# Wet Gas Scrubber Certification Test Report Lafarge North America Alpena, Michigan

Prepared for:

Lafarge North America
1435 Ford Avenue
Alpena, Michigan 49707

Prepared by:

URS Corporation
1600 Perimeter Park Drive, Suite 400
Morrisville, NC 27560

September 2014

# 1.0 OVERVIEW

## 1.1 Introduction

The Lafarge Alpena plant operates under the Michigan Department of Environmental Quality (MDEQ) ROP No: MI-ROP-B1477-2012 regulating air emissions from Kilns 22 and 23 collectively known as Kiln Group 6. Kilns 22 and 23 exhaust through a common stack, referred to as the scrubber stack equipped with Wet Gas Scrubber (WGS). Initial annual certification testing includes a relative accuracy test audit (RATA) on both the continuous emission monitoring systems (CEMS) and the flow monitors on the WGS as well as a 7-day drift check (DC) per 40CFR60 Appendix B, Performance Specifications (PS) 2 and 3. Michigan Department of Environmental Quality (MDEQ) requests that Lafarge conduct RATA testing on an emission rate basis using inputs from both the CEMS and flow monitors together as a continuous emission rate monitoring system (CERMS) per Performance Specification 6. The permit requires CEMS to continuously monitor and record emissions of sulfur dioxide ($SO_2$) and oxygen ($O_2$). All of these CEMS are referred to as the compliance CEMS because they are used to determine compliance with criteria pollutant emission rates contained in the permits.

The RATA testing was completed by a test team from URS which included Bob Jongleux, Willie Lea, Robert Griffin, Pat Turner, Fran Cobo, Sam Warnock, and Lance Burleson. The CERMS RATA testing was conducted June 19, 2014. The initial CERMS RATA testing of the WGS was conducted on May 17 during the KG6 CERMS RATA test effort which was not within required test specifications. This report summarizes and presents the findings of both sets of test data, though focuses on the June CERMS RATA test effort which was successful.

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

| URS Corporation | MDEQ - Air Quality Division | Lafarge Corporation |
|---|---|---|
| 1. Bob Jongleux<br>Senior Scientist<br>Direct: 919.461.1242<br>Main: 919.461.1100<br>bob.jongleux@urs.com | 1. Karen Kajiya-Mills<br>Compliance Support Unit<br>517-335-4874 | 1. Joshua Strapec<br>Compliance Engineer<br>989.358.3356<br>joshua.strapec@lafarge.com |
| 2. Jerry Workman, PE<br>Measurements Dept. Mgr.<br>Direct: 919.461-1289<br>Main: 919-461-1100<br>jerry.workman@urs.com | 2. Rob Dickman<br>Air Quality Division<br>(231) 876-4412<br>dickmanr@michigan.gov | 2. Robert Budnik<br>Area Environment and<br>Public Affairs Manager<br>989.358.3321<br>robert.budnik@lafarge.com |

## 1.2 Objectives

To satisfy the requirements of permit ROP MI-ROP-B1477-2012, the following PS tests from Appendix B, 40CFR60 were conducted on the WGS from KG6, while operating under normal conditions.

- Performance Specification 2 (PS2) for $SO_2$.
- Performance Specification 3 (PS3) for $O_2$.

The results of the tests are summarized in Section 1.3 and detailed in Appendix A of this report. Section 2.0 provides a description of the emission testing methodologies. Section 3.0 includes a description of the sampling locations and provides details of the sources tested. Section 4.0 describes the sampling equipment, and section 5.0 describes the quality assurance/quality control procedures.

## 1.3 Summary of Results

URS conducted the tests and analyzed the data as required by Performance Specifications 2, 3 and 6. Table 1-1 and 1-2 summarize the RATA results from both the May and June Test programs. Acceptance criteria for a CERMS RATA under Performance Specification 6 are 20% relative accuracy. All CERMS results during the June test program were within compliance with Lafarge Alpena's permit.

