REGIONAL HAZE 2ND IMPLEMENTATION PERIOD FOUR-FACTOR ANALYSIS

Ash Grove Cement > Montana City, MT

Montana City Four-Factor Analysis

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1. EXECUTIVE SUMMARY

This report documents the results of a four-factor analysis of the cement kiln at Ash Grove Cement Company's (AGC's) Montana City facility. In 2007, AGC submitted a BART Five-Factor analysis for the kiln and clinker cooler, and in 2011, AGC submitted a response to a request for additional information regarding the Montana City BART determination.

In April 2019, AGC received a letter from the Montana Department of Environmental Quality (MDEQ) requesting assistance in developing information for a reasonable further progress analysis.

This report addresses any changes made, or updates to the conclusions from, the 2007 and 2011 submittals which are included in Appendices A and B. Using guidelines from EPA for completing the four-step analysis, AGC has determined BART for SO_2 and NO_x by:

1. Identifying all available retrofit control technologies;
2. Eliminating technically infeasible control technologies;
3. Evaluating the control effectiveness of the remaining control technologies; and
4. Evaluating impacts and document results

Based on the results, AGC believes that reasonable progress compliant controls are already in place as follows:

Long Wet Kiln System (Kiln):

- SO_2 – AGC installed a semi-dry scrubber in 2012. Baseline SO_2 emissions reduced from 981 tpy in 2007 to 101 tpy in 2017/2018. Additional SO_2 controls would provide little visibility improvement and require significant expenditures. The facility is limited to 2.0 lb SO_2/ton clinker on a 30-day rolling average basis.
- NO_x – AGC installed a direct-fired low-NOx burner and Selective Non-Catalytic Reduction in September 2014. The baseline emissions have dropped from 1,759 tpy in 2007 to 809 tpy in 2017/2018. The facility is limited to 7.5 lb NOx/ton clinker on a 30-day rolling average basis.

2. INTRODUCTION AND BACKGROUND

Ash Grove's Montana City plant utilizes a long wet kiln system (kiln) that has been in operation since 1963. The kiln currently employs a baghouse for PM_{10} control, good combustion practices/low NO_X burner and SNCR for NO_X control, and semi-dry scrubbing for SO_2 control. PM_{10} emissions from the clinker cooler are also controlled by a baghouse.

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 April 2019, AGC received a letter from the MDEQ requesting assistance in developing information for the reasonable further progress analysis.

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

Factors 1 and 3 of the four factors that are listed above were considered by conducting a step-wise review of emission reduction options in a top-down fashion similar to the top-down approach that is included in the EPA

RHR guidelines[1] 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 step-wise 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 step-wise 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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[1] The BART provisions were published as amendments to the EPA's RHR in 40 CFR Part 51, Section 308 on July 5, 2005.

3. SO_2 BART EVALUATION

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.[2] The raw materials and fuels for the Montana City 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_2 within the pyroprocess to limit emissions of SO_2 as much of the sulfur leaves the process in the principle product of the kiln system called clinker.

As identified in 2007, the kiln is the only BART source at Montana City which emits SO_2; thus an SO_2 BART evaluation was performed only for the kiln.

3.1. HISTORICAL EVALUATIONS

3.1.1. 2007 Five Factor Analysis

In 2007, AGC submitted a Five Factor Analysis that analyzed four possible retrofit technologies:

- Fuel Substitution
- Raw Material Substitution
- Lime Spray Dryer (Semi-Wet or Semi-Dry scrubbing)
- Wet Lime Scrubbing

The 2007 analysis concluded that of these technologies, only Wet Lime Scrubbing and Fuel Substitution were technically feasible (AGC later determined that Wet Lime Scrubbing was not technically feasible and that a semi-dry scrubber was another technically feasible control option). Appendix A contains the 2007 Five Factor Analysis. The visibility analysis performed demonstrated that installation of control for SO_2 resulted in little improvement of visibility due to the low contribution of sulfates compared to nitrates on existing visibility. AGC proposed limiting the kiln to the baseline levels of SO_2 existing at that time (981 tpy) as BART.

3.1.2. 2011 Submittal

In 2011, EPA asked AGC to support the statement that wet scrubbing was not technically feasible and to submit a 5 factor analysis of dry scrubbing techniques. AGC submitted a response to the inquiry on October 5, 2011 (included in Appendix B). AGC stands by the data submitted regarding wet scrubbing and contends that wet scrubbing is still not technically feasible for the reasons described in the 2011 submittal.

3.2. UPDATE TO MONTANA CITY FACILITY AND BASELINE EMISSION RATES

In 2012, AGC installed a semi-dry scrubber, which reduced baseline emissions from a 2010 baseline emission rate of 612 tpy SO_2 (see 2011 submittal in Appendix B for detailed calculations) to a future year 2028 estimate of 121 tpy SO_2. Table 1 shows the baseline SO_2 emission rate evolution since the initial 2007 submittal.

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[2] Miller, F. MacGregor and Hawkins, Garth J., "Formation and Emission of Sulfur Dioxide from the Portland Cement Industry", *Proceedings of the Air and Waste Management Association*, June 18-22, 2000.

Table 3-1. Evolution of SO_2 Baseline Emission Rates

Year	Baseline Annual SO_2 Emissions (tpy)	Change from 2007 Baseline (tpy)	Notes
2007	981	N/A	Existing level of SO_2emissions in 2007, calculated by multiplying average emission rate during 2006 (254 lb/hr) by annual operating hours (7,740).
2011	612	-369	In 2007, the SO_2 CEMS had only been operating a short time and very little was known about the variability of the SO_2 emission rate. Between 2007 and 2011, plant management employed the CEMS to adjust kiln operation such that the SO_2 emission rate decreased considerably. The 2011 baseline SO_2 emission rate was calculated using the average emission rate during 2010 of 147 lb/hr and a 95 percent availability (8322 hours).
2017/2018	101	-880	AGC installed a semi-dry scrubber in 2012 and further worked with kiln operation to lower SO_2 emissions. The 2017/2018 average annual emission rate is provided.
2028 (future estimate)	121	-860	Emissions estimate projected based on 2018 emission rate (0.8 lb/ton clinker) and projected 2028 clinker production (302,000 tons).

3.3. ADDITIONAL ANALYSIS

As described in Section 2, Factors 1 and 3 of the four-factor analysis were considered by conducting a step-wise 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

Factor 4 is also addressed in the step-wise 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 a limited equipment life. This section presents the step-wise review of reduction options for SO_2. Following the step-wise review of the reduction options for SO_2 is a review of the timing of the emission reductions to satisfy Factor 2 of the four factors.

In the original 2007 SO_2 BART Evaluation for the kiln, AGC identified four possible retrofit technologies for evaluation. In the 2007 analysis, Raw Material Substitution was removed from consideration since material substitution would result in negligible SO_2 reduction. Therefore Raw Material Substitution is not considered in this analysis. Please refer to the 2007 SO_2 BART Evaluation in Appendix A for further information.

3.3.1. Step 1. Identification of Available Retrofit SO_2 Reduction Technologies

Sulfur dioxide, SO_2, is generated during fuel combustion in a cement kiln, as the sulfur in the fuel is oxidized by oxygen in the combustion air. Sulfur in the raw material can also contribute to a kiln's SO_2 emissions.

Step 1 of the top-down control review is to identify available retrofit reduction options for SO_2. The available SO_2 retrofit control technologies for the Montana City kiln are summarized in Table 3-2. The retrofit controls include both add-on controls that eliminate SO_2 after it is formed and switching to lower sulfur fuel that reduces the formation of SO_2.

Table 3-2. Available SO_2 Control Technologies for Montana City Kiln

SO_2 Control Technologies
Fuel Substitution
Wet Scrubbing
Semi-Dry Scrubbing

3.3.1.1. Fuel Substitution

Fuels that can be considered for the kiln must have sufficient heat content, be dependable and readily available locally in significant quantities to not disrupt continuous production. In addition, they must not adversely affect product quality. Currently, the fuels that the plant is permitted to use, and that are available in continuous quantities, are coal and coke. The ratios of coal/coke can be optimized to minimize SO_2 emissions. Alternative lower-sulfur fuel that can be considered is natural gas.

3.3.1.2. Wet Scrubbing

A wet scrubber is a tailpipe technology that may be installed downstream of the kiln. 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_2 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.

3.3.1.3. Semi-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_2 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.

3.3.2. Step 2. Eliminate Technically Infeasible SO_2 Control Technologies

Step 2 of the top-down control review is to eliminate technically infeasible SO_2 control technologies that were identified in Step 1.

3.3.2.1. Fuel Substitution

In the 2007 analysis, AGC discussed evaluating the coal/coke blend to determine if revising the blend would result in SO_2 reductions. Between 2007 and 2011, AGC reduced baseline emissions by 369 tpy (see Table 3-1) through blend revision. AGC continues to evaluate fuel blends in an effort to reduce SO_2.

Natural gas can also be considered as a technically feasible replacement for coal/coke as the primary fuel source at this facility, and can be evaluated further. For natural gas to be a technically feasible option, the supply of natural gas must be reliable on a continuous basis. While the Montana City facility uses natural gas for startup, the facility has been curtailed by the natural gas supplier the last two winters. And, the supplier cannot guarantee a continuous (free from curtailment) supply of natural gas in the future. Further, AGC has experienced extended downtime at another facility as a result of being reliant on natural gas. AGC's Seattle facility uses natural gas as their primary fuel. On October 9, 2018, a 36-inch natural gas pipeline ruptured in British Columbia, causing the two main natural gas supply lines to the Seattle area to be shut down. The Seattle facility had to stop production for more than a month while supply was stabilized and routed to more critical infrastructure users, such as electric utilities. Consequently, natural gas is not considered available on a continuous basis, and relying on natural gas to be the sole fuel source for the facility is not feasible.

3.3.2.2. Wet Scrubbing

In the 2011 analysis, AGC evaluated use of a wet scrubber and demonstrated that a wet scrubber was technically infeasible for the Montana City Facility. Please refer to Appendix B and the 2011 discussion. Therefore, Wet Scrubbing is deemed technically infeasible and is removed from consideration.

3.3.2.3. Semi-Dry Scrubbing

AGC already uses this technology, and installed a semi-wet/dry scrubber in 2012. Semi-wet/dry scrubbing is technically feasible and will be considered further.

3.3.3. Step 3. Evaluate Control Effectiveness of Remaining Control Technologies

Step 3 of the top-down control review is to rank the technically feasible options by effectiveness. Table 3-3 presents available and feasible SO_2 control technologies for the kiln and their associated reduction efficiencies.

Table 3-3. Ranking of SO_2 Control Technologies by Effectiveness

Pollutant	Control Technology	Potential Reduction Efficiency (%)
SO_2	Semi-Dry Scrubbing[a]	80 – 90
	Fuel Substitution[b]	30 - 50

[a] Semi-dry Scrubber reduction efficiency was estimated based on the actual reduction from 2011 levels to current levels as shown in Table 3-1.

[b] Fuel substitution reduction efficiency was estimated based on the actual reduction in SO_2 emissions of approximately 40% from 2007 to 2011 as shown in Table 3-1.

3.3.4. Step 4. Evaluate Impacts and Document Results

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 installed semi-dry scrubbing which is the control strategy with the greatest level of control.

Therefore, AGC believes that reasonable progress compliant controls are already in place. As shown in Table 3-1, AGC's SO_2 emissions have been reduced by over 860 tpy from the 2007 baseline, and the 2007 visibility analysis showed that reduction in SO_2 emissions would have little improvement on visibility. As a result, AGC proposes that the existing levels of SO_2 (projected 2028 actuals of 121 tpy SO_2) are adequate and the current controls constitute BART for the kiln. Further, Ash Grove does not propose any change to their current limit of 2.0 lb SO_2/ton clinker on a 30-day rolling average basis.

4. NO_X BART ANALYSIS

In Portland cement kilns, the NO_X that is generated is primarily classified into one of two categories, i.e., thermal NO_X or fuel NO_X[3]. Thermal NO_X occurs as a result of the high-temperature oxidation of molecular nitrogen present in the combustion air. Fuel NO_X is created by the oxidation of nitrogenous compounds present in the fuel. It is also possible for nitrogenous compounds to be present in the raw material feed and become oxidized to form additional NO_X referred to as feed NO_X.

Due to the high flame temperature in the burning zone of the rotary kiln (3400° F), NO_X emissions from the kiln tend to be mainly comprised of thermal NO_X. Although NO_X emissions from cement kilns include both nitrogen oxide (NO) and nitrogen dioxide (NO_2), typically, less than 10% of the total NO_X in the flue gas is NO_2.[4]

As identified in 2007, the kiln is the only BART source which emits NO_x, thus a NO_x BART evaluation was performed only for the kiln.

4.1. HISTORICAL EVALUATION

In 2007, AGC submitted a Five Factor Analysis that analyzed six possible retrofit technologies:

- Low NO_X Burner (LNB)
- Flue Gas Recirculation
- CKD Insufflation
- Mid-Kiln Firing of Tires
- Selective Noncatalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

The 2007 analysis concluded that of these technologies, only LNB and SNCR (either singularly or in combination) were technically feasible. Appendix A contains the 2007 Five Factor Analysis. The visibility analysis performed demonstrated significant improvement with installation of SNCR and LNB. Therefore, AGC proposed that a direct-fired LNB system with SNCR constituted BART. AGC proposed to comply with a BART emission limit of 227.25 lb/hr on a 30-day rolling basis.

4.2. UPDATE TO MONTANA CITY FACILITY AND BASELINE EMISSION RATES

In 2014, AGC installed an SNCR, which along with the direct fire LNB, has reduced baseline emissions to a future year 2028 estimate of 981 tpy NO_X from a 2007 baseline emission rate of 1,759 tpy NO_X. Table 4-1 shows the comparison of the 2007 baseline NO_X emission rate to the current projected 2028 baseline emission rate.

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[3] NO_X Formation and Variability in Portland Cement Kiln Systems, Penta Engineering, December 1998.

[4] IBID.

Table 4-1. Evolution of NO_x Baseline Emission Rates

Year	Baseline Annual NO_x Emissions (tpy)	Change from 2007 Baseline (tpy)	Notes
2007	1759	N/A	Existing level of NO_x emissions in 2007, calculated by multiplying average emission rate during 2006 (454.5 lb/hr) by annual operating hours (7,740).
2018	809	-950	AGC installed an SNCR in 2014, and along with the direct fire LNB, realized greater than a 50% decrease in emissions.
2028 (future estimate)	981	-778	Emissions estimate projected based on 2018 emission rate of 6.5 lb/ton and projected 2028 clinker production of 302,000 tons.

4.3. ADDITIONAL ANALYSIS

As described in Section 2, Factors 1 and 3 of the four-factor analysis were considered by conducting a step-wise 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

Factor 4 is also addressed in the step-wise review of the emission reduction options, primarily in the context of the costing of emission reduction options and whether any capitalization of expenses would be impacted by a limited equipment life. This section presents the step-wise review of reduction options for NO_x. Following the step-wise review of the reduction options for NO_x is a review of the timing of the emission reductions to satisfy Factor 2 of the four factors.

In the original 2007 NO_x BART Evaluation for the kiln, AGC identified six possible retrofit technologies for evaluation. In the 2007 analysis, flue gas recirculation, cement kiln dust insufflation, and mid-kiln firing of solid fuel (tires), were eliminated from consideration due to factors that still exist for the Montana City facility. Therefore, these NOx reduction strategies are not considered further in this analysis. Please refer to the 2007 NOx BART Evaluation in Appendix A for further information.

4.3.1. Step 1. Identification of Available Retrofit NOx Reduction Technologies

Nitrogen oxides, NO_x, 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_X and "fuel" NO_X when describing NO_X emissions from the combustion of fuel. Thermal NO_X emissions are produced when elemental nitrogen in the combustion air is admitted to a high temperature zone and oxidized. Fuel NO_X emissions are created during the rapid oxidation of nitrogen compounds contained in the fuel.

Most of the NO_X formed within a cement kiln is classified as thermal NO_X. Virtually all of the thermal NO_X is formed in the region of the flame at the highest temperatures, approximately 3,000 to 3,600 degrees Fahrenheit. A small portion of NO_X 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 reduction options for NO_X. The remaining available NO_X retrofit control technologies for the Montana City are summarized in Table 4-2 (other control technologies eliminated during the 2007 analysis are not considered).

Table 4-2. Available NO_x Control Technologies for Montana City Kiln

NO_x Control Technologies	
Combustion Controls	Low NO_x Burners (LNB)
Post-Combustion Controls	Selective Catalytic Reduction (SCR) Selective Non-Catalytic Reduction (SNCR)

NO_X emissions controls, as listed in Table 4-2, 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_X formation. Post-combustion controls such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR), convert NO_X in the flue gas to molecular nitrogen and water.

