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A CRH COMPANY

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March 16, 2020

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From: Ash Grove Cement Company

RE: **Regional Haze 2<sup>nd</sup> Implementation Period – Four-Factor Analysis**

Attached is the submission of Ash Grove Cement “four-factor analysis under the regional haze program” as requested by UTDEQ October 21, 2019 letter.

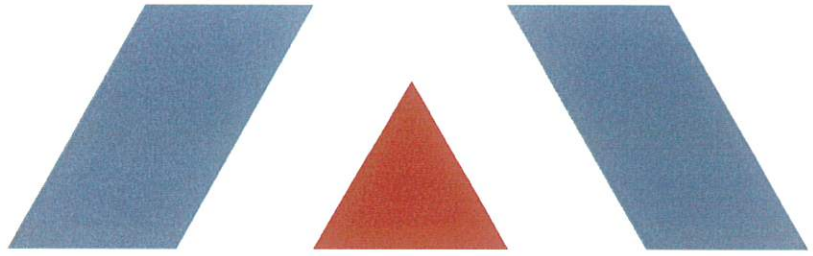
Any questions, please contact me at 435-857-1200 or  
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3/16/2020

Date

CC: Jay Baker  
Mark Atkins



**REGIONAL HAZE 2<sup>ND</sup> IMPLEMENTATION PERIOD  
FOUR-FACTOR ANALYSIS**  
**Ash Grove Cement > Leamington, UT**

**Leamington Four-Factor Analysis**

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## 1. EXECUTIVE SUMMARY

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This report documents the results of a four-factor analysis of a portland cement kiln and two (2) emergency generators at Ash Grove Cement Company's (AGC's) Leamington facility. This report is provided in response to the Utah Department of Air Quality (UDAQ) request letter dated October 21, 2019.

The Leamington facility was not identified as an eligible facility for the best available retrofit technology (BART) program during the first round of regional haze as it was built after August 7, 1977. UDAQ has identified the Leamington facility as an eligible source for the regional haze program reasonable progress analysis based on a screening process that takes into account both the quantity of emissions from the facility and the proximity to the Class I areas protected by the regional haze program.

The United States Environmental Protection Agency's (U.S. EPA) guidelines in 40 CFR Part 51.308 were used to evaluate control options for the emission source equipment. In establishing a reasonable progress goal for any mandatory Class I Federal area within the State, the State must consider the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected sources, and include a demonstration showing how these factors were taken into consideration in selecting the goal.

The purpose of this report is to provide information to UDAQ on available control technologies for NO<sub>x</sub> and SO<sub>2</sub> emissions reductions and its applicability to the Leamington facility. Since control options are only relevant for the Regional Haze Rule (RHR) if they result in a reduction in the existing visibility impairment in a Class I area, AGC assumes that UDAQ will only move forward with requiring emission reductions from the Leamington facility if the emission reductions can be demonstrated to be needed to show reasonable progress and provide the most cost effective controls among all options available to UDAQ.

Based on the following analysis, AGC believes that BART level controls are already in place for the Kiln system as follows:

SO<sub>2</sub> – AGC currently uses inherently low sulfur raw materials, thus there is very little sulfur available to create SO<sub>2</sub> in the raw mill. Further, a preheater/precalciner type kiln system is used such that the majority of any fuel bound sulfur is adsorbed by the clinker and becomes part of the cement product. The result is an actual emission rate in the range of 0.02 lb/ton clinker (2019 actual emission level). The current emission rate limit is 0.4 lb/ton which is considered BACT. Add on SO<sub>2</sub> controls would have no impact at the low existing concentrations, and fuel sulfur reductions would have no recognizable impact on emissions. Consequently, the current system of inherently low sulfur raw materials and natural scrubbing are considered BART for the facility.

