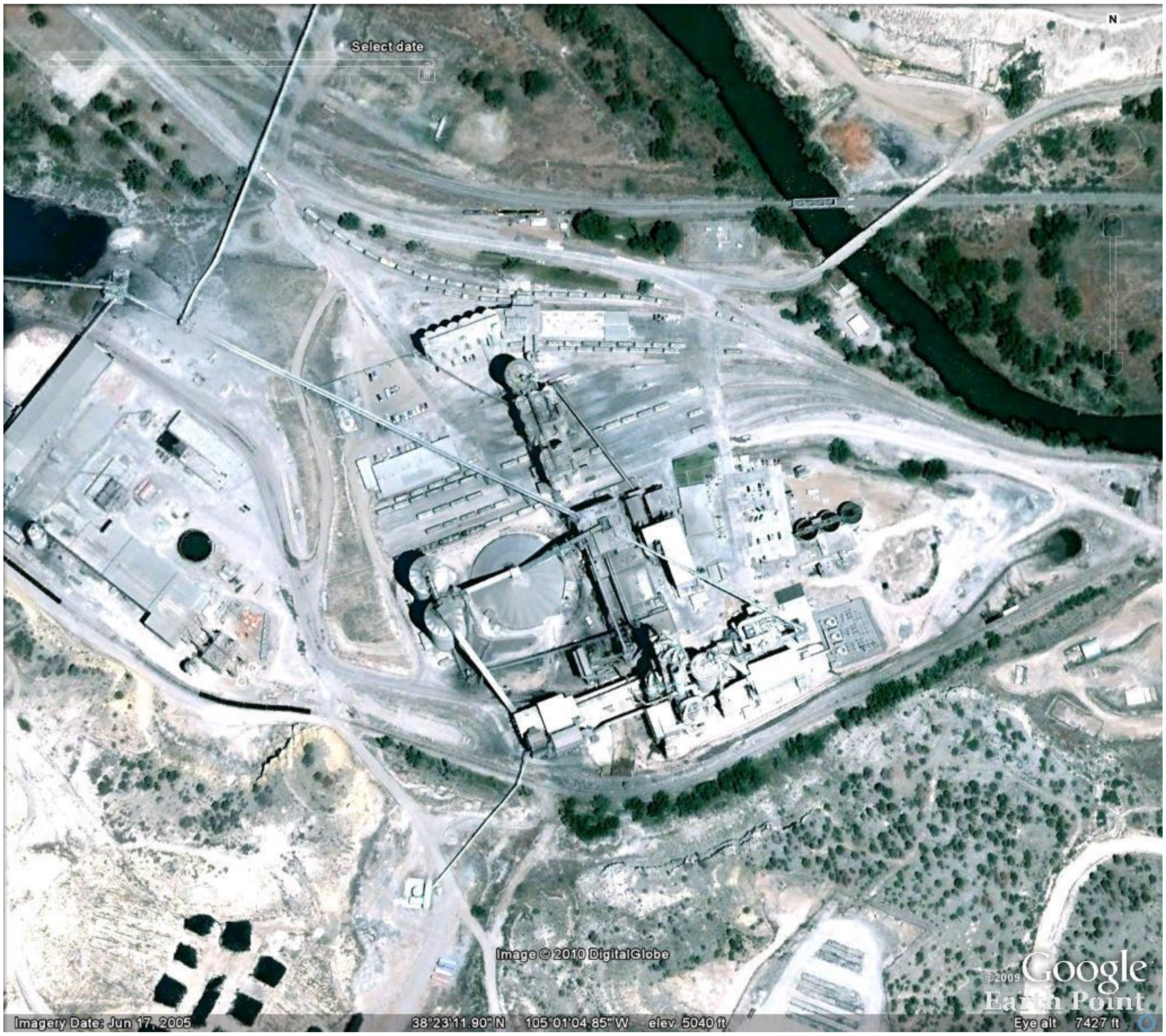
Reasonable Progress (RP) Four-Factor Analysis of Control Options
For
Holcim Portland Plant, Florence, Colorado

I. Source Description

Owner/Operator: Holcim (US) Inc.
Source Type: Portland Cement Manufacturing (dry process)
SCC (Cement Plant): 30500623
Kiln Type: Preheater/Precalciner Kiln

The Holcim Portland plant is located in Fremont County on Highway 120 near the town of Florence, Colorado, approximately 20 kilometers southeast of Canon City, and 35 kilometers northwest of Pueblo, Colorado. The plant is located 66 kilometers from Great Sand Dunes National Park. Figure 1 below provides an aerial perspective of the Portland Plant site.

Figure 1: Holcim Portland Plant Aerial Perspective



In May 2002, a newly constructed cement kiln at the Portland Plant commenced operation. This more energy-efficient 5-stage preheater/precalciner kiln replaced three older wet process kilns. As a result, Holcim was able to increase clinker production from approximately 800,000 tons of clinker per year to a permitted level of 1,873,898 tons of clinker per year, while reducing the level of NOx, SO2, and PM/PM10 emissions on a pound per ton of clinker produced basis. As a part of this project, Holcim also installed a wet lime scrubber to reduce the emissions of sulfur oxides.

The Portland Plant includes a quarry where major raw materials used to produce Portland cement, such as limestone, translime and sandstone, are mined, crushed and then conveyed to the plant site. The raw materials are further crushed and blended and then directed to the kiln feed bin from where the material is introduced into the kiln.

The dual string 5-stage preheater/precalciner/kiln system features a multi-stage combustion precalciner and a rotary kiln. The kiln system is rated at 950 mmBtu per hour of fuel input with nominal clinker production rate of 5,950 tons per day. It is permitted to burn the following fuel types and amounts (with nominal fuel heat values, where reported):

- coal (269,262 tons per year [tpy] @ 11,185 Btu/pound);
- tire derived fuel (55,000 tpy @ 14,500 Btu/pound);
- petroleum coke (5,000 tpy @ 14,372 Btu/pound);
- natural gas (6,385 million standard cubic feet @ 1,000 Btu/standard cubic foot);
- dried cellulose (55,000 tpy); and
- oil, including non-hazardous used oil (4,000 tpy @ 12,000 Btu/pound).

The clinker produced by the kiln system is cooled, grounded and blended with additives and the resulting cement product is stored for shipment. The shipment of final product from the plant is made by both truck and rail.

Emissions from the kiln system, raw mill, coal mill, alkali bypass and clinker cooler are all routed through a common main stack for discharge to atmosphere. These emissions are currently controlled by fabric filters (i.e., baghouses) for PM/PM10, by the inherent recycling and scrubbing of exhaust gases in the cement manufacturing process and by a tail-pipe wet lime scrubber for SO2, by burning alternative fuels (i.e., tire-derived fuel [TDF]) and using a Low-NOX precalciner, indirect firing, Low-NOX burners, staged combustion and a Linkman Expert Control System for NOX, and by the use of good combustion practices for both NOX and SO2.

