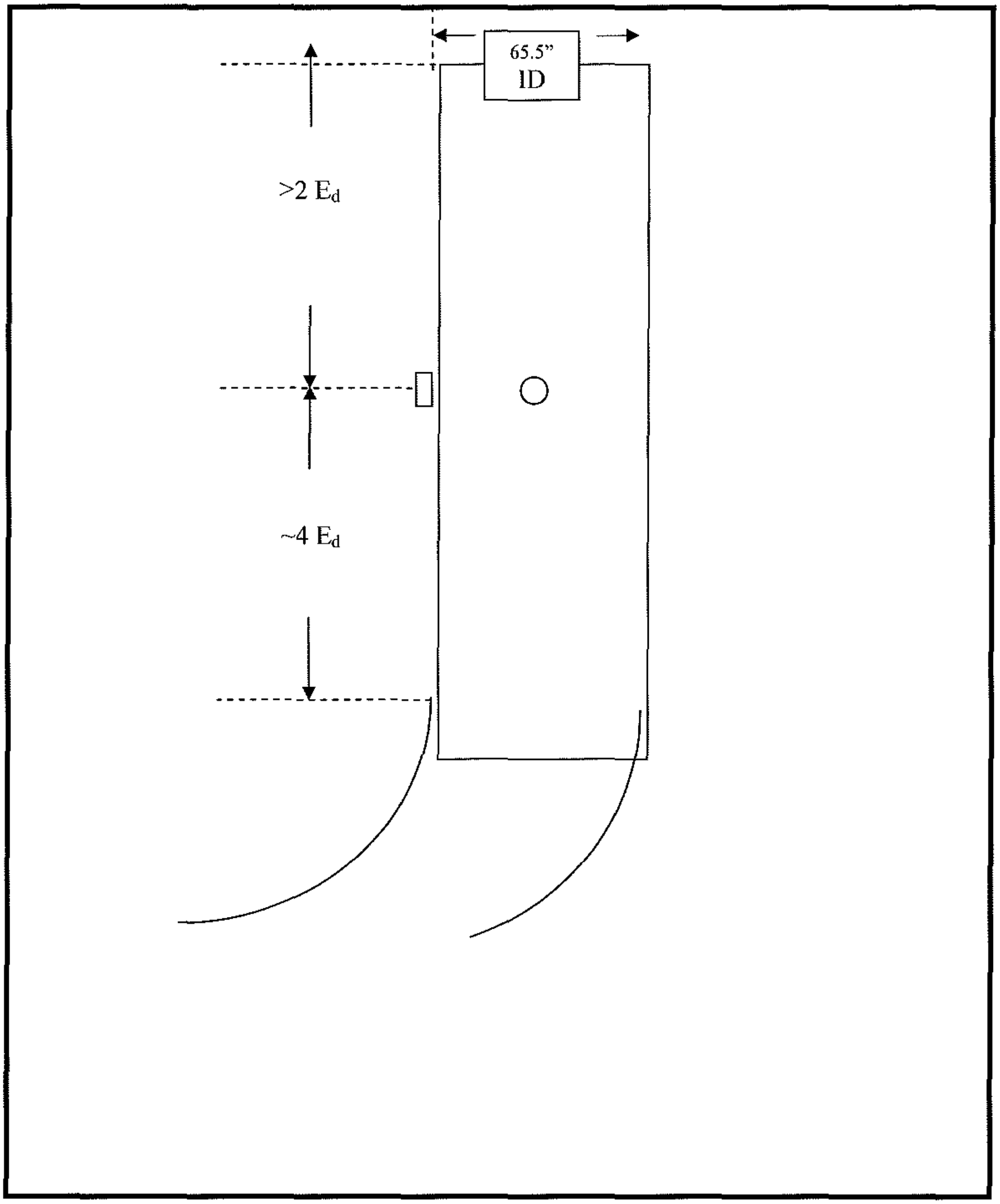


**Figure 5-6. Raw Mill Schematic**

## 5.3 Clinker Cooler Sample Locations

The sample locations for Clinker Coolers 92 and 93 are located on the rooftop of the Standard Haven building. Both stacks are identical in design with each having an inner length of 62 inches by 75.3 inches in width. Each stack has seven sample ports. Figure 5-7 illustrates the sample ports for Clinker Coolers 92 and 93.