NO<sub>x</sub> – AGC uses a Low NO<sub>x</sub> Burner (LNB) and Selective Non-Catalytic Reduction (SNCR) to reduce and control NO<sub>x</sub> emissions. These are commonly applied methods/technologies in current Best Available Control Technology (BACT) determinations for new preheater/precalciner kilns. The only other potential NO<sub>x</sub> emission control evaluated for this kiln is Selective Catalytic Reduction (SCR). There is one instance of SCR installation on a cement kiln in the U.S. for NO<sub>x</sub> control. This installation was recently implemented on a long dry cement kiln at the Joppa Cement Plant, which is significantly different from the preheater/precalciner kiln system at the Leamington facility, and was installed as a result of a consent decree. AGC believes that the currently installed control systems provide reliable reductions in NO<sub>x</sub> emissions and an SCR installation is currently not commercially available on this type of kiln system and is cost-prohibitive. Per an Approval Order dated February 3, 2016, the DEQ indicated that SNCR control at AGC would result in an estimated decrease in NO<sub>x</sub> of up to 817.89 tons per year and that the kiln stack would

be limited to 2.8 lb NO<sub>x</sub>/ton clinker on a 30-day rolling average basis. These emission levels and controls are consistent with current BACT analyses for existing preheater/precalciner type kiln systems. Consequently, the current system of LNB and SNCR is considered BART for the facility.



## 2. INTRODUCTION AND BACKGROUND

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In the 1977 amendments to the Clean Air Act (CAA), Congress set a national goal to restore national parks and wilderness areas to natural conditions by preventing any future, and remedying any existing, man-made visibility impairment. On July 1, 1999, the U.S. EPA published the final Regional Haze Rule (RHR). The objective of the RHR is to restore visibility to natural conditions in 156 specific areas across with United States, known as Class I areas. The Clean Air Act defines Class I areas as certain national parks (over 6000 acres), wilderness areas (over 5000 acres), national memorial parks (over 5000 acres), and international parks that were in existence on August 7, 1977.

The RHR requires States to set goals that provide for reasonable progress towards achieving natural visibility conditions for each Class I area in their state. In establishing a reasonable progress goal for a Class I area, the state must:

- (A) Consider the costs of compliance, the time necessary for compliance, the energy and non-air quality environmental impacts of compliance, and the remaining useful life of any potentially affected sources, and include a demonstration showing how these factors were taken into consideration in selecting the goal. 40 CFR 51. 308(d)(1)(i)(A).*
  
- (B) Analyze and determine the rate of progress needed to attain natural visibility conditions by the year 2064. To calculate this rate of progress, the State must compare baseline visibility conditions to natural visibility conditions in the mandatory Federal Class I area and determine the uniform rate of visibility improvement (measured in deciviews) that would need to be maintained during each implementation period in order to attain natural visibility conditions by 2064. In establishing the reasonable progress goal, the State must consider the uniform rate of improvement in visibility and the emission reduction. 40 CFR 51. 308(d)(1)(i)(B).*

In October 2019, UDAQ sent a letter notifying AGC that they had been selected to conduct “a four-factor analysis under the regional haze program” for the Leamington facility. AGC understands that the information provided in a four-factor review of control options will be used by UDAQ in their evaluation of reasonable progress goals for Utah. Since emission reductions are only relevant if they result in a reduction in the existing visibility impairment, ultimately helping the State show progress towards its goals, AGC assumes that UDAQ will only move forward with requiring emission reductions if the emission reductions can be demonstrated to be needed to show further reasonable progress towards the goals established based on the uniform rate of visibility improvement that is required to be demonstrated.

Therefore, the purpose of this report is to provide information to the UDAQ on available control technologies for SO<sub>2</sub> and NO<sub>x</sub> emissions reductions and its applicability to the Leamington facility.

The information presented in this report considers the following four factors for the emission reductions:

- Factor 1. Costs of compliance
- Factor 2. Time necessary for compliance
- Factor 3. Energy and non-air quality environmental impacts of compliance
- Factor 4. Remaining useful life of the kilns

The approach contained in this four factor report was to first identify all technically feasible measures by conducting a step-wise review of emission reduction options in a top-down fashion like the top-down approach

that is included in the U.S. EPA RHR guidelines<sup>1</sup> for conducting a review of Best Available Retrofit Technology (BART) for a unit. These steps are as follows:

- Step 1. Identify all available retrofit control technologies
- Step 2. Eliminate technically infeasible control technologies
- Step 3. Evaluate the control effectiveness of remaining control technologies
- Step 4. Evaluate impacts and document the results

Factor 4 is also addressed in the stepwise review of the emission reduction options, primarily in the context of the costing of emission reduction options, if any, and whether any capitalization of expenses would be impacted by limited equipment life. Once the stepwise review of reduction options was completed, a review of the timing of the emission reductions is provided to satisfy Factor 2 of the four factors.

