Best Available Retrofit Technology (BART) Analysis of Control Options
For
CEMEX Inc. – Lyons Cement Plant

I.   Source Description

Owner/Operator: Cemex
Source Type: Portland Cement Manufacturing
Kiln Type: Modified Long-dry Kiln
Review: Best Available Retrofit Technology (BART)

History:

The Cemex facility manufactures Portland cement and is located in Lyons, Colorado, approximately 20 miles from Rocky Mountain National Park. The Lyons plant was originally constructed with a long dry kiln. This plant supplies approximately 25% of the clinker used in the regional cement market. There are two potential BART eligible units at the facility: the dryer and the kiln.

In 1980, the kiln was cut to one-half its original length, and a flash vessel was added with a single-stage preheater. The permitted kiln feed rate is 120 tons per hour of raw material (kiln feed), and on average yields approximately 62 tons of clinker per hour. The kiln is the main source of SO2 and NOx emissions. The raw material dryer emits minor amounts of SO2 and NOx; in 2008 Cemex reported SO2 and NOx emissions from the dryer as 0.89 and 10.41 tons per year respectively based on stack test results.

Newer multistage preheater/precalciner kilns are designed to be more energy efficient and yield lower emissions per ton of clinker due to this when compared to the Cemex Lyons kiln. The

newer Portland cement plants studied by EPA, utilize multistage preheater/precalciner designs that are not directly comparable. Cemex has a unique single stage preheater/precalciner system with different emission profiles and energy demands. New Portland cement plants have further developed the preheater/precalciner design with multiple stages to reduce emissions and energy requirements for the process. Additionally, new plant designs allow for the effective use of Selective Non-Catalytic Reduction (SNCR), which requires ammonia like compounds to be injected into appropriate locations of the preheater/precalciner vessels where temperatures are ideal (between 1600-2000°F) for reducing NOx to elemental Nitrogen.

Process Description:

Limestone and other raw materials extracted from the quarry are processed through a primary crusher at the Dowe Flats quarry. The crushed material is transported to the plant on a 2.0 mile belt conveyor system and discharged to a stockpile. The stockpiled material is placed on a belt by means of a front end loader to be processed through a primary crusher, the dryer, and a secondary crusher. The material from the secondary crusher is stored in raw material storage silos.

These storage silos contain silica and iron ore and various quarried raw materials. Material from these storage silos is discharged to weigh belts for the formulation of a desired product. The weigh belts discharge to the raw mill. The raw mill mixes and crushes the blended materials and delivers the homogenized material to storage silos. The homogenized material from the storage silos is delivered to the calciner portion of the kiln. Pulverized coal from the coal mill is fired at the bottom of the flash calciner. The partially calcined material from the calciner then enters the 14 foot 3 inch diameter - 245 foot long rotary kiln, which is located at a slight incline along its horizontal axis. The Cemex kiln process-type is best categorized as a modified long dry kiln. The material travels towards the clinker discharge end where additional pulverized coal is fired for the clinkering process. The clinker is discharged from the kiln into the clinker cooler where it is cooled by air forced through the clinker bed by under grate fans. The cooled clinker is then moved to internal storage in an A-Frame building, or outside storage stockpiles. The stored clinker is the raw material for the finish mill. In the finish mill the clinker is combined with gypsum and other additives, ground to a fine material and stored in product silos. The material in the product silos can be loaded for bulk transport, or sent to a packaging system.

From an overall perspective, the manufacturing process may be viewed as two segments -- clinker production and cement production. The clinker storage allows the two processes to operate at different production rates. During periods of low demand for cement, clinker is accumulated. If cement is in high demand, the clinker production can be supplemented by purchase of clinker from other sources. The overall result is the clinker production can operate at a rather steady rate, while the cement production can operate in response to the current or projected demands.

II.   Source Emissions

There are two BART eligible units at the Cemex facility, the dryer (point 003) and the kiln (point 007). Regulation Number 3 requires sources to submit an Air Pollution Emission Notice (APEN) on each emission point at least every five years. Typically, emission points with low emissions are updated every five years whereas points with higher emissions are updated annually, since fees are assessed on these emissions.

Table 1 lists the APEN reported emissions from the dryer and emission inventory records collected during routine inspections. The 1999 APEN is based on emission factors, whereas the 2003, 2008 and 2009 APENs are based on a stack test. The Division has determined that the 2008 emissions best represents baseline emissions for the dryer since stack test data is considered more reliable then emission factors. Furthermore, the 2008 clinker production is representative of typical operations because it falls within the normal range of the historical average (please see Table 3 below). Consequently, for purposes of this analysis the dryer has baseline emissions of NOx = 10.41 tpy; SO2= 0.89 tpy; and PM10 = 5.12 tpy; based on a recent stack test.

Table 1: Dryer Emissions

Dryer SCC - 30500620				
Pollutant	SO2	NOx	PM10	CO
Allowable Emissions* [tpy]	36.70	13.90	22.80	57.30
1999 APEN Emissions [tpy]	31.10	13.30	22.20	55.40
2003 APEN Emissions [tpy]	0.64	1.83	1.89	3.83
2008 APEN Emissions [tpy]	**0.89**	**10.41**	**5.12**	**2.97**
2009 APEN Emissions [tpy]	0.37	4.27	2.10	1.22
Baseline [tpy]	**0.89**	**10.41**	**5.12**	**2.97**
% Baseline is below Allowable Emissions	-97.8%	-25.1%	-77.5%	-94.8%
Baseline Emissions [lbs/ton of Clinker]	0.004	0.04	0.02	0.01

Current emission limitations are contained in operating permit (95OPBO082)

Table 2 below lists the emissions from the kiln. The APEN reported SO2, NOx and CO emissions are based on continuous emission monitoring systems (CEMS) and the PM10 emissions are based on periodic stack tests. The Division has determined that the 2002 emissions best represent baseline emissions for the kiln because it corresponds to the high range for SO2 emissions (which can vary significantly due to pyrites in the limestone) and NOx emissions are within the normal historical range along with clinker production which is near the historical average. There is an increase in kiln PM10 emissions starting in 2007 because of a change in CDPHE's APEN reporting policy, which allows for the grouping of common stacks associated with kiln (process group P007) and a change to reporting PM10 emissions based on periodic stack tests rather than the use of emission factors. Consequently, the 2002 PM10 emissions are not the most realistic depiction of anticipated baghouse controls and actual emissions that are listed in more recent kiln (P007) APEN reports.

The EPA BART guidelines suggest that *"the baseline emissions rate should represent a realistic depiction of anticipated annual emissions for the source." See [70 FR 39167].* There is some variation in the short-term and long-term SO2 emissions depending on the raw material mix, type of clinker produced, and fuel used. Thus, historically there was some flexibility provided in developing the original permit limits to allow of the use of alternative fuels and raw materials, as well as longer averaging periods. The 10-year period (2000-2009) may represent a different kiln operation condition when compared to earlier periods because no petroleum coke was burned in

the kiln despite being permitted to burn such fuel. The Division determined that looking back at kiln operations prior to the year 2000 were not reasonable for purposes of BART. Consequently, the selection of 2002 as the kiln emissions baseline essentially precludes the use of petroleum coke since the use of such fuel would result in SO2 emissions far above 95 tons per year.

The justification for selecting the highest SO2 emission rate over a baseline period is associated with the fact that cement kiln SO2 emissions are not as predictable as a coal-fired boiler (power plant). The sulfur in the coal is sole source of SO2 at a power plant, whereas a cement kiln has two sources, the coal fuel and the sulfide impurities (iron pyrite) in the limestone and other raw materials added to the kiln. Consequently, it is much easier, although still a challenge, to maintain compliance with SO2 limits at coal-fired power plants through careful blending of various coals, or purchasing compliant coal to achieve more consistent sulfur content. Conversely, coal blending for cement kilns only addresses one source of SO2, the other source (the raw materials) varies depending on impurities in the mining deposit and other additives used in clinker production.