4.3.1.1. Low NOx Burners (LNB)

Low-NO_X Burners (LNBs) reduce the amount of NO_X 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_X formation by lowering flame temperatures. 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_X and fuel NO_X are minimized

4.3.1.2. Selective Catalytic Reduction

Selective catalytic reduction (SCR) is an exhaust gas treatment process in which ammonia (NH_3) is injected into the exhaust gas upstream of a catalyst bed. On the catalyst surface, NH_3 and nitric oxide (NO) or nitrogen dioxide (NO_2) react to form diatomic nitrogen and water. The overall chemical reactions can be expressed as follows:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

When operated within the optimum temperature range of 480˚F to 800˚F, the reaction can result in removal efficiencies between 70 and 90 percent.[5] The rate of NO_X 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_X removal efficiency begins to decrease. The application of SCR is extremely limited in the U.S. cement industry, as only one cement plant has installed SCR for NOx control (in 2015) and the specifics of its installation and use remain confidential.

4.3.1.3. Selective Non-Catalytic Reduction

In SNCR systems, a reagent is injected into the flue gas within an appropriate temperature window. The NO_X and reagent (ammonia or urea) react to form nitrogen and water. A typical SNCR system consists of reagent 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 NOx through a similar chemical reaction.

$$2NO+4NH_3+2O_2 \rightarrow 3N_2+6H_2O$$

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.

4.3.2. Step 2. Eliminate Technically Infeasible NOx Control Technologies

Step 2 of the top-down control review is to eliminate technically infeasible NO_X control technologies that were identified in Step 1.

4.3.2.1. Low NO_X Burners (LNB)

The AGC Montana City facility installed LNB after the 2007 analysis. This technology currently operates at the Montana City facility.

4.3.2.2. Selective Catalytic Reduction

Efficient operation of the SCR process requires constant exhaust temperatures (usually ± 200°F).[6] 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_X emissions and appreciable ammonia emissions. If the temperature is too high, oxidation of the NH_3 to NO can occur. Also, at higher removal efficiencies (beyond 80 percent), an excess of NH_3 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_3 emissions (from oxidation of SO_2 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.

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[5] Air Pollution Control Cost Manual, Section 4, Chapter 2, Selective Catalytic Reduction, NOx Controls, EPA/452/B-02-001, Page 2-9 and 2-10.

[6] USEPA, Office of Air Quality Planning and Standards. Alternative Control Technologies Document – NOx Emissions from Cement Manufacturing. EPA-453/R-94-004, Page 2-11

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_X.[7] Therefore, in addition to storage and handling equipment for the ammonia, the required equipment for the SCR system will include a catalytic reactor, heat exchanger and potentially additional NO_X 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_3 concentrations that result in high-dust levels and rapid catalyst deactivation. In the presence of calcium oxide and ammonia, SO_3 forms calcium sulfate and ammonium bisulfate via the following reactions:

$$\mathrm{SO_3 + CaO \rightarrow CaSO_4}$$

$$\mathrm{SO_3 + NH_3 \rightarrow (NH_4)HSO_4}$$

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.[8] This effect directly and negatively impacts SCR effectiveness for NO_X 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.[9]

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:

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[7] 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.

[8] Air Pollution Control Cost Manual, Section 4, Chapter 2, Selective Catalytic Reduction, NOx Controls, EPA/452/B-02-001, Page 2-6 and 2-7.

[9] Preamble to NSPS subpart F, 75 FR 54970.

> *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:

> *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.

4.3.2.3. Selective Non-Catalytic Reduction

The AGC Montana City facility installed SNCR in 2014. This technology currently operates at the Montana City facility.

4.3.3. Step 3. Evaluate Control Effectiveness of Remaining Control Technologies

Step 3 of the top-down control review is to rank the technically feasible options to effectiveness. Table 4-3 presents available and feasible NO_X control technologies for the kilns and their associated control efficiencies.

Table 4-3. Ranking of NO_x Control Technologies by Effectiveness

Pollutant	Control Technology	Potential Effectiveness
NO_x	SNCR + LNB	6.5 lb/ton[a]

a Current average annual actual emission rate based on 2017/2018 data. The current NOx limit is 7.5 lb/ton.

4.3.4. Step 4. Evaluation of Impacts For Feasible NOx 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 installed the control strategy with the greatest level of control: SNCR + LNB.

Therefore, AGC believes that reasonable progress compliant controls are already in place. As shown in Table 4-1, AGC's NO_x emissions have been reduced by over 778 tpy from the 2007 baseline. As a result, AGC proposes that the existing levels of NO_x (projected 2028 actuals of 981 tpy NO_x) are adequate and the current controls constitute BART for the kiln.

4.4. NO_X CONCLUSION

The AGC Montana City facility currently utilizes Low- NO_X burners and SNCR to control NO_X emissions. , AGC believes that the current technologies of LNB and SNCR represent BART for NOx. Further, Ash Grove does not propose any change to their current limit of 7.5 lb NO_X/ton clinker on a 30-day rolling average basis.

APPENDIX A: 2007 ANALYSIS

BART FIVE FACTOR ANALYSIS ▪ ASH GROVE CEMENT
MONTANA CITY, MONTANA

VERSION 0

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Project 071601.0069

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1. EXECUTIVE SUMMARY

This report documents the determination of the Best Available Retrofit Technology (BART) as proposed by Ash Grove Cement Company (AGC) for the Portland cement manufacturing plant located in Montana City, Montana (Montana City plant). There are two emission units at the Montana City plant for which AGC has made a BART determination: the kiln and the clinker cooler. Currently, particulate matter emissions from the kiln are controlled by an electrostatic precipitator. Particulate matter emissions from the clinker cooler are controlled by a baghouse. The Montana City plant has other lesser emitting BART-eligible emissions units, but the negligible visibility impairment attributable to these sources concludes that no additional controls are necessary to satisfy the requirements of the BART rule.[1]

AGC used the U.S. Environmental Protection Agency's (EPA's) guidelines[2] in 40 CFR Part 51 to determine BART for the kiln and clinker cooler. Specifically, AGC conducted a five-step analysis to determine BART for SO_2, NO_X, and PM_{10} that included the following:

1. Identifying all available retrofit control technologies;
2. Eliminating technically infeasible control technologies;
3. Evaluating the control effectiveness of remaining control technologies;
4. Evaluating impacts and document the results;
5. Evaluating visibility impacts

Based on the five-step analysis, AGC proposes the following as BART:

Kiln:

- PM_{10} – AGC proposes that the existing electrostatic precipitator constitutes BART. This control device is the most effective for controlling PM_{10} from a wet kiln.

- NO_X – AGC proposes to comply with a BART emission limit of 227.25 lb/hr on a 30-day rolling basis by installing and operating a direct-fired low-NOx burner (LNB) and a selective noncatalytic reduction (SNCR) system. Compliance with the emission limit will be demonstrated by continuous emissions monitoring.

- SO_2 – AGC proposes that no additional SO_2 controls are required for BART compliance. Additional SO_2 controls would provide little visibility improvement and require significant expenditures.

Clinker Cooler:

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[1] AGC submitted an inventory of all of the BART-eligible emission sources to the Montana Department of Environmental Quality. EPA Region 8 subsequently evaluated the kiln and clinker cooler to determine the applicability of BART to the Montana City plant. Trinity Consultants conducted two BART applicability visibility modeling analyses for the Montana City plant. One modeling analysis included all of the BART-eligible sources at the plant. The other modeling analysis included the kiln and clinker cooler only. The difference in the modeled visibility impact predicted for the two scenarios was negligible; thus, it was concluded that the contribution of the non-kiln and clinker cooler sources to visibility impairment is negligible, and controlling these sources would not improve any existing visibility impairment.

[2] 40 CFR 51, Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations

- PM_{10} – AGC proposes that the existing baghouse constitutes BART. This control device is the most effective for controlling PM_{10} from a clinker cooler.

The proposed BART control strategies will result in reductions of the visibility impacts attributable to the Montana City plant. A summary of the visibility improvement at the Gates of the Mountains Class I area based on the existing emission rates and proposed BART emission rates is provided in Table 1-1.

TABLE 1-1. VISIBILITY IMPAIRMENT IMPROVEMENT AT GATES OF THE MOUNTAINS WILDERNESS AREA

	98% Impact (Δdv)
Existing	2.874
BART	1.377
Improvement	52.09%

2. INTRODUCTION AND BACKGROUND

On July 1, 1999, the U.S. EPA published the final Regional Haze Rule (RHR). The objective of the RHR is to improve visibility 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.

On July 6, 2005, the EPA published amendments to its 1999 RHR, often called the Best Available Retrofit Technology (BART) rule, which included guidance for making source-specific BART determinations. The BART rule defines BART-eligible sources as sources that meet the following criteria:

(1) Have potential emissions of at least 250 tons per year of a visibility-impairing pollutant,
(2) Began operation between August 7, 1962 and August 7, 1977, and
(3) Are included as one of the 26 listed source categories in the guidance.

A BART-eligible source is subject to BART if the source is "reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area." EPA has determined that a source is reasonably anticipated to contribute to visibility impairment if the 98th percentile visibility impacts from the source are greater than 0.5 delta deciviews (Δdv) when compared against a natural background. Air quality modeling is the tool that is used to determine a source's visibility impacts.

Once it is determined that a source is subject to BART, a BART determination must address air pollution control measures for the source. The visibility regulations define BART as follows:

> *"…an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by…[a BART-eligible source]. The emission limitation must be established on a case-by-case basis, taking into consideration the technology available, the cost of compliance, the energy and non air quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonable be anticipated to result from the use of such technology.*

Specifically, the BART rule states that a BART determination should address the following five statutory factors:

1. Existing controls
2. Cost of controls
3. Energy and non-air quality environmental impacts
4. Remaining useful life of the source
5. Degree of visibility improvement as a result of controls

Further, the BART rule indicates that the five basic steps in a BART analysis can be summarized as follows:

1. Identify all available retrofit control technologies;

2. Eliminate technically infeasible control technologies;
3. Evaluate the control effectiveness of remaining control technologies;
4. Evaluate impacts and document the results;
5. Evaluate visibility impacts

A BART determination should be made for each visibility affecting pollutant (VAP) by following the five steps listed above for each VAP.

BART applicability was determined for the Montana City plant based on a combination of an applicability analysis performed by U.S. EPA Region 8 and a refined applicability analysis performed by AGC. Both analyses determined that the kiln and clinker cooler are subject to BART. The details of the applicability determination can be found in Section 3.

Subsequently, AGC performed an analysis to determine BART for each VAP for the kiln and clinker cooler. The VAPs emitted by the kiln and clinker cooler include NO_x, SO_2, and particulate matter with a mass mean diameter smaller than ten microns (PM_{10}) of various forms (filterable coarse particulate matter [PM_c], filterable fine particle matter [PM_f], elemental carbon [EC], inorganic condensable particulate matter [IOR CPM] as sulfates [SO_4], and organic condensable particulate matter [OR CPM] also referred to as secondary organic aerosols [SOA]). The BART determinations for SO_2, NO_X, and PM_{10} can be found in Sections 4, 5, and 6, respectively.

3. BART APPLICABILITY DETERMINATION

As stated in Section 2, a BART-eligible source is subject-to-BART if the source is “reasonably anticipated to cause or contribute to visibility impairment in any federal mandatory Class I area.” EPA has determined that a source is reasonably anticipated to contribute to visibility impairment if the 98th percentile of the visibility impacts from the source is greater than 0.5 Δdv when compared against a natural background. U.S. EPA Region 8 (EPA) conducted air quality modeling to predict the existing visibility impairment attributable to the Montana City plant in the following Class I areas:

- Gates of the Mountains Wilderness Area
- Scapegoat Wilderness Area
- Anaconda – Pintler Wilderness Area
- Bob Marshall Wilderness Area
- Mission Mountains Wilderness Area
- Selway – Bitterroot Wilderness
- Yellowstone National Park
- Red Rock Lakes Wilderness Area
- Glacier National Park
- North Absaroka Wilderness Area
- Washakie Wilderness Area
- Teton Wilderness Area

Based on this modeling, EPA concluded that the Montana City plant was subject to BART since the 98th percentile of the visibility impacts attributable to the kiln and clinker cooler are greater than 0.5 Δdv when compared against a natural background for one Class I area: Gates of the Mountains Wilderness Area. The results of the applicability modeling are summarized in Table 3-1.

TABLE 3-1. SUMMARY OF U.S. EPA REGION 8 BART APPLICABILITY MODELING RESULTS

Class I Area	Minimum Distance (km)	98th Percentile Visibility Impact for Each Year (Δ dv)			Overall 98th Percentile Visibility Impact (Δ dv)
		2001	2002	2003	
Gates of the Mountains	30	2.17	1.82	2.52	2.17
Scapegoat	80	0.36	0.42	0.26	0.34
Anaconda - Pintler	113	0.09	0.09	0.07	0.08
Bob Marshall	116	0.39	0.30	0.18	0.30
Mission Mountains WA	162	0.05	0.06	0.04	0.05
Selway-Bitterroot Wilderness	173	0.01	0.01	0.01	0.01
Yellowstone NP	175	0.00	0.01	0.01	0.01
Red Rock Lakes	207	0.00	0.00	0.00	0.00
Glacier NP	223	0.10	0.04	0.04	0.05
North Absaroka Wilderness	228	0.00	0.00	0.00	0.00
Washakie Wilderness	276	0.00	0.00	0.00	0.00
Teton Wilderness	289	0.00	0.00	0.00	0.00

AGC verified EPA's results by performing a refined modeling analysis for the Class I area located closest to the Montana City plant: Gates of the Mountains Wilderness Area. The modeling methods used by AGC and EPA Region 8 differed slightly and are summarized in Table 3-2.

TABLE 3-2. SUMMARY OF MODELING METHOD DIFFERENCES BETWEEN EPA AND AGC

Processor/Model	Parameter	Ash Grove (AGC) Modeling Analysis	EPA Region 8 (EPA) Modeling Analysis
CALMET	Surface Stations	AGC included all the 36 surface stations listed in the MDEQ Draft Protocol ("protocol") in the CALMET processing.	EPA included all the 36 surface stations listed in the MDEQ Draft Protocol as well as 3 additional surface stations in the CALMET processing.
CALMET	Precipitation Stations	AGC included 146 precipitation stations in the CALMET processing.	EPA did not include precipitation stations in the CALMET processing.
CALMET	Surface Station for Surface Temperature	AGC used the Helena Regional Airport surface station for the surface temperature, as this is the surface station nearest the Montana City plant (7.6 km).	EPA used the Billings Logan Airport surface station for surface temperature. This station is 272.4 km from the Montana City plant.
CALPUFF	Puff Splitting	AGC included puff splitting, per the protocol.	EPA did not include puff splitting.
CALPUFF	Coordinate System	AGC used Lambert Conformal Coordinates. The following are the reference coordinates: Reference Latitude: 43.1861N Reference Longitude: -116.2657 W Latitude 1: 43 N Latitude 2: 49 N	EPA used Lambert Conformal Coordinates. The following are the reference coordinates: Reference Latitude: 44.29 N Reference Longitude: -109.5 W Latitude 1: 45 N Latitude 2: 49 N False Easting: 600 meters
CALPUFF	Grid Size	AGC used a grid size of 2 km. This smaller grid size was selected due to the distance of the closest Class I area to the Montana City plant (Gates of the Mountains, 30 km).	EPA used a grid size of 6 km.
CALPUFF	Background Ozone	AGC used default background ozone concentrations of 30 parts per billion (ppb) for October through May and 50 ppb for June through September.	EPA used a default background ozone concentration of 80 ppb for the entire year.
CALPOST	Monthly Relative Humidity Adjustment Factor	AGC used the monthly relative humidity adjustment factors based on the representative IMPROVE site location for the Class I area, as shown in the MDEQ protocol.	EPA used the monthly relative humidity adjustment factors based on the centroid of the Class 1 Area.

In addition to different modeling methods, AGC also modeled slightly different NO_X and SO_2 emission rates for the kiln. EPA modeled the Montana City plant based on emissions data that AGC had submitted to MDEQ (and, subsequently, EPA) for the BART applicability analysis. The kiln NO_X and SO_2 emissions data provided in that submittal was from stack testing performed in April of 2006. In May of 2006, a SO_2/NO_X analyzer was installed on the kiln exhaust and AGC has collected additional data on SO_2 and NO_X emissions from the kiln. The data from May 2006 through the end of 2006 show that the maximum actual SO_2 and NO_x emission rates from the kiln are higher than the SO_2 and NO_x emission rate originally submitted to MDEQ. The emissions data are summarized in Table 3-3.