**Table 1-1. Summary of CERMS Performance Specification Test Results (June 19, 2014)**

| Compliance Thresholds | $O_2$ | | $SO_2$ | |
|---|---|---|---|---|
| | Criteria | Results | Criteria | Results |
| Reference Method (%) | 1.0 | 0.25 | 20 | 6.0 |

**Table 1-2. Summary of CERMS Performance Specification Test Results (May 17, 2014)**

| Compliance Thresholds | $O_2$ | | $SO_2$ | |
|---|---|---|---|---|
| | Criteria | Results | Criteria | Results |
| Reference Method (%) | 1.0 | 0.64 | 20 | 26.0 |

## 1.4 Discussion of Results

The flow monitors at the WGS were adjusted and calibrated prior to the May CERMS RATA test effort on May 17 based on an engineering evaluation and test data of the Kiln 22 and Kiln 23 Duct volumetric gas flows from the individual kilns ducts conducted the previous day(s). The stack (WGS) flow monitor was adjusted prior to May 17 testing to compensate for the perceived inaccuracy between the empirical pretest flow measurements (via EPA Method 2) and the theoretical air flow from established kiln operating parameters. The resulting CERMS RATA conducted on May 17, 2014 did not meet specifications for $SO_2$, but passed specifications criteria for $O_2$ and stack volumetric flow. The $SO_2$ concentrations for both the plant monitor and the

reference method (URS) tracked each other but exhibited a consistent offset across the RATA testing.

A second CERMS RATA test was successfully conducted on June 19, 2014 after the plant CEM monitoring and extraction system was extensively reviewed by factory based instrument representatives, plant personnel and other third party reviewers. The MIRS instrument calibration and water interference curves were checked and reviewed. Heated extraction lines were evaluated for temperature (cold spots) and the plant system was rechecked for overall system integrity (leak tightness). The plant flow monitors were adjusted to a tighter tolerance based on the pretest EPA Method 2 volumetric stack flow measurements (empirical data) prior to the formal CERMS RATA conducted on June 19$^{th}$. The final adjustments to the plant flow monitors were based on a robust data set comprised of 14 EPA Method 2 volumetric flow rate traverses at the WGS stack. The result of the combined corrective actions taken resulted in a successful RATA on June 19th.

# 2.0 EMISSIONS TESTING METHODOLOGY DESCRIPTIONS

As part of the PS for the $SO_2$ and $O_2$ CEMS, a requirement is a test for seven day calibration drift and relative accuracy. Provided below is a brief definition of the methodologies that were followed during testing.

## 2.1 Calibration Drift

Calibration drift (CD) is defined as the difference between the analyzer output and the calibration gas value measured following 24 hours of operating at more than 50% of normal load during which no unscheduled maintenance, repair or adjustments to the system took place. Calibration drift testing occurs every day for a period of seven days and is evaluated at the zero and upscale level each day. For the flow monitors, the reference value is an electronic signal, generated by the data acquisition system (DAS) that is fed to the monitors to simulate a flow signal.

## 2.2 Relative Accuracy

Relative accuracy (RA) is determined by simultaneously measuring emissions with the installed CEMS and reference method analyzers. The analyzers are certified against flue gas concentrations measured according to EPA Reference Method 6C for $SO_2$, Method 3A for $O_2$, and Methods 1-3 for volumetric flow rate. The stack was considered saturated and therefore EPA Method 4 was not performed.

A minimum of 9 reference method test runs (with a maximum of 12 runs) were performed. For each 21-minute test run, averages of each gas concentration were calculated from both the reference method and CEMS data. The average values were used to calculate the difference between the reference method and CEMS result. The absolute value of the average difference of all applicable test runs was added to a confidence coefficient, which accounts for data scatter, and was divided by the average reference method value to calculate a percentage-based RA.

The regulations covering flow monitors are written in conjunction with Performance Specification 6 for CERMS. The RA requirement for the flow monitors is incorporated into the CERMS specification. The resulting calculated emission rates did not exceed an average relative accuracy (RA) 20% for $SO_2$ or 1 % $O_2$.