Table 2: Kiln Emissions

Kiln SCC – 30500606 (120 tons/hour maximum feed rate – 967,680 tons/year dry basis)				
Pollutant	SO2	NOx	PM10	CO
Allowable Emissions [tpy]	1,340.0	2,649.0	133.0	396.0
2000 APEN Emissions [tpy]	14.4	1,729.6		
2001 APEN Emissions [tpy]	18.7	1,858.9	8.7	233.2
2002 APEN Emissions [tpy]	**95.0**	**1,747.1**	**8.5**	**235.3**
2003 APEN Emissions [tpy]	48.0	1,835.0	9.6	210.0
2004 APEN Emissions [tpy]	26.3	1,708.9	9.1	209.0
2005 APEN Emissions [tpy]	27.2	1,591.3	8.5	156.0
2006 APEN Emissions [tpy]	44.7	2,011.7	8.5	239.2
2007 APEN Emissions [tpy]	65.0	1,689.0	56.0	311.0
2008 APEN Emissions [tpy]	55.8	1,295.5	42.0	345.1
2009 APEN Emissions [tpy]	15.5	495.5	17.5	102.4
Baseline [tpy]	**95.0**	**1,747.1**	**8.5**	**235.3**
% Baseline is below Allowable Emissions	-92.9%	-34.0%	-93.6%	-40.6%
Baseline Emissions [lbs/ton of Clinker]	0.402	7.388	0.036	0.995

The average clinker production over the period (2000 – 2008) is 486,031 tons. The year 2009 was excluded from the average as clinker production was well below the average production level.

Table 3: Kiln-Flash Calciner – Historical Emissions

Year	Actual Clinker Production [tpy]	SO2 [tpy]	SO2 [lbs/ton of Clinker]	NOx [tpy]	NOx [lbs/ton of Clinker]
2000	539,992	14.4	0.053	1,729.6	6.42
2001	508,733	18.7	0.074	1,858.9	7.31
2002	**472,945**	**95.0**	**0.402**	**1,747.1**	**7.39**
2003	516,251	48.0	0.186	1,835.0	7.11
2004	472,053	26.3	0.111	1,708.9	7.24
2005	440,384	27.2	0.123	1,591.3	7.23
2006	466,173	44.7	0.192	2,011.7	8.63
2007	479,225	65.0	0.271	1,689.0	7.05
2008	478,520	55.8	0.233	1,295.5	5.41
2009	185,076	15.5	0.167	495.5	5.35

III.   BART Evaluation

There are two BART eligible units at the Cemex facility, the dryer and the kiln. The dryer is natural gas-fired with actual emissions of NOx = 10.41 tpy; SO2= 0.89 tpy; and PM10 = 5.12 tpy; based on a recent stack test. CALPUFF modeling[1], of the dryer and kiln combined indicates a 98th percentile visibility impact (at Rocky Mountain National Park) of 0.78 delta deciview[2] (Δdv) and 98th percentile visibility impact at of only the kiln is 0.76 Δdv[3]. Thus, the visibility impact of the dryer alone is the resultant difference which is 0.02 Δdv. Because the dryer uses the cleanest fossil fuel available and post combustion controls on such extremely low concentrations are not practical, the Division has determined that no meaningful emission reductions (and thus no meaningful visibility improvements) would occur pursuant to any conceivable controls on the dryer. Accordingly, the Division has determined that no additional emission control analysis of the dryer is necessary or appropriate since the total elimination of the emissions would not result in any measurable visibility improvement which is a fundamental factor in the BART evaluation. Consequently, the current SO2, NOx and PM10 emission limits (see Table 1 –Dryer Allowable Emissions) established in the Cemex – Lyons Operating Permit (95OPBO082) have been determined to satisfy the requirements for BART.

III.A. Review of Sulfur Dioxide Controls on the Kiln

Step 1: Identify All Available Technologies

Cemex originally identified four available technologies for the removal of sulfur dioxide from Portland cement kilns. A copy of Cemex's BART analysis is included with this analysis as an attachment, and provides further support and documentation for the conclusions reached herein. The Division added Dry Sorbent Injection (DSI) as another option that is available for control of

---

[1] Cemex Inc., Lyons Colorado - BART Five Factor Analysis; dated August 29, 2008
[2] Table 3-6 of the Cemex BART Five Factor Analysis
[3] Table 4-7 of the Cemex BART Five Factor Analysis

SO2 emissions. The Division also reviewed the RACT/BACT/LAER clearinghouse and other BART analyses develop the following list of available technologies:

1. Fuel Substitution
2. Raw Material Substitution
3. Lime Addition to Kiln Feed
4. Dry Sorbent Injection
5. Wet Lime Scrubbing

Step 2: Eliminate Technically Infeasible Options

Cemex concluded that fuel substitution and raw material substitution are not technically feasible at the plant. Because of the physical, chemical and engineering principles involved in manufacturing Portland cement, technical difficulties would arguably preclude the successful use of these control options at the plant. Nonetheless, the Division has determined that each of the foregoing technologies is "technically feasible" for the facility, as that term is discussed in EPA's BART guidelines.

Step 3: Evaluate Control Effectiveness of Each Remaining Control Technology

Step 4: Evaluate Impacts and Document Results

1.   Fuel Substitution:

Cemex is authorized to burn coal, coke and tire derived fuel (TDF) at the facility, although coal is the primary fuel. The coal used in the kiln typically has a sulfur content of less than 1.5%, whereas the sulfur content of coke can be as high as 6% sulfur. Removal of SO2 is inherent to the cement manufacturing process as the hot combustion gases come in contact with the limestone generating free lime, which then reacts with the SO2 in the free gas stream resulting in removal of sulfur in the clinker product. Removal efficiencies in rotary kiln systems can range between 38% and 99% of sulfur input. Cemex estimates the SO2 removal efficiency of about 80%. Based on the low level of SO2 emissions (based on CEMS) emitted from the kiln, it is apparent that a high level of SO2 control is achieved through the inherent removal process within the kiln. Since inherent removal accounts for at least 80% reduction in kiln SO2 emissions, any further lowering of the sulfur content of the fuel results in about a 20% reduction in directly emitted SO2.

In November 2002, a preliminary performance (stack) test was conducted on the kiln that compared fossil fuel (coal & natural gas) with coal supplemented with TDF (coal & tires) which indicated about a 40% reduction in SOx in the exhaust stream. The stack tests show that TDF can be burned without exceeding applicable emission limits for either criteria pollutants or hazardous air pollutants. Both the Division and Cemex continue to believe that firing TDF is a viable emission control strategy under appropriate conditions along with consideration of the stack tests results and the fact that TDF is widely used as an alternative fuel. Nevertheless, some in the Lyons community have expressed reservations about the tire burning, and requested a moratorium on using TDF. In response to concerns, and in consideration of a Division issued Compliance Order on Consent (Case No. 2005-049), Cemex agreed not to use TDF as an alternative fuel in the kiln for a period that expired on December 31, 2007. Presently, Cemex may commence using TDF as permitted in accordance with the terms and conditions of Permit No. 95OPBO082, unless TDF is prohibited by another legally enforceable requirement.

Cost of Compliance:

Cemex provided limited TDF cost information because of ongoing community concerns associated with burning tires. The annualized costs are about $172,179 per year; however the costs of acquiring TDF and the transportation costs were not included. Assuming the above annual cost and the estimated 40% SO2 reduction, the control cost is estimated at about $4,531 per ton of SO2 reduced.

Energy Impacts and Non Air-Quality Impacts:

There is community concern associated with fuel switching to TDF.

Existing Controls in Use at Source:

The source uses low sulfur coal and inherent removal of SO2 emissions through contact with the clinker results in about 80% control.