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<sup>1</sup> The BART provisions were published as amendments to the EPA's RHR in 40 CFR Part 51, Section 308 on July 5, 2005.



### 3. SOURCE DESCRIPTION

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The AGC Leamington facility is located in Juab County, Utah, approximately 6 miles northeast of Leamington. The nearest Class I area to the facility is the Capitol Reef National Park. It is approximately 84 miles southeast of the Leamington facility.

The facility operates one preheater/precalciner type cement kiln. The majority of the kiln exhaust gas is directed through a raw mill for preheating before being vented through a baghouse prior to the main stack. A small fraction of the kiln gas is also directed to the coal mill for pre-heating the fuel prior to being directed to the coal mill baghouse/stack.

The Kiln System is currently permitted to use the following fuels:

- A. Coal
- B. Diaper Derived Fuel (DDF)
- C. Tire Derived Fuel (TDF) – not to exceed 15% of energy input
- D. Natural Gas
- E. Coke
- F. Fuel Oil
- G. Used Oil Fuel
- H. Synthetic Fuel
- I. Wood
- J. Cherry Pits
- K. Tire Poly Cord Fuel
- L. Plastic Resin Waste
- M. Coal Additives consisting of alternative fuels approved by the Director – not to exceed 15% of energy input

## 4. EXISTING EMISSIONS

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This section summarizes emission rates from calendar year 2019 that are used as baseline rates in the four factor analyses presented in Sections 5, 6, and 7 of this report.

Baseline annual emissions for SO<sub>2</sub> are calculated based on stack test data and annual production levels. Baseline emissions of NO<sub>x</sub> are based on CEMS data. These same baseline rates are provided to UDAQ for use in the on-the-books/on-the-way basis for modeling because no changes to kiln operation are expected between now and 2028. The baseline annual emission rates are summarized in Table 4-1.

**Table 4-1. Annual Baseline Emission Rates**

<b>Pollutant</b>	<b>Kiln</b>
NO <sub>x</sub>	1198
SO <sub>2</sub>	8.0

## 5. SO<sub>2</sub> FOUR FACTOR EVALUATION

The four-factor analysis is satisfied by conducting a stepwise review of emission reduction options in a top-down fashion. The steps are as follows:

- Step 1. Identify all available retrofit control technologies
- Step 2. Eliminate technically infeasible control technologies
- Step 3. Evaluate the control effectiveness of remaining control technologies
- Step 4. Evaluate impacts and document the results

Cost (Factor 1) and energy / non-air quality impacts (Factor 3) are key factors determined in Step 4 of the stepwise review. However, timing for compliance (Factor 2) and remaining useful life (Factor 4) are also discussed in Step 4 to fully address all four factors as part of the discussion of impacts. Factor 4 is primarily addressed in the context of the costing of emission reduction options and whether any capitalization of expenses would be impacted by a limited equipment life.

The baseline SO<sub>2</sub> emission rates that are used in the SO<sub>2</sub> four-factor analysis are summarized in Table 4-1. The basis of the emission rates is provided in Section 4 of this report. The kiln system and two (2) emergency generators are the sources at the Leamington facility which emit SO<sub>2</sub>. However, as emissions from the generators contribute less than 0.01 tons of SO<sub>2</sub>, they will not be analyzed.

### 5.1. STEP 1: IDENTIFICATION OF AVAILABLE RETROFIT SO<sub>2</sub> CONTROL TECHNOLOGIES

Sulfur, in the form of metallic sulfides (pyrite), sulfate, or organosulfur compounds, is often found in the raw materials used to manufacture cement and in the solid and liquid fuels burned in cement kilns. The raw materials and fuels for the Leamington plant are no exception. Sulfur dioxide can be generated by the oxidation of sulfur compounds in the raw materials and fuels during operation of the pyroprocess. Constituents found in fuels, raw materials, and in-process materials, such as the alkali metals (sodium and potassium), calcium carbonate, and calcium oxide often react with SO<sub>2</sub> within the pyroprocess to limit emissions of SO<sub>2</sub> as much of the sulfur leaves the process in the principle product of the kiln system called clinker.