The mean difference, standard deviation of the differences, and confidence coefficient between the reference method and the plant CEMS data are used to calculate the relative accuracy. The equations are as follows:

**Arithmetic Mean:** Calculate the arithmetic mean of the difference of a data set as follows.

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i \qquad \text{(Equation 2-1)}$$

where:

n = number of data points

$\sum_{i=1}^{n} d_i$ = Algebraic sum of the individual differences $d_i$

**Standard Deviation:** Calculate the standard deviation, $S_d$ as follows:

$$S_d = \left[ \frac{\sum_{i=1}^{n} d_i^{\,2} - \frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1} \right]^{1/2} \qquad \text{(Equation 2-2)}$$

**Confidence Coefficient**: Calculate the 2.5% error confidence coefficient (one-tailed), CC, as follows:

$$CC = t_{0.975}\frac{S_d}{\sqrt{n}} \qquad \text{(Equation 2-3)}$$

where:

$t_{0.975}$ = single-tailed t-value for n-1 degrees of freedom

**Relative Accuracy:** Calculate the relative accuracy of a set of data as follows:

$$RA = \frac{|\bar{d}| + |CC|}{\overline{RM}} \times 100\% \qquad \text{(Equation 2-4)}$$

For alternate relative accuracy based on concentration limits

$$RA = |\bar{d}| + |CC| \qquad \text{(Equation 2-5)}$$

where:

$|\bar{d}|$ = Absolute value of the mean of differences

$|CC|$ = Absolute value of the confidence coefficient

$\overline{RM}$ = Average ref e rence method value

# 3.0 SAMPLING LOCATIONS AND SOURCE DESCRIPTIONS

## 3.1 Plant Analyzers

Concentrations of $SO_2$ and $O_2$ at the stack are measured by a MIR 9000H Multigas Analyzer. Both of these analyzers use the gaseous filter correlation principle to measure gas concentrations using infrared spectroscopy. All polyatomic gases absorb electromagnetic radiation of a given wavelength. The quality and quantity analysis based on this phenomenon is called absorption spectroscopy. Additional descriptions of the Lafarge Sampling system can be found in Section 4.0 of this test report. A custom designed pitot tube-based system by EMRC measures the flue gas flow in each of the sampling locations. Certification is performed annually on each of the systems.

The Cirrus data acquisition system, manufactured by Wunderlich-Malec, collected data from analog inputs, averages the analog data, and stored the data in internal memory. These data were used to evaluate and document compliance status.

## 3.2 Sampling Location (WGS)

The WGS stack location is located at the 200 foot level of the scrubber tower assembly and is accessible by stairwell. Test equipment is brought to the test location by an installed hoist assembly. The WGS test location houses a semi-enclosed platform with a heated work shelter. Additional test ports located around the non-enclosed platform were used for the EPA Method 2 volumetric flow traverses. The test location is adequate for conducting volumetric flow traverse. The flow profile is non-cyclonic per EPA Method 2 specifications. The sampling ports are under positive pressure. The MIRS sample probes extend approximately 45 inches into the duct, which meets requirements of the Performance Specifications 2 and 3. The extraction line is heated from the heated extraction probe down to the CEM shelter which is located ~ 200 feet below at grade level.

Figure 3-1 depicts the stack sampling location and the nearest disturbances upstream and downstream. The nearest disturbance upstream is 4.5 effective diameters ($E_d$) and the nearest disturbance downstream is 6 $E_d$. The scrubber stack and ports are fabricated of reinforced thermoplastic resin. The scrubber stack diameter is 12 feet at approximately the 200 foot level on the new scrubber tower. There are four 4-inch diameter ports with 8-bolt flanges at 90° spacing around the stack, adjacent to the CEMS probe ports. Figure 3-2 is a photograph of the ports used to extract the flue gases sampled for the RATA testing. Figure 3-3 is a photograph showing the arrangement of the bag house exit ducts and the approximate location of the CEMS probes.