For this analysis, the Division also relied on the existing construction permit, historical information regarding the Holcim facility, and information about similar facilities to determine RP for NOx, SO2, and PM10. EPA's BART guidelines recommend that states utilize a five step process for determining BART for EGU sources above 750 MW. Although this five step process is not required for making Reasonable Progress (RP) determinations, the Division has elected to largely follow it in RP. This is for ease of reference, and because the statutory factors that must considered in making BART and RP determinations are largely the same.

The Division has elected to set a de minimis threshold for actual baseline emissions for evaluating reasonable progress units at each facility equal to the federal Prevention of Significant Deterioration (PSD) levels. The Division defines "unit" as an Air Pollutant Emission Notice (APEN) subject source, or a stationary source, defined as "any building, structure, facility, equipment, or installation, or any combination thereof belonging to the same industrial grouping that emit or may emit any air pollutant subject to regulation under the Federal Act that is located on one or more contiguous or adjacent properties and that is owned or operated by the same person or by persons under common control1." These levels are as follows:

- NO_x – 40 tons per year
- SO_2 – 40 tons per year
- PM_{10} – 15 tons per year

In addition to the kiln system/main stack emissions, there are two other process points whose PM/PM10 emissions exceed the PSD significance level thresholds and were considered as a part of this Reasonable Progress analysis: 1) the raw material extraction and alkali bypass dust disposal operations associated with the quarry, and 2) the cement processing operations associated with the finish mill. Emissions from the quarry are currently controlled through a robust fugitive dust control plan and emissions from the finish mills are controlled by a series of baghouses.

Holcim did not initially complete a detailed four-factor analysis for the Portland Plant, though it did submit limited information on the feasibility of post-combustion NOX controls for the kiln system. In late October through early December 2010, Holcim did submit detailed information, including data on baseline emissions, existing controls and additional control options, and visibility modeling to support the reasonable progress determination process. The previous September 14, 2010 version of this document has been revised to reflect this additional information.

II. Source Emissions

Table 1 summarizes the NOX, SO2 and PM10 actual emissions for the period of 2007-2009. Table 2 summarizes each unit at the facility and applicable NOx, SO2 and PM10 actual emissions.

Table 1 – Summary of Plant-Wide Emissions

Year	Pollutant (1, 2)		
	PM10 (tpy)	NOx (tpy)	SO2 (tpy)
2007	262.05	2,447.30	189.80
2008	268.98	2,294.60	306.66
2009	183.26	1,251.66	297.14

Notes:
(1) Emission data from CDPHE – PTS data base.
(2) Annual emissions are less than permitted emissions due in part to economic conditions resulting in less than full production.

---

[1] Colorado Department of Public Health and Environment. Air Quality Control Commission Common Provisions Regulation 5 CCR 1001-2. Amended December 17, 2009. Effective January 30, 2010. Page 19.

Table 2 – Summary of Emissions by Unit Process

AIRS ID	Process	Pollutant	Emissions(2,3) (tons per year)			
			2007 (1)	2008	2009	Average
101A	Top soil removed Topsoil hauled Wind erosion	PM10 (fug)	----	1.14	0.57	0.855
101B	Explosives	PM10 (fug) NOx SO2	----	0.29 7.47 0.88	0.20 4.99 0.59	0.245 6.23 0.735
101C	Overburden removed/hauled	PM10 (fug)	----	14.43	11.41	12.92
101D	Raw material removed/hauled	PM10 (fug)	----	25.91	16.68	21.295
101E	CKD disposed/hauled	PM10 (fug)	----	0.40	0.60	0.50
101F	Disturbed Area	PM10 (fug)	----	83.61	83.61	83.61
101G	Mined land Reclamation	PM10 (fug)	----	0	0	0
102A	Unload Crusher #1	PM10 (fug)	----	0.01	0	0.005
102B	Unload Crusher #2	PM10 (fug)	----	0.01	0.01	0.01
102C	Crusher #1	PM10	----	0.03	0.02	0.025
102D	Transfer to secondary crusher	PM10	----	0.01	0	0.005
102E	Secondary crusher	PM10	----	0.02	0.01	0.015
102F	Crusher #2	PM10	----	0.64	0.41	0.535
102G	Transfer to storage silo	PM10	----	0.06	0.03	0.045
102H	Transfer to blending hall	PM10	----	0.19	0.13	0.16
102J	Transfer outside materials	PM10	----	0	0	0
102K	Pre-Blend Hall activities	PM10	----	0.18	0.11	0.145
102L	Transfer from Bins	PM10	----	0.15	0.10	0.125
103A	Coal unloaded	PM10 (fug)	----	0.98	0.68	0.83
103B	Coal Stockpile/Coal stored	PM10 (fug)	----	0.18	0.12	0.15
103C	Coal Handled	PM10	----	0.10	0.07	0.085
103D	Coal screened/. Crushed	PM10	----	0.09	0.06	0.075

AIRS ID	Process	Pollutant	Emissions(2,3) (tons per year)			
			2007 (1)	2008	2009	Average
103E	Coal Transferred	PM10	----	0.01	0.01	0.01
104	Unloading additives	PM10 (fug)	----	0.05	0.04	0.045
105	Coal transferred	PM10	----	0.01	0.01	0.01
106	Raw material Blend	PM10	----	0.15	0.10	0.125
107	Coal Mill	PM10	----	5.16	1.52	3.34
108	Raw Material Milled	PM10	----	4.28	2.76	3.52
109	Raw Meal Elevated	PM10	----	2.68	1.73	2.205
110	Raw Meal Handled	PM10	----	1.07	0.69	0.83
111	Kiln Operations	PM10 NOx SO2	68.17 2,439.7 188.9	47.23 2,287.04 305.76	13.9 1,246.55 296.55	43.1 1,931.1 263.7
112	Cement clinker cooler	PM10	----	21.52	6.34	13.93
113	Cement clinker stored	PM10	----	0.05	0.03	0.04
114	Cement clinker handled	PM10	----	0.06	0.04	0.05
115	Total cement produced	PM10	59.62	52.12	37.61	32.38
116	Cement handled	PM10	----	1.78	1.29	1.485
117	Cement bagged	PM10	----	0.	0	0
118	Cement bulk loadout	PM10	----	2.04	1.32	1.68
119	Cement product hauled	PM10 (fug)	----	1.00	0.64	0.82
135	Clinker import	PM10	----	0	0	0
138	Tire shredder	PM10 (fug)	----	0.29	0.08	0.185
139	Clinker reclaim	PM10	----	0.26	0.08	0.17
142	Tire debeader	PM10 NOx SO2	----	0.01 0.09 0.	0 0.02 0	0.005 0.055 0
144	Tire shredder	PM10 (fug)	----	0.82	0.23	0.523
145	Clinker export	PM10 (fug)	----	----	0.02	0.02

Notes:

1) A different reporting format was used in 2007.

2) Production has been limited in recent years due to economic factors. The plant is permitted to produce up to 1,873,898 tons of clinker per year. Production in 2008 = 1,332,888 tons and in 2009 = 914,193 tons. Emissions would be higher if the plant were operating at its permitted production level.