Remaining Useful Life:

No impact

2.   Raw Material Substitution:

Sulfide sulfur in the raw materials (primarily limestone), 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:

$$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$$
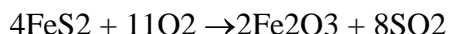
Using raw materials with lower pyritic sulfur content would reduce the potential for SO2 emissions from the kiln system. However, while pyrites are present in the limestone and other raw materials used at the plant, concentrations of sulfide sulfur in these materials is typically low. On average, the sulfide content of the raw materials is less than 2%. It is uncertain that lower sulfur content materials are available. Since the raw materials and fuel used at the plant already have very low sulfide sulfur, raw material substitution is not likely to produce significant sulfur reductions.

Similar to most cement plants, the Cemex facility is built near the mine source of limestone, the primary raw material for cement manufacture. To require transport of materials with lower sulfide concentrations from elsewhere would impose an economic penalty that would cause most plants 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 can be economically prohibitive.

The Division has determined that raw material substitution with a different source of limestone is not a practical control option as SO2 emissions vary depending on the level of pyrite contamination which is inherently difficult to predict. Consequently, raw material substitution has been eliminated from further review and consideration.

3.   Lime Addition to Kiln Feed:

Lime Addition to Kiln Feed at the Lyons plant would consist of mixing lime (CaO) with the raw Kiln feed. The CaO would react with SO2 driven off in the kiln to form calcium sulfite (CaSO3) and calcium sulfate (CaSO4) according to the following reactions:

$$CaO + SO_2 \rightarrow CaSO_3$$

$$CaSO3 + \tfrac{1}{2} O2 \rightarrow \quad CaSO4$$
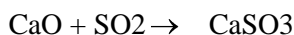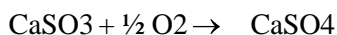
These reactions can occur in the calciner, throughout the rotary kiln, and in the lower stages of the flash calciner (i.e., at any location in the system at which CaO and SO2 are present simultaneously and are mixed adequately). The amount of SO2 absorbed through this mechanism at any location in the pyroprocess is dependent on the site-specific temperature and other factors such as the time of contact between the reactants. Once sulfur is absorbed as CaSO4 in the materials in the pyroprocess, it is unlikely to be released again as SO2. CaSO4 would be retained in the raw mix and ultimately be converted into clinker. Cemex anticipates that Lime Addition to Kiln Feed could achieve 25% control of the SO2 emitted from the system. Considering the length of the kiln and the corresponding amount of contact time, it appears that 25% control of SO2 is possible depending on the amount of lime that is fed into the kiln.

Cost of Compliance:

The cost of Lime Addition to Kiln Feed was determined by calculating the cost of the CaO needed to react with the SO2 in the system. In an exhaust gas stream, the molar ratio of CaO needed to react with a mole of SO2 (to achieve a near 90% reaction) is on the order of 1:1. However in the situation of Cemex – Lyons, adding the CaO directly to the feed would result in a diminished effectiveness because of the lower SO2 concentrations. Cemex has indicated that, based on data from Cemex's Wampum, PA plant, an addition of 2-3 ton/hr of CaO to a similar Kiln feed stream resulted in approximately a 25% reduction in the SO2 concentration (from 600 ppm down to 450 ppm). The concentration of SO2 in the gas stream at the Lyons plant is significantly lower (a typical 24-hr average is in the 6 ppm range) and it is unknown how much more CaO is needed to achieve the desired reduction. Since the typical emission range at Cemex-Lyons is 100 times lower than the tested levels at Cemex-Wampum, it is expected that more CaO would be needed to achieve adequate contact time with the lower concentrations of sulfur in the exhaust stream. Moreover, the effectiveness of CaO addition is further limited by the alkali byproducts associated with the use of more CaO. Consequently, Cemex has conservatively estimated that it could take about 4 tons per hour of CaO addition to achieve a 25% SO2 reduction.

Cemex – Lyons kiln is limited to 8,064 hours per year of operation based on a permit limit in the Operating Permit (95OPBO082), thus the resulting annual CaO usage is 32,256 tons (4*8064). Cemex's 2007 BART application identified the CaO cost at $60/ton, but this was for raw CaO (un-calcined) which has different properties. The appropriate material is the use of calcined CaO (lime or quick lime) which cost about $143/ton. Therefore, the annual operating cost would be 32,256 tons x $143/ton = $4,612,608. The lime (CaO) addition would yield approximately 90% conversion to clinker, or 29,030 tpy of clinker, which has a value of $1,161,216 @ $40/ton. Therefore, the actual operating cost would be approximately $4,612,608 - $1,161,216 = $3,451,392. At 25 % control effectiveness, the annual SO2 emissions would be lowered from the proposed permit limit of 95.0 tpy to 71.25 tons/year. The cost effectiveness would be approximately $153,271per ton of SO2 removed.

Energy Impacts and Non Air-Quality Impacts:

Alkali impurities in the CaO could result in additional wasting of kiln dust to meet low alkali limits. Additional fugitive PM10 emission may result from handling of the CaO.

Existing Controls in Use at Source:

The source uses low sulfur coal and inherent removal of SO2 emissions through contact with the clinker results in about 80% control.

Remaining Useful Life:

The remaining useful life of the kiln does not impact the annualized costs for lime addition to kiln feed.

4.   Dry Sorbent Injection:

Dry Sorbent Injection (DSI) utilizes finely ground sorbent which is injected in the gas stream of the kiln. The sorbent typically used is a hydrated lime, sodium bicarbonate or Trona (soda ash). Water may be injected separately from the sorbent either downstream or upstream of the dry sorbent injection point to humidify the flue gas. The relative position of the dry sorbent and water injection is optimized to maximally promote droplet scavenging or impacts between sorbent particles and water droplets, both suspended in gas stream. Fly ash, reaction products, and any unreacted sorbent are collected in the particulate control device.

Cost of Compliance:

Cemex did not provide any DSI costs specific to the Lyons kiln.

Energy Impacts and Non Air-Quality Impacts:

There are no energy or non-air quality impacts associated with dry sorbent injection.

Existing Controls in Use at Source:

The source uses low sulfur coal and inherent removal of SO2 emissions through contact with the clinker which results in about 80% control.

Remaining Useful Life:

The remaining useful life of the kiln does not impact the annualized costs for dry sorbent injection.

5.   Wet Lime Scrubbing:

Wet lime scrubbing (WLS) is the term used 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 WLS 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. *See* Cemex BART submittal at 4-4, *citing* "EPA Fact Sheet – Flue Gas Desulfurization (FGD) Wet, Spray Dry, and Dry Scrubbers."

Cost of Compliance:

Cemex performed an economic analysis to determine the annualized cost for WLS based on a recent vendor bid for a cement plant with a similar exhaust flow rate. The "annual tons reduced" were determined by subtracting the estimated controlled annual emissions from the Division proposed annual permit limit of 95 tpy SO2. The estimated controlled annual emissions, 9.5 tpy,

were calculated by applying 90 percent control efficiency to the 95 tpy of SO2. Utilizing this methodology and correcting a math error on the amount of sludge generated, the estimated annualized cost[4] is $2,529,018 for WLS, the projected SO2 control cost per ton is $29,579/ton. A detailed cost analysis is included in Table 4-5 of Cemex's BART submittal, which was corrected by the Division to account for the longer amortization period.

Energy and Non Air-Quality Impacts: Wet Lime Scrubbing (WLS)

Based upon its experience, the Division has determined that wet scrubbing has several negative energy and non air quality environmental impacts, including significant water usage which is a precious commodity in the arid West. Cemex estimates that an appropriately sized wet scrubber would consume approximately 16 million gallons of water per year. Most of this water would be emitted as a steam vapor with a small portion in the sludge that would be generated by the control device. A wet scrubber would also require an additional fan of considerable horsepower to move the flue gas through the scrubber.

Wet scrubbing may also lead to an increase in PM emissions at the Cemex facility, because some particles of limestone or CaSO4 will be entrained in the flue gas and subsequently be emitted from the scrubber. Wet scrubbing is also known to increase emissions of sulfuric acid mist.