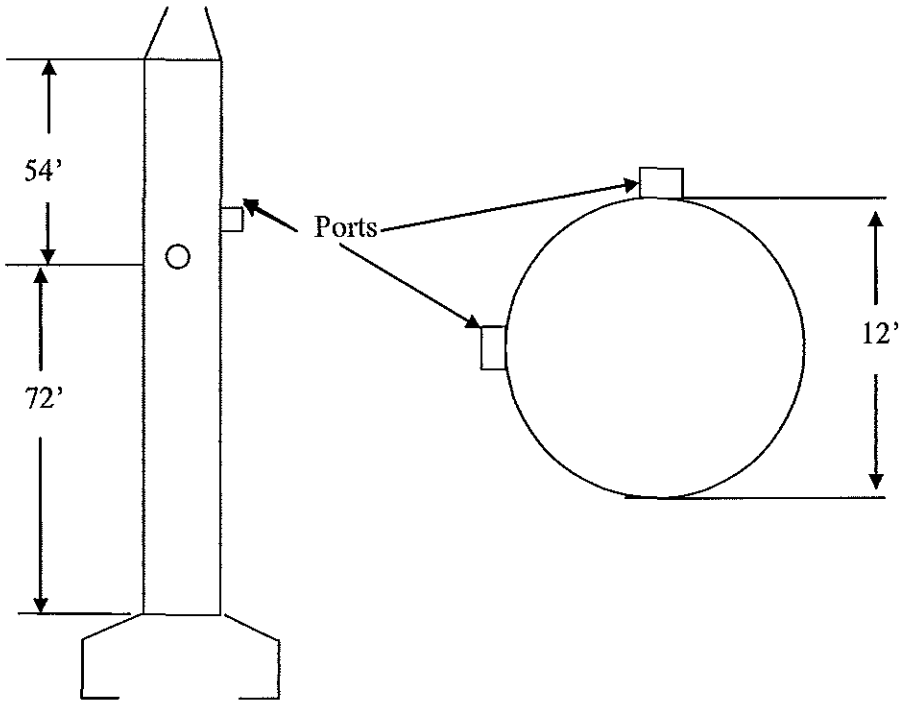


**Figure 3-1. Kiln Group 6 Scrubber Stack Port Locations**

## 3.3 Process Overview

Lafarge's Alpena Michigan plant includes five rotary kilns and auxiliary equipment to manufacture Portland cement by the dry process known as Kiln Group 5 (KG5) and Kiln Group 6 (KG6). All kilns are capable of burning a mixture of pulverized coal /petroleum coke, and plastics as fuel. All five kilns operate with waste-heat boilers for energy recovery and fabric filter baghouses for control of particulate matter emissions. The KG6 is now further controlled by installation of the wet gas scrubber after the exhausts of each kiln baghouse (K22 andK23) have been combined. Additional NOx control is recognized through SNCR in each kiln.