TABLE 3-3. KILN EMISSION RATES IN BART DATA SUBMITTAL VS. 2006 ANALYZER DATA

Pollutant	BART Data Submittal to MDEQ (lb/hr)	Comment	2006 Analyzer Data (lb/hr)	Comment
SO_2	285.83	Stack Test Data, April 2006	473.87	2006 Maximum Actual 24-Hour SO_2 Emission Rate From Analyzer Data (Hourly Equivalent)
NO_X	439.17	Stack Test Data, April 2006	848.74	2006 Maximum Actual 24-Hour NO_X Emission Rate From Analyzer Data (Hourly Equivalent)
PM_{10}	37.17	Stack Test Data, April 2006	37.17	Stack Test Data, April 2006

AGC updated the emission rates used in the refined BART applicability modeling to the emission rates based on the analyzer data. Table 3-4 summarizes the emission rates that EPA and AGC modeled for SO_2, NO_X, and PM_{10}, including the speciated PM_{10} emissions. The total PM_{10} emission rates include both the filterable and condensable fractions and are speciated into the following:

- ▲ Coarse particulate matter (PM_C)
- ▲ Fine particulate matter (PM_f)
- ▲ Sulfates (SO_4)
- ▲ Secondary organic aerosols (SOA)
- ▲ Elemental carbon (EC)

TABLE 3-4. EXISTING MAXIMUM 24-HOUR SO_2, NO_X, AND PM_{10} EMISSIONS (AS HOURLY EQUIVALENTS)

Model	Source	SO_2 (lb/hr)	NO_X (lb/hr)	Total PM_{10} (lb/hr)	SO_4 (lb/hr)	PM_c (lb/hr)	PM_f (lb/hr)	SOA (lb/hr)	EC (lb/hr)
EPA Region 8 Applicability	Kiln	285.83	439.17	37.17	6.80	7.28	21.35	0.93	0.82
	Clinker Cooler	0.00	0.00	6.00	0.00	0.00	5.94	0.00	0.06
AGC Refined Applicability	Kiln	473.87	848.74	37.17	6.80	7.28	21.35	0.93	0.82
	Clinker Cooler	0.00	0.00	6.00	0.00	0.00	5.94	0.00	0.06

Table 3-5 summarizes the stack parameters that were used to model the kiln and clinker cooler.

TABLE 3-5. SUMMARY OF EXISTING STACK PARAMETERS

	Kiln	Clinker Cooler
Latitude (degrees)	46.544	46.539
Longitude (degrees)	-111.921	-111.922
Stack height (ft)	100	50
Stack Diameter (ft)	9	4
Exhaust Velocity (ft/s)	47	54
Exhaust Temperature (K)	384	132

The results of AGC's refined modeling verified EPA's BART determination; the results are summarized in Table 3-6. The 98th percentile of the visibility impacts attributable to the kiln and clinker cooler are greater than 0.5 Δdv when compared against a natural background for the Gates of the Mountains Wilderness Area.

TABLE 3-6. EXISTING VISIBILITY IMPAIRMENT ATTRIBUTABLE TO MONTANA CITY PLANT KILN AND CLINKER COOLER

Class I Area	Minimum Distance	98th Percentile Visibility Impact for Each Year (Δ dv)			Overall 98th Percentile Visibility Impact
	(km)	2001	2002	2003	(dv)
Gates of the Mountains	30	2.736	2.874	3.038	2.874

4. SO_2 BART EVALUATION

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.[3] The raw materials and fuels for the Montana City 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_2 within the pyroprocess to limit emissions of SO_2 as much of the sulfur leaves the process in the principle product of the kiln system called clinker.

The kiln is the only BART source which emits SO_2, thus an SO_2 BART evaluation was performed only for the kiln. The maximum actual 24-hour kiln SO_2 emission rate that was modeled for the BART applicability determination is summarized in Table 4-1. The SO_2 24-hour maximum actual emission rate was determined from analyzer data for 2006.

TABLE 4-1. EXISTING ACTUAL MAXIMUM 24-HOUR SO_2 EMISSION RATES

	SO_2 24-Hour Emission Rate (ton/24-hr)	SO_2 Hourly Equivalent Emission Rate (lb/hr)
Kiln	5.69	473.87

4.1 IDENTIFICATION OF AVAILABLE RETROFIT SO_2 CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit SO_2 control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, publicly-available air permits, applications, and technical literature published by the U.S. EPA, state agencies, and Regional Planning Organizations (RPOs).

The available retrofit SO_2 control technologies are summarized in Table 4-2.

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[3] Miller, F. MacGregor and Hawkins, Garth J., "Formation and Emission of Sulfur Dioxide from the Portland Cement Industry", *Proceedings of the Air and Waste Management Association*, June 18-22, 2000.

TABLE 4-2. AVAILABLE SO_2 CONTROL TECHNOLOGIES

SO_2 Control Technologies
Fuel Substitution
Raw Material Substitution
Lime Spray Dryer
Wet Lime Scrubbing

4.2 ELIMINATE TECHNICALLY INFEASIBLE SO_2 CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible SO_2 control technologies that were identified in Step 1.

4.2.1 FUEL SUBSTITUTION

AGC uses a mixture of coal and petroleum coke as the primary fuels for the kiln; natural gas is combusted during startup. The 2006 fuel usage breakdown, on an energy input basis, was 58 percent petroleum coke, 41 percent coal, and 1 percent natural gas. The sulfur content of the petroleum coke is approximately 4.5 percent and the sulfur content of the coal is approximately 0.8 percent.

The design of the long wet kiln system is such that much of the SO_2 resulting from fuel combustion is emitted. Therefore, if AGC reduces sulfur in fuel input to the kiln, a corresponding reduction in SO_2 emissions from the kiln would be expected. Fuel sulfur content could be reduced by burning a different blend of coal and coke which results in a lower overall sulfur content. Therefore, AGC anticipates that lowering the input of sulfur through fuel substitution would be an effective and technically feasible SO_2 control technology for the kiln.

4.2.2 RAW MATERIAL SUBSTITUTION

Sulfide sulfur in the raw materials, usually in the form of iron pyrite, is thermally decomposed and oxidized or "roasted" to form SO_2. The pyritic sulfur reacts with oxygen according to the following reaction:

$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$

Using raw materials with lower pyritic sulfur content can reduce the potential for SO_2 emissions from a wet kiln system. While pyrites are present in the limestone and other raw materials used at the Montana City plant, the concentrations of sulfide sulfur in these materials are already very low. With rare exceptions, cement plants are built at or near a source of limestone, the primary raw material for cement manufacture. To do otherwise is an economic penalty that would cause most plants, including Montana City plant, to be economically infeasible. During the production of cement clinker, the limestone loses about one-third of its weight as CO_2. The shipping costs for the "lost" weight in the limestone often can be economically prohibitive.

Since material substitution would result in a negligible reduction in SO_2 for the kiln, raw material substitution is not considered an SO_2 control technology for the kiln and is removed from further consideration as BART.

4.2.3 LIME SPRAY DRYING

Lime spray drying (LSD) consists of injecting an aqueous $Ca(OH)_2$ suspension in fine droplets into the flue gas. The $Ca(OH)_2$ reacts with SO_2 in the flue gas stream to create fine particles of $CaSO_3$ or $CaSO_4$. The moisture evaporates from the particles, and the particles are collected in the particulate matter control device (PMCD) serving the kiln. For optimum effectiveness, the reaction of $Ca(OH)_2$ with SO_2 must have adequate gas retention time and must be followed by a PMCD for capturing the sulfates created by the reaction.

Unlike a preheater/precalciner kiln system that provides by its design a natural location for a spray dryer type control system to be utilized between the top of the preheater tower and the PMCD, a wet kiln does not have that attribute. In other words, the back-end of a wet kiln has a relatively short retention time between that and it's associated PMCD. Additionally, the PMCD in place was not designed for the additional loading or for the increased water vapor that would need to be moved through the system to accommodate adequate lime spray drying control. It is also expected that with the added moisture generated from the wet process slurry that rates of evaporation for spray drying to occur could be retarded as compared to other combustion systems that might employ this type of system.

Lastly, the added gas cooling that would result from the injection of slurry prior to the PMCD would have the potential for undesirable acid dewpoint conditions to occur in the PMCD that could reduce its effectiveness. For these reasons and as there are no known applications of lime spray dryers on wet cement kilns, this technology considered is technically infeasible and is removed from further consideration as BART.

4.2.4 WET LIME SCRUBBING

Wet lime scrubbing (WLS) is a name for a traditional tailpipe wet scrubber. This process involves passing the flue gas from the main PMCD through a sprayed aqueous suspension of $Ca(OH)_2$ or $CaCO_3$ (limestone) that is contained in an appropriate scrubbing device. In the case of the Montana City plant, the basic underlying economics would dictate the use of ground limestone as the scrubbing reagent. In WLS, the aqueous suspension of scrubbing reagent is not taken to dryness as it is in LSD. The SO_2 reacts with the scrubbing reagent to form $CaSO_3$ that is collected and retained as aqueous sludge. Typically, the sludge is dewatered and disposed in an on-site landfill. In some cases involving cement plants, the $CaSO_3$ sludge could be oxidized to $CaSO_4$ and used in the finish mills as a substitute for purchased gypsum for regulation of the setting time of the cement product.

Typically, WLS is considered to have a scrubbing efficiency of up to 90 percent of the SO_2 in the flue gas treated by the scrubber.[4] WLS is a high maintenance process with high rates of downtime expected as the scrubber matures and corrosion of components becomes a serious problem. Conceivably, a pair of wet scrubbers ultimately would be required so that one is in operation while the other is repaired.

Despite these identified drawbacks, WLS is considered a technically feasible BART option.

4.3 RANK OF TECHNICALLY FEASIBLE SO_2 CONTROL OPTIONS BY EFFECTIVENESS

The third step in the BART analysis is to rank the technically feasible options according to effectiveness. Table 4-3 presents potential SO_2 technically feasible control technologies for the kiln and the associated SO_2 emission levels.

TABLE 4-3. RANKING OF TECHNICALLY FEASIBLE KILN SO_2 CONTROL TECHNOLOGIES BY EFFECTIVENESS

Pollutant	Control Technology	Effectiveness SO_2 Emissions Level (lb/hr)
SO_2		
	Wet Lime Scrubbing	25.35 lb/hr as a 30-day rolling average†
	Fuel Switching	126.76 lb/hr as a 30-day rolling average *

†Based on a 90% removal efficiency from the 2006 average 24-hour emission rate hourly equivalent (253.52 lb/hr). The 90 percent reduction was applied to the 2006 average 24-hour SO_2 emission rate rather than the maximum 24-hour SO_2 emission rate to best reflect the performance of the control on a 30 day rolling basis.

*Based on a fuel switching scenario that reduces sulfur emissions by 50% from the 2006 average 24-hour emission rate hourly equivalent (253.52 lb/hr). The 90 percent reduction was applied to the 2006 average 24-hour SO_2 emission rate rather than the maximum 24-hour SO_2 emission rate to best reflect the performance of the control on a 30 day rolling basis.

4.4 EVALUATION OF IMPACTS FOR FEASIBLE SO_2 CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list the four factors to be considered in the impact analysis:

- Cost of compliance
- Energy impacts
- Non-air quality impacts; and
- The remaining useful life of the source

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[4] EPA Air Pollution Control Technology Fact Sheet – Flue Gas Desulfurization (FGD) Wet, Spray Dry, and Dry Scrubbers. A control efficiency of up to 95% is listed. However, at an uptime of 95%, the actual annual control efficiency would be 90.2%

AGC has conducted an impact analysis for the two control options with the highest SO_2 control efficiencies: WLS and fuel switching.

4.4.1 WET LIME SCRUBBING

Cost of Compliance

AGC obtained a site-specific WLS proposal from a vendor and performed an economic analysis to determine the annualized cost for WLS. AGC divided the annualized cost of WLS by the annual tons of SO_2 reduced to determine the cost effectiveness for WLS. The "annual tons reduced" were determined by subtracting the estimated controlled annual emissions from the existing annual emissions. The existing annual emissions are based on the average 24-hour SO_2 emission rate (hourly equivalent) in 2006, as recorded by the gas analyzer, multiplied by the 2006 operating hours. The estimated controlled annual emissions were calculated by applying the 90 percent control efficiency to the existing annual emissions. Table 4-4 provides the cost effectiveness analysis related to WLS. Note that the cost effectiveness analysis does not include the cost to construct a new exhaust stack, which would be needed to employ the WLS technology.

TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING

Direct Costs	
Purchased Equipment Costs	
Wet Scrubber Unit	$5,687,500
Instrumentation (10% of EC)	$568,750
Sales Tax (3% of EC)	$170,625
Freight (5% of EC)	$284,375
Subtotal, Purchased Equipment Cost (PEC)	$6,711,250
Direct Installation Costs	
Foundation (6% of PEC)	$402,675
Supports (6% of PEC)	$402,675
Handling and Erection (40% of PEC)	$2,684,500
Electrical (1% of PEC)	$67,113
Piping (30% of PEC)	$2,013,375
Insulation for Ductwork (1% of PEC)	$67,113
Painting (1% of PEC)	$67,113
Subtotal, Direct Installation Cost	$5,704,563
Site Preparation	N/A
Buildings	N/A
Total Direct Cost	**$12,415,813**
Indirect Costs	
Engineering (10% of PEC)	$671,125
Construction and Field Expense (10% of PEC)	$671,125
Contractor Fees (10% of PEC)	$671,125
Start-up (1% of PEC)	$67,113
Performance Test (1% of PEC)	$67,113
Contingencies (3% of PEC)	$201,338
Total Indirect Cost	**$2,348,938**
Total Capital Investment (TCI)	**$14,764,750**

TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING (CONTINUED)

Direct Annual Costs		
Hours per Year	(365 days per year, 24 hours per day)	8,760
Operating Labor		
	Operator (0.5 hr/shift, 3 shifts/day, 365 d/yr, $16/hr)	$8,760
	Supervisor (15% of operator)	$1,314
	Subtotal, Operating Labor	$10,074
Maintenance		
	Labor (0.5 hr/shift, 3 shifts/day, 365 d/yr, $16/hr)	$8,760
	Material (100% of maintenance labor)	$8,760
	Subtotal, Maintenance	$17,520
Utilities		
	Electricity	
	Pump (kW)	380.48
	Cost ($/kW-hr)	$0.0537
	Subtotal, Electricity	$179,082
	Limestone Slurry	
	Amount Required (ton/yr)	2,847
	Cost ($/ton)	$15.00
	Subtotal, Lime	$42,705
	Water	
	Amount Required (gpm)	31.0
	Cost ($/1000 gallons)	$3.075
	Subtotal, Water	$50,101
	Sludge Disposal	
	Amount Generated (tpy)	5,913
	Disposal Fee ($/ton)	$23.00
	Subtotal, Sludge	$135,999
	Subtotal, Utilities	$407,887
	Total Direct Annual Costs	**$435,481**

TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING (CONTINUED)

Indirect Annual Costs		
Overhead (60% of sum of operating, supervisor, maintenance labor & materials)		$153,839
Administrative (2% TCI)		$295,295
Property Tax (1% TCI)		$147,648
Insurance (1% TCI)		$147,648
Capital Recovery	(10 year life, 7 percent interest)	$2,102,168
	Total Indirect Annual Cost	**$2,846,597**
Conclusion		
	Total Annualized Cost	**$3,282,078**
	Pollutant Emission Rate Prior to Scrubber (tons SO_2/yr)	**981**
	Pollutant Removed (tons SO_2/yr)	**883**
	Cost Per Ton of Pollutant Removed	**$3,716**

Energy Impacts

A wet scrubber requires an additional fan of considerable horsepower to move the flue gas through the scrubber.

Non Air-Quality Impacts

WLS may lead to an increase in PM emissions because some particles of limestone or $CaSO_3$ will be entrained in the flue gas and subsequently be emitted from the scrubber. WLS is also known to increase emissions of sulfuric acid mist.[5] A frequent steam plume can be expected at the discharge of the wet scrubber that would result in visual impairment in the area.

Utilization of a wet scrubber would require the use of a significant amount of water. An appropriately sized wet scrubber would consume approximately 16 million gallons of water per year. Most of this water would be emitted as vapor with a small portion in the sludge that would be generated by the control device.

In addition to the consumption of a large amount of water, the WLS technology would also generate a large amount of sludge. Disposal or treatment of WLS sludge presents additional environmental impacts.

Remaining Useful Life

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[5] *Innovations in Portland Cement* Manufacturing, Portland Cement Association, 2004, pg. 660 & 669

The remaining useful life of the kiln does not impact the annualized cost of WLS because the useful life is anticipated to be at least as long as the capital cost recovery period, which is 10 years.

4.4.2 FUEL SUBSTITUTION

Cost of Compliance

The cost of fuel substitution was determined by calculating the cost of the current coal/coke fuel blend and determining the increased cost of switching to combusting a fuel blend that would reduce fuel sulfur content by 50 percent from the 2006 levels. The proposed solution discussed in this evaluation would equate to reducing coke usage from the proportions used in 2006. At this time, AGC has not fully evaluated the potential fuel blends that could be used to reduce fuel sulfur content.

The current coal/coke fuel blend costs are based on 2006 fuel usage and cost data for the Montana City plant. The fuel switching costs are based on a switch to an 18.5% coke and 81.5% coal blend, where the specific coal and coke assumed for the blend are the coal and coke that are currently burned at the plant. This fuel blend results in an approximate 50% reduction in fuel sulfur content from the fuel blend used in 2006. Again, AGC has not fully evaluated all potential fuel blends that would result in a 50% reduction in fuel sulfur content; this fuel blend was used only for costing purposes. In practice, AGC may utilize higher quality coal or lower sulfur coke to meet the energy requirements of the kiln. It was assumed in this analysis that fuel switching will not require any capital expenses.