Step 1 of the top-down control review is to identify available retrofit control options for SO<sub>2</sub>. The available SO<sub>2</sub> retrofit control technologies for the Leamington kiln are as follows:

- Fuel Substitution
- Semi-Dry scrubbing – Add on control
- Wet Scrubbing – Add on control

The retrofit controls include both add-on controls that reduce SO<sub>2</sub> after it is formed and switching to lower sulfur fuels which reduce the opportunity for formation of SO<sub>2</sub>.

#### 5.1.1. Fuel Substitution

The concept of fuel substitution in a combustion system is that if the fuel sulfur is reduced, the amount of sulfur available for oxidation into SO<sub>2</sub> is reduced, and thus there should then be a direct relationship between the reduction of sulfur and the reduction of SO<sub>2</sub> emissions.

And, although for a typical industrial type boiler that is correct, the process is not that simple in a modern preheater/precalciner type portland cement kiln. In a portland cement kiln, fuel bound sulfur is released from the fuel during combustion and forms SO<sub>2</sub>. However, combustion is occurring at the hot ends of the system where there are also very high concentrations of CaO (lime, which is the material used in lime scrubbing) and other volatilized alkalis. The combination of high levels of CaO and high temperatures results in the majority of any SO<sub>2</sub> immediately reacting to form calcium and alkali sulphates which bind to the clinker and ultimately become part of the cement product. Consequently, variations in the fuel sulfur content have very little impact on SO<sub>2</sub> emission levels from the kiln stack (which are instead typically dominated by SO<sub>2</sub> driven off from the raw materials in the raw mill, prior to the formation of CaO in the system)<sup>2</sup>.

Regardless, AGC already has restrictions on fuel sulfur content, and does not anticipate that further restrictions would have any impact on SO<sub>2</sub> emission levels from the main stack. Currently, AGC is limited to a sulfur content of fuel burned to no greater than 1.0 lbs sulfur/MMBtu for any mixture of coal and 0.85 pounds sulfur per million gross Btu heat input for any oil except used oil or 0.5 percent by weight for any used oil.

### 5.1.2. Wet Scrubbing

A wet scrubber is a tailpipe technology that may be installed downstream of the kiln and raw mill. In a typical wet scrubber, the flue gas flows upward through a reactor vessel that has an alkaline reagent flowing down from the top. The scrubber mixes the flue gas and alkaline reagent using a series of spray nozzles to distribute the reagent across the scrubber vessel. The alkaline reagent, often a calcium compound, reacts with the SO<sub>2</sub> in the flue gas to form calcium sulfite and/or calcium sulfate that is removed with the scrubber sludge and disposed. Most wet scrubber systems used forced oxidation to assure that only calcium sulfate sludge is produced.

### 5.1.3. Semi-Wet/Dry Scrubbing

This technology is considered a semi-wet or semi-dry control technology. A scrubber tower is installed prior to the baghouse. Atomized hydrated lime slurry is sprayed into the exhaust flue gas. The lime absorbs the SO<sub>2</sub> in the exhaust and is converted to a powdered calcium/sulfur compound. The particulate control device removes the solid reaction products from the gas stream.

## 5.2. STEP 2: ELIMINATE TECHNICALLY INFEASIBLE SO<sub>2</sub> CONTROL TECHNOLOGIES

Step 2 of the top-down control review is to eliminate technically infeasible SO<sub>2</sub> control technologies that were identified in Step 1.

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<sup>2</sup> Moses P.M. Chinyama (August 9th 2011). Alternative Fuels in Cement Manufacturing, Alternative Fuel, Maximino Manzanera, IntechOpen, DOI: 10.5772/22319. Available from: <https://www.intechopen.com/books/alternative-fuel/alternative-fuels-in-cement-manufacturing>, Section 2.4.