Existing Controls in Use at Source:

The source uses low sulfur coal and inherent removal of SO2 emissions through contact with the clinker results in about 80% control.

Remaining Useful Life:

The remaining useful life of the kiln is impacted by the remaining life of the quarry, which Cemex has estimated to be approximately 8 years from the date that a BART control would be required based on the expiration of Boulder County SUP 93-14 for quarry operations. The continued viability of the cement production operation relies on finding additional limestone feedstock of very similar composition within a distance that allows for economic operation. The Division is not aware that Cemex has successfully secured additional limestone supplies that would provide additional useful life to the facility. Presently, Cemex is unwilling to consent to closure date in the operating permit therefore the Division has used 20 years as the capital recovery period.

---

[4] Capital Recovery based on an assumed 20 year life and 7% interest rate

Table 4 below lists the most feasible and effective options, ranked by control effectiveness.

Table 4: Kiln SO2 Control Options

Control Technology	Estimated Control Efficiency	Annual Controlled Hourly SO2 Emissions [lbs/hr]	Annual Controlled SO2 Emissions [tpy]	Annual Controlled SO2 Emissions [lb/ton of Clinker]
Baseline SO2 Emissions		25.3	95.0	0.40
Lime Addition to Kiln Feed	25%	19.0	71.3	0.30
Fuel Substitution (coal supplemented with TDF)	40%	15.2	57.0	0.24
Dry Sorbent Injection	50%	12.7	47.5	0.20
Wet Lime Scrubbing (Tailpipe scrubber)	90%	2.5	9.5	0.04

Table 5 below lists the SO2 emission reduction, annualized costs and the control cost effectiveness for the feasible controls, ranked by control effectiveness.

Table 5: Summary of Cost Effectiveness of SO2 Control Technologies for the Kiln

Control Technology	SO2 Emission Reduction [tons/yr]	Annualized Cost [$/yr]	Cost Effectiveness [$/ton]	Incremental Cost Effectiveness [$/ton]
Baseline SO2 Emissions	-			
Lime Addition to Kiln Feed	23.8	$3,640,178	$153,271	
Fuel Substitution (coal supplemented with TDF)	38.0	$172,179	$4,531	-$243,368
Dry Sorbent Injection	47.5	Not provided	-	
Wet Lime Scrubbing (Tailpipe scrubber)	85.5	$2,529,018	$29,579	$49,618

Step 5: Evaluate Visibility Results

CALPUFF modeling was used to determine the projected visibility improvement associated with various control scenarios. Cemex also conducted refined CALMET modeling which indicates that Rocky Mountain National Park is the only Class I Area where the Lyons plant causes or contributes to visibility impairment. Cemex's refined modeling is discussed in detail in the attached Cemex BART 5-Factor Analysis which was reviewed by the Division and found to meet all required performance requirements.

The amount of visibility improvement associated with various SO2 control scenarios using CALPUFF modeling are listed in Table 6.

Table 6: Visibility improvement for SO2 Controls – Kiln Only

Control Method	98th Percentile Impact (Δdv)	98th Percentile Improvement (from 24-hr Max) (Δdv)	Cost Effectiveness ($/Δdv)
24-hr Maximum (≈ 104 lbs/hr)	0.760	-	
Baseline (≈ 25.3 lbs/hr)*	0.730	0.030	
Lime Addition to Kiln (≈ 19.0 lbs/hr)*	0.727	0.033	$110,308,420
Fuel Substitution (≈ 15.2 lbs/hr)*	0.726	0.034	$5,064,088
Dry Sorbent Injection (≈ 12.7 lbs/hr)*	0.724	0.036	
Wet Lime Scrubbing (≈ 2.5 lbs/hr)	0.720	0.040	$63,225,462

- Visibility impacts interpolated from original BART modeling

The SO2 baseline of 95 tons/year is based on 2002 APEN report which results in a 0.03 Δdv of visibility improvement over the 24-hour maximum emission rate of 104 lb/hour (419 tons/year). The SO2 reduction from lime addition to kiln feed is estimated at 25% and the anticipated degree visibility improvement (from 24-hr Maximum) is about 0.033 Δdv at a cost of $110.3 million dollars per Δdv. The control efficiency of fuel substitution could be as high as 40% (about 38 tons/year) based on very limited testing and the anticipated degree of visibility improvement (from 24-hr Maximum) is about 0.034 Δdv at a cost of $5 million dollars per Δdv. Dry sorbent injection has a visibility improvement of 0.036 Δdv, based on an estimated 47.5 tpy reduction in SO2 emissions. Wet lime scrubbing reduces SO2 emissions by about 85.5 tpy with 0.04 Δdv visibility improvement at a cost of $63 million dollars per Δdv. The visibility projections for the below listed emission levels are based on scaling the existing BART modeling.

Step 6: Select BART Control

The Division reviewed the Cemex data on raw material substitution. Since the raw materials (mostly limestone) consumed at the plant typically have low sulfide sulfur content, material substitution would not result in a significant reduction in SO2 in the Kiln. The Division agrees that raw material substitution is not an appropriate or realistic SO2 control technology for the Kiln.

The Division has eliminated the Lime Addition to Kiln Feed SO2 control option from consideration based on excessive cost ($153,271 per ton) and minimal visibility improvement (0.033 Δdv). Despite not having cost information on Dry Sorbent Injection, the Division has determined that the minimal visibility improvement of 0.036 Δdv does not justify further consideration of this control technology.

The Division has eliminated the Wet Lime Scrubbing SO2 control option from consideration based on excessive cost ($29,579 per ton) and minimal visibility improvement (0.04 Δdv improvement). Moreover, wet scrubbing has a number of adverse energy and environmental impacts as described above.

The Division has considered the five factors and has thoroughly reviewed the data supplied by Cemex to determine that process control (inherent removal in the kiln) from the 2002 baseline period represents Best Available Retrofit Technology for control of SO2 emissions in the kiln. Table 7 specifies the Division SO2 BART determination of 25.3 pounds per hour and 95.0 tons

per year that are 12-month rolling averages. The Division considered establishing an SO2 emissions limit based on clinker production, however, the Cemex-Lyons facility does not have the capability to weigh clinker product upon exiting the kiln. Consequently, compliance with the SO2 BART limits will be determined by a continuous emissions monitor system (CEMS).

Table 7: SO2 Emission Limits on the Kiln

Subject Unit	SO2 Control Technology	SO2 Emission Limits
Kiln System	Inherent Removal	25.3 lbs/hr (12-month rolling average)
		95.0 tons/yr (12-month rolling average)

The federal BART rule requires that emission limits must be enforceable and specify a reasonable averaging time consistent with established reference methods. The Division finds that in consideration of the potential for variability in SO2 emissions associated with pyrites in the limestone and other raw materials used at the plant, an annual averaging period provides long-term compliance with the low levels of SO2 emitted from the kiln while allowing for short-term variability in SO2 emissions. Shorter term averaging periods are not practical as the sources of the sulfur impurities are not readily detectable in the quarry materials. The type of cement produced also potentially impacts the variability of SO2 emissions in the kiln feed mix which necessitates longer averaging periods.

In consideration of establishing the SO2 emission limit, the Division reviewed not only the 5 factor analysis, but also looked at emission limits from the RACT/BACT/LAER clearinghouse to determine SO2 emission limits for other cement kilns across the nation. The Division was unable to find an operationally similar kiln to the Cemex - Lyons kiln, but the SO2 emission limits for newer higher efficiency kilns do establish a reasonable range to consider. Table 8 identifies SO2 limits ranging from 0.2 to 12.0 lb per ton of clinker. In comparing the Division proposed SO2 BART limit (approximately equal to 0.40 lb per ton of clinker) to the values approved for new Portland cement kilns in the RACT/BACT/LAER clearinghouse, it is well below the higher limits established in Missouri, and is slightly higher than those established in Florida.