3) For some emission points, permit limits have been decreased over the last several years so that current permit limits are now lower than historical actual emissions.

Because clinker production in 2009 was significantly lower than in previous recent years, due in large part to challenging economic conditions, the state instead included 2004 and 2005 in the baseline calculation to represent a more realistic depiction of anticipated annual production and emissions for the plant. Table 3 presents emissions and production data for the 2004, 2005, 2006, 2007 and 2008 baseline years:

Table 3 – Kiln System Production and Emissions (2004 through 2008)

Year	Actual Emissions/Production					Projected Annual Emissions at Full Production of 1,873,898 tpy clinker	
	NO_x (tons)	SO_2 (tons)	Clinker (tons)	NO_x (lbs/ton)	SO_2 (lbs/ton)	NO_x (tons)	SO_2 (tons)
2004	2,741.3	780.6	1,641,423	3.34	0.95	3,129.6	891.2
2005	2,572.3	371.5	1,642,740	3.13	0.45	2,934.3	423.8
2006	3,098.0	366.4	1,686,451	3.67	0.43	3,442.3	407.1
2007	2,439.7	188.9	1,361,523	3.58	0.28	3,357.8	260.0
2008	2,287.0	305.8	1,332,888	3.43	0.46	3,215.3	429.9
Avg	2,627.7	402.6	1,533,005	3.43	0.51	3,215.8	482.4
Max	3,098.0	780.6	1,686,451	3.67	0.95	3,442.3	891.2

III. Units Evaluated for Control

As discussed above, the only emission points whose current permitted level of emissions exceed the *de minimis* thresholds are the kiln system, quarry and finish mill. These emission points will be evaluated as a part of this reasonable progress analysis. The other emission points at the Portland Plant will not be considered further.

IV. Reasonable Progress Evaluation of the Kiln System

A. Sulfur Dioxide (SO_2)

Step 1: Identify All Available Technologies

In addition to good combustion practices and the inherent recycling and scrubbing of acid gases by the raw materials, such as limestone, used in the cement manufacturing process, the Portland Plant kiln system has a tail-pipe wet lime scrubber. The wet lime scrubbing process involves passing the flue gas from the kiln system through a sprayed aqueous calcium-based suspension that is contained within the scrubbing device. In the wet lime scrubber, the SO_2 reacts with the scrubbing reagent to form $CaSO_4$ that is collected and retained as aqueous sludge. The sludge is then dewatered and disposed.

Holcim has reported that this combination of controls achieves an overall sulfur removal rate of 98.3% for the kiln system, as measured by the total sulfur input in to the system versus the amount of sulfur emitted to atmosphere. Holcim has also reported that they estimate that the wet scrubber at the Portland Plant achieves an overall removal efficiency of over 90% of the SO_2 emissions entering the scrubber. This control technology represents the highest level of control for Portland cement kilns. As a result, the state did not consider other control technologies as a part of this RP analysis.

Step 2: Eliminate Technically Infeasible Options

The currently installed combination of good combustion practices, the inherent scrubbing nature of the cement manufacturing process, and the wet lime scrubber represent the highest level of control for Portland cement kilns. This set of controls is operating and is technically feasible.

Step 3: Evaluate Control Effectiveness of Each Remaining Technology

The currently installed and operating controls are the only controls being considered and are assumed to be cost-effective.

Step 4: Evaluate Factors and Present Determination

Factor 1: Cost of Compliance

The currently installed and operating controls are assumed to be cost-effective.

Factor 2: Time Necessary for Compliance

The controls are already installed and operating.

Factor 3: Energy and Non-Air Quality Impacts

Because there are no changes to the existing controls for SO2, there are no associated energy and non-air quality impacts for this determination.

Factor 4: Remaining Useful Life

There are no remaining useful life issues for the source, as the state has presumed that the source and controls will remain in service for a 20-year amortization period.

Factor 5 (optional): Evaluate Visibility Results

CALPUFF modeling was conducted by the Division as a part of the development of the September 14, 2010 version of this document for the kiln system using a SO2 emission rate of 99.17 pounds per hour (lbs/hour), a NOx emission rate of 837.96 lbs/hour, and a PM10 emission rate of 19.83 lbs/hour. The modeling indicated a 98th percentile visibility impact of 0.435 delta deciview (Δdv) at Great Sand Dunes National Park. Because the baseline emission rates and proposed RP emission rates have been revised, this specific impact value is no longer directly associated with the emission rates discussed in this section. However, in any event, because no additional controls are proposed for SO2 emissions, there is no visibility improvement associated with SO2 emissions.

Determination

While the state has determined that the existing controls represent the top-level control technology, the state did assess the corresponding SO2 emissions rates. The facility is currently permitted to emit 1,006.5 tpy of SO2 from the kiln system main stack. At a permitted clinker production level of 1,873,898 tpy, this equates to an annual average of 1.08 pounds of SO2 per ton of clinker (the current permit does not contain an annual pound per ton of clinker or a short-term emission limit for SO2). The actual kiln SO2 emissions divided by the actual clinker production for the five-year baseline period used in this analysis (2004, 2005, 2006, 2007 and 2008) calculate to an overall annual average rate of 0.51 pound of SO2 per ton of clinker, with a standard deviation of 0.26 pound per ton. The highest annual emission rate in the baseline years was 0.95 pound per ton of clinker.

As a part of their submittals, Holcim analyzed continuous hourly emission data for SO2. The hourly emission data from 2004 to 2008 (baseline years) were used to calculate the daily emission rates. A 30-day rolling average emission rate was calculated by dividing the total emissions from the previous 30 operating days by the total clinker production from the previous 30 operating days. The 99th percentile of the 30-day rolling average data was used to establish the short-term baseline emissions limit of 1.30 pounds of SO2 per ton of clinker. The 99th percentile accounts for emission changes due to short-term and long-term inherent process, raw material and fuel variability. The long-term annual limit was calculated at 721.4 tpy by multiplying the long-term baseline SO2 value of 0.77 pound per ton (the mean of 0.51 pound per ton plus one standard deviation of 0.26 pound per ton) by the annual clinker limit of 1,873,898 tpy, and then dividing by 2,000 pounds per ton.

For the kiln system, based upon our consideration and weighing of the four factors, the state has determined that no additional SO2 emissions control is warranted given that the Holcim Portland Plant already is equipped with the top performing control technologies – the inherent recycling and scrubbing effect of the process itself followed by a tail-pipe wet lime scrubber. The RP analysis provides sufficient basis to establish a short-term SO2 emission limit of 1.30 pounds per ton of clinker on a 30-day rolling average basis and a long-term annual emission limit of 721.4 tons of SO2 per year (12-month rolling total) for the kiln system. There is no specific visibility improvement associated with this emission limitation.