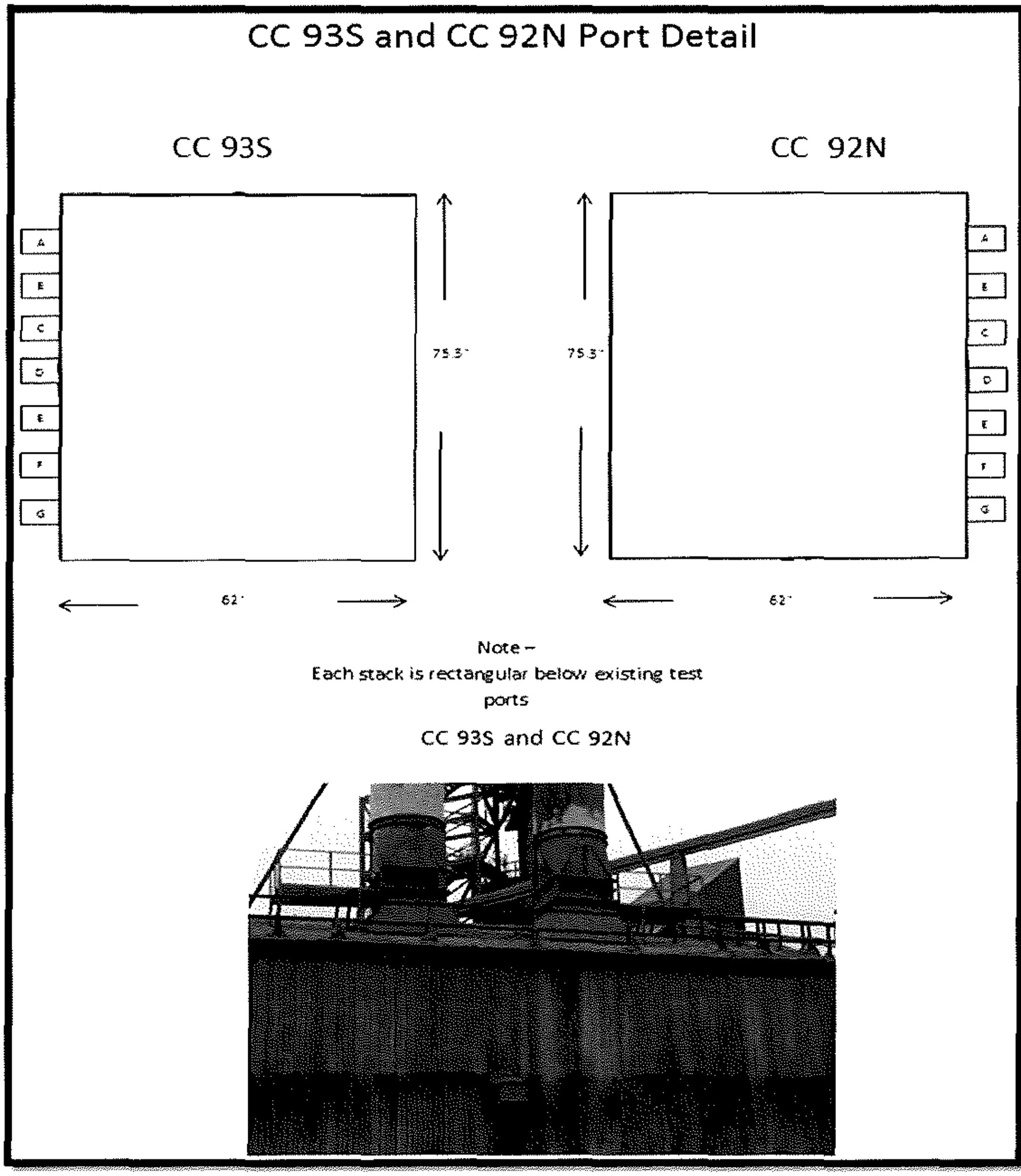


**Figure 5-7. Sample Location for CC 92, 93 and PM-CPMS Monitors**

The sample locations for Clinker Coolers 22 and 23 are located on a rooftop of the Standard Haven building. Each emission sampling location is approximately forty feet above grade elevation. Both stacks have an inner length of 66 inches by an 84.8 inch width. Figure 5-8 illustrates the sample ports and the PM CPMS monitor location for CC 22. Figure 5-9 illustrates the sample ports and PM CPMS monitor position for CC 23.