Table 8: RACT/BACT/LAER data for Cement Kilns

RBLC ID	SO2 Control	SO2 Limit	Units	Year
FL 0297	Process	0.2	lb/ton clinker	2007
MO-0072	Process	1.93	lb/ton clinker	2006
FL-0271	Process	0.2	lb/ton clinker	2006
FL-0268	Process	0.23	lb/ton clinker	2004
FL-0267	Process	0.28	lb/ton clinker	2004
SD-003	Process	632	ton/hr	2003
MO-0059	Wet Scrubber	12	lb/ton clinker	2002
IA-0052	Process	4850	ton/year	2002
TX-0355	Process	20	lb/hr	2001
FL-0139	Process	0.27	lb/ton clinker	2000

The Division also evaluated a recent local BACT determination (2007) on Grupo Cementos de Chihuahua (GCC) Rio Grande Pueblo Portland cement plant that establishes a SO2 emission limit of 1.99 lb/ton of clinker. In considering the RBL clearinghouse ranges and a recent Colorado BACT determination, the Division finds that the proposed SO2 BART limits (approximately equal to 0.40 lb/ton of clinker) to be a reasonable limit for such a relatively small SO2 emission source.

Accordingly, based upon its consideration and weighing of the five factors, the Division has determined that the use of low sulfur coal and the inherent control resulting from the Portland cement process provides sufficient basis to establish annual SO2 emission limits of 25.3 lbs/hour and 95.0 tpy (approximately equal to 0.40 lb per ton of clinker) as SO2 BART for the kiln at this facility. No additional controls are warranted because about 80% of the sulfur is captured in the clinker, making the inherent control of the process the SO2 control. Additional SO2 scrubbing is also provided by the limestone coating in the baghouse as the exhaust gas passes through the baghouse filter surface.

III.B. Review of Nitrogen Oxide Controls on the Kiln

As explained above, in Section III, no evaluation of the dryer is warranted because of extremely low emissions. Based on actual 2008 data, the NOx emissions from the kiln are 1295.5 tpy and the raw material dryer are 10.41 tpy. Since the average emissions from the dryer (about 2.8 pounds per hour) are very small compared to the kiln (about 343.9 pounds per hour); the following BART evaluation focuses only on the kiln.

Step 1: Identify All Available Technologies

The primary pollutant of concern for regional haze from the Lyons plant is the NOx generated from the kiln system. Cemex's current allowable NOx emission rate is 2,649 tpy NOx, which equates to an average allowable emission rate of 667 pounds NOx per hour based on the permit limit of 8064 hours of operation per year. Using 2002 as the baseline, the annual average NOx emission rate is 464.3 lbs/hr (1,747.1 tpy) or about 4.73 lbs/ton of dry kiln feed.

Variations in kiln NOx emissions occur with the composition of the raw materials used to produce different types of cement, which depends on market demand. Also, changes in the raw materials (natural rock composition) and seasonal temperature variations occur, as indicated in the following excerpt from a study[5], *"The results of these changes range from zero emissions of NOx during a complete outage of the system to significantly higher than normal NOx emissions when the fuel input is increased to restore the process equilibrium and a normal production rate. More subtle changes in the process, e.g. variations in ambient temperature (short-term and seasonal), variations in the feed rates or fuel or raw materials, demand operator responses that also serve to vary NOx emissions. For a variety of factors, the operation of some pre-calciner kiln systems is more stable than others. Almost invariability, however, pre-calciner kiln systems exhibit more stable operation than the three other types of kiln systems, and experience the least variability in NOx emissions."* The Cemex - Lyons kiln is a modified long dry kiln, thus some consideration of a longer averaging period is appropriate to account for variation in NOx emissions depending on cement product produced and variations in raw materials.

---

[5] See "Variability of NOx Emissions from Precalciner Cement Kiln Systems", Walter L. Greer, Curtis D. Lesslie

Cemex identified six available technologies for the removal of NOx from Portland cement kilns. The Division reviewed the RACT/BACT/LAER Clearinghouse and other BART analyses and agrees with CEMEX's identification of available technologies. The available technologies are the following:

1. Water Injection
2. CKD Insufflation
3. Firing Tire-Derived Fuel
4. Indirect Firing with Low NOx Burners (LNB)
5. Selective Non Catalytic Reduction (SNCR)
6. LNB with SNCR
7. Selective Catalytic Reduction (SCR)

Step 2: Eliminate Technically Infeasible Options

Cemex has concluded that water injection and kiln dust insufflation are not technically feasible at the plant. Because of the physical, chemical and engineering principles involved in manufacturing Portland cement, technical difficulties would arguably preclude the successful use of these control options at the plant. Nonetheless, the Division has determined that these technologies are "technically feasible" for the facility, as that term is discussed in EPA's BART guidelines. As further discussed below, however, the Division has also determined that water injection and kiln dust insufflation are not appropriate NOx controls for purposes of BART at the facility.

7. Selective Catalytic Reduction (SCR):

Selective catalytic reduction (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 NOx 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 NOx 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 NOx 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:

$$4\ NH3 + 4\ NO + O2 \rightarrow 4\ N2 + 6\ H2O$$
and
$$4\ NH3 + 2\ NO2 + O2 \rightarrow 3\ N2 + 6\ H2O$$
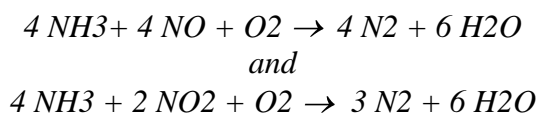
The first equation is the predominant reaction because 90-95% of NO$_x$ in flue gas is NO. It is important to note that the desired chemical reactions are identical with SNCR and SCR. The only difference is that a catalyst is present with SCR, which allows the reactions to occur at a lower temperature. 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/m3 (~ 0.8 lb/t) of NO$_x$ is typically achieved from an inlet of 1,050 mg/Nm3 (4.2 lb/t) or 80% control. Also, ammonia slip was less than 1 mg/m3. 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.
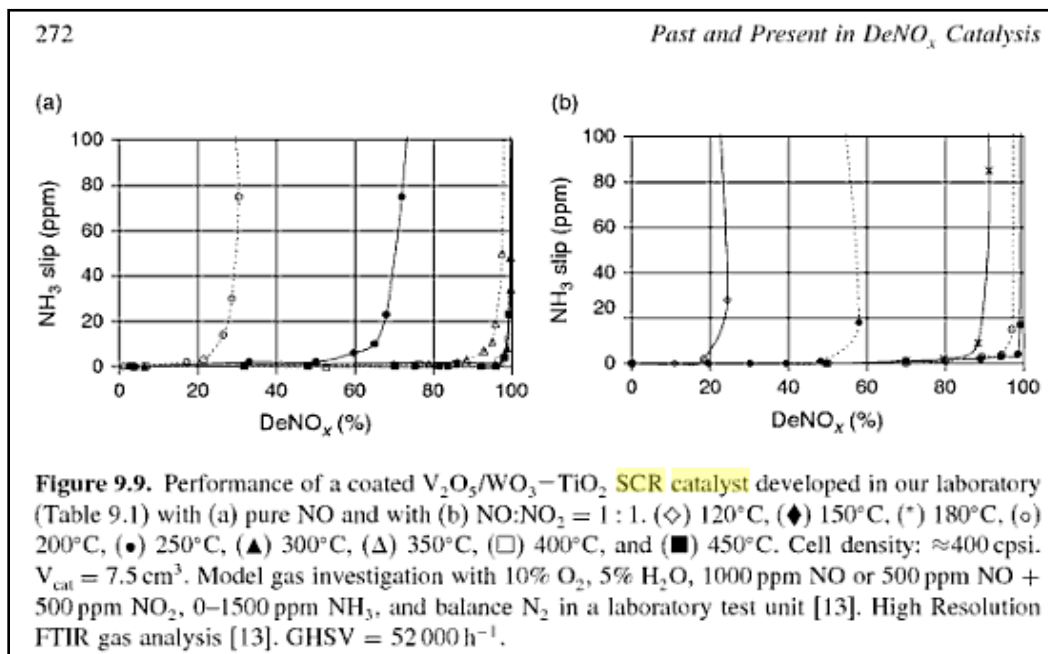
The design of a SCR system is expected to be site specific. According to Schreiber[6], the technology transfer of SCR systems from the power plant industry to the Portland cement industry requires substantial research and pilot testing before the technology could be considered commercially available. Figure 1, from Granger[7] shows the performance of a typical catalyst under different conditions of temperature and gas composition. The highest NOx reduction