Finally, on August 9, 2010, EPA finalized changes to the New Source Performance Standards (NSPS) for Portland Cement Plants and to the Maximum Achievable Control Technology standards for the Portland Cement Manufacturing Industry (PC MACT). The NSPS requires, new, modified or reconstructed cement kilns to meet an emission standard of 0.4 pound of SO2 per ton of clinker on a 30-day rolling average or a 90% reduction as measured at the inlet and outlet of the control device. While the new NSPS does not apply to the Holcim Portland Plant because it is an existing facility, it is important to note that the estimated level of control achieved by Holcim's wet scrubber (~90%) is consistent with the level of control prescribed by the NSPS for new sources.

Summary of SO_2 RP Determination for Kiln System

1.30 pounds of SO_2 per ton of clinker (30-day rolling average)

721.4 tons of SO2 per year (12-month rolling total)

B. Filterable Particulate Matter (PM and PM_{10})

Step 1: Identify All Available Technologies

The state has determined that the existing baghouses installed on the kiln system represent the most stringent control option. Baghouses, or fabric filters, operate on the same principle as a vacuum cleaner. Air carrying dust particles is forced through a cloth bag. As the air passes through the fabric, the dust accumulates on the cloth, providing a cleaner air stream. The dust is periodically removed from the cloth by shaking or by reversing the air flow. The layer of dust, known as dust cake, trapped on the surface of the fabric results in high efficiency rates for particles ranging in size from submicron to several hundred microns in diameter.

Holcim has reported nominal control efficiency for the kiln system baghouses at 99.5%. The units are exceeding a PM control efficiency of 95% and this control technology represents the highest level of control for Portland cement kilns. As a result, the state did not consider other control technologies as a part of this RP analysis.

Step 2: Eliminate Technically Infeasible Options

The currently installed baghouses represent the highest level of control for Portland cement kilns. This set of controls is operating and is technically feasible.

Step 3: Evaluate Control Effectiveness of Each Remaining Technology

The currently installed and operating controls are the only controls being considered and are assumed to be cost-effective.

Step 4: Evaluate Factors and Present Determination

Factor 1: Cost of Compliance

The currently installed and operating controls are assumed to be cost-effective.

Factor 2: Time Necessary for Compliance

The controls are already installed and operating.

Factor 3: Energy and Non-Air Quality Impacts

Because there are no changes to the existing controls for PM/PM10, there are no associated energy and non-air quality impacts for this determination.

Factor 4: Remaining Useful Life

There are no remaining useful life issues for the source, as the state has presumed that the source and controls will remain in service for a 20-year amortization period.

Factor 5 (optional): Evaluate Visibility Results

As described above, CALPUFF modeling was conducted by the Division as a part of the development of the September 14, 2010 version of this document for the kiln system using a SO2 emission rate of 99.17 lbs/hour, a NOx emission rate of 837.96 pounds per hour (lbs/hour), and a PM10 emission rate of 19.83 lbs/hour. The modeling indicates a 98th percentile visibility impact of 0.435 delta deciview (Δdv) at Great Sand Dunes National Park.

As a part of our September 14, 2010 analysis, the state modeled possible visibility improvements associated with two emission rates – an emission rate of 0.08 pound of PM_{10} per ton of clinker (19.83 lbs/hour) and a rate of 0.04 pound of PM_{10} per ton of clinker (9.92 lbs/hour). This analysis assumed the emissions were all attributable to the kiln (i.e., no contribution from the clinker cooler) to assess the impact of a possible reduction of the kiln emission limit. There was no change to the 98th percentile impact deciview value from 19.83 lbs/hour to 9.92 lbs/hour and therefore, no visibility improvement associated with this change.

The state's modeling results showed that the most significant contributors to the visibility impairment from the Portland Plant were nitrates (NO_3) followed by sulfates (SO_4).The contribution of PM_{10} to the total visibility impairment was insignificant in the analysis. The level of PM_{10} emissions evaluated had no discernable impact on visibility.

Determination

While the state has determined that the existing controls represent the top-level control technology, the state did assess the corresponding PM_{10} emissions rates. The facility is currently permitted to emit 246.3 tpy of PM_{10} from the kiln system main stack (includes emissions from the clinker cooler). At a permitted clinker production level of 1,873,898 tpy, this equates to an annual average of 0.26 pound of PM_{10} per ton of clinker (the current permit does not contain an annual pound per ton of clinker or a short-term emission limit for PM_{10}). The actual kiln system PM_{10} emissions divided by the actual clinker production for the five-year baseline period used in this analysis (2004, 2005, 2006, 2007 and 2008) average to a rate of 0.16 pound of PM_{10} per ton of clinker (combined emissions from main stack). This value is derived from the limited annual stack test data, which are effectively snapshots in time, and does not take into account the short-term inherent variability in the manufacturing process, raw material and fuel.

For the kiln system, based upon our consideration and weighing of the four factors and the very limited impact of PM_{10} emissions from the kiln system on visibility impairment, the state has determined that no additional PM_{10} emissions control is warranted given that the Holcim Portland Plant already is equipped with the top performing control technology – fabric filter baghouses. These baghouses and the current permit limit of 246.3 tpy of PM_{10} (12-month rolling total) from the kiln system main stack (including emissions from the clinker cooler) represent RP for this source. Furthermore, the Portland Plant is subject to the PC MACT and the recent amendments to the PC MACT include new, lower standards for PM emissions. As an existing facility, the Portland Plant kiln system will be subject to this standard once it becomes effective on September 9, 2013. Compliance with the new PC MACT PM emission standards will result in further reductions in the PM_{10} emissions.

Summary of PM/PM10 RP Determination for Kiln System

246.3 tons of PM10 per year (12-month rolling total)

C. Nitrogen Oxides (NOx)

Step 1: Identify All Available Technologies

There are a number of technologies available to reduce NOX emissions from the Portland Plant kiln system below the current baseline emissions level (the current configuration already includes indirect firing, low-NOX burners, staged combustion, a low-NOX precalciner, and a Linkman Process Control Expert system). These include water injection (the injection of water or steam into the main flame of a kiln to act as a heat sink to reduce the flame temperature), and selective non-catalytic reduction (SNCR). These technologies were determined to be technically feasible and appropriate for reducing NOX emissions from Portland cement kilns. Additional discussion on SNCR is provided below:

For SNCR, within the relatively narrow temperature window of 1600 to 2000°F, ammonia (NH3) reacts with NOx without the need for a catalyst to form water and molecular nitrogen in accordance with the following simplified reactions:

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

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

Above this temperature range, the NH3 is oxidized to NOx, thereby increasing NOx 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 rotary kiln systems. The NH3 could be delivered to the kiln system through the use of anhydrous NH3, or an aqueous solution of NH3 (ammonium hydroxide) or urea [(NH2)2CO]. A concern about application of SNCR technology is the breakthrough of unreacted NH3 as "ammonia slip" and its subsequent reaction in the atmosphere with SO2, sulfur trioxide (SO3), hydrogen chloride (HCl) and/or chlorine (Cl2) to form a detached plume of PM10–PM2.5.