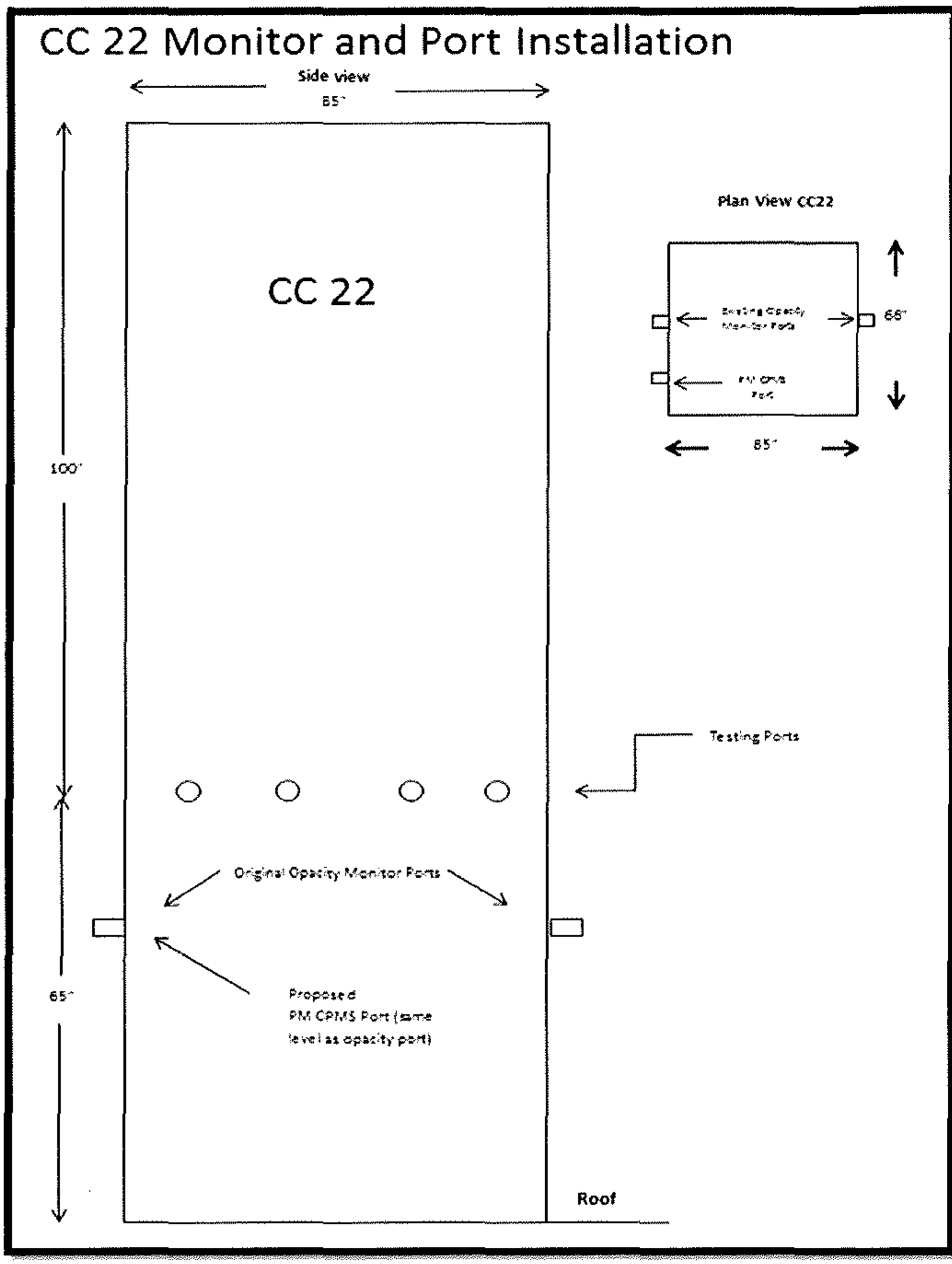


**Figure 5-8. Clinker Cooler 22 Sample Ports and PM CPMS Monitor**

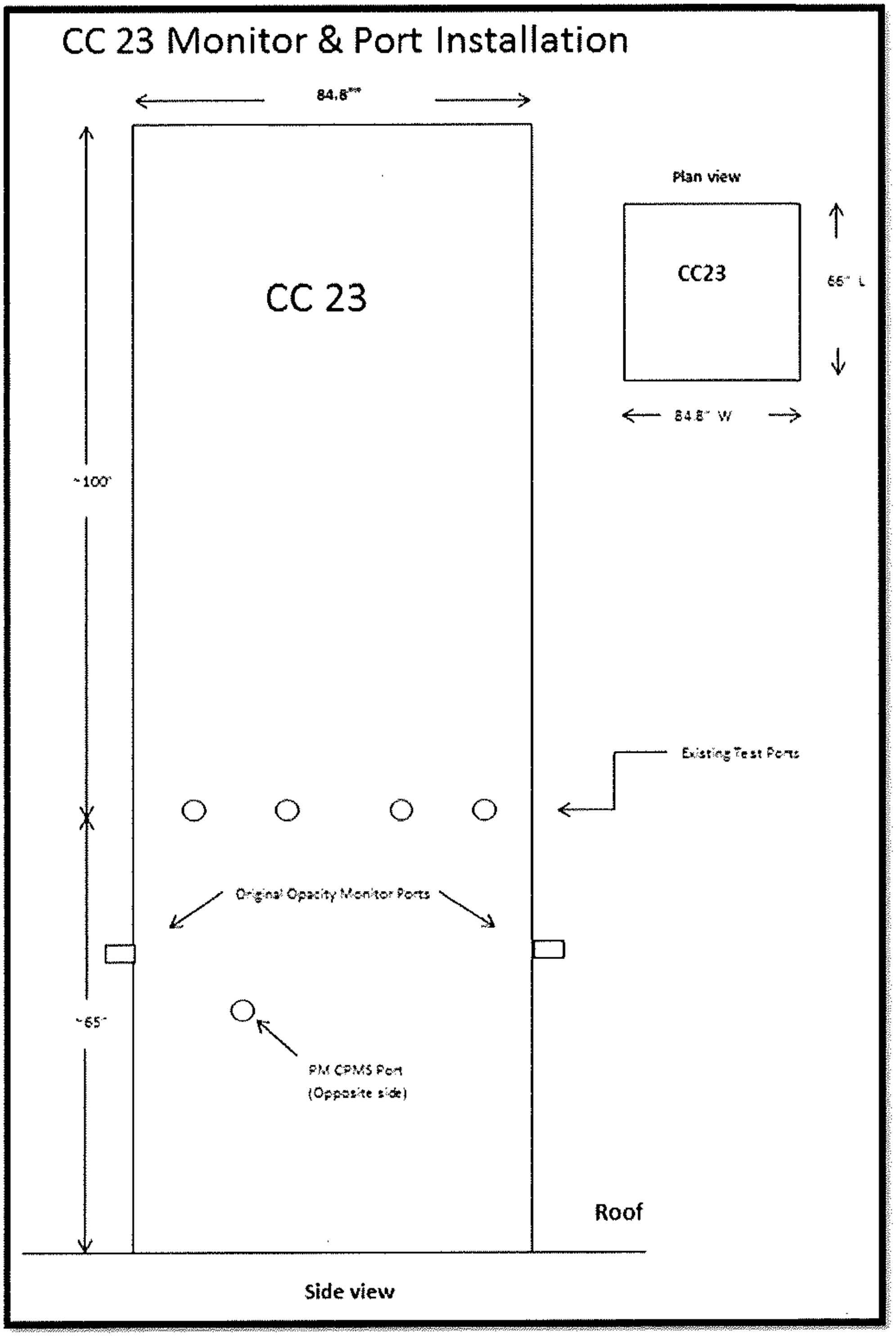


**Figure 5-9. Clinker Cooler 23 Sample Ports and PM CPMS Monitor**

## 6.0 SAMPLING AND ANALYTICAL PROCEDURES

AECOM conducted emissions measurements in accordance with procedures specified in the United States Environmental Protection Agency's (U.S. EPA's) CFR Promulgated Test Methods and MDEQ's "General Rules, Part 10, Intermittent Testing and Sampling." The test methods used to perform the sampling and analysis are provided in Table 5-1.

**Table 5-1. Test Methods**

| Parameter Measured | Method | Method Description |
|---|---|---|
| Hydrogen Chloride | EPA Method 26A | Determination of Hydrogen Chloride Emissions From Stationary Sources |
| Particulate Matter | EPA Method 5 | Determination of Particulate Matter Emissions from Stationary Sources |
| Velocity | EPA Method 2 | Determination of Stack Gas Velocity and Volumetric Flow Rate |
| Oxygen and Carbon Dioxide | Certified Plant Instrumentation / 40 CFR 60 Appendix A: Method 3A | Certified by EPA Method 3A: Determination Of Oxygen And Carbon Dioxide Concentration In Emissions From Stationary Sources (Instrumental Analyzer Procedure) |
| Moisture | EPA Method 4 | Determination of Moisture Content In Stack Gases |

## 6.1 Audit Sample

EPA Method 26A results were certified by audit samples through the Source Sampling Audit Sample (SSAS) program that were acquired from an Accredited Audit Sample Provider (AASP). One HCl audit sample was requested for this element of the test program. The SSAS was analyzed in conjunction with the field samples in the laboratory. Table 6-1 summarizes the results from the SSAS. The SSAS result was "acceptable" by definition from the AASP.

