

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

VERSION 0

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June 2007

Project 071601.0069

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TABLE OF CONTENTS

1.	EXECUTIVE SUMMARY	1-1
2.	INTRODUCTION AND BACKGROUND.....	2-3
3.	BART APPLICABILITY DETERMINATION.....	3-5
4.	SO₂ BART EVALUATION	4-1
4.1	IDENTIFICATION OF AVAILABLE RETROFIT SO ₂ CONTROL TECHNOLOGIES	4-1
4.2	ELIMINATE TECHNICALLY INFEASIBLE SO ₂ CONTROL TECHNOLOGIES	4-2
4.2.1	FUEL SUBSTITUTION	4-2
4.2.2	RAW MATERIAL SUBSTITUTION	4-2
4.2.3	LIME SPRAY DRYING	4-3
4.2.4	WET LIME SCRUBBING	4-3
4.3	RANK OF TECHNICALLY FEASIBLE SO ₂ CONTROL OPTIONS BY EFFECTIVENESS ..	4-4
4.4	EVALUATION OF IMPACTS FOR FEASIBLE SO ₂ CONTROLS.....	4-4
4.4.1	WET LIME SCRUBBING	4-5
4.4.2	FUEL SUBSTITUTION	4-9
4.5	EVALUATION OF VISIBILITY IMPACT OF FEASIBLE SO ₂ CONTROLS	4-12
4.6	PROPOSED BART FOR SO ₂	4-1
5.	NO_x BART EVALUATION.....	5-3
5.1	IDENTIFICATION OF AVAILABLE RETROFIT NO _x CONTROL TECHNOLOGIES	5-3
5.2	ELIMINATE TECHNICALLY INFEASIBLE NO _x CONTROL TECHNOLOGIES	5-4
5.2.1	LOW-NO _x BURNER IN THE ROTARY KILN	5-4
5.2.2	FLUE GAS RECIRCULATION	5-6
5.2.3	CEMENT KILN DUST INSUFFLATION	5-6
5.2.4	MID-KILN FIRING OF SOLID FUEL (TIRES) WITH MIXING AIR FAN.....	5-7
5.2.5	SELECTIVE NONCATALYTIC REDUCTION.....	5-8
5.2.6	SELECTIVE CATALYTIC REDUCTION.....	5-9
5.3	RANK OF TECHNICALLY FEASIBLE NO _x CONTROL OPTIONS BY EFFECTIVENESS	5-12
5.4	EVALUATION OF IMPACTS FOR FEASIBLE NO _x CONTROLS	5-13
5.4.1	SNCR AND LNB	5-13
5.5	EVALUATION OF VISIBILITY IMPACT OF FEASIBLE NO _x CONTROLS	5-14
5.6	PROPOSED BART FOR NO _x	5-15
6.	PM BART EVALUATION.....	6-1

LIST OF TABLES

TABLE 1-1. VISIBILITY IMPAIRMENT IMPROVEMENT AT GATES OF THE MOUNTAINS WILDERNESS AREA	1-2
TABLE 3-1. SUMMARY OF U.S. EPA REGION 8 BART APPLICABILITY MODELING RESULTS	3-6
TABLE 3-2. SUMMARY OF MODELING METHOD DIFFERENCES BETWEEN EPA AND AGC	3-7
TABLE 3-3. KILN EMISSION RATES IN BART DATA SUBMITTAL VS. 2006 ANALYZER DATA.....	3-8
TABLE 3-4. EXISTING MAXIMUM 24-HOUR SO ₂ , NO _x , AND PM ₁₀ EMISSIONS (AS HOURLY EQUIVALENTS)	3-8
TABLE 3-5. SUMMARY OF EXISTING STACK PARAMETERS	3-9
TABLE 3-6. EXISTING VISIBILITY IMPAIRMENT ATTRIBUTABLE TO MONTANA CITY PLANT KILN AND CLINKER COOLER.....	3-9
TABLE 4-1. EXISTING ACTUAL MAXIMUM 24-HOUR SO ₂ EMISSION RATES.....	4-1
TABLE 4-2. AVAILABLE SO ₂ CONTROL TECHNOLOGIES.....	4-2
TABLE 4-3. RANKING OF TECHNICALLY FEASIBLE KILN SO ₂ CONTROL TECHNOLOGIES BY EFFECTIVENESS	4-4
TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING	4-6
TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING (CONTINUED).....	4-7
TABLE 4-4. COST ANALYSIS FOR WET LIME SCRUBBING (CONTINUED).....	4-8
TABLE 4-5. SUMMARY OF COST EFFECTIVENESS FOR FUEL SUBSTITUTION.....	4-11
TABLE 4-6. SUMMARY OF EMISSION RATES MODELED IN SO ₂ CONTROL VISIBILITY IMPACT ANALYSIS	4-12
TABLE 4-7. SUMMARY OF MODELED IMPACTS FROM SO ₂ CONTROL VISIBILITY IMPACT ANALYSIS.....	4-1
TABLE 4-8. SUMMARY OF COST EFFECTIVENESS OF SO ₂ CONTROL TECHNOLOGIES	4-1
TABLE 5-1. EXISTING ACTUAL MAXIMUM 24-HOUR NO _x EMISSION RATES.....	5-3
TABLE 5-2. POSSIBLE NO _x CONTROL TECHNOLOGIES	5-4
TABLE 5-3. RANKING OF TECHNICALLY FEASIBLE KILN NO _x CONTROL TECHNOLOGIES BY EFFECTIVENESS	5-13