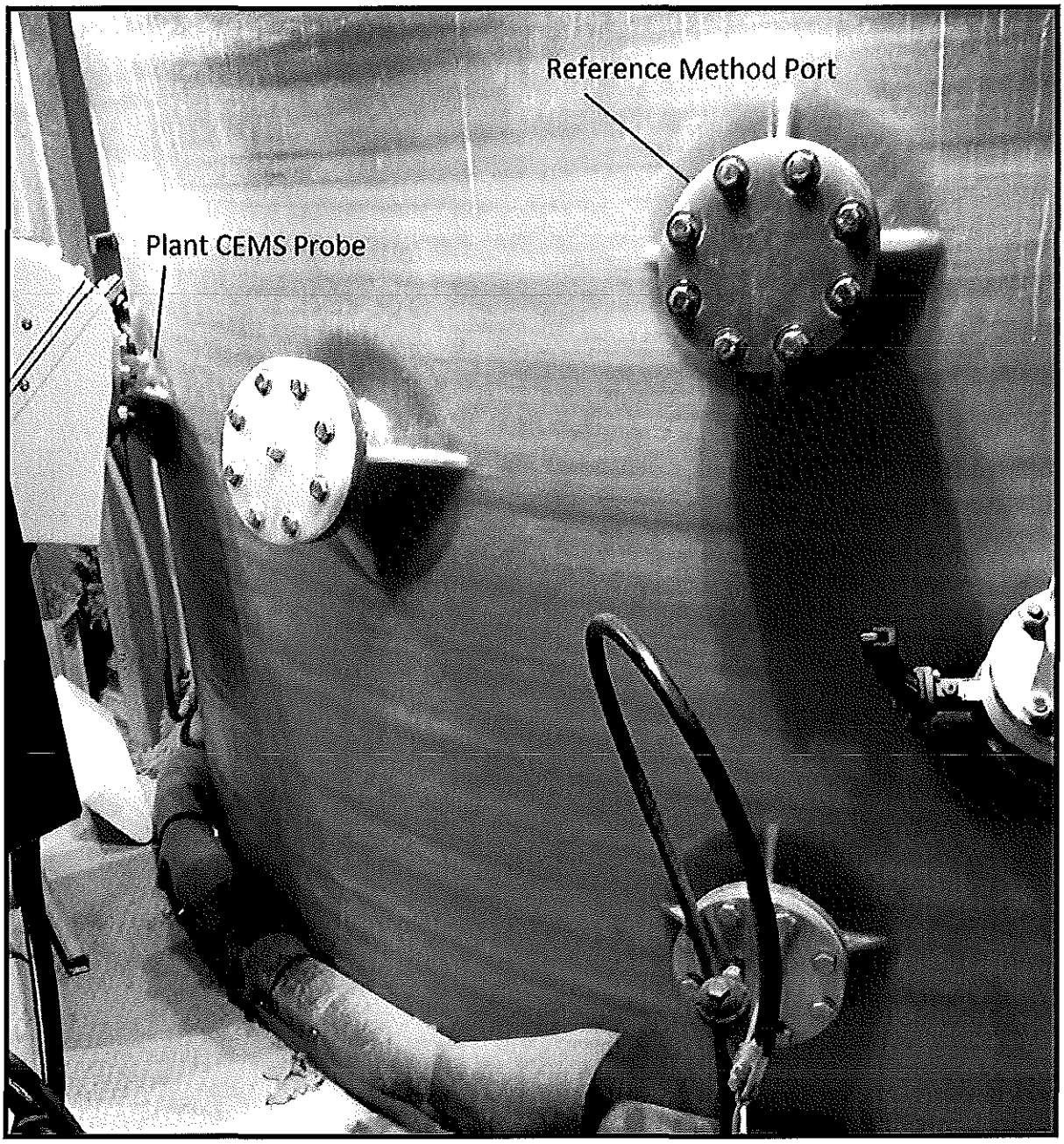


**Figure 3-2. Kiln Group 6 Scrubber Stack Ports**

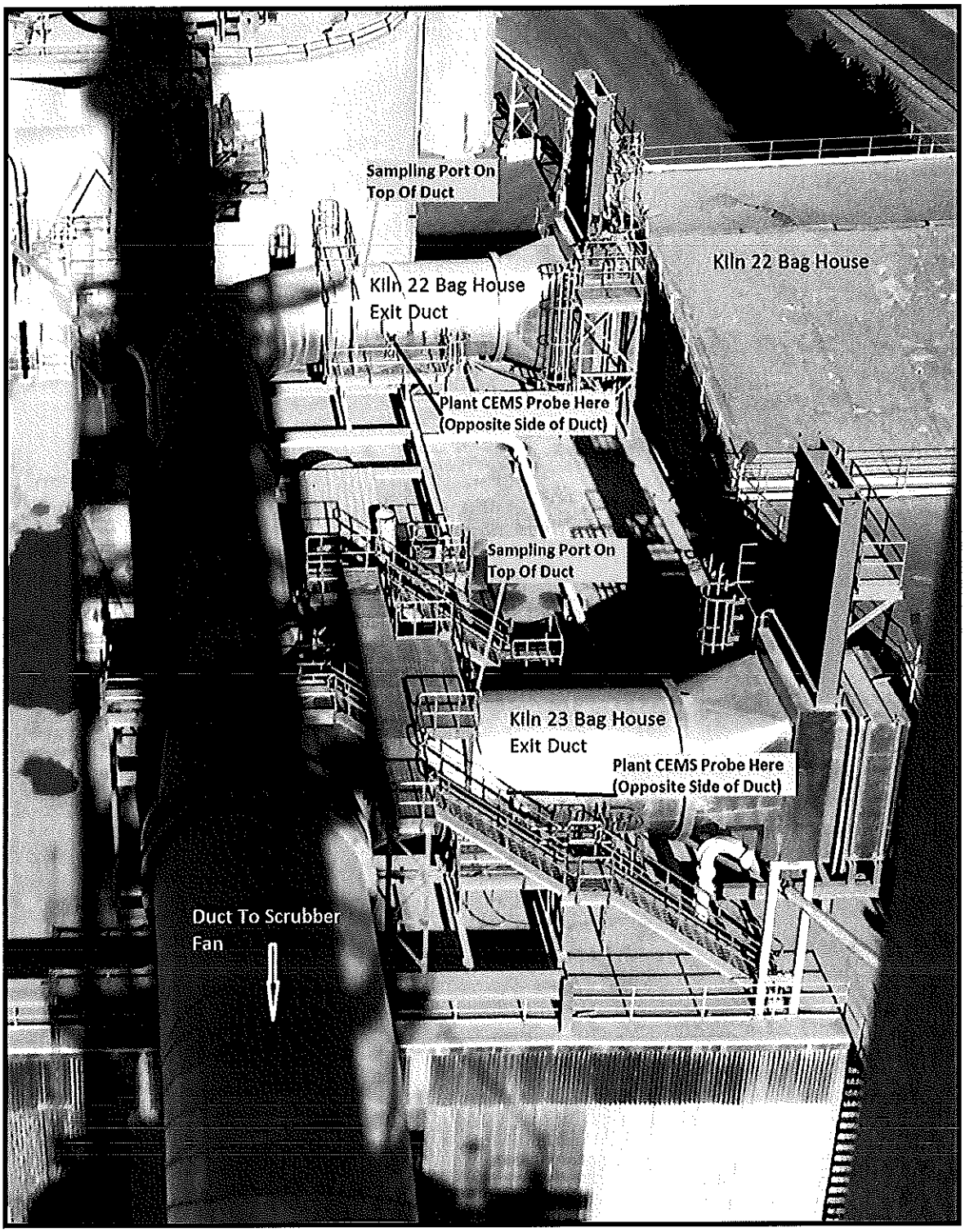


**Figure 3-3. Kiln Group 6 Bag House Exit Ducts**

Figure 3-3 depicts the Kiln Group 6 duct exits. Kiln Group 6 kilns were manufactured by Fuller Co., are 500 feet long and have a 19.6-foot inner 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 clinker. The kilns rotate at a rate up to 80 revolutions per hour using two 350-hp motors. 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 breaching duct that connects the baghouses to a new induced draft fan and wet gas scrubber tower assembly. Figure 3-3 is a photograph of the new baghouse exit ducts to the WGS fan and scrubber tower assembly.

Production rate is indicated by the raw mix feed rate, measured in tons/hour. The process monitoring system records raw mix feed rate, dust recycle rate and burning zone temperature for all kilns in one-minute averages. All process data can be found in Appendix D. Production rate was monitored and recorded during the testing to ensure that the kilns were operating at greater than 50% of normal load during the RATA testing.

# 4.0 SAMPLING EQUIPMENT DESCRIPTIONS

## 4.1 WGS Lafarge Sampling Equipment Descriptions

The sample gas transport system collects the sample gas from the ductwork, transfers the gas to the analyzers, and conditions the sampling gas. The heated extraction line is maintained at a programmed set temperature of 356 ° F. The MIRS 9000H is a hot wet analyzer with multi-component measurement capability. It is currently setup for measuring $SO_2$ and $O_2$.