The total annual cost of fuel switching was divided by the annual tons of SO_2 reduced to determine the cost effectiveness for fuel switching. The "annual tons reduced" were determined by subtracting the estimated controlled annual emissions from the existing annual emissions. The existing annual emissions are based on the average 24-hour SO_2 emission rate (hourly equivalent) in 2006, as recorded by the gas analyzer, multiplied by the 2006 operating hours. The estimated controlled annual emission rates were calculated by reducing the existing annual emission rate by 50%. The sulfur content of the existing coal/coke fuel blend is 2.09 percent; this is calculated based on the sulfur contents of the fuels (3 percent for coke and 0.8 percent for coal) and the 2006 fuel usage (by MMBtu). The calculation for the sulfur content of the coal/coke fuel blend is as follows:

$$\frac{\text{905,045 Coke MMBtu}}{\text{1,548,421 Total MMBtu}}\ \bigg|\ \text{4.5\% Sulfur} + \frac{\text{643,376 Coal MMBtu}}{\text{1,548,421 Total MMBtu}}\ \bigg|\ \text{0.8 \% Sulfur} = \text{2 96 \% Sulfur}$$

The sulfur content of the fuel switching scenario is calculated based on a 11% coke and 89% coal blend. The calculation of the sulfur content of the fuel blend and the reduced emissions are shown below:

$$\frac{\text{286,458 Coke MMBtu}}{\text{1,548,421 Total MMBtu}}\ \bigg|\ \text{4.5\% Sulfur} + \frac{\text{1,261,963 Coal MMBtu}}{\text{1,548,421 Total MMBtu}}\ \bigg|\ \text{0.8 \% Sulfur} = \text{1.48 \% Sulfur}$$

$$\frac{2.96\ \%\ \text{Sulfur} - 1.48\%\ \text{Sulfur}}{2.96\ \%\ \text{Sulfur}} = 50\ \%$$

$$\frac{253.52\ \text{lb}}{\text{hr}} \left| \frac{7{,}741\ \text{hr}}{\text{yr}} \right| \frac{\text{ton}}{2{,}000\ \text{lb}} \left| \ 50\ \% \right. = 491\ \frac{\text{ton SO2 Reduced}}{\text{yr}}$$

The cost of fuel switching is summarized in Table 4-5.

TABLE 4-5. SUMMARY OF COST EFFECTIVENESS FOR FUEL SUBSTITUTION

Existing Annual Emissions (tons/yr)	Controlled Annual Emissions (tons/yr)	Reduced Annual Emissions (tons/yr)	Existing Annual Energy (Coal/Coke) Usage (MMBtu/yr)	Existing Coal/Coke Cost* ($/yr)	Average Heating Value Btu/lb	Annual Fuel Usage Tons/yr	Cost $/ton	Annual Fuel Cost ($/yr)	Cost of Switching Fuels ($/yr)	Cost Effectiveness ($/ton)
981	492	490	1,548,421	$1,860,967	14,582 (Coke) 8,426 (Coal)	9,822 (Coke) 74,885 (Coal)	16.38 (Coke) 35.43 (Coal)	2,814,066	953,099	1,946.81

*The existing coal/coke cost is based on 2006 actual usage data (31,033 tons coke * $16.38/ton + 38,178 tons Coal * 35.43/ton = $1,860,967).

Energy Impacts and Non Air-Quality Impacts

There are no energy or non-air quality impacts associated with fuel switching.

Remaining Useful Life

The remaining useful life of the kiln does not impact the annualized costs for fuel switching, since, for this analysis, it is assumed that fuel switching will not require any capital costs.

4.5 EVALUATION OF VISIBILITY IMPACT OF FEASIBLE SO_2 CONTROLS

A final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the emission rates of WLS and fuel switching. The existing emission rates and emission rates associated with WLS and fuel switching were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis. The SO_2 emissions rates associated with WLS and fuel switching are the proposed BART emission limits in lb/hr based on reductions from the 2006 average 24-hour emission rate (as an hourly equivalent).

The SO_2 emission reductions from the WLS and fuel switching control options were applied to the 2006 average 24-hour SO_2 emission rate rather than the maximum 24-hour SO_2 emission rate because the BART limit is proposed as a 30-day rolling average. Had the reductions been applied to the maximum 24-hour SO_2 emission rates, the controlled emission rates would be much higher than what AGC anticipates could be achieved by the WLS and fuel switching control options on a 30-day rolling basis. The emission rates are summarized in Table 4-6.

TABLE 4-6. SUMMARY OF EMISSION RATES MODELED IN SO_2 CONTROL VISIBILITY IMPACT ANALYSIS

Emission Rate Scenario	Emission Rate		
	SO_2 (lb/hr)	NO_X (lb/hr)	PM_{10} (lb/hr)
WLS	25.35	848.74	37.17
Fuel Substitution	126.76	848.74	37.17

Comparisons of the existing visibility impacts and the visibility impacts based on WLS and fuel switching for the Gates of the Mountains Wilderness Area are provided in Table 4-7. The visibility improvement associated with WLS and fuel switching are also shown in Table 4-7; this value was calculated as the difference between the existing visibility impairment and the visibility impairment for the controlled emission rates as measured by the 98th percentile modeled visibility impact.

TABLE 4-7. SUMMARY OF MODELED IMPACTS FROM SO_2 CONTROL VISIBILITY IMPACT ANALYSIS

	98% Impact (Δdv)	Improvement
Existing	2.87	--
Fuel Switching	2.70	6.05%
WLS	2.63	8.39%

As shown in Table 4-7, the installation of a WLS on the kiln results in an 8.39 percent improvement to the existing visibility impairment. Fuel switching results in a 6.05 percent improvement to the existing visibility impairment. Therefore, utilization of WLS as compared to fuel switching results in only a 2% incremental improvement (0.07 Δdv). The minimal visibility improvement was expected due to the low contribution of sulfates to the existing visibility impairment when compared to nitrates.

4.6 PROPOSED BART FOR SO_2

In order to determine BART for SO_2, AGC evaluated each control option's cost of compliance, energy impacts, and non-air quality impacts, as well as the remaining useful life of the kiln. Table 4-8 summarizes the cost effectiveness for each control option based on the tons of SO_2 reduced and the visibility improvement in deciviews. The cost effectiveness for the fuel switching is $1,947 per ton of SO_2 reduced and $5.5 million per deciview of visibility improvement. This corresponds to a nominal visibility improvement from 2.87 Δdv to 2.70 Δdv. The cost effectiveness for the WLS is $3,716 per ton of SO_2 reduced and $13.6 million per deciview of visibility improvement. This corresponds to a nominal visibility improvement from 2.87 Δdv to 2.63 Δdv. The incremental cost of utilizing WLS as opposed to fuel switching is $33,271,129 per deciview.

TABLE 4-8. SUMMARY OF COST EFFECTIVENESS OF SO_2 CONTROL TECHNOLOGIES

	Existing Emissions (tons/yr)	Controlled Emissions (tons/yr)	Reduced Annual Emissions (tons/yr)	Annual Cost ($/yr)	Cost Effectiveness ($/ton)
Fuel Switching	981	492	490	953,099	1,947
WLS	981	98	883	3,282,078	3,716

	Base 98th Percentile Impact (DV)	98^{th} Percentile Impact (DV)	98th Percentile Improvement (DV)	98th Percentile Improvement (%)	Cost Effectiveness ($/DV)
Fuel Switching	2.87	2.70	0.17	6.05	5,477,581
WLS	2.87	2.63	0.24	8.39	13,618,583

Based on the five step analysis outlined by EPA, fuel switching and WLS were identified as the two technically feasible technologies. Cost, energy and environmental impacts were assessed for both technologies and the visibility improvements associated with both options were evaluated against existing conditions. This analysis demonstrates that the cost of compliance associated with both control options is high while the visibility impact analysis demonstrates that the visibility improvements associated with both control options are nominal due to the fact that the percentage of visibility impairment attributable to SO_4 is relatively low. As a result, AGC has determined that additional SO_2 control technologies (fuel switching and WLS) would provide little visibility improvement and require significant expenditures. Therefore, AGC proposes that limiting the kiln to the existing levels of SO_2 emissions constitutes BART for the kiln.

In Portland cement kilns, the NO_X that is generated is primarily classified into one of two categories, i.e., thermal NO_X or fuel NO_X[6]. Thermal NO_X occurs as a result of the high-temperature oxidation of molecular nitrogen present in the combustion air. Fuel NO_X is created by the oxidation of nitrogenous compounds present in the fuel. It is also possible for nitrogenous compounds to be present in the raw material feed and become oxidized to form additional NO_X referred to as feed NO_X.

Due to the high flame temperature in the burning zone of the rotary kiln (3400° F), NO_X emissions from the kiln tend to be mainly comprised of thermal NO_X. Although NO_X emissions from cement kilns include both nitrogen oxide (NO) and nitrogen dioxide (NO_2), typically, less than 10% of the total NO_X in the flue gas is NO_2.[7]

The kiln is the only BART source which emits NO_x, thus a NO_x BART evaluation was performed only for the kiln. The maximum actual 24-hour kiln NO_x emission rate that was modeled for the BART applicability determination is summarized in Table 4-1. The NO_x 24-hour maximum actual emission rate was determined from analyzer data for 2006.

TABLE 5-1. EXISTING ACTUAL MAXIMUM 24-HOUR NO_x EMISSION RATES

	NO_x 24-Hour Emission Rate (ton/24-hr)	NO_x Hourly Equivalent Emission Rate (lb/hr)
Kiln	10.18	848.74

5.1 IDENTIFICATION OF AVAILABLE RETROFIT NO_X CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit NO_X control technologies. A list of control technologies was obtained by reviewing the U.S. EPA's Clean Air Technology Center, control equipment vendor information, publicly-available air permits, applications, and technical literature published by the U.S. EPA and the RPOs.

The available retrofit NO_X control technologies are summarized in Table 5-2.

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[6] NO_X Formation and Variability in Portland Cement Kiln Systems, Penta Engineering, December 1998.

[7] IBID.

TABLE 5-2. POSSIBLE NO_X CONTROL TECHNOLOGIES

Kiln Control Technologies
Low NO_X Burner Flue Gas Recirculation CKD Insufflation Mid-Kiln Firing of Tires Selective Noncatalytic Reduction Selective Catalytic Reduction

5.2 ELIMINATE TECHNICALLY INFEASIBLE NO_X CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible NO_X control technologies that were identified in Step 1.

5.2.1 LOW-NO_X BURNER IN THE ROTARY KILN

Low NO_x burners (LNBs) reduce the amount of NO_x formed at the flame. The principle of all LNBs is the same: stepwise or staged combustion and localized exhaust gas recirculation (i.e. at the flame). As applied to the rotary cement kiln, the low-NO_X burner creates primary and secondary combustion zones at the end of the main burner pipe to reduce the amount of NO_x initially formed at the flame. In the high-temperature primary zone, combustion is initiated in a fuel-rich environment in the presence of a less than stoichiometric oxygen concentration. The oxygen-deficient condition at the primary combustion site minimizes thermal and fuel NO_X formation and produces free radicals that chemically reduce some of the NO_X that is being generated in the flame.

In the secondary zone, combustion is completed in an oxygen-rich environment. The temperature in the secondary combustion zone is much lower than in the first; therefore, lower NO_X formation is achieved as combustion is completed. CO that has been generated in the primary combustion zone as an artifact of the sub-stoichiometric combustion is fully oxidized in the secondary combustion zone.

The EPA has indicated that a 14% reduction in NO_x emissions may be anticipated in switching from a direct-fired standard burner to an indirect-fired LNB[8]. This is based on a study conducted on an indirect-fired LNB at the Dragon Product Company cement kiln at the plant located in Thomaston, Maine. However, the EPA has also determined that the [emission reduction] contribution of the LNB itself and of the firing system conversion [direct to indirect] can not be isolated from the limited data available[9]. The terms direct and indirect firing have unique meaning in the context of kiln firing (unlike the more general meanings where direct firing implies that the products of combustion contact the

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[8] NO_X Control Technologies for the Cement Industry, EC/R Incorporated, Chapel Hill, NC, USA, U.S. EPA Contract NO. 68-D98-025, U.S. EPA RTP, September 19, 2000.

[9] USEPA, Office of Air Quality Planning and Standards. *Alternative Controls Technology Document - NOx Emissions from Cement manufacturing.* EPA-453/R-94-004, Page 5-5 to 5-8.

process materials whereas indirect firing involves a heat transfer medium). In kiln firing, direct and indirect firing describes the manner in which pulverized fuel is conveyed from the fuel grinding mill to the burner.

In the direct firing configuration, fuel is pneumatically conveyed directly from the coal mill to the burner. The quantity of air introduced to the primary combustion zone is dictated by the minimum air requirements of the coal mill and the conveyance system, rather than the optimum flame requirements. The Montana City plant kiln uses a direct firing system.

In the indirect firing configuration, the coal mill air is separated from the pulverized fuel which is stored in a tank before being fed to the kiln. The pulverized fuel is then conveyed to the burner with the quantity of air that is optimum for flame considerations. There have been no controlled studies conducted on cement kilns that verify that this method of burning solid fuel reduces the formation of NO_x.

The AGC Midlothian, Texas plant, which also operates direct-fired wet kilns, utilizes a direct fired LNB system that consists of a plugged annual burner pipe. In this design, the burner pipe has a central plug, which reduces the pressure at the core of the jet. As a result, the pressure of the primary air jet is relieved inward, reducing the rate of the expansion of the flame. This produces a non-divergent flame that minimizes surface area of the flame and maintains the fuel concentrated in the core of the flame. The annual burner pipe is shown in Figures 5-1 and 5-2.

FIGURE 5-1 ANNUAL BURNER PIPE WITH CONTRACTED FLAME

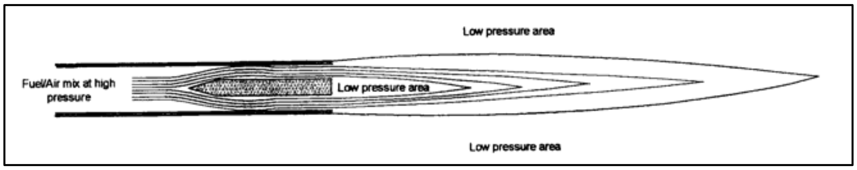
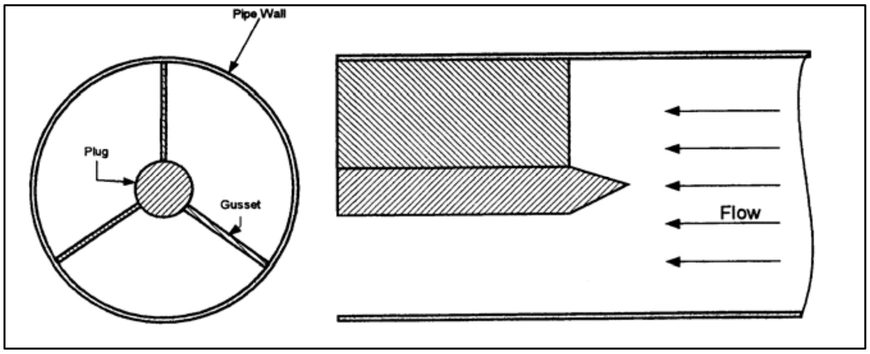


FIGURE 5-2 SCHEMATIC OF ANNUAL BURNER PIPE



When compared to simple free jet burners without the annual nozzle, these burners enhance NO_X control by reducing flame turbulence, delaying fuel/air mixing, and establishing a fuel rich core in the flame for initial combustion. Low-NO_X burners are considered to be a technically feasible option for NO_X control.

5.2.2 FLUE GAS RECIRCULATION

Flue gas recirculation involves the use of oxygen-deficient flue gas from some point in the process as a substitute for primary air in the main burner pipe in the rotary kiln. Flue gas recirculation (FGR) lowers the peak flame temperature and develops localized reducing conditions in the burning zone through a significant reduction of the oxygen content of the primary combustion "air." The intended effect of the lower flame temperature and reducing conditions in the flame is to decrease both thermal and fuel NO_X formation in the rotary kiln.

While FGR is a practiced control technology in the electric utility industry, AGC is not aware of any attempt to apply FGR to a cement kiln because of the unique process requirements of the industry, i.e., a hot flame is required to complete the chemical reactions that form clinker minerals from the raw materials. The process of producing clinker in a cement kiln requires the heating of raw materials to about 2700°F for a brief but appropriate time to allow the desired chemical reactions that form the clinker minerals to occur. A short, high-temperature flame of about 3400°F is necessary to meet this process requirement. The long/lazy flame that would be produced by FGR would result in the production of lower or unacceptable quality clinker because of the resulting undesirable mineralogy. Clinkering reactions must take place in an oxidizing atmosphere in the burning zone to generate clinker that can be used to produce acceptable cement. FGR would tend to produce localized or general reducing conditions that also could detrimentally affect clinker quality. Due to these important limitations on the application of FGR and the lack of a successful demonstration on a cement kiln in the United States, FGR is not a technically feasible control option for NO_X control at this time.