### 5.2.1. Fuel Substitution

Although fuel substitution is a feasible technology for older wet-type kilns or long-dry kilns, it is widely accepted that the design of a preheater/precalciner kiln system is such that nearly 100% of the sulfur contained in the fuel is absorbed in the clinker product and is not available to be converted to SO<sub>2</sub>. Therefore, reducing the sulfur in the fuel input to the kiln is not expected to result in any appreciable reduction in SO<sub>2</sub> emissions from the kiln. As AGC anticipates that lowering the input of sulfur through fuel substitution would not have any impact on reducing SO<sub>2</sub> emissions, it is not considered an effective SO<sub>2</sub> control technology for this kiln system and will not be considered further.

### 5.2.2. Wet Scrubbing

A wet scrubbing system utilizes a ground alkaline agent, such as lime or limestone in slurry to remove SO<sub>2</sub> from the stack gas. The spent slurry is dewatered using settling basins and filtration equipment. Recovered water is typically reused to blend new slurry for the wet scrubber. A significant amount of makeup water is required to produce enough slurry to maintain the scrubber's design removal efficiency. Water losses from the system occur from evaporation into the stack gas, evaporation from settling basins, and retained moisture in scrubber sludge.

Wet scrubbing systems are commonly used to reduce SO<sub>2</sub> concentrations from gas streams in the 500 ppm to 1000 ppm range or higher down to the 50 ppm to 100 ppm range. Ash Grove's kiln system has SO<sub>2</sub> concentrations in the 1 to 2.5 ppm range. For example, the most recent test of the kiln system stack, June 20, 2019, had an average SO<sub>2</sub> concentration of 0.9 ppm. As AGC's kiln exhaust concentrations are extremely low, wet scrubbing would have no impact on SO<sub>2</sub> emission levels. Consequently, this technology is not considered technically feasible and will not be considered further.

### 5.2.3. Semi-Dry Scrubbing

Semi-Dry scrubbing is similar to wet scrubbing and commonly used to reduce SO<sub>2</sub> concentrations from gas streams in the 500 ppm to 1000 ppm range or higher down to the 50 ppm to 100 ppm range. As AGC's kiln system has SO<sub>2</sub> concentrations in the 1 to 2.5 ppm range, semi-dry scrubbing would have no impact on SO<sub>2</sub> levels. Consequently, this technology is not considered technically feasible and will not be considered further.

## 5.3. STEP 3: RANK OF TECHNICALLY FEASIBLE SO<sub>2</sub> CONTROL OPTIONS BY EFFECTIVENESS

Step 3 of the top-down control review is to rank the technically feasible options by effectiveness. As no technologies are available to reduce the SO<sub>2</sub> concentrations below what are already extremely low levels, no further technologies will be evaluated.

## 5.4. STEP 4: EVALUATION OF IMPACTS FOR FEASIBLE SO<sub>2</sub> CONTROLS

Step 4 of the top-down control review is the impact analysis. Ash Grove's actual emission rate of SO<sub>2</sub> in 2019 was 8.0 tons or approximately 0.02 lbs/ton clinker. As this emission rate is well below the NSPS for new sources, and no technologies are available to reduce it further, the current process of using inherently low sulfur raw materials and natural scrubbing is considered BART for the kiln system.

## 6. NO<sub>x</sub> FOUR FACTOR ANALYSIS

The four-factor analysis is satisfied by conducting a stepwise review of emission reduction options in a top-down fashion. The steps are as follows:

- Step 1. Identify all available retrofit control technologies
- Step 2. Eliminate technically infeasible control technologies
- Step 3. Evaluate the control effectiveness of remaining control technologies
- Step 4. Evaluate impacts and document the results

Cost (Factor 1) and energy / non-air quality impacts (Factor 3) are key factors determined in Step 4 of the stepwise review. However, timing for compliance (Factor 2) and remaining useful life (Factor 4) are also discussed in Step 4 to fully address all four factors as part of the discussion of impacts. Factor 4 is primarily addressed in the context of the costing of emission reduction options and whether any capitalization of expenses would be impacted by a limited equipment life.

The baseline NO<sub>x</sub> emission rates that are used in the NO<sub>x</sub> four-factor analysis are summarized in Table 4-1. The basis of the emission rates is provided in Section 4 of this report. The kiln system and two (2) emergency generators are the sources at the Leamington facility which emits NO<sub>x</sub>. However, emissions from the generators contribute only 0.2 tons of total NO<sub>x</sub> and will not be analyzed.