As part of this analysis, the state also considered the use selective catalytic reduction (SCR) as a NOX control technology. The state has determined that SCR is not commercially available for the cement kiln system at the Holcim Portland Plant. Presently, SCR has not been applied to a cement plant of any type in the United States. Holcim notes that the major SCR vendors have either indicated that SCR is not commercially available for cement kilns at this time, or if they are willing to provide a quotation for an SCR system, the associated limitations that are attached with the quote severely undercut the efficacy of the system. The state does not believe that a limited use - trial basis application of an SCR control technology on three modern kilns in Europe, constitutes "available" control technology for purposes of RP at the Holcim Portland Plant. The state believes that commercial demonstration of SCR controls on a cement plant in the United States is appropriate when considering whether a control technology is "available" for purposes of retrofitting such control technology on an existing source.

In the preamble to the recently finalized changes to the Portland Cement MACT/NSPS, EPA stated: "However, although SCR has been demonstrated at a few cement plants in Europe and has been demonstrated on coal-fired power plants in the US, the Agency is not satisfied that it has been sufficiently demonstrated as an off-the-shelf control technology that is readily applicable to cement kilns." Based on our research and EPA's analysis for the MACT/NSPS standards, the state has eliminated SCR as an available control technology for the Holcim Portland Plant for purposes of this RP analysis. Additional information regarding SCR, as developed by the state as part of its BART analysis for the CEMEX Lyons plant is provided below:

SCR refers to the reduction of NOx in the presence of ammonia to water and elemental nitrogen in the presence of a catalyst. The term "selective" refers to the unique ability of ammonia to react selectively with NOx. The EPA released a NOx control technology update for new cement kilns entitled "Alternative Control Techniques Document Update – NOx Emissions from New Cement Kilns," EPA-453/R-07-006, November 2007 that discusses SCR control for cement kilns. The following discussion is excerpted from the EPA report:

> *SCR is the process of adding ammonia or urea in the presence of a catalyst to selectively reduce* NO_x *emissions from exhaust gases. The SCR process has been used extensively on gas turbines, internal combustion (IC) engines, and fossil fuel-fired utility boilers. In the SCR system, anhydrous ammonia, usually diluted with air or steam or aqueous ammonia solution, is injected through a catalyst bed to reduce* NO_x *emissions. A number of catalyst materials have been used, such as titanium dioxide, vanadium pentoxide, and zeolite-based materials. The catalyst is typically supported on ceramic materials (e.g., alumina in a honeycomb monolith*

form) and promotes the NO_x reduction reactions by providing a site for these reactions to occur. The catalyst is not consumed in the process, but allows the reactions to occur at a lower temperature. The optimum temperature for the catalyst reactions depends on the specific catalyst used. Several different catalysts are available for use at different exhaust gas temperatures. Base metal catalysts are useful between 450 °F and 800 °F (232 °C and 427 °C). For high temperature operations (675 °F [357 °C] to over 1100 °F [593 °C]), zeolite catalysts containing precious metals such as platinum and palladium are useful. The two principal reactions in the SCR process at cement plants using SCR are the following:

$$4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N2 + 6\ H_2O$$

and

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

The first equation is the predominant reaction because 90-95% of NO_x in flue gas is NO. It is important to note that the desired chemical reactions are identical with SNCR and SCR. The only difference is that a catalyst is present with SCR, which allows the reactions to occur at a lower temperature. In an SCR system, ammonia is typically injected to produce a NH_3: NO_x molar ratio of 1.05–1.1:1 to achieve a NO_x conversion of 80–90% with an ammonia slip of about 10 ppm of unreacted ammonia in gases leaving the reactor. The NO_x removal efficiency depends on the flue gas temperature, the molar ratio of ammonia to NO_x, and the flue gas residence time in the catalyst bed. All these factors must be considered in designing the desired NO_x reduction, the appropriate reagent ratios, the catalyst bed volume, and the operating conditions. As with SNCR, the appropriate temperature window must be maintained to assure that ammonia slip does not result in a visible plume. SCR can be installed at a cement kiln at two possible locations:

After the PM control device – a "low-dust" system
After the last cyclone without ducting – a "high-dust" system.

The advantages of a "low-dust" system are longer catalyst life and lower danger of blockage. *The disadvantage is the additional energy costs required to heat the cooled exhaust to achieve proper reaction temperatures in the catalyst. On a worldwide basis, three cement kilns have used SCR: Solnhofen Zementwerkes in Germany and Cementeria di Monselice and Italcementi Sarche di Calavino in Italy. The SCR system was operated at the Solnhofen plant from 2001 to January 2006, at which time the plant began using SNCR to compare the operational costs of the two systems to evaluate which technology is better and more economical. Both Solnhofen and Cementeria di Monselice have preheater kilns. The Italcementi plant operates a small Polysius Lepol technology kiln, which is a traveling grate preheater kiln. Both plants use a 25% aqueous ammonia solution, have 6 catalyst layers but only use 3 layers. Both plants have similar designs and facilities that are similar in size and raw materials. At Solnhofen, 200 mg/m^3 (~ 0.8 lb/t) of NO_x is typically achieved from an inlet of 1,050 mg/Nm^3 (4.2 lb/t) or 80% control. Also, ammonia slip was less than 1 mg/m^3. Greater than 80% control is frequently achieved. At the end of 2003, the catalyst had logged 20,000–25,000 hours with no discernable problems. The catalyst was guaranteed for 16,000 hrs, with an expected catalyst life of 3–4 yrs.*

> *The SCR system at Cementeria di Monselice in Bergamo, Italy began operation in June 2006. Catalyst activity remains high after 3,500 hours of operation. Following startup in June 2006, continuous testing was conducted for six weeks.*

The design of a SCR system is expected to be site specific. According to Schreiber[2], the technology transfer of SCR systems from the power plant industry to the Portland cement industry requires substantial research and pilot testing before the technology could be considered commercially available. Figure 2, from Granger[3] shows the performance of a typical catalyst under different conditions of temperature and gas composition. The highest NOx reduction efficiencies for this particular catalyst (vanadium pentoxide with titanium dioxide substrate) were achieved at a temperature range of 350°C to 450°C. At a particular temperature, as denoted by the sweeping arcs, small incremental increases in ammonia result in an increase in the NOx reduction until the optimal rate is achieved beyond which a rapid increase in ammonia slip results. This also provides evidence of the narrow temperature window for effective SCR performance.