The concentration of $SO_2$ is measured by the MIR 9000H Multigas Analyzer. This analyzer uses the gaseous filter correlation principle to measure all gases using infrared spectroscopy. Table 4-1 lists the monitors audited during this test program, and their span values.

**Table 4-1. Analyzers and Span Values**

| CEMS | Manufacturer | Model | Span Values |
|---|---|---|---|
| $O_2$ | Altech | MIR 9000H | 25% $O_2$ |
| $SO_2$ | Altech | MIR 9000H | 300 ppmv |
| Flow | EMRC | Custom Pitot with pressure transmitter | WGS Stack - 0-2"WC |

## 4.2 URS Testing Equipment

### Heated Lines

Heated sample lines were used to transfer the flue gas samples to the instrument trailer. These lines were heated to 250°F to prevent condensation. All heated lines contained one 3/8" Teflon tube to carry the sample, and a second ¼" tube to carry calibration gas. Temperatures were monitored with Type K thermocouples. A heated-head pump pulled the sample through the heated lines and exhausted the sample to the gas conditioning system.

### Gas Conditioning

A condenser style gas conditioning system was used to separate the moisture from the flue gas. The conditioning system cooled the gas to 34°F and condensed moisture in the sample. Condensate was immediately removed from the sample path reducing the potential for sample bias. Additionally, the system operated under positive pressure so that any leak would not affect the sample gas concentration. After the sample was dried in the condenser, it passed through a 5-micron filter to remove any particulate matter remaining in the gas stream.

### $SO_2$

$SO_2$ measurements were performed utilizing a Bovar 721-M analyzer. This instrument operates on the principle that molecules of $SO_2$ absorb ultraviolet energy in direct proportion to the concentration of $SO_2$ in the sample. In operation, a modulated beam of ultraviolet light is directed into the sample cell and is selectively absorbed by $SO_2$. A photomultiplier tube measures the intensity of ultraviolet light that passes through the sample cell, with the resulting signal conditioned within the analyzer to provide an output voltage proportional to the measured $SO_2$ concentration.

Note: A second $SO_2$ analyzer was used to independently monitor the WGS concentration flue gas concentration in the URS CEM trailer during the June 19 WGS RATA as a reference instrument. The data for this reference instrument was not needed because there was acceptable agreement between the plant (Lafarge) and reference method (URS) $SO_2$ instruments.

### $O_2$

Oxygen ($O_2$) was measured using a Teledyne 200EH analyzer. The $O_2$ module is a paramagnetic analyzer. Paramagnetic analyzers operate on the principal that $O_2$ molecules have magnetic properties under certain conditions. The sample tube is subjected to a magnetic field, which induces a flow of gas proportional to the $O_2$ concentration present in the sample. This flow is measured and converted into a voltage signal that is an input to the data system.

### URS Data Acquisition

The data acquisition system (DAS) consists of utilizing the STRATA™ a Windows based data acquisition system, to collect data in the field. The DAS scans the instrument output and logs digitized voltages. A URS computer program translates the digitized voltages into relevant concentrations in engineering units (ppmV, %V, etc.). The computer program has several modes of operations, which include calibration and data acquisition. The data was then reduced and formatted using URS internal spreadsheets.

## 5.0 QA/QC PROCEDURES

All tests incorporated the appropriate QA/QC procedures specified in EPA Reference Methods 3A and 6C to URS standard operating procedures.

URS performed all drift checks through the entire sampling system. A tee fitting at the reference method CEM probe/ heated line interface allowed standard gases to be directed from the gas cylinder through the entire sample system (probe, heat traced line pumps, and conditioners) upstream of the analyzers. A line bias check was performed at the beginning of each test day. The calibration gas was first sent directly to the appropriate analyzer and the response was recorded. The same gas was then sent to the analyzer via the sample line (i.e., through the heat traced line, to the CEM probe and back to the analyzer) and this response was compared to the direct response. The line bias requirements are 5% of span for all analyzers. All line bias checks were within specifications. Leak checks were incorporated in each calibration. The criterion used for this test was an $O_2$ response to a zero gas of less than 0.5% $O_2$.