**Table 6-1. Summary of SSAS Audit Results**

| Parameter | Units | Laboratory Result | Acceptable Range | Assigned Value | Result |
|---|---|---|---|---|---|
| Hydrogen Chloride | mg/L (ppm) | 20.6 | 18.2 – 22.2 | 20.2 | Acceptable |

# 7.0 TEST RESULTS AND DISCUSSION

## 7.1 Detailed Results

Table 7-1summarizes the detailed results of the HCl emission testing program. Both HCl and $Cl^-$ fraction concentrations were determined in the emissions calculations. Example calculations can be found in Appendix E. HCl equivalent concentrations are reported using the following equation:

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

The $O_2$ concentrations measured by the plant monitors were used to correct the as-measured HCl results to a 7% $O_2$basis as specified in the ROP permit. The plant $O_2$ monitor(s) accuracy was verified by the CERMS RATA conducted contemporaneous with the annual HCl and PM testing.

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's data acquisition system (DAS). Table 7-5 presents the detailed kiln operating conditions during each test run. The plant DAS generates production and process data in metric tons per hour (mtons/hr). The production and process data has been calculated and reported in standard tons per hour (tons/hr) for compliance reporting purposes.

The EPA Method 5/26A testing for HCl and $Cl^-$ met all sampling and analytical QA/QC parameters. Testing was completed utilizing a front half Method 5 and back half Method 26A sample train for Kilns 19-21 and the WGS.

The $O_2$ monitor for Kiln 20 was verified by the RATA prior to HCl testing. The RATA for Kiln 20 occurred on 7/11/2016. HCl and PM results for Kiln 20 on 7/12/2016 were invalidated due to process malfunctions where plastics were not able to be fired during testing. Additionally, the PTFE filters used to sample for PM during Runs 1 and 2 were damaged by high gas effluent temperatures which rendered them void. As discussed with Mark Dziadosz of MDEQ on-site during testing, the filter media was changed to Quartz filters after these runs and Kiln 20 was retested on 7/13/2016 for HCl and PM. The invalidated run data can be found in Appendix A-5.

Of the three runs conducted on the July 16, 2016 test of the WGS, the first HCl test run had a result in the halide fraction that was higher as compared to the successive runs. An internal review of recovery procedures indicates a potential for contamination from the previous source in the impinger glassware which may have caused a high positive bias in the analytical result for the first test run. The average HCl test result for the WGS, although potential biased high, still remains at an insignificant level in comparison with the permitted limit.

PM testing was performed using EPA Method 5 on Raw Mill 14 and 15, Clinker Coolers 22-23 and Clinker Coolers 92-93.

A review of the analytical analysis of the initial particulate matter test results from Raw Mill 14 Main Baghouse on July 12$^{th}$yielded an anomaly in the result of Run 1. The PM result was nearly seven times greater than Runs 2 and 3. This first run is the only run that is in excess of any of the permit standards and as a result raised the average of the three runs to beyond the permit limit of 0.03 lb/1000 lbs dry exhaust gas. The primary reason for the anomaly is unknown. It was determined that a second test to demonstrate compliance was necessary. The following describes corrective actions that took place on the Main Baghouse after the initial testing was conducted on July 12th.

After conducting the stack sampling on Raw Mill 14 Main Baghouse (Equipment Number: 20-270) on July 12th and prior to receiving the preliminary results of the particulate matter testing, two separate malfunctions were identified that required corrective actions to be completed on the filtration system. On July 13, 2016 two solenoid valves were identified and subsequently changed as they were identified as not functioning properly. On August 2, 2016 visible emissions were identified by plant personnel that initiated immediate corrective action. Investigation of the system found five fabric filters had failed and which necessitated their replacement.

These are the only actions that were completed to the 20-270 dust collector between the time of the initial sampling and the retest completed on August 25, 2016.It is believed that one of these corrective actions contributed to the demonstrated compliance of the PM standards for Raw Mill 14.

The PM sampling and analytical results met standard method specifications and quality control procedures. The detailed PM results are shown in Table 7-3 for the raw mills and in Table 7-4 for the clinker coolers. Table 7-5 details the operating conditions for the kilns and WGS. Tables 7-6 and 7-7 indicate the process operating conditions for the test runs on the raw mills and clinker coolers, respectively.