Figure 2: Catalyst Performance for NOx Control and Ammonia slip at Various Temperatures

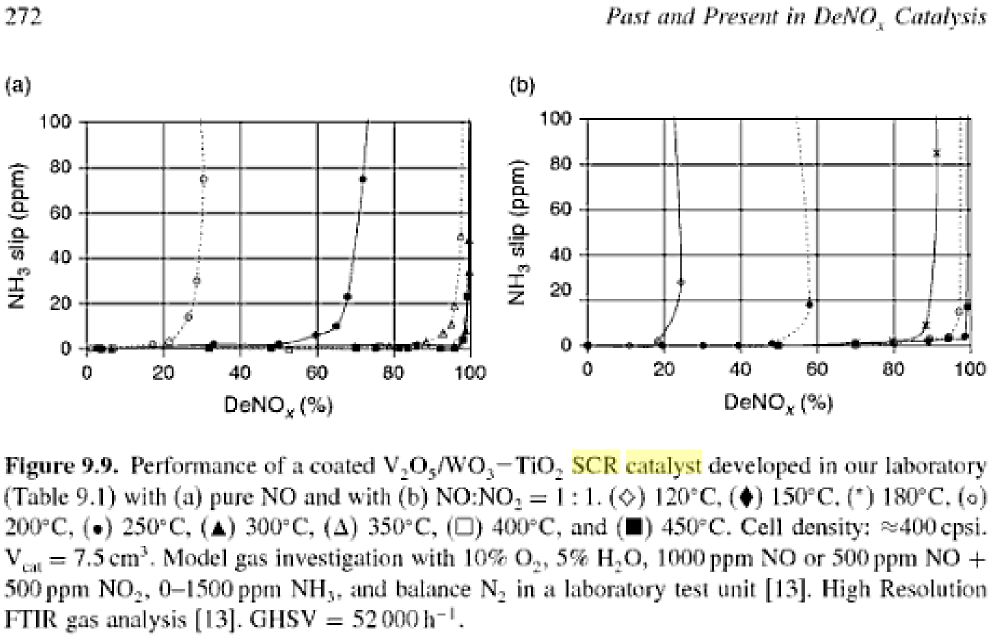

272 *Past and Present in DeNO$_x$ Catalysis*

Figure 9.9. Performance of a coated V_2O_5/WO_3-TiO_2 SCR catalyst developed in our laboratory (Table 9.1) with (a) pure NO and with (b) NO:NO_2 = 1 : 1. (◇) 120°C, (♦) 150°C, (*) 180°C, (○) 200°C, (•) 250°C, (▲) 300°C, (△) 350°C, (□) 400°C, and (■) 450°C. Cell density: ≈400 cpsi. $V_{cat} = 7.5\,cm^3$. Model gas investigation with 10% O_2, 5% H_2O, 1000 ppm NO or 500 ppm NO + 500 ppm NO_2, 0–1500 ppm NH_3, and balance N_2 in a laboratory test unit [13]. High Resolution FTIR gas analysis [13]. GHSV = $52\,000\,h^{-1}$.

Additionally, multiple challenges exist to achieve SCR effectiveness: selection of catalyst type, positioning of the catalyst, management of catalyst life, catalyst poisoning and ammonia slip. A good catalyst must ensure high activity and selectivity for NOx reduction and low activity in the oxidation of SO2 to SO4. Because of the high selectivity, the catalyst will have a specific temperature window at which the NOx reduction is optimal (Granger 2007).

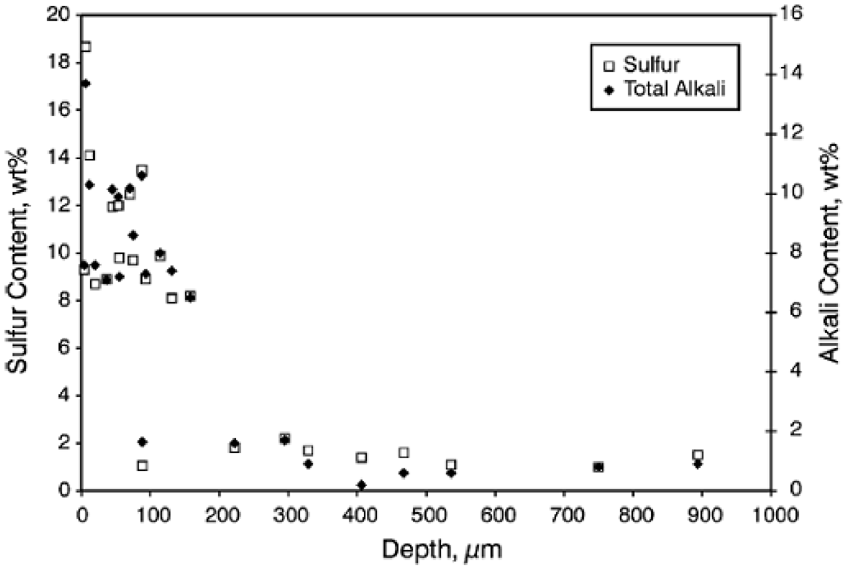
---

[2] See Schreiber, R, *et al* "Evaluation of Suitability of Selective Catalytic Reduction and Selective Non-Catalytic Reduction for use in Portland Cement Industry", (2006)

[3] See Granger, P. Elsevier, "Past and Present in DeNOx Catalysis: From Molecular Modeling to Chemical Engineering", (2007)

There is limited information regarding the geometry and optimal positioning of the catalyst to allow for effective NOx reduction and low pressure loss. Further, engineering analysis on overall efficiency during the catalyst life-cycle would be required to ascertain effectiveness. According to Benson[4], alkali and alkaline-earth rich oxides (sodium, magnesium, calcium and potassium) have strong influence on catalyst deactivation (*See also* Nicosia *et al.*, 2008, and Strege *et al.*, 2008). Figure 3 shows evidence of catalyst poisoning by both sulfur and alkalies[5]. The contaminants occupy active sites that otherwise would be available for ammonia storage thus reducing the reactivity and selectivity of the catalyst resulting in lower NOx control effectiveness. Also, particulates from the calcining process would likely combine with available ammonia to form a sticky dust that may adhere to the active sites on the catalyst thereby further reducing the effectiveness of the NOx reduction. Particulate scouring of the catalyst surface has been identified as another mechanism that reduces the effectiveness of the catalyst.

Figure 3: Sulfur and Alkali Penetration into the pores of the catalyst



Total alkali (Na + K) and sulfur content with depth beneath catalyst surface.

Figure 3 indicates that sulfur and alkali compounds penetrate into the catalyst surface resulting in a reduction in the number of active sites thereby reducing the activity and selectivity toward NOx reduction (see Strege *et al.*, 2008).