TABLE 5-4. SUMMARY OF EMISSION RATES MODELED IN NO_x CONTROL VISIBILITY IMPACT ANALYSIS 5-15

TABLE 5-5. NO_x CONTROL VISIBILITY IMPACT ANALYSIS 5-15

TABLE 6-1. EXISTING MAXIMUM 24-HOUR PM₁₀ EMISSION RATE 6-1

TABLE 6-2. VAP VISIBILITY IMPAIRMENT CONTRIBUTIONS AT GATES OF THE MOUNTAINS 6-1

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) guidelines² 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 SO₂, NO_x, and PM₁₀ 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:

- PM₁₀ – AGC proposes that the existing electrostatic precipitator constitutes BART. This control device is the most effective for controlling PM₁₀ 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-NO_x burner (LNB) and a selective noncatalytic reduction (SNCR) system. Compliance with the emission limit will be demonstrated by continuous emissions monitoring.
- SO₂ – AGC proposes that no additional SO₂ controls are required for BART compliance. Additional SO₂ controls would provide little visibility improvement and require significant expenditures.

Clinker Cooler:

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

- PM₁₀ – AGC proposes that the existing baghouse constitutes BART. This control device is the most effective for controlling PM₁₀ 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, SO₂, and particulate matter with a mass mean diameter smaller than ten microns (PM₁₀) 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 [SO₄], and organic condensable particulate matter [OR CPM] also referred to as secondary organic aerosols [SOA]). The BART determinations for SO₂, NO_x, and PM₁₀ 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 Δ dv 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 Δ dv 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 98 th 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 SO₂ 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 SO₂ emissions data provided in that submittal was from stack testing performed in April of 2006. In May of 2006, a SO₂/NO_x analyzer was installed on the kiln exhaust and AGC has collected additional data on SO₂ and NO_x emissions from the kiln. The data from May 2006 through the end of 2006 show that the maximum actual SO₂ and NO_x emission rates from the kiln are higher than the SO₂ 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 SO₂, NO_x, and PM₁₀, including the speciated PM₁₀ emissions. The total PM₁₀ 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 (SO₄)
- ▲ Secondary organic aerosols (SOA)
- ▲ Elemental carbon (EC)

TABLE 3-4. EXISTING MAXIMUM 24-HOUR SO₂, NO_x, AND PM₁₀ 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 (Δdv)			Overall 98 th Percentile Visibility Impact (dv)
		(km)	2001	2002	
Gates of the Mountains	30	2.736	2.874	3.038	2.874

4. SO₂ 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 SO₂ within the pyroprocess to limit emissions of SO₂ 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 SO₂, thus an SO₂ BART evaluation was performed only for the kiln. The maximum actual 24-hour kiln SO₂ emission rate that was modeled for the BART applicability determination is summarized in Table 4-1. The SO₂ 24-hour maximum actual emission rate was determined from analyzer data for 2006.

TABLE 4-1. EXISTING ACTUAL MAXIMUM 24-HOUR SO₂ 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 SO₂ CONTROL TECHNOLOGIES

Step 1 of the BART determination is the identification of all available retrofit SO₂ 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 SO₂ control technologies are summarized in Table 4-2.