## Table 7-1. Detailed HCl Results for Kilns and WGS (2016)

| Kiln | Run | $O_2$ (% dry basis) | HCl Concentrations Uncorrected (ppmv, dry) | HCl Concentrations Corrected (ppmv,dry @7% $O_2$) | $Cl^-$ Concentrations Uncorrected (ppmv, dry) | $Cl^-$ Concentrations Corrected (ppmv,dry @7% $O_2$) | HCl Equivalent Emission (ppmv,dry @7% O2)[b] | HCl Equivalent Permit Limit (ppmv,dry @7% $O_2$) | HCl Equivalent Emission Rate (lb/hr) | HCl Equivalent Emission Rate Permit Limit (lb/hr)[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 1 | 7.2 | 40.97 | 41.54 | 0.13 | 0.13 | 41.80 | | 13.87 | |
| | 2 | 7.2 | 37.23 | 37.87 | 0.10 | 0.10 | 38.07 | | 13.43 | |
| | 3 | 7.3 | 31.87 | 32.47 | 0.12 | 0.13 | 32.73 | | 11.28 | |
| | Avg | 7.2 | 36.69 | 37.29 | 0.12 | 0.12 | **37.53** | **65** | **12.87** | **36** |
| 20 | 4 | 8.8 | 19.76 | 22.75 | 0.14 | 0.17 | 23.09 | | 10.15 | |
| | 5 | 8.8 | 14.92 | 17.08 | 0.10 | 0.12 | 17.32 | | 8.12 | |
| | 6 | 8.7 | 23.28 | 26.43 | 0.14 | 0.15 | 26.73 | | 12.43 | |
| | Avg | 8.7 | 19.32 | 22.08 | 0.13 | 0.15 | **22.38** | **65** | **10.23** | **36** |
| 21 | 1 | 10.6 | 9.30 | 12.61 | 0.08 | 0.11 | 12.83 | | 4.39 | |
| | 2 | 10.6 | 7.25 | 9.76 | 0.08 | 0.11 | 9.98 | | 3.42 | |
| | 3 | 10.6 | 7.71 | 10.44 | 0.07 | 0.09 | 10.62 | | 3.75 | |
| | Avg | 10.6 | 8.08 | 10.94 | 0.08 | 0.10 | **11.14** | **65** | **3.84** | **36** |
| WGS | 1 | 7.3 | 3.10 | 3.18 | 0.08 | 0.09 | 3.36 | | 6.02 | |
| | 2 | 7.5 | 0.03 | 0.03 | 0.07 | 0.07 | 0.17 | | 0.17 | |
| | 3 | 7.0 | 0.04 | 0.04 | 0.08 | 0.09 | 0.22 | | 0.22 | |
| | Avg | 7.3 | 1.06 | 1.08 | 0.08 | 0.08 | **1.24** | **170[a]** | **2.09** | **162[a]** |

[a] WGS is the emission point for Kiln 22 and Kiln 23. Existing permit limit is for each kiln.
[b] HCl + 2 x (Cl2) = HCl Equivalents.

## Table 7-2. Detailed PM Results for Kilns and WGS (2016)

| Source | Run | Date | PM Emissions (lb/1000 lbs dry exhaust gas) | PM Limit (lb/1000 lbs dry exhaust gas) |
|---|---|---|---|---|
| 19 | 1 | 7/13/2016 | 0.038 | 0.25 |
| | 2 | 7/13/2016 | 0.014 | |
| | 3 | 7/13/2016 | 0.003 | |
| | Average | | **0.019** | |
| 20 | 1 | 7/13/2016 | 0.004 | 0.25 |
| | 2 | 7/13/2016 | 0.045 | |
| | 3 | 7/13/2016 | 0.004 | |
| | Average | | **0.018** | |
| 21 | 1 | 7/11/2016 | 0.010 | 0.25 |
| | 2 | 7/11/2016 | 0.006 | |
| | 3 | 7/11/2016 | 0.003 | |
| | Average | | **0.006** | |
| WGS | 1 | 7/16/2016 | 0.004 | 0.25 |
| | 2 | 7/16/2016 | 0.002 | |
| | 3 | 7/16/2016 | 0.002 | |
| | Average | | **0.003** | |

## Table 7-3. Detailed Raw Mill PM Test Results (2016)

| Source | Run | Date | PM Emissions (lb/1000 lbs dry exhaust gas) | PM Limit (lb/1000 lbs dry exhaust gas) |
|---|---|---|---|---|
| RM 14[a] | 1 | 8/25/2016 | 0.010 | 0.15 |
| | 2 | 8/25/2016 | 0.008 | |
| | 3 | 8/25/2016 | 0.009 | |
| | Average | | **0.008** | |
| RM 15 | 1 | 7/18/2016 | 0.010 | 0.15 |
| | 2 | 7/18/2016 | 0.007 | |
| | 3 | 7/18/2016 | 0.007 | |
| | Average | | **0.008** | |

[a]PM Results are from retest on 8/25/16. Detailed test data from 7/12/16 is presented in Appendix A.