5.2.3 CEMENT KILN DUST INSUFFLATION

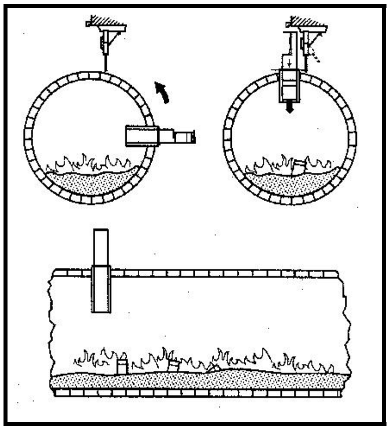
Cement kiln dust (CKD) is a residual byproduct that can be produced by any of the four basic types of cement kiln systems. CKD is most often treated as a waste even though there are some beneficial uses. However, as a means of recycling usable CKD to the cement pyroprocess, CKD sometimes is injected or insufflated into the burning zone of the rotary kiln in or near the main flame. The presence of these cold solids within or in close proximity to the flame has the effect of cooling the flame and/or the burning zone thereby reducing the formation of thermal NO_X. The insufflation process is somewhat counterintuitive because a basic requirement of a cement kiln is a very hot flame to heat the clinkering raw materials to about 2700° F in as short a time as possible. Because there is an increased requirement for thermal energy in the burning zone when insufflation is employed, it is not an attractive technology for recirculation of CKD in wet kiln systems. Other, more efficient procedures are available. Therefore, this option is removed from consideration for BART.

5.2.4 MID-KILN FIRING OF SOLID FUEL (TIRES) WITH MIXING AIR FAN

Secondary combustion is defined as follows: a portion of the fuel is fired in a location other than the burning zone. This reduces thermal NO_x generation because the temperature in the secondary combustion zone is less than 2100 °F. Mid-kiln firing (MKF) of solid fuels, such as used tires, is an example of secondary combustion. MKF allows part of the kiln fuel to be burned at a material calcination temperature (secondary combustion zone) which is much lower than the clinker burning temperature.

The Cadence feed form MKF technology was first introduced in 1989. It is comprised of three primary components: (1) a staging arm or "feed fork," that picks up the fuel modules and positions them for entry into the kiln, (2) two pivoting doors that open to allow the fuel to drop into the kiln, and (3) a drop tube that extends through the side wall of the kiln. In addition to these basic components, feed fork technology also requires a delivery system which positions the fuel models so they can be picked up by the feed fork and a mechanism for opening the doors so the fuel can enter the kiln. Due to rotation of the kiln, fuel can only be injected once per revolution from the top, as shown in Figure 5-3.

FIGURE 5-3. MID-KILN FIRING SCHEMATIC[10]



High-pressure air, in the range of a 2-10 percent replacement of the primary combustion air, could be injected through the shell of the rotary kiln and into the calcining zone to where a mixing air fan mixes the air with the gas and fuel within the rotary kiln for more complete combustion of the solid fuel.

By adding fuel mid-kiln, MKF changes both the flame temperature and flame length. These changes should reduce thermal NO_X formation by burning part of the fuel at a lower temperature and by creating reducing conditions at the mid-kiln fuel injection point which may destroy some of the NO_X formed upstream in the kiln burning zone.

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[10] NO_X Control Technologies for the Cement Industry, EC/R Incorporated, Chapel Hill, NC, USA, U.S. EPA Contract NO. 68-D98-025, U.S. EPA RTP, September 19, 2000.

The discontinuous fuel feed from MKF may also result in increased carbon monoxide (CO) emissions. To control CO emissions, the kiln may have to have increased combustion air which can decrease production capacity.

AGC currently utilizes MKF of tires on three wet kilns at the Midlothian, Texas plant; approximately 4 million tires are burned each year for the three wet kilns. This accounts for about 20% of the fuel usage (BTU basis) at the Midlothian plant. It is estimated that approximately 1.3 million tires would be required at Montana City to achieve the same fuel replacement and equivalent NO_X reductions. A study by the Montana Environmental Quality Council[11] estimated that between 527,400 and 879,000 waste tires are generated each year in Montana. Therefore, in order for the Montana City plant to obtain the required amount of tires, tires would likely need to be imported from surrounding states. Furthermore, the Holcim Trident cement plant located in Three Forks, Montana, is currently seeking approval from MDEQ to burn up to 1,137,539 tires per year as supplemental fuel. In the Draft Environmental Impact Statement submitted by Holcim to MDEQ in July 2006, Holcim states that it will transport tires from out of state to supplement the number of tires available in Montana. This would create an additional strain on the supply of tires available in the region for the Montana City plant.

Transportation of tires from surrounding states would increase the cost associated with MKF and generate additional air pollutant emissions for motor vehicle transportation and fugitive dust from traffic at the Montana City plant. Therefore, while MKF of tires is technically feasible, AGC proposes to eliminate this control option from further consideration as BART due to the supply shortage of tires.

5.2.5 SELECTIVE NONCATALYTIC REDUCTION

In the relatively narrow temperature window of 1600 to 1995°F, ammonia (NH_3) reacts with NO_X without the need for a catalyst to form water and molecular nitrogen in accordance with the following simplified reactions.

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$
$$2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$$

As applied to NO_X control from cement kilns and other combustion sources, this technology is called selective noncatalytic reduction (SNCR). Above this temperature range, the NH_3 is oxidized to NO_X thereby increasing NO_X emissions. Below this temperature range, the reaction rate is too slow for completion and unreacted NH_3 may be emitted from the pyroprocess. This temperature window generally is available at some location within the rotary kiln. The NH_3 could be delivered to the kiln shell through the use of anhydrous NH_3, or an aqueous solution of NH_3 (ammonium hydroxide) or urea.

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[11] Status of and Alternatives for Management of Waste Tires in Montana: Report to the 56th Legislature, Montana Environmental Quality Council, October 1998.

A concern about application of SNCR technology is the breakthrough of unreacted NH_3 as "ammonia slip" and its subsequent reaction in the atmosphere with SO_2, sulfur trioxide (SO_3), hydrogen chloride (HCl) and/or chlorine (Cl_2) to form a detached plume of PM_{10} – $PM_{2.5}$.

SNCR is currently being used successfully as an independent technology on wet cement kiln systems in Europe and recently, authorization was granted to AGC to test SNCR at its wet kiln in Midlothian, Texas. AGC installed a full scale SNCR system on one of its wet kilns and the system has been running for several months; it is achieving a 35 to 40% NOx reduction on a consistent basis.

As SNCR is currently being operated on one of AGC's wet cement kiln at the Midlothian Texas plant, it is considered a technically feasible NO_x control option for the Montana City plant

5.2.6 SELECTIVE CATALYTIC REDUCTION

Selective Catalytic Reduction (SCR) is an add-on control technology for the control of emissions of the oxides of nitrogen (NO_x) from a combustion process. SCR has been successfully employed in the electric power industry. The basic SCR system consists of a system of catalyst grids placed in series with each other within a vessel that is located in a part of the process where the normal flue gas temperature is in the required range. An ammonia-containing reagent is injected at a controlled rate upstream of the catalyst grids that are designed to ensure relatively even flue gas distribution within the grids, to provide good mixing of the reagent and flue gas, and to result in minimum ammonia (NH_3) slip.[12] The NH_3 reacts with NO_x compounds (i.e., NO and NO_2) on the surface of the catalyst in equal molar amounts (i.e., one molecule of NH_3 reacts with one molecule of NO_x). Common reagents include aqueous NH_3, anhydrous NH_3 and urea [$(NH_2)_2CO$]. In the presence of the catalyst, the injected ammonia is converted by OH^- radicals to ammonia radicals (i.e., NH_2^-), which, in turn, react with NO_x to form N_2 and H_2O. The SCR catalyst enables the necessary reactions to occur at lower temperatures than those required for Selective Non-Catalytic Reduction (SNCR). While catalysts can be effective over a larger range of temperatures, the optimal temperature range for SCR is 570 - 750° F.

The catalyst system used in SCR applications usually consists of (1) a porous honeycomb of a ceramic substrate onto which catalyst has been attached to the surface of the ceramic material, or (2) a flat or corrugated plate onto which catalytic material has been deposited on the surface. A porous metal oxide with a high surface area-to-volume ratio acts as a catalyst base. On this base, typically titanium dioxide (TiO_2), one or more metal oxide catalysts are deposited in various concentrations. In SCR applications, the active catalyst material typically consists of vanadium pentoxide (V_2O_5), tungsten trioxide (WO_3), and molybdenum trioxide (MoO_3) in various combinations. The composition, also known as the catalyst formulation, is tailored by the catalyst vendor to best suit a particular SCR

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[12] Slip refers to the quantity of unreacted reagent that exits the SCR reactor.

application. Catalyst deactivation through poisoning, fouling, masking, sintering and erosion are common problems for SCR catalysts that, without careful process design and operation, could be exacerbated. If not fouled by sulfur dioxide (SO_2), the catalysts used in SCR have a propensity to oxidize sulfur dioxide (SO_2) in the flue gas to sulfur trioxide (SO_3), a more undesirable pollutant.

Because the reaction rate of NH_3 and NO_x is temperature dependent, the temperature of the flue gas stream to be controlled is the most important consideration in applying SCR technology to any combustion source. The optimum temperature range for SCR application is about 300º C (570º F) to 450º C (840º F). This range of normal process temperature may be found in the exhaust gas from the wet kiln at the PMCD inlet.

SCR has not been applied to a cement plant of any type in the United States. SCR has been applied successfully at a cement plant in Solnhofen, Germany. The Solnhofen plant has a kiln with a preheater tower as opposed to the wet kiln system at AGC's Montana City plant. SCR has also been successfully applied at a cement plant in Moncelice, Italy; however, this plant is also a preheater plant as opposed to the wet cement kiln system at Montana City.

Earlier this year, as part of permitting a new cement plant to be located on the Moapa Pauite Indian Reservation in Nevada (Moapa Paiute plant), AGC carefully assessed all of the publicly available information regarding SCR application at Solnhofen to determine (1) whether the Solnhofen testing indicates that the SCR technology exceeds the performance of SNCR and (2) whether the technology is commercially available for preheater/precalciner system such as that intended for AGC's proposed Moapa Paiute plant. In order to ensure a comprehensive review, AGC engaged an independent expert in SCR technology to conduct an extensive analysis of SCR and its availability in relation to the Moapa Paiute plant. This analysis determined that the SCR system at Solnhofen does not result in a lower NOx emission rate than that which can be gained from SNCR.[13] The study also concluded that the cost and time required for pilot testing to select the appropriate catalyst and SCR size/configuration needed to achieve the same emission levels achievable by SNCR is unknown. In the draft Moapa Paiute PSD permit put out for public comment this spring, EPA Region 9 concluded that SCR did not constitute BACT for cement kilns as it could not be demonstrated to outperform SNCR (that permit is expected to be issued upon completion of the Endangered Species Act consultation).

The major SCR vendors have also indicated that SCR is not commercially available for cement kilns at this time. The St. Lawrence Cement Company recently issued a Request for Proposals (RFP) for SCR for the company's proposed new cement kiln in Greenport, New York. Of the four major vendors contacted, two, Lurgi PSI Inc. (Lurgi) and Babcock & Wilcox, did not provide any proposal, with Lurgi stating that their technology was not yet ready for commercial release. A third with relevant experience from the Solnhofen

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[13] Schreiber, Robert J., Evaluation of Suitability of Selective Catalytic Reduction for Use in Portland Cement Manufacturing, 2006

demonstration plant, KWH,[14] indicated that technical uncertainties prevented them from designing an SCR system without pilot plant testing. Only Alstom provided a proposal that suggested SCR could be supplied to a cement kiln system. However, careful review of the Alstom proposal, indicated that the Alstom proposal did not identify a commercial SCR system that would be viable for a cement kiln system application

AGC has reviewed the publicly available SCR assessments and vendor documents related to the Greenport plant. Ash Grove believes that the Greenport vendor evaluation continues to be relevant and supports the conclusion that an SCR system is not commercially available as defined in the NSR Workshop Manual, pages B.17 and B.18, which states that:

> *…Two key concepts are important in determining whether an undemonstrated technology is feasible: "availability" and "applicability."*

As explained in more detail below, a technology is considered "available" if it can be obtained by the applicant through commercial channels or is otherwise available within the common sense meaning of the term. An available technology is "applicable" if it can reasonably be installed and operated on the source type under consideration. A technology that is available and applicable is technically feasible. Availability in this context is further explained using the following process commonly used for bringing a control technology concept to reality as a commercial product: concept stage; research and patenting; bench scale or laboratory testing; pilot scale testing; licensing and commercial demonstration; and commercial sales.

A control technique is considered available, within the context presented above, if it has reached the licensing and commercial sales stage of development. A source would not be required to experience extended time delays or resource penalties to allow research to be conducted on a new technique. Neither is it expected that an applicant would be required to experience extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, technologies in the pilot scale testing stages of development would not be considered available. An exception would be if the technology were proposed and permitted under the qualifications of an innovative control device consistent with the provisions of 40 CFR 52.21(v) or, where appropriate, the applicable SIP [in which case it would be considered available].

Commercial availability by itself, however, is not necessarily sufficient basis for concluding a technology to be applicable and therefore technically feasible. Technical feasibility, as determined in Step 2, also means a control option may reasonably be deployed on or "applicable" to the source type under consideration. (NSR Page B.18)

As SCR would require pilot scale testing, Ash Grove concluded that SCR was not "available" with respect to the Moapa Paiute plant because it was not commercially

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[14] KWH teamed with Elex, a German engineering firm who was responsible for some aspects of the Solnhofen installation. Elex holds a patent covering certain applications of SCR to cement kilns in the United States.

available. This determination has also been the finding of the Florida DEP as recently as March 2005, which in a BACT determination for Florida Rock Industries, Newberry Plant, concluded that "there has been no pilot study conducted in the United States, and there have been no indications that a pilot plant will be constructed to test SCR by any Portland cement facilities in the United States." Further, "…Some additional time would be needed to conduct tests to determine the correct catalyst formulation" and, "The Department does not consider SCR necessary to achieve a BACT level of control in Florida."[15].

In conclusion, AGC has determined that SNCR is as good as SCR based on Solnhofen and, due to commercial unavailability that AGC determined for the Moapa Paiute plant and since there is no known application of SCR on a wet kiln system, SCR is eliminated from further consideration as BART for NO_x control at the Montana City plant.

5.3 RANK OF TECHNICALLY FEASIBLE NO_X CONTROL OPTIONS BY EFFECTIVENESS

The third step in the BART analysis is to rank the technically feasible options according to effectiveness. Table 5-3 presents potential NO_X technically feasible control technologies for the kiln and the associated NO_x emission levels. The emission rates are largely based AGC's experience with wet kiln NO_X control technologies at AGC's Midlothian, Texas plant.

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[15] Air Permit No: 0010087-013-AC; PSD-FL-350 - BACT Determination, Comment written by Al Linero, Florida DEP, 3/30/2005, Pages BD-10 and BD-11.

TABLE 5-3. RANKING OF TECHNICALLY FEASIBLE KILN NO_X CONTROL TECHNOLOGIES BY EFFECTIVENESS

Pollutant	Control Technology	Effectiveness NO_X Emissions Level (lb/hr)
NO_X		
	LNB and SNCR	227.25 lb/hr (~35 % control)†
	SNCR	295.36 lb/ hr (~35 % control) §
	LNB	422.59 lb/ hr (~7% control) ††

†The effectiveness level for SNCR and LNB corresponds to a 50% NO_X reduction from the 2006 average 24-hour emission rate as an hourly equivalent (454.50 lb/hr). The 90 percent reduction was applied to the 2006 average 24-hour NO_x emission rate rather than the maximum 24-hour NO_x emission rate to best reflect the performance of the control on a 30 day rolling basis.

§ The effectiveness level for SNCR corresponds to a 35% NO_X reduction from the 2006 average 24-hour emission rate as an hourly equivalent (454.50 lb/hr). The 90 percent reduction was applied to the 2006 average 24-hour NO_x emission rate rather than the maximum 24-hour NO_x emission rate to best reflect the performance of the control on a 30 day rolling basis.

††The effectiveness level for the direct-fired LNB system is based on AGC's experience with a system at the Midlothian, Texas plant. The effectiveness corresponds to a 7% NO_X reduction from the 2006 average 24-hour emission rate as an hourly equivalent (454.50 lb/hr). The 90 percent reduction was applied to the 2006 average 24-hour NO_x emission rate rather than the maximum 24-hour NO_x emission rate to best reflect the performance of the control on a 30 day rolling basis.

5.4 EVALUATION OF IMPACTS FOR FEASIBLE NO_X CONTROLS

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list four factors to be considered in the impact analysis:

- Cost of compliance
- Energy impacts
- Non-air quality impacts; and
- The remaining useful life of the source

5.4.1 SNCR AND LNB

Cost of Compliance

Since AGC is proposing the most stringent control option as BART, the cost of compliance is not evaluated.