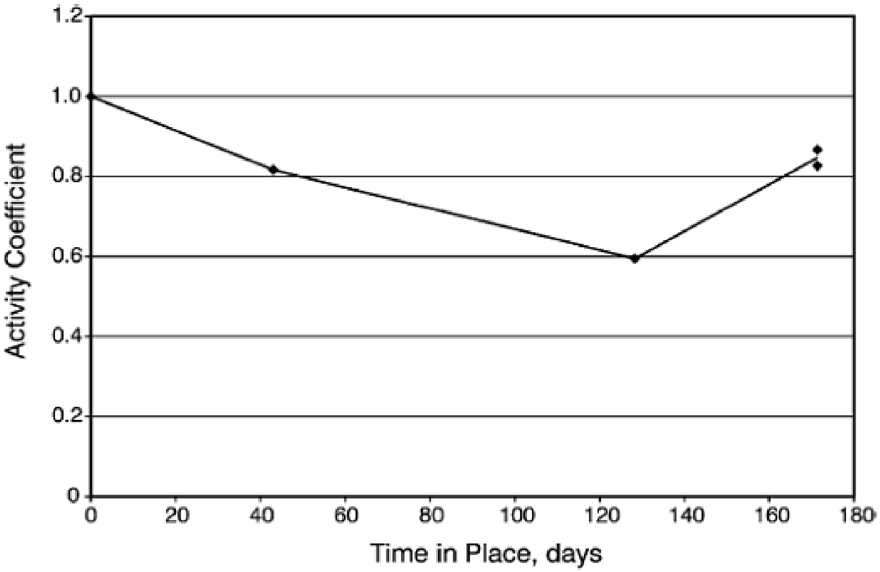
---

[4] See Benson, S. *et al.* "SCR catalyst performance in flue gases derived from subbituminous and lignite coals, Fuel Processing Technology, Vol. 86" (2005)

[5] See Strege, J. et al., "SCR deactivation in a full-scale cofired utility boiler, Fuel 87" (2008)

Figure 4: Bench Scale Test Results of Catalyst Deactivation over a Period of Time

J.R. Strege et al. / Fuel



Bench-scale test results of catalyst deactivation with time.

Figure 4 provides evidence of catalyst deactivation. If the catalyst life is assumed to end when activity coefficient is around 0.6, then the catalyst life is about 130 days or 3,100 hours, which is much lower than the ~23,000 hour catalyst life cited in the report on the Solnhofen Zementwerkes in Germany.

Ammonia slip is also an issue of concern as it readily reacts to form secondary particulates. A catalyst must combine high NOx conversions to elemental nitrogen and water along with low ammonia slip. In principle, the catalyst has acidic surfaces that retain unreacted ammonia; the storage capacity of these acidic sites depends on temperature. According to Barbaro[6], a good flow distribution is needed to ensure minimal ammonia slip. The potential for ammonia slip to create visibility impairment that is readily transported into nearby Great Sand Dunes National Park exists.

The state finds that a limited use - trial basis application of an SCR control technology on three kilns in Europe does not constitute “available” control technology for purposes of Reasonable Progress at the Holcim Portland Plant. The Division notes that very specific temperature and dust content parameters must be achieved prior to the catalyst reactor elements to preclude plugging issues. As mentioned in the EPA report, *“The advantages to the low dust configuration are longer catalyst life and lower danger of blockage. The disadvantage is the additional energy costs required to heat the cooled exhaust to achieve proper reaction temperatures in the catalyst*.” Cement kilns are inherently very dusty environments; consequently for many cement kilns, the catalyst reactor must be installed after the baghouse.

---

[6] See Barbaro, P.; Bianxhini, C. Wiley-VCH, Catalysis for Sustainable Energy Production (2009)

The Division believes that commercial demonstration of SCR controls on a cement plant in the United States is necessary for a control technology to be “available” for purposes of retrofitting such control technology on the Portland Plant. Reasonable Progress should not be a forum to test new experimental controls to see if they work, particularly when ideal design parameters are constrained in retrofit situations. Therefore, given this fact and the difficulty that Holcim has had in obtaining viable vendor quotations for an SCR system, the Division has eliminated SCR as an available control technology for the Holcim Portland Plant for purposes of Reasonable Progress.

Step 2: Eliminate Technically Infeasible Options

As described above, water injection and SNCR were determined to be technically feasible and appropriate for reducing NO_X emissions from Portland cement kilns.

Step 3: Evaluate Control Effectiveness of Each Remaining Technology

The design of the Holcim Portland Plant does allow for the effective use of SNCR, which requires ammonia-containing compounds to be injected into appropriate locations of the preheater/precalciner vessels where temperatures are ideal (between 1600-2000ºF) for reducing NOX to elemental nitrogen. Holcim has indicated to the state that SNCR is technically and economically feasible for the Portland Plant.

The facility is currently permitted to emit 3,185.7 tpy of NOX from the kiln system main stack. At a permitted clinker production level of 1,873,898 tpy, this equates to an annual average of 3.40 pounds of NOX per ton of clinker (the current permit does not contain an annual pound per ton of clinker or a short-term emission limit for NOX). The actual kiln NOX emissions divided by the actual clinker production for the five-year baseline period used in this analysis (2004, 2005, 2006, 2007 and 2008) calculate to an overall annual average rate of 3.43 pounds of NOX per ton of clinker, with a standard deviation of 0.21 pound per ton. The highest annual emission rate in the baseline years was 3.67 pounds per ton of clinker.

As a part of their submittals, Holcim analyzed continuous hourly emission data for NOX. The hourly emission data from 2004 to 2008 (baseline years) were used to calculate the daily emission rates. A 30-day rolling average emission rate was calculated by dividing the total emissions from the previous 30 operating days by the total clinker production from the previous 30 operating days. The 99th percentile of the 30-day rolling average data was used to establish the short-term baseline emission rate of 4.47 pounds of NOX per ton of clinker. The 99th percentile accounts for emission changes due to short-term and long-term inherent process, raw material and fuel variability.

Holcim is permitted to burn up to 55,000 tpy of TDF annually and has been using TDF during the baseline years. Use of TDF as a NOX control strategy has been well documented and recognized by EPA. A reduction in NOX emissions of up to 30% to 40% has been reported. Since the TDF market and possible associated TDF-use incentives are unpredictable and TDF’s long-term future availability is unknown, the baseline emission rate was adjusted upward by a conservative factor of 10% to account for the NOX reduction in the baseline years as a result of the use of TDF during this baseline period that might not be available in future years. This increased the baseline 30-day rolling average emissions rate from 4.47 to 4.97 pounds of NOX per ton of clinker.

An SNCR control efficiency of 50% is feasible for the Portland Plant kiln. However, to achieve the necessary system configuration and temperature profile, SNCR will be applied at the top of the preheater tower and thus the alkali bypass exhaust stream cannot be treated. To achieve the proper cement product specifications, the Portland Plant alkali bypass varies from 0 - 30% of main kiln gas flow. Adjusting by 10%, (conservative estimate) for the alkali bypass to account for the exhaust gas that is not treated (i.e., bypassed) by the SNCR system, the overall SNCR control efficiency for the main stack will be 45%.

Based on the above discussion, the 30-day rolling average short-term limit was calculated at 2.73 pounds of NO_X per ton of clinker by adjusting upward the short-term baseline emission rate of 4.47 pounds of NO_X per ton clinker by 10% for TDF and then accounting for SNCR 45% overall control efficiency [4.47/0.9*(1-0.45) = 2.73]. The long-term annual limit was calculated at 2,086.8 tpy by adjusting upward the annual baseline emission rate of 3.64 lbs/ton clinker (the mean of 3.43 pounds per ton plus one standard deviation of 0.21 pound per ton) by 10% for TDF and then accounting for SNCR 45% overall control efficiency [3.64/0.9*(1-0.45) = 2.23 lb/ton]. This calculated value of 2.23 pounds per ton was then multiplied by the annual clinker limit of 1,873,898 tpy, and then divided by 2,000 pounds per ton to arrive at the 2,086.8 tpy NO_X limit.