## Table 7-4. Detailed Clinker Cooler PM Results (2016)

| Source | Run | Date | PM Emissions (lb/1000 lbs dry exhaust gas) | PM Limit (lb/1000 lbs dry exhaust gas) | PM Emissions (lb/ton dry feed) | PM Limit (lb/ton dry feed) | PM Emissions (lb/ton clinker) | PM Limit (lb/ton clinker) |
|---|---|---|---|---|---|---|---|---|
| CC 22 | 1 | 7/14/2016 | 0.005 | **0.04** | 0.008 | **0.10** | 0.014 | **0.07** |
| | 2 | 7/14/2016 | 0.007 | | 0.012 | | 0.019 | |
| | 3 | 7/14/2016 | 0.003 | | 0.005 | | 0.008 | |
| | Average | | **0.005** | | **0.008** | | **0.014** | |
| CC 23* | 1 | 7/15/2016 | 0.009 | **0.04** | 0.020 | **0.10** | 0.032 | **0.07** |
| | 3 | 7/15/2016 | 0.009 | | 0.019 | | 0.030 | |
| | 4 | 7/16/2016 | 0.016 | | 0.050 | | 0.080 | |
| | Average | | **0.011** | | **0.029** | | **0.047** | |
| CC 92 | 1 | 7/19/2016 | 0.009 | **0.04** | 0.025 | **0.10** | 0.041 | **0.07** |
| | 2 | 7/19/2016 | 0.005 | | 0.009 | | 0.014 | |
| | 3 | 7/19/2016 | 0.007 | | 0.017 | | 0.028 | |
| | Average | | **0.007** | | **0.017** | | **0.028** | |
| CC 93 | 1 | 7/19/2016 | 0.006 | **0.04** | 0.016 | **0.10** | 0.027 | **0.07** |
| | 2 | 7/19/2016 | 0.004 | | 0.007 | | 0.012 | |
| | 3 | 7/19/2016 | 0.007 | | 0.018 | | 0.029 | |
| | Average | | **0.006** | | **0.014** | | **0.023** | |

*Run 2 not used due to insufficient sample volume collection during the test run.

## Table 7-5. Detailed Kiln Operating Conditions during HCl-PM Testing

| Source | Date | Run | Raw Material Feed Rate (tons/hr) | Clinker Production Rate (tons/hr) | Differential Pressure (kPa) | Plastics Feed[a] (tons/hr) |
|---|---|---|---|---|---|---|
| K19 | 7/13/2016 | 1 | 62.44 | 37.77 | 1.10 | 49.58 |
| | 7/13/2016 | 2 | 90.89 | 54.98 | 1.08 | 52.97 |
| | 7/13/2016 | 3 | 81.15 | 49.09 | 1.09 | 0.46 |
| | Average: | | **78.16** | **47.28** | **1.09** | **34.34** |
| K20 | 7/13/2016 | 4 | 67.02 | 41.51 | 0.61 | 25.74 |
| | 7/13/2016 | 5 | 64.06 | 39.68 | 0.63 | 49.57 |
| | 7/13/2016 | 6 | 69.68 | 43.16 | 0.62 | 49.58 |
| | Average: | | **66.92** | **41.45** | **0.61** | **41.63** |
| K21 | 7/11/2016 | 1 | 81.27 | 49.16 | 0.45 | 49.56 |
| | 7/11/2016 | 2 | 70.64 | 42.73 | 0.46 | 22.78 |
| | 7/11/2016 | 3 | 70.79 | 42.83 | 0.46 | 43.30 |
| | Average: | | **74.23** | **44.91** | **0.45** | **38.55** |
| WGS – K22 | 7/16/2016 | 1 | 122.14 | 73.09 | 1.06 | 33.07 |
| | 7/16/2016 | 2 | 104.75 | 62.69 | 1.02 | 33.07 |
| | 7/16/2016 | 3 | 135.27 | 80.95 | 1.02 | 33.07 |
| | Average: | | **120.72** | **72.24** | **1.03** | **33.07** |
| WGS – K23 | 7/16/2016 | 1 | 121.77 | 73.66 | 0.96 | 33.07 |
| | 7/16/2016 | 2 | 104.28 | 63.08 | 0.96 | 33.07 |
| | 7/16/2016 | 3 | 135.48 | 81.96 | 0.99 | 33.07 |
| | Average: | | **120.51** | **72.90** | **0.97** | **33.07** |

[a]Plant provided feed estimates that plastics were split evenly between K22 and K23