Energy Impacts and Non Air-Quality Impacts

SNCR systems require electricity to operate the blowers and pumps. The generation of the electricity will most likely involve fuel combustion, which will cause emissions. While the required electricity will result in the emissions, the emissions should be small compared to the reduction in NO_x that would be gained by operating an SNCR system

Ammonia slip from SNCR systems occurs either from ammonia injection at temperatures too low for effective reaction with NO_X, leading to an excess of unreacted ammonia, or from over-injection of reagent leading to uneven distribution; which also leads to an excess of unreacted ammonia. Based on AGC's experience at the Midlothian, Texas plant, we believe that ammonia slip will be less than 10 ppm above baseline emissions. While the presence of ammonia slip is recognized here as an impact attributable to SNCR systems, it is an air-quality impact and so is legally not part of the BART analysis process.

Remaining Useful Life

The remaining useful life of the kiln does not impact the annualized costs of SNCR because the useful life is anticipated to be at least as long as the capital cost recovery period, which is 10 years.

5.5 EVALUATION OF VISIBILITY IMPACT OF FEASIBLE NO_X CONTROLS

The final impact analysis was conducted to assess the visibility improvement for existing emission rates when compared to the emission rates of the SNCR and LNB combined control option. The existing emission rates and emission rates associated with SNCR and LNB were modeled using CALPUFF. The existing emission rates are the same rates that were modeled for the BART applicability analysis.

The NO_x emission rate associated with the SNCR and LNB control option is the 2006 average 24-hour NO_x emission rate (hourly equivalent) reduced by 50 percent. This 50 percent reduction was applied to the 2006 average 24-hour NO_x emission rate rather than the maximum 24-hour NO_x emission rate because the BART limit is proposed as a 30-day rolling average. Had the 50 percent reduction been applied to the maximum 24-hour NO_x emission rate, the controlled emission rate would be much higher than what AGC anticipates could be achieved by the SNCR and LNB on a 30-day rolling basis. The emission rates are summarized in Table 5-4.

TABLE 5-4. SUMMARY OF EMISSION RATES MODELED IN NO_X CONTROL VISIBILITY IMPACT ANALYSIS

Unit	Emission Rate Scenario	Emission Rate		
		SO_2 (lb/hr)	NO_X (lb/hr)	PM_{10} (lb/hr)
Kiln	SNCR and LNB	473.87	227.25	37.17
	Existing	473.87	848.74	37.17

Comparisons of the 98th percentile existing visibility impacts and the visibility impacts based on LNB and SNCR for the Gates of the Mountains Wilderness Area are provided in Table 5-5. The visibility improvement associated with LNB and SNCR are also shown in Table 5-5; this was calculated as the difference between the existing visibility impairment and the visibility impairment for the remaining control options as measured by the 98th percentile modeled visibility impact.

TABLE 5-5. NO_X CONTROL VISIBILITY IMPACT ANALYSIS

	98% Impact (Δdv)	Improvement
Existing	2.874	-
SNCR and LNB	1.377	52.09%

As seen in Tables 5-5, the SNCR and LNB result in a visibility improvement of 52.09 percent.

5.6 PROPOSED BART FOR NO_X

Based on the five step analysis outlined by EPA, SNCR with LNB was identified as the sole technically feasible add-on control technology. Cost, energy and environmental impacts were assessed for this technology and the visibility improvements were evaluated against existing conditions. Consistent with EPA guidance, economic impacts were not assessed as AGC was willing to utilize the highest ranked control technology. The visibility impact analysis demonstrates that the utilization of SNCR and LNB to achieve a 227.25 lb/hr NO_x emission rate results in significant visibility improvements. Neither non-air quality nor energy impacts associated with this control technology are material and so do not present a basis for eliminating SNCR/LNB in favor of retaining the existing rates as BART. Therefore, AGC proposes that a direct-fired LNB system with SNCR is BART for NO_x. AGC proposes to comply with a BART emissions limit of 227.25 lb/hr on a 30-day rolling basis. Compliance with the emission limit will be demonstrated by continuous emissions monitoring.

6. PM BART EVALUATION

PM is generated by the kiln and clinker cooler. The PM emissions are from the kiln are currently controlled by an ESP, and the PM emissions from the clinker cooler are controlled by a baghouse.

The maximum daily PM_{10} emission rates that were modeled for the BART applicability determination are summarized in Table 6-1.

TABLE 6-1. EXISTING MAXIMUM 24-HOUR PM_{10} EMISSION RATE

	PM_{10} 24-Hour Emission Rate (ton/24-hr)	PM_{10} Hourly Emission Rate (lb/hr)
Kiln	0.45	37.17
Clinker Cooler	0.07	6.00

A comparison of Table 6-1 with Table 4-1 and Table 5-1 shows that the current PM_{10} emission rates for the kiln and clinker cooler are much less than the current emission rates of SO_2 and NO_X for the kiln. The low PM_{10} emission rates correspond to low visibility impacts attributable to PM_{10} when compared to the impacts attributable to SO_2 and NO_X, as shown in Table 6-2.

TABLE 6-2. VAP VISIBILITY IMPAIRMENT CONTRIBUTIONS AT GATES OF THE MOUNTAINS

98th Percentile Impact (Δ dv)	Visibility Impairment Attributable to SO_4[1] (%)	Visibility Impairment Attributable to NO_3[2] (%)	Visibility Impairment Attributable to PM_{10}[3] (%)
2.16	23.1	66.5	10.4

1 The visibility impairment attributable to SO_4 is primarily from SO_2 emissions. A very small portion is from SO_4 emitted as condensable particulate.

2 The visibility impairment attributable to NO_3 is entirely from NO_X emissions.
3 The visibility impairment attributable to PM_{10} is the sum of the visibility impairment attributable to all modeled primary PM species (PMc, PMf, EC, and SOA).

As mentioned, the kiln has an existing ESP for particulate matter control. The ESP is the most effective particulate matter control device for a wet kiln, due to the temperature of the exhaust exiting the kiln. The exhaust from the kiln is well over 500^0F at times under normal operations and would require an extensive gas conditioning system to operate a fabric filter PMCD properly.

Also, as mentioned, the clinker cooler has an existing baghouse for particulate matter control. A baghouse is currently the best device for controlling particulate matter from a source.

As no particulate control devices were identified that are more effective than the existing PMCDs, AGC proposes that no additional PM control technologies are required for either the kiln or clinker cooler for BART. AGC believes that the existing controls are the best, most technically feasible controls for these types of sources. Because AGC is proposing to retain the most effective particulate control devices on the two BART units, there is no need to evaluate other impacts in establishing these control technologies as BART.

APPENDIX B: 2011 RESPONSE

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October 5, 2011

U.S Environmental Protection Agency Region 8
1595 Wynkoop St.
Denver, CO 80202-1129
Attention: Vanessa Hinkle, 8P-AR

Re: Response to Request for Additional Information for Montana City BART Determination

Dear Vanessa:

On September 19, 2011, Ash Grove Cement Company ("Ash Grove") received by mail your information request made pursuant to Section 114 of the Clean Air Act and requesting information for use in determining Best Available Retrofit Technology ("BART") for the Montana City facility. Specifically, you requested that Ash Grove document that wet scrubbing is not technically feasible and that Ash Grove submit a five factor analysis of dry scrubbing techniques. This submittal was requested to be submitted by September 30, 2011—9 working days after receipt of the 114 request by mail. As I communicated to you, Ash Grove believes that this is an unreasonable amount of time to allow for response to such a significant request. A complete 5 factor analysis cannot be performed in 9 days. However, Ash Grove committed to do the best it could do within the time frame allowed. This letter constitutes Ash Grove's response to this request.

I. Confidential Business Information

Ash Grove is claiming confidential business information ("CBI") status for the information provided in this 114 response. This information complies with 40 CFR §§ 2.203(b) and 2.301 as well as Montana law. The identified information is eligible for CBI treatment under 40 CFR § 2.208 for the following reasons: (a) this claim of confidentiality has not expired by its own terms, been withdrawn, or waived; (b) Ash Grove does not release information claimed as CBI to non-employees; only limited authorized employees have access to the financial information and production information claimed as CBI; Ash Grove intends to continue to keep internal distribution of this material limited and external distribution of this material prohibited; (c) the information is not obtainable without Ash Grove's consent; (d) there is no statutory obligation to disclose this information; and (e) disclosure of this information would harm Ash Grove's competitive position by making capital investment, cost of production, and operating information, not otherwise available, potentially known to Ash Grove's competitors.

The cement business is intensely competitive as manufacturers compete for shares in a limited market. The market is increasingly threatened by the import of overseas products and by new competitors. Consequently, information related to production, operation, performance, cost, pricing, and value, if disclosed to competitors can reveal critical data regarding Ash Grove's ability to compete in the market.

II. Background

Ash Grove's Montana City kiln is a long wet kiln that has been in operation since 1963. The kiln currently employs an electrostatic precipitator ("ESP") for the control of particulate ("PM"), good combustion practices and burner pipe maintenance/position for NOx control and inherent scrubbing and the use of low sulfur coal as a component of the fuel mix for SO_2 control. As was previously described in Ash Grove's February 28, 2008 letter to Ms. Callie Videtich, a mass balance of sulfur inputs and emissions indicate that in 2006 the inherent dry scrubbing achieved by the kiln design resulted in 80 percent control of SO_2. Although inlet/outlet testing has not been performed, the kiln ESP would be expected to achieve 95 to 99 percent control. The PM emissions from the clinker cooler are controlled by a baghouse. Although inlet/outlet testing has not been performed, the clinker cooler baghouse would be expected to achieve 99 percent control.

III. Response to Questions

Ash Grove has undertaken to respond to EPA's request to the best of its ability. Ash Grove reserves all objections to this information request and the obviously inability of the company to respond to a request of this magnitude in the time provided. In your September 9, 2011 letter, you posed two questions. Each of those questions is reproduced below in italics and the response follows.

Request No 1: Support your statement that wet scrubbing is not technically feasible.

In my letter of July 18, 2011, I explained that wet scrubbers are no longer a technically feasible control for consideration as BART technology for the Montana City kiln. As explained in further detail below, this conclusion was based on an analysis performed consistent with EPA's guidance in the July 6, 2005 BART guidelines.

In a BART analysis data are collected through a five step process to arrive at a selection of the best methods of emissions reduction of NO_x, SO_2, and PM at the BART source. The five steps followed to develop information for making the BART determination are the following:

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

These steps generate data that are used to evaluate the costs and benefits of various control technologies and, ultimately, identify the retrofit technology appropriate for installation at the source.

Step 2 of the BART analysis involves the evaluation of all the identified available retrofit control technologies to determine technical feasibility. A control technology is technically feasible if it has been previously installed and operated successfully at a similar type of source or if there is technical agreement that the technology can be applied to the source. Two terms, "available" and "applicable," are used to define the technical feasibility of a control technology. A technology that is being offered commercially by vendors or is in commercial demonstration or licensing is generally deemed an available technology. Technologies that are in development and testing stages are classified as not available. Similarly, unless a technology can be demonstrated to comply with all applicable requirements, it cannot be considered available. The fact that a technology might be considered available is not a sufficient basis for concluding that a technology is applicable, and, therefore, technically feasible. A commercially available technology must also be "applicable," i.e., it must have been previously installed and operated at a similar type of source or a source with similar gas stream characteristics. Unless the technology is identified as both available and applicable, the technology is not considered technically feasible and, therefore, is not carried into Step 3 of the BART analysis process.

Wet scrubbing is no longer an "available" control technology for wet cement kilns. As part of the February 28, 2008 BART submittal, Ash Grove included a proposal from MECS for its Dynawave Scrubbing System. At that time, wet scrubbing was considered technically feasible for a wet kiln such as the one employed at Ash Grove's Montana City plant. The MECS proposal was dated April 27, 2007 and thus predated by several years the imposition of stringent new and existing source PM limits for cement kilns. At that time, the other primary supplier of wet scrubbing technology to the cement industry was Solios. Since the 2007 proposal was issued, EPA has imposed stringent new PM requirements. Specifically, the revised NESHAP

PM limit for existing kilns is 0.04 lb/ton clinker and the limit for new kilns is 0.01 lb/ton clinker. The revised NSPS limit for new, modified or reconstructed kilns is also 0.01 lb/ton clinker. Since these standards were issued, Solios withdrew from the market, now being unwilling to guarantee that their wet scrubbing technology will meet the cement NSPS and NESHAP PM limits. Similarly, MECS will not guarantee that its Dynawave technology will meet the NSPS and new source NESHAP limits. The total capital cost of installing a wet scrubber (based on a 2010 MECS proposal) is slightly more than $30 million (see attached cost-effectiveness analysis for costing details). Ash Grove could not be realistically expected to install a $30 million control system on a 50 year old kiln without upgrading the kiln to maximize its output. Such a capital outlay would not be justified under any circumstances, but certainly not where the kiln is operating at its current levels. If EPA requires installation of a $30 million wet scrubber, the result will either be plant closure or reconstruction of the kiln. Reconstruction of the kiln would necessarily trigger NSPS and the 0.01 lb/ton clinker PM standard which the wet scrubber manufacturers will not guarantee that a wet scrubber can meet. Because a wet scrubber is not available, as that term is used in the BART guidelines, the technology cannot be considered technically feasible.

Wet scrubbing is also not an applicable technology for a wet kiln such as Ash Grove's Montana City kiln. The Montana City kiln is a long wet kiln. Although there are 5 kilns in the U.S. that are using wet scrubbers to control SO_2 emissions, none of these kilns are wet kilns. Each of the 5 kilns is a preheater/precalciner kiln. There is no basis for assuming that the technology employed on a preheater/precalciner kiln will be transferrable over to a long wet kiln without extensive experimentation and pilot studies to determine how the equipment must be modified to meet the PM standards. Therefore, wet scrubbing is not applicable, as that term is used in the BART guidelines, and so cannot be considered technically feasible.

Ash Grove performed an independent analysis of the limited data available on those few kilns where wet scrubbers have been installed in order to verify the PM compliance issue. As noted above, the 5 kilns in the U.S. using wet scrubbers to control SO_2 emissions are all preheater/precalciner kilns while the Montana City kiln is a long wet kiln. The significantly different exhaust gas characteristics between a preheater/precalciner kiln and a long wet kiln are, in part, responsible for the technology not being directly transferrable. For example, the air flow through a wet kiln is roughly twice that of a dry kiln on a dscf/ton feed basis. However, even if those differences are disregarded, the evidence indicates that a wet scrubber will increase filterable particulate matter emissions to a point that the plant will be unable to consistently meet the existing source NESHAP PM emission limit of 0.04 lbs/ton of clinker, let alone the new source emission PM limit (NSPS and NESHAP) of 0.01 lbs/ton of clinker. This conclusion is based on the data Ash Grove collected and assessed of PM emission tests for four of the five kilns to determine the expected PM emissions from a wet scrubber on a cement kiln.

As EPA has previously recognized, in order to accurately predict long term performance, it is necessary to take into account the variability that occurs test-to-test as well as run-to-run. EPA has long understood that it must employ statistical methodologies to address the need to account for variability in developing emission limits that accurately represent the ability of a source to perform over an extended period of time. For example, EPA stated in the preamble to the Hazardous Waste Combustor ("HWC") NESHAP that "sources which are lowest emitting in single emission tests may not be the lowest emitters over time due to their test-to-test variability." 72 Fed. Reg. 54875, 54878 (Sept. 27, 2007). Later in the HWC NESHAP, EPA discussed the issue of variability for controls other than fabric filters ("FF"):

> Sources equipped with control devices other than FFs are likely to emit more over time than they do in individual test conditions, even after adjusting test results to account for run-to-run variability. (Put another way, these sources' performance in individual test conditions are likely not representative of what they will emit over time.) This is because test-to-test variability, that is, long-term variability, has not been taken into account. Since these other control devices are known to be more variable and less efficient than FFs, TSD Vol. III pp. 16–3 to 4 and 11, failure to consider long-term variability (i.e., looking exclusively at results of single performance tests) results in these sources' performance not being fully characterized. Long-term variability exists due to, among other things, variation over time in control device performance and varying ash feed rates. EPA confirmed in a series of analyses of HWCs that this test-to-test variability for non-FF equipped devices both exists and is appreciable. *Id* at 54878-79.

This same issue of variability and the need to account for it was discussed extensively in the PC NESHAP. In that context, EPA stated that it sought to define the NESHAP limits based on the use of available data such that if they were to randomly select a future test from any of the sources, they would be 99 percent confident that the future value would fall below the established limit. 75 Fed. Reg. 54969, 54975 (Sept. 9, 2010).

Although Ash Grove does not necessarily agree that EPA's approach is a fair method to use to set enforceable limits monitored using CEMs, Ash Grove applied a similar methodology to evaluate how the wet scrubber controlled kilns would perform. First, in order to normalize results and employ the available data, it was necessary to determine what grain loading would be necessary in order to achieve the existing source PM standard of 0.04 lbs/ton of clinker. This was determined by taking the actual flow rate and production levels during several source tests performed at the Montana City kiln. This gives the information necessary to convert the lbs/ton clinker limit to a gr/dscf limit.