Because SNCR is technically and economically feasible, the state did not further consider water injection because the levels of control associated with this option are not as high as with SNCR.

The following table lists the most feasible and effective option (SNCR):

NOx Control Technology	Estimated Control Efficiency	30-day Rolling Average Emissions (lb/ton of Clinker)	Annual Controlled NOx Emissions (tpy)
Baseline NOx Emissions	-	4.97	3,185.7[1]
SNCR	45%[2]	2.73	2,086.8

[1] Defaulted to the permit limit since the calculated baseline was higher.

[2] This is calculated based on the 50% SNCR removal efficiency and 10% bypass

Step 4: Evaluate Factors and Present Determination

Factor 1: Cost of Compliance

In April 2008, Holcim provided information to the state on SNCR systems that was based on trials that were conducted at the plant in the 4th quarter of 2006. Holcim estimated that NOX emissions could be reduced in the general range of 60 to 80% (based on a 1,000 pound per hour emission rate) at an approximate cost of $1,028 per ton. This was based on a short-term testing and showed considerable ammonia slip which could cause significant environmental, safety and operational issues. Considering the concern with the ammonia slip, an overall SNCR removal efficiency of 45% was used in this analysis. This estimate was based on an installation cost of $400,000 to $600,000 and an annual cost of $2,520,000. In February 2010, Holcim also provided a general direct capital investment cost estimate of $700,000 to $1,400,000 (excluding the capability for winter operations). The following table lists the emission reductions, annualized costs and the control cost effectiveness for the feasible controls:

Holcim Portland Plant – Kiln System				
NOx Control Technology	NOx Emission Reduction	Annualized Cost	Cost Effectiveness	Incremental Cost Effectiveness
	(tons/yr)	($/yr)	($/ton)	($/ton)
Baseline NOx Emissions	-			
SNCR (45% control)	1,098.9	$2,520,000[1]	$2,293	-

[1] Annualized cost is based on the estimates provided by Holcim. The state believes that the $2,293/ton value is generally representative of control costs for the scenario evaluated in this RP analysis.

Factor 2: Time Necessary for Compliance

It is anticipated that within five years or less after SIP approval, all the work necessary to study, design, construct and begin operating the SNCR system would be complete.

Factor 3: Energy and Non-Air Quality Impacts

SNCR systems do increase power needs to operate injection equipment, drive the pumps and fans necessary to supply reagents, and overcome additional pressure drops caused by the control equipment. Installing SNCR also increases levels of ammonia emissions, and can create a ‘blue plume’ if ammonia rates are not adequately controlled. Other environmental factors include the storage and transportation of the selected ammonia-based reagent. For SNCR systems, these types of energy and non-air quality impacts, while necessary to address, are not generally considered significant and do not adversely affect the selection of this technology.

Factor 4: Remaining Useful Life

The state is not aware of any near-term limitations on the useful life of the cement kiln system, so it can be assumed that it will remain in service for a 20-year amortization period. Thus, this factor does not influence the selection of controls.

Factor 5 (optional): Evaluate Visibility Results

As described above, CALPUFF modeling was conducted by the Division as a part of the development of the September 14, 2010 version of this document for the kiln system using a SO2 emission rate of 99.17 lbs/hour, a NOx emission rate of 837.96 pounds per hour (lbs/hour), and a PM10 emission rate of 19.83 lbs/hour. The modeling indicates a 98th percentile visibility impact of 0.435 delta deciview (Δdv) at Great Sand Dunes National Park.

As a part of their late October 2010 submittals, Holcim provided modeling data for their proposed NOx RP limitations. The following table lists the projected visibility improvements for these NOx controls, as identified by Holcim:

Holcim Portland Plant – Kiln System		
NOx Control Method	98th Percentile Impact (Δdv)	98th Percentile Improvement (Δdv)
Maximum (24-hr max) (based on modeled emission rates of 1,363 lb/hr NOx, 586 lb/hr SO_2, 86.4 lb/hr PM_{10})	0.814	N/A
SNCR 45% overall NOx control efficiency Limits of **2.73 lb/ton** (30-day rolling average) and **2,086.8 tons per year** (based on modeled emission rates of 750 lb/hr NOx, 586 lb/hr SO_2, 86.4 lb/hr PM_{10})	0.526	0.288

Determination

For the kiln system, the state has determined that SNCR is the best NOx control system available with NOx RP emission limits of 2.73 pounds per ton of clinker (30-day rolling average) and 2,086.8 tons per year (12-month rolling total). The emissions rate and the control efficiency reflect the best performance from the control options evaluated. This RP determination affords the most NOx reduction from the kiln system (1,098.9 tpy) and contributes to significant visibility improvement.

Summary of NOx RP Determination for Kiln System

2.73 pounds of NOx per ton of clinker (30-day rolling average)

2,086.8 tons of NOx per year (12-month rolling total)

V. Reasonable Progress Evaluation of the Quarry and Finish Mill

Because of the high level of existing fugitive dust controls employed at the quarry and the baghouse controls already installed on the finish mill emission points, the state has determined that no meaningful emission reductions (and thus no meaningful visibility improvements) would occur pursuant to any conceivable additional controls on these points. Accordingly, the state has determined that no additional visibility analysis is necessary or appropriate since even the total elimination of the emissions from the quarry and finish mill would not result in any meaningful visibility improvement. For the quarry, the current PM10 emission limitation is 47.9 tpy (fugitive) and for the finish mill it is 34.3 tpy (point source). These limitations are included in the existing Holcim Portland Plant construction permit.

Particulate Matter RP Determination for Quarry

The state has determined that the existing fugitive dust control plan and associated control measures which include: watering and the use of chemical stabilizers, compaction and re-vegetation of stockpiles, vehicle speed limitations, reclamation and sequential extraction of materials, paving, graveling and cleaning of haul roads, sequential blasting, wet drilling, and the suspension of activities during high wind events represent the most stringent control option for these types of emission sources. The existing fugitive dust control plan and the 47.9 tpy fugitive PM10 emission limit (12-month rolling total) for the quarry represent RP for PM10.

Summary of PM/PM10 RP Determination for Quarry

47.9 tons of fugitive PM10 per year (12-month rolling total)

Particulate Matter RP Determination for Finish Mill

The state has determined that the existing fabric filter baghouses and the existing emissions limits of 34.3 tpy of PM10 (12-month rolling total) for the finish mill represent the most stringent control option. Holcim has reported nominal control efficiency for the finish mill baghouses of 99.5%. The units are exceeding a PM control efficiency of 95%, and the control technology and emission limits represent RP for PM10 for the finish mill. In addition to the ton per year emission limit associated with this RP determination, the finish mill will also be subject to the recent changes to the PC MACT standard, which contains a visible emission limitation for finish mills.

Summary of PM/PM10 RP Determination for Finish Mill

34.3 tons of PM10 per year (12-month rolling total)