### 6.1. STEP 1: IDENTIFICATION OF AVAILABLE RETROFIT NO<sub>x</sub> CONTROL TECHNOLOGIES

NO<sub>x</sub> emissions are produced during fuel combustion when nitrogen contained in the fuel and combustion air is exposed to high temperatures. The origin of the nitrogen (i.e. fuel vs. combustion air) has led to the use of the terms “thermal” NO<sub>x</sub> and “fuel” NO<sub>x</sub> when describing NO<sub>x</sub> emissions from the combustion of fuel. Thermal NO<sub>x</sub> emissions are produced when elemental nitrogen in the combustion air is admitted to a high temperature zone and oxidized. A small portion of NO<sub>x</sub> is formed from nitrogen in the fuel that is liberated and reacts with the oxygen in the combustion air.

Step 1 of the top-down control review is to identify available retrofit control options for NO<sub>x</sub>. The available NO<sub>x</sub> retrofit control technologies for the AGC kiln (preheater/precalciner) and raw mill are summarized in Table 6-1.

**Table 6-1. Available NO<sub>x</sub> Control Technologies for the Kiln System**

NO <sub>x</sub> Control Technologies	
Combustion Controls	Low-NO <sub>x</sub> Burners (LNB)
Post-Combustion Controls	Selective Catalytic Reduction (SCR) Selective Non-Catalytic Reduction (SNCR) (Already Installed)

NO<sub>x</sub> emissions controls, as listed in Table 6-1, can be categorized as combustion or post-combustion controls. Combustion controls reduce the peak flame temperature and excess air in the kiln burner, which minimizes NO<sub>x</sub> formation. Post-combustion controls, such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) convert NO<sub>x</sub> in the flue gas to molecular nitrogen and water.



The kiln system currently utilizes a LNB and SNCR system.

### 6.1.1. Combustion Controls

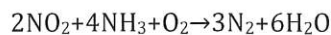
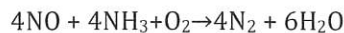
#### 6.1.1.1. Low-NO<sub>x</sub> Burners (LNBs)

LNBs reduce the amount of NO<sub>x</sub> initially formed in the flame. The principle of all LNBs is the same: stepwise or staged combustion and localized exhaust gas recirculation (i.e., at the flame). LNBs are designed to reduce flame turbulence, delay fuel/air mixing, and establish fuel-rich zones for initial combustion. The longer, less intense flames reduce thermal NO<sub>x</sub> formation by lowering flame temperatures. Control of air turbulence and speed is often controlled via mixing air fans. Some of the burner designs produce a low-pressure zone at the burner center by injecting fuel at high velocities along the burner edges. Such a low-pressure zone tends to recirculate hot combustion gas which is retrieved through an internal reverse flow zone around the extension of the burner centerline. The recirculated combustion gas is deficient in oxygen, thus producing the effect of flue gas recirculation. Reducing the oxygen content of the primary air creates a fuel-rich combustion zone that then generates a reducing atmosphere for combustion. Due to fuel-rich conditions and lack of available oxygen, formation of thermal NO<sub>x</sub> and fuel NO<sub>x</sub> are minimized<sup>3</sup>. The Leamington facility has already installed a LNB on the kiln and has demonstrated compliance with a federally enforceable NO<sub>x</sub> emission rate of 2.8 lbs/ton clinker (30 day rolling average).<sup>4</sup>

### 6.1.2. Post Combustion Controls

#### 6.1.2.1. Selective Catalytic Reduction (SCR)

SCR is an exhaust gas treatment process in which ammonia (NH<sub>3</sub>) is injected into the exhaust gas upstream of a catalyst bed. On the catalyst surface, NH<sub>3</sub> and nitric oxide (NO) or nitrogen dioxide (NO<sub>2</sub>) react to form diatomic nitrogen and water. The overall chemical reactions can be expressed as follows:



When operated within the optimum temperature range of 500°F to 800°F, the reaction can result in removal efficiencies between 70 and 90 percent.<sup>5</sup> The rate of NO<sub>x</sub> removal increases with temperature up to a maximum removal rate at a temperature between 700°F and 750°F. As the temperature increases above the optimum temperature, the NO<sub>x</sub> removal efficiency begins to decrease. SCR use in the cement industry is incredibly limited, with only a handful of uses in Europe and one instance, i.e. the Joppa Cement Plant operated by LaFargeHolcim in the United States.