Table 1: Montana City Kiln

Date of Test Run	Flow Rate (dscfm)	Production Rate (TPH)	dscf/ton clinker	MACT Limit-pounds per ton of clinker	MACT Limit - Grains per ton of clinker	Grains per dscf to meet the MACT Limit during this stack test
9/7/2010	56649	38.8	87601.5	0.04	280	0.00320
9/7/2010	61164	38.9	94340.4	0.04	280	0.00297
9/7/2010	64547	39.0	99303.1	0.04	280	0.00282
9/8/2010	58938	38.8	91141.2	0.04	280	0.00307
9/8/2010	60382	38.9	93134.2	0.04	280	0.00301
9/8/2010	56870	38.9	87717.2	0.04	280	0.00319
10/7/2009	57471	39.3	87742.0	0.04	280	0.00319
10/7/2009	58772	39.3	89728.2	0.04	280	0.00312
10/7/2009	57682	39.3	88064.1	0.04	280	0.00318
					Average	0.00308
					STDev	0.00013
					95% Percentile (low)	0.00287
					95% Percentile (high)	0.00330
					Minimum	0.00282

In evaluating the results of this conversion, Ash Grove applied a 90 percent confidence interval by adding 1.65 standard deviations ("STDev") to the average of the data set. Because a 90 percent confidence interval means that there is a 90 percent likelihood that a value will not lie above or below the data set, this means that if EPA sets a limit equal to the 90 percent confidence interval, they would predict that 5 percent of future test values would fall outside of each end of the range. As this test is not as rigorous as the one defined by EPA in the PC NESHAP, if the 90 percent confidence interval generates a value equal to or greater than the regulatory limit, the kiln in questions would not be deemed compliant.

Ash Grove found one stack test for the Holcim kiln located in Florence, Colorado. This preheater/precalciner kiln employs a wet scrubber to control SO_2 emissions and there is a baghouse upstream of the wet scrubber. The PM emission rate from this single test was 0.0020 gr/dscf. While this might suggest that a wet scrubber controlled kiln could comply with the range of grain loading limits necessary to achieve compliance with the existing source standard at Montana City, more comprehensive testing at other kilns with wet scrubbers paints a very different picture.

Ash Grove found two stack tests for the TXI kiln located in Midlothian, Texas. This preheater/ precalciner kiln employs a wet scrubber to control SO_2 emissions and has a baghouse upstream of the wet scrubber. The results of each of the runs for these two stack tests are presented in Table 2.

Table 2: TXI: Midlothian, TX

Date	Test Runs	#/hr	gr/dscf	bws	O2	T stack (F)
9/26/2006	8:30 to 9:37	12.15	0.0027	0.180	12.4	286
9/26/2006	13:38 to 14:47	10.3	0.0023	0.187	11.6	283
9/29/2006	8:07 to 9:13	7.67	0.0017	0.183	11.6	280
9/28/2006	6:35 to 7:51	16.45	0.0040	0.181	11.4	272
9/28/2006	10:20 to 11:28	8.54	0.0020	0.185	11.8	278
9/28/2006	14:02 to 15:08	18.8	0.0046	0.186	10.4	272
	Average	12.31833	0.0029			
	STDev		0.0012			
	95% Percentile		0.0048			

These data from the TXI Midlothian kiln show that the 95th percentile grain loading based on these six test runs would be 0.0048 gr/dscf. This is well above the upper bound 95th percentile that would be required to be in compliance with the existing source PM standard at Ash Grove's Montana City kiln. Similarly, the 95th percentile value required to meet the existing source PM standard at Ash Grove's Montana City kiln is 0.0033 gr/dscf. The 95th percentile value for TXI's Midlothian kiln is significantly higher than that of the 95th percentile value at the Montana City kiln and the average value for the TXI kiln is only slightly lower that the average Montana City compliant value. This indicates that with a scrubber downstream of a baghouse, Ash Grove's Montana City kiln would be expected to violate the existing source PM standard a significant amount of the time. This is not consistent with EPA's stated target of being 99 percent confident that future values would fall below the established limit.

Data from nine stack tests for the Holcim Kiln 1 located in Midlothian, Texas further bear out this trend. Holcim Kiln 1 is a preheater/ precalciner kiln that employs a wet scrubber to control SO_2 emissions with an upstream baghouse to control particulate. The results of those stack tests are presented in Table 3.

Table 3: Holcim Kiln No. 1; Midlothian, TX

Test Date	#/hr	gr/dscf	bws	O2	T stack (F)
10/9-10/2000	13.21	0.0056	0.188	12.4	137
10/11-13/2000	16.15	0.0074	0.196	13.2	139
6/24-25/2002	8.64	0.0034	0.192	12.2	138
6/25-26/2002	15.90	0.0062	0.184	11.7	139
11/3/2004	5.53	0.0020	0.180	14.2	135
11/4/2004	17.00	0.0062	0.192	12.6	138
3/14/2007	3.91	0.0015	0.172	13.2	133
3/15/2007	11.82	0.0057	0.206	11.1	141
8/25/2008	11.10	0.0042	0.218	12.5	146
Average	11.47	0.0047			
STDev		0.0020			
95th Percentile		0.008			

As can be seen from this set of source tests, the average grain loading at Holcim's Kiln No. 1 is well in excess of the upper bound 95th percentile value of grain loadings that would demonstrate compliance with the existing source PM standard at Ash Grove's Montana City . As with the TXI kiln data, the Holcim Kiln No. 1 data indicate that using a wet scrubber downstream from a baghouse would result in Ash Grove's Montana City kiln exceeding the existing source PM standard considerably more than 50 percent of the time.

This is again demonstrated when examining the data from Holcim Kiln No. 2 in Midlothian, TX. Ash Grove obtained sixteen stack tests for the Holcim Kiln 2, thus providing a very robust data set. As with the other kilns examined, this preheater/ precalciner kiln employs a wet scrubber to control SO_2 emissions with a baghouse upstream of the scrubber. The results of the stack tests from Holcim Kiln No. 2 are shown in Table 4.

Table 4: Holcim Kiln No. 2; Midlothian, TX

Test Date	#/hr	gr/dscf	bws	O2	T stack (F)
12/4-5/2000	11.75	0.0046	0.189	12.9	141
1/3-4/2001	15.85	0.0069	0.182	12.9	145
6/24-25/2002	3.75	0.0014	0.207	13.0	142
6/25-27/2002	5.97	0.0021	0.207	12.7	142
8/26/2003	15.30	0.0057	0.195	10.3	139
11/4/2004	1.06	0.0016	0.188	13.3	137
11/3/2004	9.20	0.0035	0.175	13.5	135
2/28 -3/02/2007	6.36	0.0022	0.168	12.2	134
2/28 -3/01/2007	8.09	0.0031	0.174	11.6	136
8/28/2008	18.30	0.0062	0.195	12.8	146
7/30/2009	16.00	0.0056	0.189	13.0	138.7
7/30-31/2009	8.60	0.0031	0.208	12.3	141.4
7/21/2010	4.80	0.0017	0.178	13.0	144.5
7/20/2010	9.00	0.0033	0.184	12.8	137.2
11/9/2010	1.14	0.0004	0.164	13.2	135
11/9-11/2010	2.75	0.0011	0.169	12.6	135
Average	8.62	0.0033			
STDev		0.0020			
95th Percentile		0.0066			

Again, as with all of the tests except the single test on the Florence kiln, these data clearly show that a kiln with a wet scrubber, even one with a baghouse upstream of that scrubber, cannot reliably meet the existing source NESHAP PM limit. The average value for all of these tests is 0.0033 gr/dscf—exactly equal to the upper bound 95th percentile for the range of grain loadings predicted to meet the existing source PM standard at the Montana City kiln. Thus, these data indicate that were the Montana City kiln to employ a wet scrubber, it would be expected to exceed the existing source PM standard approximately half of the time.

No stack tests were found for the Lehigh Davenport kiln.

These stack test results provide a compelling basis for concluding that if the Montana City cement kiln employs a wet scrubber, it cannot reliably meet the existing source NESHAP PM limit. The data summarized above demonstrate that a kiln with a wet scrubber would at best meet the PM standard only about half of the time. However, the NESHAP requires that kilns demonstrate continuous compliance utilizing a PM CEM. Given the available data, one cannot conclude that compliance with the existing source PM limit can be consistently demonstrated when a PM CEM is employed. This explains why one leading manufacturer of wet scrubbers for the cement industry is no longer selling wet scrubbers for cement kilns and the other primary manufacturer will no longer provide written guarantees that the equipment will meet the standard. In light of the test data and the lack of confidence of the manufacturers that their wet scrubbing equipment can meet the existing source PM standard (let alone the standard that would apply if Ash Grove were to reconstruct its kiln) there is no basis on which to conclude that wet scrubbing is currently technically feasible. EPA cannot consider a control technology to be technically feasible if those controls are unlikely to be capable of operation without causing the Montana City plant to exceed the existing source PC NESHAP PM standard.

In addition to the technical feasibility issues associated with the inability of the Montana City kiln to comply with the PC NESHAP and NSPS PM standards, wet scrubbing is also technically infeasible due to the lack of available water to operate the scrubber. Since the 2007 BART analysis was prepared, the State of Montana has decreased the water right held by Ash Grove's Montana City plant to match historical use. As a result, a considerable amount of the water for which the plant previously held a water right, has now been withdrawn by the State. The Montana City plant is in an area that only receives 11.9 inches of water per year. In such an area, water is an extremely valuable commodity. Because of the overappropriation of water rights, the State has become increasingly active in trimming existing water rights to match historic use. This is what occurred to Ash Grove. A wet scrubber is anticipated to consume approximately 38 gallons/minute of water, a total of approximately 19 million gallons/yr (~61 acre-ft/year). EPA cannot require Ash Grove to install and operate such a technology in an arid part of the country where there is no certainty that Ash Grove would even be able to obtain a 61 acre-ft/year water right. Furthermore, even if Ash Grove were able to obtain a water right to such a large quantity of water, there is no guarantee that the company would be able to rely on that water right. In a dryer year than normal, a more senior water rights holder could require that Ash Grove cease its use thus resulting in the closure of the plant. The large amount of water required to operate a wet scrubber in the arid location of the Montana City plant poses one more reason why a wet scrubber is not technically feasible.

For the reasons stated above, Ash Grove has concluded that wet scrubbing is not a technically feasible technology for the wet kiln at the Montana City plant. We also note that based on Ash Grove's latest information regarding the cost of wet scrubbing, the cost per ton of SO_2 controlled is nearly $11,000 per ton. We have included with this response the most recent cost-effectiveness calculations prepared by Trinity Consultants. At this cost, wet scrubbing is unquestionably not cost-effective and so cannot be considered BART for SO_2.

Request No 2: Submit a 5 factor analysis of dry scrubbing techniques

You had also requested that Ash Grove conduct a 5 factor analysis of dry scrubbing technologies for SO_2 control. Although you did not define what you meant by "dry scrubbing technologies," Ash Grove conservatively opted to include both Dry Adsorbant Addition ("DAA") as well as Semi-Wet Scrubbing.

The BART rule states that a BART determination should address the following five statutory factors:

1. Existing controls
2. Cost of controls
3. Energy and non-air quality environmental impacts
4. Remaining useful life of the source
5. Degree of visibility improvement as a result of controls

Further, the BART rule indicates that the five basic steps in a BART analysis can be summarized as follows:

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

Ash Grove has prepared this analysis specific to DAA and semi-wet scrubbing, while otherwise remaining consistent with the methodology outlined above.

1. Identify All Available Retrofit Control Technologies

As at EPA's request, this analysis is limited to DAA and semi-wet scrubbing, this particular step of the analysis is pre-determined.

2. Eliminate Technically Infeasible Control Technologies

Ash Grove believes that neither DAA nor semi-wet scrubbing is technically feasible. DAA is in the earliest stages of development and while various companies have begun experiments in its application to cement kilns, it is not a proven technology at this time.

Semi-wet scrubbing is similarly unproven. Semi-wet scrubbing is not being operated on any cement kiln in the country. Ash Grove has proposed semi-wet control to EPA Headquarters in relation to its Midlothian, TX plant, but as an Innovative Control Technology project where Ash Grove would seek to implement a pilot project for the technology. That site was chosen because its SO_2 emissions are several fold higher than those from the Montana City plant. As discussed above, a control technology is technically feasible only if it has been previously installed and operated successfully at a similar type of source or if there is technical agreement that the technology can be applied to the source. In addition, the technology must be both "available" and "applicable." Technologies that are in development and testing stages are not considered available. A commercially available technology must also be "applicable," i.e., it must have been previously installed and operated at a similar type of source or a source with similar gas stream characteristics. Unless the technology is identified as both available and applicable, the technology is not considered technically feasible and, therefore, is not carried into Step 3 of the BART analysis process. Because semi-wet scrubbing is not being operated on any cement kiln in the country, let alone a wet cement kiln, it is not considered technically feasible. Again, as was clearly stated in the BART rule preamble, "[EPA does] not expect a source owner to conduct extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, you would not consider technologies in the pilot scale testing stages of development as ''available'' for purposes of BART review." 70 Fed. Reg. at 39165. As semi-wet scrubbing is in the pilot scale testing stages of development, it must be eliminated from consideration in Step 2.

Although both DAA and semi-wet scrubbing are properly eliminated in Step 2, we have nonetheless carried both technologies through into the subsequent steps. For DAA, this is because Ash Grove is proposing to install DAA as an innovative control technology on its Montana City kiln. For semi-wet scrubbing, Ash Grove has carried the technology through the subsequent stages so as to document all of the additional reasons why, even if it were technically feasible, semi-wet scrubbing would not constitute BART.

3. Evaluate The Control Effectiveness Of Remaining Control Technologies

Because of the technical infeasibility issues associated with both DAA and semi-wet scrubbing, it is extremely difficult to estimate the control effectiveness. For DAA, there is no record which can be used to estimate a specific system removal efficiency ("SRE"). Given the lack of information, Ash Grove is conservatively estimating that it will achieve an SRE of 20 percent of the existing baseline.[1] Ash Grove has also conservatively estimated that semi-wet scrubbing

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[1] Ash Grove wishes to note that the existing baseline SO_2 emission rate has changed since the 2007 BART submittal. As described in the 2007 document, an SO_2 CEM had been operating

(continued . . .)

will achieve an SRE of 90 percent. While the SRE for semi-wet scrubbing may be extremely optimistic, Ash Grove does not believe that it changes the outcome of this analysis.

4. Evaluate Impacts And Document The Results

Step four for the BART analysis procedure is the impact analysis. The BART determination guidelines list the four factors to be considered in the impact analysis:

- Cost of compliance
- Energy impacts
- Non-air quality environmental impacts; and
- The remaining useful life of the source

AGC has conducted an impact analysis for both of the two control options notwithstanding the fact that neither is considered technically feasible.

Cost of Compliance

Ash Grove's construction consultant derived the cost of a semi-wet scrubbing system based on a vendor quote that was not site-specific. Based on this cost, Trinity Consultants performed an economic analysis to determine the annualized cost for semi-wet scrubbing using the standardized OAQPS format. Ash Grove divided the annualized cost of semi-wet scrubbing by the annual tons of SO_2 reduced to determine the cost effectiveness for semi-wet scrubbing. The "annual tons reduced" were determined by subtracting the estimated controlled annual emissions

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(. . . continued)
only a short time as of the preparation date of that submittal. As a result, very little was known about the variability of the SO_2 emission rate or how to control that emission rate through process changes. Since that time the plant management has employed the CEM to adjust kiln operation in a manner that the SO_2 emission rate has decreased considerably. Specifically, in the original BART submittal Ash Grove estimated that the annual SO_2 emission rate was 981 tons/yr derived by multiplying the average emission rate during 2006 (254 lb/hr) by the annual operating hours (7,740 hours). Based on the average emission rate during 2010, Ash Grove now estimates the hourly SO_2 emission rate as 612 tons/yr. Ash Grove believes that this revised emission rate, which assumes an average emission rate of 147 lb/hr and 95 percent availability (8,322 hours), more accurately characterizes the baseline emission rate for the plant as it has been operated during the past several years.

from the baseline annual emission rate of 612 tons/yr (see above). The estimated controlled annual emissions were calculated by applying the 90 percent control efficiency to the baseline annual emissions rate. The attached cost-effectiveness spreadsheet provides the cost effectiveness analysis related to semi-wet scrubbing. As can be seen from the analysis, the cost of control is not considered cost-effective. Other BART determinations have considered costs in excess of $4,000 per ton of pollutant controlled to be excessively expensive. Here, Ash Grove has documented that the cost would be $4,052/per ton. This is not considered cost-effective.

As Ash Grove is proposing to employ DAA as BART, it did not prepare a cost-effectiveness analysis for the technology.

Energy Impacts

A semi-wet scrubber requires an additional fan of considerable horsepower to move the flue gas through the scrubber. Therefore, this element of the analysis also weighs against requiring a semi-wet scrubber as BART.