---

[6] See Schreiber, R, *et al* "Evaluation of Suitability of Selective Catalytic Reduction and Selective Non-Catalytic Reduction for use in Portland Cement Industry", (2006)
[7] See Granger, P. Elsevier, "Past and Present in DeNOx Catalysis: From Molecular Modeling to Chemical Engineering", (2007)

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

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) $NO:NO_2 = 1:1$. ($\diamond$) 120°C, ($\blacklozenge$) 150°C, ($\ast$) 180°C, ($\circ$) 200°C, ($\bullet$) 250°C, ($\blacktriangle$) 300°C, ($\triangle$) 350°C, ($\square$) 400°C, and ($\blacksquare$) 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. Each challenge presents additional confounding issues related to the application at the Cemex – Lyons facility due to the unique design of the modified long dry kiln. 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). Specific to the Cemex – Lyons kiln, the exit temperature, after the baghouse, will require reheating of the exhaust gases to reach the optimal temperature for effective NOx control. If post NOx control cooling is required, additional water usage would be necessary along with the challenges of the resultant high moisture (20-25%) exhaust gas stream.

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[8], 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 2 shows evidence of catalyst poisoning by both sulfur and alkalies[9].

---

[8] See Benson, S. *et al.* "SCR catalyst performance in flue gases derived from subbituminous and lignite coals, Fuel Processing Technology, Vol. 86" (2005)
[9] See Strege, J. et al., "SCR deactivation in a full-scale cofired utility boiler, Fuel 87" (2008)

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. The exit gas of the Cemex – Lyons kiln presents additional specific issues including moisture in the exhaust stream and alkali dust. The combination of both could result in rapid loss of catalyst activity depending on the type of catalyst materials used.

Figure 2: Sulfur and Alkali Penetration into the pores of the catalyst
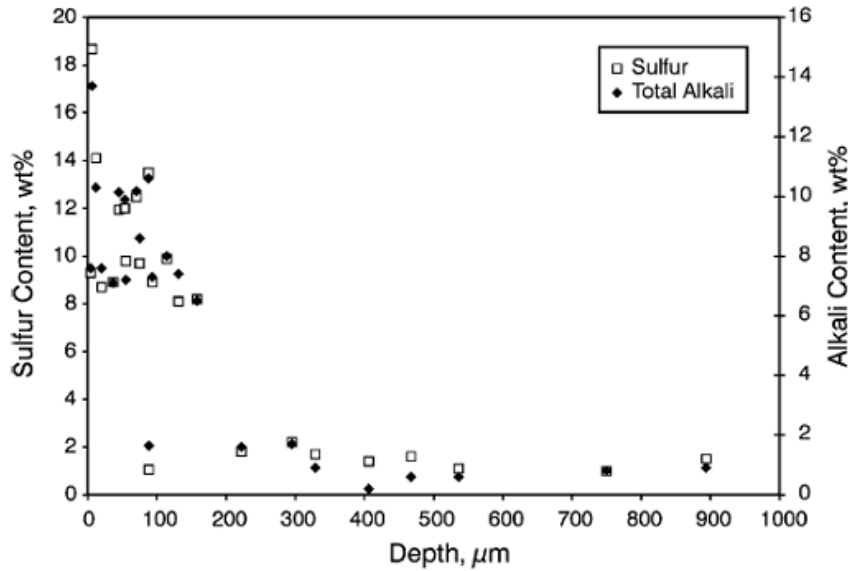
Total alkali (Na + K) and sulfur content with depth beneath catalyst surface.

The above figure 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).

Figure 3: 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.
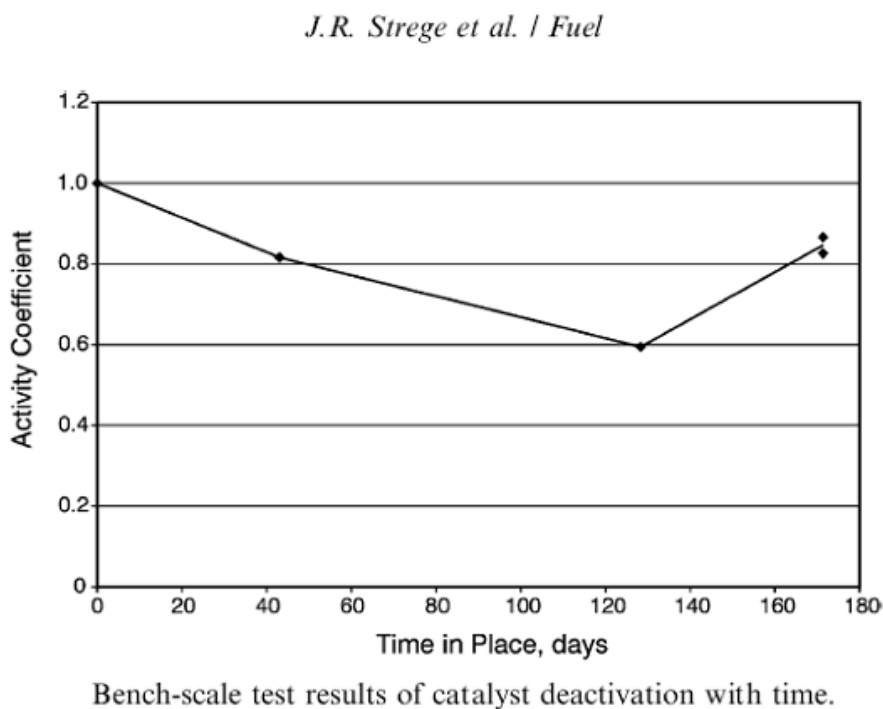
The above figure provides evidence of catalyst deactivation. If the catalyst life is assumed to end when activity coefficient is around 0.6, then the catalyst life is about 130 days or 3,100 hours, which is much lower than the ~23,000 hour catalyst life cited in the report on the Solnhofen Zementwerkes 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[10], a good flow distribution is needed to ensure minimal ammonia slip. The Cemex – Lyons kiln has neither the temperature nor the flow characteristics necessary for optimal catalyst performance. Another concern for the Cemex – Lyons kiln, is the potential for ammonia slip to create visibility impairment that is readily transported into nearby Rocky Mountain National Park.

Presently, SCR has not been applied to a cement plant of any type in the United States. Cemex notes that the major SCR vendors have indicated that SCR is not commercially available for cement kilns at this time.

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 demonstration plant, KWH, indicated that technical uncertainties prevented them from designing an SCR system. Only Alstom provided a proposal that suggested SCR could be supplied to a cement kiln system.

---

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

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.

The Division finds that a limited use - trial basis application of an SCR control technology on three modern kilns in Europe that differ significantly from the Cemex – Lyons kiln design does not constitute "available" control technology for purposes of BART. 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 as would be required for the Cemex - Lyons kiln, which is a modified long-dry kiln design. 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 an existing source. BART 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, the Division has eliminated SCR as an available control technology for purposes of BART.

Step 3: Evaluate Control Effectiveness of Each Remaining Control Technology

Step 4: Evaluate Impacts and Document Results

1.   Water Injection:
The injection of water or steam into the main flame of a kiln can act as a heat sink to reduce the flame temperature. Since NOx formation is a function of the flame temperature and residence time at that temperature, water injection reduces the generation of thermal NOx. Cemex - Lyons has stated that its own experience indicates that water injection can reduce the thermal NOx by approximately 7%. The Division anticipates some reduction in thermal NOx formation when water is injected into the area where the flame temperature is the highest. Aside from actual testing in the kiln, a 7% reduction seems reasonable.