## Table 7-6. Detailed WGS Operating Conditions during HCl-PM Testing

| Source | Date | pH | Pressure Drop (hPa) | Spray Pump Pressure (kPa) |
|---|---|---|---|---|
| WGS | 7/16/2016 | 5.13 | 0.004 | 84.99 |
| | 7/16/2016 | 5.14 | 0.002 | 85.05 |
| | 7/16/2016 | 5.16 | -0.007 | 85.07 |
| Average: | | **5.14** | **-0.003** | **85.04** |

## Table 7-7. Detailed Raw Mill Operating Conditions

| Source | Date | Run | Raw Feed Rate (tons/hr) | Baghouse Differential Pressure (kPa) | Baghouse Inlet Temp. (°C) |
|---|---|---|---|---|---|
| RG14 | 8/25/2016 | 1 | 306.25 | 1.39 | 85.08 |
| | 8/25/2016 | 2 | 306.61 | 1.33 | 84.71 |
| | 8/25/2016 | 3 | 306.97 | 1.34 | 85.21 |
| | Average: | | **306.61** | **1.35** | **85.00** |
| RG15 | 7/18/2016 | 1 | 277.11 | 1.03 | 86.44 |
| | 7/18/2016 | 2 | 277.04 | 1.04 | 88.11 |
| | 7/18/2016 | 3 | 277.59 | 1.05 | 88.41 |
| | Average: | | **277.24** | **1.04** | **87.65** |

## Table 7-8. Detailed Clinker Cooler Operating Conditions

| Source | Date | Run | Raw Feed Rate (tons/hr) | Clinker Produced (tons/hr) | PM CPMS (mA) |
|---|---|---|---|---|---|
| CC 22 | 7/14/2016 | 1 | 139.75 | 83.49 | 4.13 |
| | 7/14/2016 | 2 | 129.58 | 77.41 | 4.11 |
| | 7/14/2016 | 3 | 130.09 | 77.71 | 4.09 |
| | Average: | | **133.14** | **79.54** | **4.11** |
| CC 23 | 7/15/2016 | 1 | 69.51 | 43.05 | 4.17 |
| | 7/15/2016 | 3 | 65.72 | 40.71 | 4.18 |
| | 7/16/2016 | 4 | 72.00 | 44.60 | 4.60 |
| | Average: | | **69.08** | **42.79** | **4.32** |
| CC 92[a] | 7/19/2016 | 1 | 78.21 | 47.31 | 4.49 |
| | 7/19/2016 | 2 | 111.21 | 67.28 | 4.43 |
| | 7/19/2016 | 3 | 75.08 | 45.42 | 4.44 |
| | Average: | | **88.17** | **53.34** | **4.45** |
| CC 93[a] | 7/19/2016 | 1 | 139.19 | 84.21 | 4.22 |
| | 7/19/2016 | 2 | 200.74 | 121.44 | 4.21 |
| | 7/19/2016 | 3 | 140.20 | 84.81 | 4.21 |
| | Average: | | **160.04** | **96.82** | **4.22** |

[a]CC92-93 production is as a representative percent of the total volumetric flow for KG5.

# 8.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific quality assurance and quality control (QA/QC) procedures that were identified in the test plan were followed during the testing execution to ensure collection of useful and valid data. Table 8-1 lists the acceptance criteria and control limits for the test program. 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.

## 8.1 Laboratory QC

Enthalpy Analytical of Durham North Carolina analyzed the acid and basic fractions of the Method 26A samples by ion chromatography (IC), following analytical procedures in EPA Method 26A, Determination of Hydrogen halide and Halogen Emissions from Stationary Sources Isokinetic Method (40 CFR Part 60, Appendix A).The caustic samples were collected and analyzed by Enthalpy Analytical as required by MDEQ. Table 8-1 lists the results of all of the QC procedures that were conducted as part of Enthalpy Anlaytical's analysis. QC results were within the acceptance criteria. All samples were analyzed within their required hold times. Method and laboratory reagent blanks contained no chloride at concentrations greater than the Limit of Quantification (LOQ).

A quadratic curve type was used instead of the method specified linear curve. The calibration curves met all method specified precision criteria for the calibration curve. The acid fractions were analyzed using the Metrohm 761 Ion chromatograph "Nelson". The base fractions were analyzed using the Metrohm 861 Ion Chromatograph "Smithers". All samples were analyzed in duplicate. Calibration records for these analyzers can be found in Appendix B.

**Table 8-1. 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. | $R^2 \geq 0.99995$ |
| LCS/LCSD Duplicate | Extracted blank matrix samples spiked with second source standard. | One LCS per standard calibration preparation. | 85 – 115% recovery. | LCS spike recovery between 98.6% - 102% |
| 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
IC Ion Chromatography
QC Quality Control