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 SO₂ CONTROL TECHNOLOGIES

SO₂ Control Technologies
Fuel Substitution
Raw Material Substitution
Lime Spray Dryer
Wet Lime Scrubbing

4.2 ELIMINATE TECHNICALLY INFEASIBLE SO₂ CONTROL TECHNOLOGIES

Step 2 of the BART determination is to eliminate technically infeasible SO₂ control technologies that were identified in Step 1.

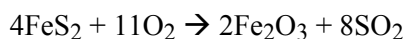
4.2.1 FUEL SUBSTITUTION

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 SO₂ resulting from fuel combustion is emitted. Therefore, if AGC reduces sulfur in fuel input to the kiln, a corresponding reduction in SO₂ 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 SO₂ 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 SO₂. The pyritic sulfur reacts with oxygen according to the following reaction:



Using raw materials with lower pyritic sulfur content can reduce the potential for SO₂ 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 CO₂. 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 SO₂ for the kiln, raw material substitution is not considered an SO₂ 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 SO₂ in the flue gas stream to create fine particles of CaSO₃ or CaSO₄. 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 SO₂ 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 its 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 CaCO₃ (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 SO₂ reacts with the scrubbing reagent to form CaSO₃ 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 CaSO₃ sludge could be oxidized to CaSO₄ 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 SO₂ 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 SO₂ 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 SO₂ technically feasible control technologies for the kiln and the associated SO₂ emission levels.

TABLE 4-3. RANKING OF TECHNICALLY FEASIBLE KILN SO₂ 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 SO₂ emission rate rather than the maximum 24-hour SO₂ 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 SO₂ emission rate rather than the maximum 24-hour SO₂ emission rate to best reflect the performance of the control on a 30 day rolling basis.

4.4 EVALUATION OF IMPACTS FOR FEASIBLE SO₂ 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

⁴EPA 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 SO₂ 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 SO₂ 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 SO₂ 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	
<u>Purchased Equipment Costs</u>	
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
<u>Direct Installation Costs</u>	
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
<u>Indirect Costs</u>	
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 SO₂/yr)	981
Pollutant Removed (tons SO₂/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 CaSO₃ 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

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 SO₂ 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 SO₂ 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:

$$\frac{905,045 \text{ Coke MMBtu}}{1,548,421 \text{ Total MMBtu}} \left| \begin{array}{l} 4.5\% \text{ Sulfur} \\ \hline \end{array} \right. + \frac{643,376 \text{ Coal MMBtu}}{1,548,421 \text{ Total MMBtu}} \left| \begin{array}{l} 0.8\% \text{ Sulfur} \\ \hline \end{array} \right. = 2.96\% \text{ Sulfur}$$

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:

$$\frac{286,458 \text{ Coke MMBtu}}{1,548,421 \text{ Total MMBtu}} \left| \begin{array}{l} 4.5\% \text{ Sulfur} \\ \hline \end{array} \right. + \frac{1,261,963 \text{ Coal MMBtu}}{1,548,421 \text{ Total MMBtu}} \left| \begin{array}{l} 0.8\% \text{ Sulfur} \\ \hline \end{array} \right. = 1.48\% \text{ Sulfur}$$

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

$$\frac{253.52 \text{ lb}}{\text{hr}} \Big| \frac{7,741 \text{ hr}}{\text{yr}} \Big| \frac{\text{ton}}{2,000 \text{ lb}} \Big| 50 \% = 491 \frac{\text{ton SO}_2 \text{ Reduced}}{\text{yr}}$$

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 SO₂ 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 SO₂ 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 SO₂ emission reductions from the WLS and fuel switching control options were applied to the 2006 average 24-hour SO₂ emission rate rather than the maximum 24-hour SO₂ emission rate because the BART limit is proposed as a 30-day rolling average. Had the reductions been applied to the maximum 24-hour SO₂ 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 SO₂ 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 SO₂ 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 SO₂

In order to determine BART for SO₂, 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 SO₂ reduced and the visibility improvement in deciviews. The cost effectiveness for the fuel switching is \$1,947 per ton of SO₂ 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 SO₂ 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 SO₂ 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.

5. NO_x BART EVALUATION

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_x⁶. 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 (NO₂), typically, less than 10% of the total NO_x in the flue gas is NO₂.⁷

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.