Cost of Compliance:
Based on information from Cemex – Lyons, the Division estimates the annualized costs of water injection at about $43,598 with minimal annual operating costs. Assuming a 7% NOx reduction, the control cost is about $356 per ton of NOx reduced.

Energy Impacts and Non Air-Quality Impacts:
The only non-air quality impacts associated with water injection is the use of a precious resource in limited supply in the arid west.

Existing Controls in Use at Source:
None.

Remaining Useful Life:
The remaining useful life of the kiln does not impact the annualized costs for water injection.

2.   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 NOx. 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 of the thermal inefficiency associated with the practice, CKD insufflation is not an attractive control option for NOx. While the Division does not agree that the thermal inefficiency makes kiln dust insufflation technically infeasible, the Division has determined that that inefficiency, coupled with the much greater reduction achieved through SNCR (discussed below), render insufflation inappropriate for the Cemex plant. Cemex provided additional information that indicates that CKD insufflation is not typically done because of operational issues including ring formation in the kiln. Consequently, the Division is not evaluating this control option further because of operational issues and the greater reduction achieved through SNCR.

3.   Firing Tire-Derived Fuel:

Secondary combustion is defined as follows: a portion of the fuel is fired in a location other than the burning zone. This reduces thermal NOx generation because the temperature in the secondary combustion zone is less than 2100 °F. Firing of solid fuels, such as used tires, is an example of secondary combustion. The Cemex – Lyons kiln has conducted testing of tire derived fuel (TDF) which can be introduced at the kiln feed shelf, creating a secondary combustion zone in the riser between the kiln and the combustion chamber.

In November 2002, a preliminary performance (stack) test was conducted to compare fossil fuel (coal & natural gas) with coal supplemented with TDF (coal & tires) which indicated about a 24.4 % reduction in NOx in the exhaust stream. Cemex estimates that firing TDF can reduce NOx by 10% on a long term basis if utilized. The stack tests show that TDF can be burned without exceeding applicable emission limits for either criteria pollutants or hazardous air pollutants. Both the Division and Cemex continue to believe that firing TDF is a viable NOx reduction control strategy under appropriate conditions along with consideration of the stack tests results and the fact that TDF is widely used as an alternative fuel. Nevertheless, some in the Lyons community have expressed reservations about the tire burning, and requested a moratorium on using TDF. In response to concerns, and in consideration of a Division issued Compliance Order on Consent (Case No. 2005-049), Cemex agreed not to use TDF as an alternative fuel in the kiln for a period that expired on December 31, 2007. Presently, Cemex may commence using TDF as permitted in accordance with the terms and conditions of Permit No. 95OPBO082, unless TDF is prohibited by another legally enforceable requirement. Potentially, TDF could be used in combination with other control technologies, such as SNCR to meet additional BART NOx reduction objectives.

Cost of Compliance:

Cemex provided limited TDF cost information because of ongoing community concerns associated with burning tires. The annualized costs are about $172,179 per year; however the costs of acquiring TDF and the transportation costs were not included. Assuming the above

annual cost and the estimated 10% NOx reduction, the control cost is estimated at about $986 per ton of NOx reduced.

Energy Impacts and Non Air-Quality Impacts:
There is community concern associated with fuel switching to TDF.

Existing Controls in Use at Source:
None.

Remaining Useful Life:
No impact

4.   Indirect Firing with Low-NOx Burners:

Low NOx burners (LNBs) reduce the amount of NOx 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-NOx burner creates primary and secondary combustion zones at the end of the main burner pipe to reduce the amount of NOx 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 NOx formation and produces free radicals that chemically reduce some of the NOx 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 NOx 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 NOx emissions may be anticipated in switching from a direct-fired standard burner to an indirect-fired LNB. 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 cannot be isolated from the limited data available. 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 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. Cemex has estimated that a LNB would lower NOx by 20% at the Lyons plant.

Cost of Compliance:
Cemex also provided information from a NESCAUM report (Dec 2000) that indicates 20-30% NOx reduction can be achieved through the use of indirect firing with LNBs. Cost data was included from a study of California Portland Cement (Colton, CA) that evaluated TDF along with indirect firing w/LNBs that indicates $7 million capital cost and $350,000 annual O&M costs. This study includes TDF firing and does not separate out the actual cost associated with

the indirect firing with LNBs. The Division has estimated the annualized cost at about $710,750 with a result control cost of about $2,034 per ton of NOx reduced.

Energy Impacts and Non Air-Quality Impacts:
None.

Existing Controls in Use at Source:
None.

Remaining Useful Life:
No impact

5.   Selective Non-Catalytic Reduction (SNCR):
In the relatively narrow temperature window of 1600 to 1995°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.

$$4NO + 4NH3 + O2 \rightarrow 4N2 + 6H2O$$

$$2NO2 + 4NH3 + O2 \rightarrow 3N2 + 6H2O$$
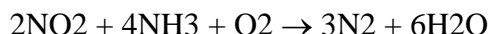
As applied to NOx control from cement kilns and other combustion sources, this technology is called Selective Non-Catalytic Reduction (SNCR). Above this temperature range, the NH3 is oxidized to NOx, thereby increasing NOx emissions. Below this temperature range, the reaction rate is too slow for completion 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.

SNCR is being evaluated at 45 to 50% control efficiency depending on the averaging period. The Cemex kiln/flash calciner configuration is best described as a modified long dry kiln. The Division has conducted extensive research and has not found any documentation on similar kiln types. EPA's Alternative Control Techniques Document Update – NOx Emissions from New Cement Kilns (November 2007) addresses only new cement kilns. These new kilns are multi-stage (4 or 5 stage) preheater/precalciner kilns and are not comparable to Cemex – Lyons unusual modified long dry kiln. The Division has also considered the Cemex Brooksville plant in Florida, but it is a multi stage preheater design and is not comparable to the Lyons facility. The Division's evaluation reveals that the Solnhofen facility achieved only 50% reduction with SCR. Significantly, the Division is concerned that requiring a higher reduction through SNCR (beyond 45% on a 30 day rolling average) could cause excessive ammonia slip that would exacerbate the nitrogen deposition concerns at Rocky Mountain National Park. Considering the close proximity of Cemex to RMNP, any unreacted ammonia (slip) is available to react with oxides of nitrogen or sulfur to form particulates (nitrate or sulfate) a potentially significant contributor to visibility impairment.

It is important to note, that all kilns are not created equal. Modern 5-stage preheater/calciner kilns are not an appropriate comparison to the unusual and modified configuration of the Cemex

– Lyons 40-year old kiln. Consequently, it is difficult to assert what amount of NOx reduction can be achieved with SNCR controls on this older modified long dry kiln. It is important to realize that a higher SNCR control efficiency in a long type kiln necessitates the injection of more ammonia (higher molar ratio) to increase the opportunity for reacting with oxides of nitrogen. This is particularly important to understand with older kilns where operating parameters are often less than the engineering ideal. Often residence time and temperature limit the effectiveness of the reaction. Any excess ammonia (slip) that fails to react, largely because the temperature is too low, is exhausted out the stack to eventually form particulates which counteracts the original basis for the emissions control –visibility. Thus, if EPA desires higher control efficiency, the penalty is more visibility impairment downwind of the source. Therefore, the engineering evaluation must consider the balance between high control efficiency and ammonia slip.

Cost of Compliance:

Based on information provided by Cemex – Lyons, the Division estimates the annual costs at about $1,636,636 per year. Assuming a 48.43% NOx reduction, the control cost is about $1,934 per ton of NOx reduced.

Energy Impacts and Non Air-Quality Impacts:

None.

Existing Controls in Use at Source:

None.

Remaining Useful Life:

No impact.