#### 6.1.2.2. Selective Non-Catalytic Reduction (SNCR)

In SNCR systems, a reagent is injected into the flue gas within an appropriate temperature window. The NO<sub>x</sub> and reagent (ammonia or urea) react to form nitrogen and water. A typical SNCR system consists of reagent

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<sup>3</sup> USEPA, Office of Air Quality Planning and Standards. Alternative Control Technologies Document – NO<sub>x</sub> Emissions from Cement Manufacturing. EPA-453/R-94-004, Page 5-5 to 5-8.

<sup>4</sup> Per UDAQ Class I Permit #2300015004

<sup>5</sup> Air Pollution Control Cost Manual, Section 4, Chapter 2, Selective Catalytic Reduction, NO<sub>x</sub> Controls, EPA/452/B-02-001, Page 2-9 and 2-10.

storage, multi-level reagent-injection equipment, and associated control instrumentation. The SNCR reagent storage and handling systems are similar to those for SCR systems.

Like SCR, SNCR uses ammonia or a solution of urea to reduce NO<sub>x</sub> through a similar chemical reaction.



SNCR requires a higher temperature range than SCR of between 1,600°F and 1,900°F due to the lack of a catalyst to lower the activation energies of the reactions.

The Leamington facility has already installed a SNCR system on the kiln and has demonstrated compliance with a federally enforceable NO<sub>x</sub> emission rate of 2.8 lbs/ton clinker (30 day rolling average).<sup>6</sup>

## 6.2. STEP 2: ELIMINATE TECHNICALLY INFEASIBLE NO<sub>x</sub> CONTROL TECHNOLOGIES

Step 2 of the top-down control review is to eliminate technically infeasible NO<sub>x</sub> control measures that are identified as available reduction options in Step 1. Since a LNB and SNCR have already been installed on the kiln, only the SCR will be evaluated for technical feasibility in this section.

### 6.2.1. Post Combustion Controls

#### 6.2.1.1. Selective Catalytic Reduction (SCR)

Efficient operation of the SCR process requires constant exhaust temperatures (usually ± 200°F).<sup>7</sup> Fluctuation in exhaust gas temperatures reduces removal efficiency. If the temperature is too low, ammonia slip occurs. Ammonia slip is caused by low reaction rates and results in both higher NO<sub>x</sub> emissions and appreciable ammonia emissions. If the temperature is too high, oxidation of the NH<sub>3</sub> to NO can occur. Also, at higher removal efficiencies (beyond 80 percent), an excess of NH<sub>3</sub> is necessary, thereby resulting in some ammonia slip. Other emissions possibly affected by SCR include increased PM emissions (from ammonia salts in a detached plume) and increased SO<sub>3</sub> emissions (from oxidation of SO<sub>2</sub> on the catalyst). These ammonia, PM, and ammonia salt emissions contribute negatively to visibility impairment in the region—an effect that is directly counter to the goals of the program.

To reduce fouling the catalyst bed with the PM in the exhaust stream, an SCR unit can be located downstream of the particulate matter control device (PMCD). However, due to the low exhaust gas temperature exiting the PMCD (approximately 350 °F); a heat exchanger system would be required to reheat the exhaust stream to the desired reaction temperature range of between 480 °F to 800 °F. The source of heat for the heat exchanger would be the combustion of fuel, with combustion products that would enter the process gas stream and generate additional NO<sub>x</sub>.<sup>8</sup> Therefore, in addition to storage and handling equipment for the ammonia, the required equipment for the SCR system will include a catalytic reactor, heat

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<sup>6</sup> Per UDAQ Class I Permit #2300015004

<sup>7</sup> USEPA, Office of Air Quality Planning and Standards. Alternative Control Technologies Document – NO<sub>x</sub> Emissions from Cement Manufacturing. EPA-453/R-94-004, Page 2-11

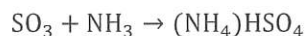
<sup>8</sup> The fuel would likely be natural gas supplied at the facility through a pipeline while coal will be excluded, as it would require an additional dust collector.

exchanger and potentially additional NO<sub>x</sub> control equipment for the emissions associated with the heat exchanger fuel combustion.