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 LNB⁸. 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 available⁹. 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

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 - NO_x 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

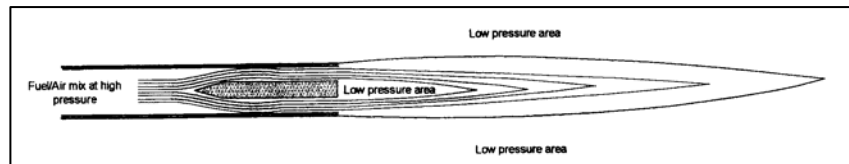
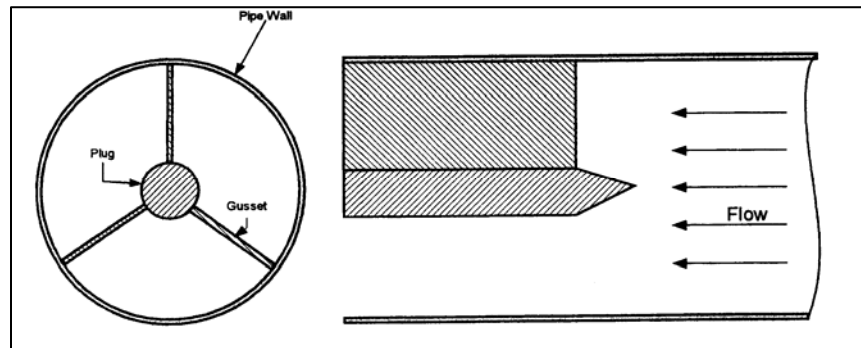


FIGURE 5-2 SCHEMATIC OF ANNUAL BURNER PIPE



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

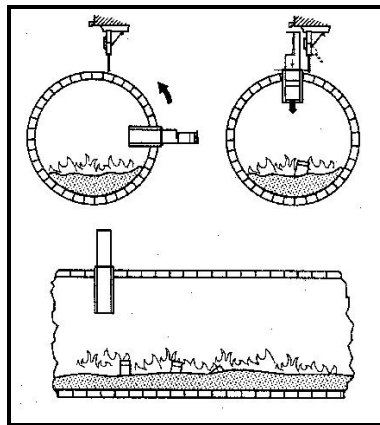
Cement kiln dust (CKD) is a residual byproduct that can be produced by any of the four basic types of cement kiln systems. CKD is most often treated as a waste even though there are some beneficial uses. However, as a means of recycling usable CKD to the cement pyroprocess, CKD sometimes is injected 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 SCHEMATIC¹⁰



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.

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.

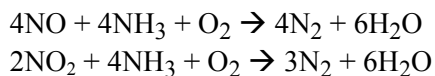
The discontinuous fuel feed from MKF may also result in increased carbon monoxide (CO) emissions. To control CO emissions, the kiln may have to have increased combustion air which can decrease production capacity.

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 Council¹¹ 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 (NH₃) reacts with NO_x without the need for a catalyst to form water and molecular nitrogen in accordance with the following simplified reactions.



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 NH₃ is oxidized to NO_x thereby increasing NO_x emissions. Below this temperature range, the reaction rate is too slow for completion and unreacted NH₃ may be emitted from the pyroprocess. This temperature window generally is available at some location within the rotary kiln. The NH₃ could be delivered to the kiln shell through the use of anhydrous NH₃, or an aqueous solution of NH₃ (ammonium hydroxide) or urea.

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} – $\text{PM}_{2.5}$.

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% NO_x 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 [$(\text{NH}_2)_2\text{CO}$]. 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

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 (SO₂), the catalysts used in SCR have a propensity to oxidize sulfur dioxide (SO₂) in the flue gas to sulfur trioxide (SO₃), a more undesirable pollutant.

Because the reaction rate of NH₃ 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 300° C (570° F) to 450° C (840° 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 Paiute 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 NO_x 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

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

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.

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 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 PM₁₀ emission rates that were modeled for the BART applicability determination are summarized in Table 6-1.

TABLE 6-1. EXISTING MAXIMUM 24-HOUR PM₁₀ 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 PM₁₀ emission rates for the kiln and clinker cooler are much less than the current emission rates of SO₂ and NO_x for the kiln. The low PM₁₀ emission rates correspond to low visibility impacts attributable to PM₁₀ when compared to the impacts attributable to SO₂ and NO_x, as shown in Table 6-2.

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

98 th 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 SO₄ is primarily from SO₂ emissions. A very small portion is from SO₄ emitted as condensable particulate.

² The visibility impairment attributable to NO₃ is entirely from NO_x emissions.

³ The visibility impairment attributable to PM₁₀ 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 500⁰F 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.