Non-Air Quality Environmental Impacts

The key non-air quality environmental impacts associated with semi-wet scrubbing, as opposed to DAA, is the consumption of water. DAA relies on the inherent moisture in the exhaust gas to operate. By contrast, semi-wet scrubbing requires 3.5 gallons/minute or nearly 2 million gallons of water per year. As noted above, the Montana City plant is located in an extremely arid location and its water right was just severely reduced by the State of Montana to match historic use. This means that new water use would require ash Grove to obtain additional water rights in an area where all surface water is fully appropriated and groundwater is limited and subject to being turned off during dry periods if a senior water right is affected. EPA has a long record of not requiring water intensive control technologies in arid regions due to the severe environmental impacts. In this case, semi-wet scrubbing should not be required as BART due to its consumption of significant quantities of water that may simply not be available.

Remaining Useful Life of Source

Ash Grove does not believe that the remaining useful life of the source is a relevant factor to the analysis.

5. Evaluate Visibility Impacts

The final step of the analysis is to evaluate the visibility impacts associated with the different control alternatives. In performing this assessment, it is important to note that SO_2 is not a controlling pollutant in Ash Grove's visibility analysis. The predominant driver of visibility impacts at Class I areas from the Montana City kiln are the NOx emissions. SO_2 emissions contribute an almost insignificant amount to visibility impacts from the Montana City plant. As Table 5 below shows, this means that the imposition of any SO_2 control at the plant results in minimal visibility improvement. The incremental improvement in visibility attributable to requiring semi-wet scrubbing as BART is a mere 5 percent improvement or a 0.16 dv improvement in visibility. Based on the annualized cost of the semi-wet scrubbers, this results in a cost of well over $13 million dollars per deciview of improvement. This cost is clearly not justified and semi-wet scrubbing should not be required as BART.

TABLE 5

	Maximum 8th High (Δdv)	Change From Baseline (dv)	Percent Improvement
Existing	2.699	--	--
DAA	2.666	-0.033	1 %
Semi-Wet Scrubber	2.539	-0.16	6 %

A more detailed summary table of the modeling results is included as an attachment to this letter.

6. Select BART for SO_2

Based on the analysis above, there is a strong argument that semi-wet scrubbing is not a technically feasible control technology. However, even if that concern is ignored, the environmental impacts, cost impacts and lack of any material improvement in visibility associated with semi-wet scrubbing all combine to demonstrate that it would be arbitrary and capricious to consider this technology to constitute BART. Although similar arguments against DAA being a technically feasible control technology exist, Ash Grove is willing to take on this technology as a innovative control and commit to operate the technology such that SO_2 emissions are limited to 147 lb/hr (30 day rolling average). As with semi-wet scrubbing, this control technology will not result in significant visibility improvement. However, the development of DAA technology for wet kilns may prove useful at other plants across the country and so there is separate merit in installing the technology.

IV. PM BART

Although EPA did not request additional information regarding BART for PM, Ash Grove wanted to update the agency as to its current plans for PM control. As noted above, Ash Grove currently operates an ESP for controlling PM from the kiln. Estimated annual PM emissions have averaged approximately 100 tons/yr with the ESP in operation. However, Ash Grove is moving forward with installing a baghouse on the kiln exhaust which it anticipates will decrease kiln PM emissions from approximately 37 lb/hr used in the modeling to approximately 5 lb/hr, an estimated reduction in actual PM emissions of over 85 percent. While NOx, not PM, is not the primary driver of visibility impacts, we wished to make EPA aware of this increase in emissions control that the company is investing in.

V. Statement of Certification

Included as an attachment to this letter is a Statement of Certification from Dick Johnson, the plant manager of Ash Grove's Montana plant, certifying the accuracy of the statements and materials comprising this submittal. However, Ash Grove is unable to certify that the submittal is complete given the unreasonably short time frame allowed for the response.

Please let me know if you have any questions after reviewing this submittal.

Sincerely,

Thomas R. Wood

cc: Dick Johnson
Jeff Briggs
Fran Streitman
Curtis Lesslie
Bob Vantuyl
Kasi Dubbs

Attachments:

1. Wet scrubber cost-effectiveness analysis
2. Semi-wet scrubber cost-effectiveness analysis
3. Revised modeling summary
4. Certification statement

AGC Montana City
SO_2 Control Cost Effectiveness Analysis
Wet Scrubber

			Notes
Direct Costs			
Purchased Equipment Costs			
	Wet Scrubber Unit	$12,140,000	MECS Dynawave Scrubber Quote 2010 ($9,000 k Scrubber, $1,500 k Reagent prep & filter, $240 k Filter building, $800 k Sludge disposal, $600 k Effluent handling)
	Instrumentation	incl	
	Sales Tax (3% of EC)	$364,200	0.03 A
	Freight (5% of EC)	$607,000	0.05 A
	Subtotal, Purchased Equipment Cost (PEC)	$13,111,200	B
Direct Installation Costs			
	Foundation (6% of PEC)	$786,672	0.06 B, from CONTROL COST MANUAL - EPA 452/B-02-001 (CCM)
	Supports (6% of PEC)	$786,672	0.06 B, from CCM
	Handling and Erection (40% of PEC)	$5,244,480	0.40 B, from CCM
	Electrical (1% of PEC)	$131,112	0.01 B, from CCM
	Piping (30% of PEC)	$3,933,360	0.30 B, from CCM
	Insulation for Ductwork (1% of PEC)	$131,112	0.01 B, from CCM
	Painting (1% of PEC)	$131,112	0.01 B, from CCM
	Subtotal, Direct Installation Cost	$11,144,520	
	Total Direct Cost	**$24,255,720**	
Indirect Costs			
	Engineering	$260,000	MECS Dynawave Scrubber Quote 2010
	Construction and Field Expense (10% of PEC)	$1,311,120	0.10 B, CCM
	Contractor Fees (10% of PEC)	$1,311,120	0.10 B, CCM
	Start-up (1% of PEC)	$131,112	0.01 B, CCM
	Performance Test (1% of PEC)	$131,112	0.01 B, CCM
	Contingencies (20% of PEC)	$2,622,240	AGC - Engineering Estimate
	Total Indirect Cost	**$5,766,704**	
	Total Capital Investment (TCI)	**$30,022,424**	
Direct Annual Costs			
Hours per Year	95% Annual Run Time	8,322	
Operating Labor			
	Operator (0.5 hr/shift, 3 shifts/day, 365 d/yr, $25/hr)	$13,688	estimate
	Supervisor (15% of operator)	$2,053	CCM
	Subtotal, Operating Labor	$15,741	
Maintenance			
	Labor (0.5 hr/shift, 3 shifts/day, 365 d/yr, $25/hr)	$13,688	estimate
	Material (100% of maintenance labor)	$13,688	CCM
	Subtotal, Maintenance	$27,375	
Utilities			
	Electricity		
	Pump (kW)	463.51	MECS Dynawave Scrubber Quote 2007, 510 hp (380 kW) system usage, scaled up according to 0.6 power rule from 75,000 scfm (115,057 acfm) to 160,000 acfm @ 350 deg F flue gas flow rate
	Cost ($/kW-hr)	$0.0671	NorthWestern Energy, small industry, Helena, MT [a]
	Subtotal, Electricity	$258,827	
	Limestone Slurry		
	Amount Required (ton/yr)	3,296	MECS Dynawave Scrubber Quote 2007, 650 lb/hr limestone usage scaled up according to 0.6 power rule from 75,000 scfm (115,057 acfm) to 160,000 acfm @ 350 deg F flue gas flow rate
	Cost ($/ton)	$15.00	($15 from Table 3.1-2 of NLA[b] evaluation)
	Subtotal, Lime	$49,446	
	Water		
	Amount Required (gpm)	37.8	MECS Dynawave Scrubber Quote 2007, 31 gal/min water usage scaled up according to 0.6 power rule from 75,000 scfm (115,057 acfm) to 160,000 acfm @ 350 deg F flue gas flow rate
	Cost ($/1000 gallons)	$3.476	Helena Water - $2.60 per 748 gallons [c]
	Subtotal, Water	$65,575	
	Sludge Disposal		
	Amount Generated (tpy)	6,846	MECS Dynawave Scrubber Quote 2007, 1,350 lb/hr sludge generation, scaled up according to 0.6 power rule from 75,000 scfm (115,057 acfm) to 160,000 acfm @ 350 deg F flue gas flow rate
	Disposal Fee ($/ton)	$50.00	Lewis and Clark County Landfill [d]
	Subtotal, Sludge	$342,315	
	Subtotal, Utilities	$716,162	
	Total Direct Annual Costs	**$759,278**	
Indirect Annual Costs			
Overhead (60% of sum of operating, supervisor, maintenance labor & materials)		$300,271	Does not include electricity
Administrative (2% TCI)		$600,448	0.02 TCI
Property Tax (1% TCI)		$300,224	0.01 TCI
Insurance (1% TCI)		$300,224	0.01 TCI
Capital Recovery	(15 year life, 7 percent interest)	$3,296,301	
	Total Indirect Annual Cost	**$4,797,468**	
Conclusion			
	Total Annualized Cost	**$5,556,746**	
	Pollutant Emission Rate Prior to Scrubber (tons SO_2/yr)	**612**	Based on 2010 average emission rate of 147 lb/hr SO2 (with process controls implemented), 95% uptime
	Pollutant Removed (tons SO_2/yr)	**523**	90% removal. Assumes 95% control equipment uptime
	Cost Per Ton of Pollutant Removed	[redacted]	
	Total Annualized Cost	**$5,556,746**	
	Deciview Improvement	**0.160**	
	$ / Deciview Improvement	**$34,729,663**	

a http://www.northwesternenergy.com/ourcustomers/shared/ratecompare.aspx

b NLA Evaluation - WET FLUE GAS DESULFURIZATION TECHNOLOGY EVALUATION, JANUARY 2003 (Sargent and Lundy LLC)

c http://www.ci.helena.mt.us/departments/administrative-services/finance/utility-customer-services/customer-inquiries/water-rates.html

d http://www.co.lewis-clark.mt.us/departments/public-works/solid-waste.html

AGC Montana City
SO_2 Control Cost Effectiveness Analysis
Semi-Wet Scrubber

			Notes
Direct Costs			
Purchased Equipment Costs			
	Scrubber Unit	$3,690,000	Solios Enhanced Semi-wet Scrubber Quote 2010 (2010 Quote)
	Instrumentation	$730,000	2010 Quote
	Sales Tax (3% of EC)	$132,600	0.03 A
	Freight	$300,000	2010 Quote
	Subtotal, Purchased Equipment Cost (PEC)	$4,852,600	B
Direct Installation Costs			
	Civil Structural (incl. mat'l)	$1,020,000	2010 Quote
	Foundation	Incl	
	Supports	Incl	
	Handling and Erection	$1,690,000	2010 Quote
	Electrical	$620,000	2010 Quote
	Piping	Incl	
	Insulation for Ductwork	Incl	
	Painting	Incl	
	Subtotal, Direct Installation Cost	$3,330,000	
	Total Direct Cost	**$8,182,600**	
Indirect Costs			
	Engineering	$400,000	2010 Quote
	Construction and Field Expense	$660,000	2010 Quote
	Contractor Fees (10% of PEC)	$485,260	from CONTROL COST MANUAL - EPA/452/B-02-001 (CCM), Section 5.1, Chapter 1, Table 1.3
	Start-up (1% of PEC)	$48,526	CCM, Section 5.1, Chapter 1, Table 1.3
	Performance Test (1% of PEC)	$48,526	CCM, Section 5.1, Chapter 1, Table 1.3
	Contingencies	$1,820,000	2010 Quote
	Total Indirect Cost	**$3,462,312**	
	Total Capital Investment (TCI)	**$11,644,912**	
Direct Annual Costs			
Hours per Year	95% Annual Run Time	8,322	
Operating Labor			
	Operator (0.5 hr/shift, 3 shifts/day, 365 d/yr, $25/hr)	$13,688	estimate
	Supervisor (15% of operator)	$2,053	CCM
	Subtotal, Operating Labor	$15,741	
Maintenance			
	Labor (0.5 hr/shift, 3 shifts/day, 365 d/yr, $25/hr)	$13,688	estimate
	Material (100% of maintenance labor)	$13,688	CCM
	Subtotal, Maintenance	$27,375	
Utilities			
	Electricity		
	Demand (kW)	75.16	Estimated based on 2011 Turbosonic system for a lime kiln with 69,000 cfm flue gas at 300 deg F - 377,600 kw-hr, scaled up according to 0.6 power rule to 160,000 cfm.
	Cost ($/kW-hr)	$0.0671	NorthWestern Energy; small industry, Helena, MT a
	Subtotal, Electricity	$41,968	
	Hydrated Lime		
	Amount Required (ton/yr)	1,096	Based on 2010 average emission rate of 147 lb/hr SO2 (with process controls implemented), CaOH/SO2 ratio of 1.5, 96.8% purity
	Cost ($/ton)	$145.00	$/ton delivered (Quote from Graymont)
	Subtotal, Lime	$158,910	
	Subtotal, Utilities	$200,878	
	Water		
	Amount Required (gpm)	3.5	AGC - Engineering Estimate
	Cost ($/1000 gallons)	$3.476	Helena Water - $2.60 per 748 gallons a
	Subtotal, Water	$6,075	
	Total Direct Annual Costs	**$250,068**	
Indirect Annual Costs			
Overhead (60% of sum of operating, supervisor, maintenance labor & materials)		$124,860	
Administrative (2% TCI)		$232,898	0.02 TCI, CCM, Sec 5.1, Ch 1, Table 1.4
Property Tax (1% TCI)		$116,449	0.01 TCI, CCM, Sec 5.1, Ch 1, Table 1.4
Insurance (1% TCI)		$116,449	0.01 TCI, CCM, Sec 5.1, Ch 1, Table 1.4
Capital Recovery	(15 year life, 7 percent interest)	$1,278,549	CCM, Sec 1, Ch 2, Eqn 2.8a
	Total Indirect Annual Cost	**$1,869,205**	
	Total Annualized Cost	**$2,119,273**	
	Pollutant Emission Rate Prior to Scrubber (tons SO_2/yr)	**612**	Based on 2010 average emission rate of 147 lb/hr SO2 (with process controls implemented), 95% uptime
	Pollutant Removed (tons SO_2/yr)	**523**	90% removal. Assumes 95% control equipment uptime
	Cost Per Ton of Pollutant Removed	[redacted]	
	Total Annualized Cost	**$2,119,273**	
	Deciview Improvement	**0.160**	
	$ / Deciview Improvement	**$13,245,457**	

a http://www.ci.helena.mt.us/departments/administrative-services-finance/utility-customer-services/customer-inquiries/water-rates.html

Method 8 Mode 5 post processing.

Class I Area: Gates of the Mountain	**Natural Background Method**	**Ranked 2001 Ddv**	**Ranked 2002 Ddv**	**Ranked 2003 Ddv**	**Maximum 8th- High Ddv Ddv**	**3yr 98th Percentile (22nd High) Ddv**	**Change from Baseline Based on Maximum 8th-High Ddv**	**Percent Change from Baseline Based on Maximum 8th-High Ddv**
Baseline/Process Control	Annual Average	4.196	4.638	4.234	2.699	2.699	N/A	N/A
		3.777	4.527	4.194				
		3.698	4.037	4.072				
		3.217	3.291	3.458				
		3.118	3.169	3.300				
		2.869	2.872	2.897				
		2.769	2.724	2.768				
		2.461	2.597	2.699				
	Total # days over 0.50 ddv	98	82	71	total across 3yrs	251		
	Total # days over 1.0 ddv	56	43	42	total across 3yrs	141		
20% Reduction. DAA	Annual Average	4.170	4.581	4.174	2.666	2.666	-0.033	-1%
		3.748	4.486	4.150				
		3.629	3.984	3.987				
		3.174	3.231	3.412				
		3.094	3.112	3.240				
		2.850	2.825	2.878				
		2.706	2.69	2.681				
		2.420	2.571	2.666				
	Total # days over 0.50 ddv	98	82	69	total across 3yrs	249		
	Total # days over 1.0 ddv	55	42	41	total across 3yrs	138		
90% Reduction. Semi-Wet or Wet Scrubber	Annual Average	4.078	4.376	3.994	2.539	2.487	-0.16	-6%
		3.646	4.343	3.962				
		3.388	3.794	3.682				
		3.020	3.015	3.250				
		3.013	2.912	3.038				
		2.781	2.657	2.813				
		2.486	2.575	2.551				
		2.277	2.487	2.539				
	Total # days over 0.50 ddv	97	81	66	total across 3yrs	244		
	Total # days over 1.0 ddv	52	37	39	total across 3yrs	128		

CONCLUSION: Since Nitrates is a largest percentage of the deciview a large reduction in sulfates does not yield a large reduction in deciviews.
See individual year tabs for species % of deciview for top 22 ddv.

Statement of Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information , including the possibility of fine or imprisonment.

Signature:

Title: Plant Manager

Date: 10-5-2011