High dust and clean-side SCR technologies are still highly experimental. A high dust SCR would be installed prior to the dust collectors, where the kiln exhaust temperature is closer to the optimal operating range for an SCR. It requires a larger volume of catalyst than a tail pipe unit, and a mechanism for periodic cleaning of catalyst. A high dust SCR also uses more energy than a tail pipe system due to catalyst cleaning and pressure losses.

A clean-side system is similar to a high dust system. However, the SCR is placed downstream of the baghouse.

Only one cement kiln in the U. S. is using SCR, and the details of its installation and use remain confidential. While several cement kilns in Europe have installed SCR, the cement industries between Europe and the U.S. differ significantly due to the increased sulfur content found in the processed raw materials in U.S. cement kiln operations. The pyritic sulfur found in raw materials used by U.S. cement plants have high SO<sub>3</sub> concentrations that result in high-dust levels and rapid catalyst deactivation. In the presence of calcium oxide and ammonia, SO<sub>3</sub> forms calcium sulfate and ammonium bisulfate via the following reactions:



Calcium sulfate can deactivate the catalyst, while ammonium bisulfate can plug the catalyst. Catalyst poisoning can also occur through the exposure to sodium, potassium, arsenic trioxide, and calcium sulfate.<sup>9</sup> This effect directly and negatively impacts SCR effectiveness for NO<sub>x</sub> reduction.

Dust buildup on the catalyst is influenced by site-specific raw material characteristics present in the facility's quarry, such as trace contaminants that may produce a stickier particulate than is experienced at sites where the technology is being demonstrated. This buildup is typical of cement kilns, resulting in reduced effectiveness, catalyst cleaning challenges, and increased kiln downtime at significant cost.<sup>10</sup> In the EPA's guidance for regional haze analysis, the term "available," one of two key qualifiers for technical feasibility in a BART analysis, is clarified with the following statement:

*Consequently, you would not consider technologies in the pilot scale testing stages of development as "available" for the purposes of BART review.*

The EPA has also acknowledged, in response to comments made by the Portland Cement Association's (PCA) comments on the latest edition of the Control Cost Manual, that:

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<sup>9</sup> Air Pollution Control Cost Manual, Section 4, Chapter 2, Selective Catalytic Reduction, NO<sub>x</sub> Controls, EPA/452/B-02-001, Page 2-6 and 2-7.

<sup>10</sup> Preamble to NSPS subpart F, 75 FR 54970.

*For some industrial applications, such as cement kilns where flue gas composition varies with the raw materials used, a slip stream pilot study can be conducted to determine whether trace elements and dust characteristics of the flue gas are compatible with the selected catalyst.*

Based on these conclusions, SCR is not widely available for use with cement kilns, in large part because the site-specificity limits the commercial availability of systems. For this reason, high-dust and clean-side SCR's are not considered technically feasible for this facility at this time.

### **6.3. STEP 3: RANK OF TECHNICALLY FEASIBLE NO<sub>x</sub> CONTROL OPTIONS BY EFFECTIVENESS**

Step 3 of the top-down control review is to rank the technically feasible options in order of effectiveness. All technically feasible control options, LNB and SNCR, have already been installed by the Leamington facility.

### **6.4. STEP 4: EVALUATION OF IMPACTS FOR FEASIBLE NO<sub>x</sub> CONTROLS**

Step 4 of the top-down control review is the impact analysis. While the impact analysis considers the cost of compliance, energy impacts, non-air quality impacts, and the remaining useful life of the source, AGC has already installed the control strategies with the greatest level of control: LNB and SNCR.

Therefore, AGC believes that reasonable progress compliant controls are already in place. AGC's actual NO<sub>x</sub> emission level of 1198 tpy is adequate and the Leamington facility does not propose any change to their current limit of 2.8 lbs/ton clinker on a 30-day rolling average basis.

## 7. CONCLUSION

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This report outlines AGC's evaluation of possible options for reducing the emissions of NO<sub>x</sub> and SO<sub>2</sub> at its Leamington facility. There are currently no technically feasible and cost-effective reduction options available for the Leamington facility beyond current best practices and controls.