6.   Selective Non-Catalytic Reduction with Low NOx Burners (LNB):

Cemex conducted a BART analysis for the kiln located in Lyons, Colorado and concluded that SNCR could reduce nitrogen oxides (NOx) emissions on a long-term basis by about 50 percent. Various entities have suggested that Cemex provide an analysis combining low NOx burners and SNCR with the goal of achieving a higher NOx reduction, perhaps as high as 60 percent. Accordingly, this analysis has been revised to evaluate the combination of low NOx burners and SNCR.

In the cement manufacturing industry, it is well known that thermal NOx represents the majority of the NOx formation in cement kiln systems. Thermal NOx is a side effect of the high temperatures necessary in the cement kiln to produce a quality clinker product. One effort to combat the thermal NOx formation in the cement industry has been the installation and use of LNB. LNB have been used to a limited degree in the cement industry for over 30 years. The concept of LNB is to minimize primary air as a source of nitrogen, reduce flame turbulence, delay air and fuel mixing, and establish a fuel rich zone for initial combustion. The resulting longer, less intense flame from the staging of combustion in this manner reduces flame temperatures and is therefore thought to reduce thermal NOx formation.

In practice, LNB create two distinct combustion zones: the primary and the secondary combustion zones. In the primary, or initial, combustion zone flame turbulence and air and fuel mixing are suppressed by decreasing the amount of primary air supplied to the burning zone. It

is well understood that the higher the primary air, the higher the NOx from the kiln system.[11] Typical primary air for LNB ranges from 5 to 7 percent.[12] The result is a fuel-rich, oxygen-lean, high temperature combustion zone created by reducing the amount of primary air and delaying the combustion of all of the fuel. The peak flame temperatures in the primary combustion zone must be maintained high to initiate the clinkering reactions. However, thermal NOx formation is thought to be suppressed due to the oxygen-lean environment in the primary combustion zone which generates excess CO and other radicals known to react with NOx.

The primary combustion zone is followed by an oxygen-rich secondary combustion zone where fuel combustion is completed. Lower temperature secondary combustion air is mixed into the secondary combustion zone, thereby lowering the peak combustion temperatures. Although excess oxygen is available, NO$_x$ formation is suppressed in the secondary combustion zone because the temperatures are insufficient for significant thermal NOx formation.

The Lyons Plant is currently equipped with a two channel, straight pipe burner with one channel for coal and a second channel for air used to adjust the momentum of the flame. The burner configuration is closer to a mono-channel than to a multi-channel burner definition. The measured primary air at the Lyons Plant ranges from 40 to 65 percent accordingly to the amount of momentum air used, with most of the primary air coming from the coal mill's minimum air evacuation requirements. The application of LNB at the Lyons Plant would primarily consist of replacing the existing main kiln burner.

The level of NOx reduction reported in the literature for LNB applications on cement kiln systems vary considerably. Factors affecting the variability include, but are not limited to the specific type of LNB, pre-installation NOx emission levels, kiln type, and fuels used. According to EPA's "Alternative Control Techniques Document Update – NOx Emissions from Cement Manufacturing," EPA-453/R-94-004, March 2004, the NOx reduction achievable with LNB ranges from 20 to 30% for typical kiln systems. The level of control achieved is generally greater for newer kiln systems. Many older kiln systems may achieve lower NOx reductions due to the specific operating characteristics of the kiln systems. There are also a few non-typical kiln systems in the US, with one being the Lyons Plant. Considering the unique design and age of the Lyons Plant cement kiln system, it is uncertain whether meaningful NOx reductions would be expected from the installation of LNB in combination with SNCR.

Cemex has proposed the installation and use of SNCR to achieve about a 50% NOx reduction (long term) at the Lyons Plant. This level of NOx reduction has been demonstrated on several cement kiln systems in the US, is recognized in the recently EPA proposed New Source Performance Standards as the demonstrable control efficiency for SNCR, and represents a high level of control with little risk of the known side effects to ammonia injection. The main risk for SNCR is the formation of a detached plume attributable to excessive ammonia slip due to injecting at too high of a normalized stoichiometric ratio (NSR) (i.e., pushing the SNCR technology too far to achieve higher levels of NOx reduction leads to the formation of a detached ammonia plume, called ammonia slip). Ammonia slip from SNCR is non-existent to minimal when the reagent is injected at or below an NSR of about 0.7. Operating SNCR above this NSR significantly increases the ammonia slip to the point where conditions are favorable for the

---

[11] Battye, R., Walsh, S., and Greco, J. 2000. NOx control technologies for the cement industry. Final report. Pages 30-31. EPA contract No. 68-D98-026.

[12] Battye, R., Walsh, S., and Greco, J. 2000. NOx control technologies for the cement industry. Final report. Page 59. EPA contract No. 68-D98-026.

formation of a detached plume containing ammonium chloride and ammonium sulfide compounds. These compounds, as well as any unreacted ammonia, would result in visibility degradation which is counter to the intent of BART.

Therefore, the Division concludes that given the reasonable uncertainty in the benefits of LNB, the existing proposal to utilize the existing burner along with SNCR remains the best control option for the Lyons Plant kiln.

Cost of Compliance:

Based on information provided by Cemex – Lyons, the Division estimates the annual costs at about $1,686,395 per year. Cemex provided an estimated 55% NOx reduction resulting in an estimated control cost of about $1,755 per ton of NOx reduced.

Energy Impacts and Non Air-Quality Impacts:

None.

Existing Controls in Use at Source:

None.

Remaining Useful Life:

No impact.

Table 10 below contains a ranking by control effectiveness of the remaining control technologies.

Table 10: Kiln NOx Control Options

Control Technology	Estimated Control Efficiency	Annual Controlled Hourly NOx Emissions [lbs/hr]	Annual Controlled NOx Emissions [tpy]	Annual Controlled NOx Emissions [lb/ton of Clinker]
Baseline NOx Emissions	-	464.3	1,747.1	7.39
Water Injection	7%	431.8	1,624.8	6.87
Firing TDF	10%	417.8	1,572.3	6.65
Indirect Firing with LNB	20%	371.4	1,397.6	5.91
SNCR	45%	255.3	960.9	4.06
SNCR	48.43%	239.4	901.0	3.81
SNCR w/LNB	55%	208.9	786.2	3.33
SCR	Not technically feasible			

Table 11 below lists the NOx emission reduction, annualized costs and the control cost effectiveness for the feasible controls, ranked by control effectiveness.

Table 11: Summary of Cost Effectiveness of NOx Control Technologies for the Kiln

Control Technology	NOx Emission Reduction [tons/yr]	Annualized Cost [$/yr]	Cost Effectiveness [$/ton]	Incremental Cost Effectiveness [$/ton]
Baseline NOx Emissions	-			
Water Injection	122.3	$43,598	$356	
Firing TDF	174.7	$172,179	$986	$2,453
Indirect Firing with LNB	349.4	$710,750	$2,034	$3,083
SNCR (45% control)	786.2	$1,636,636	$2,082	$2,120
SNCR (48.43% control)	846.1	$1,636,636	$1,934	$1,864
SNCR w/LNB (55% control w/uncertainty)	960.9	$1,686,395	$1,755	$434

Based on the above discussion, the combination of SNCR with LNB has an uncertain level of control due to the unique nature of the Lyons kiln. The Division has determined that SNCR is the best available NOx control option for the Cemex – Lyons modified long dry kiln. Because Cemex has proposed SNCR as the preferred control option, it is not necessary or appropriate to further evaluate the lesser control options, including relative costs.

SNCR requires injection of the reagents in the kiln at a temperature between 870 to 1,090°C (1,600 to 2,000°F). In principle, any of a number of nitrogen compounds may be used as SNCR reagents (e.g., cyanuric acid, pyridine, and ammonium acetate). However, for reasons of cost, safety, simplicity, and by-product formation, ammonia and urea have been used in most of the SNCR applications. The selection of reagents is process and temperature specific. At higher temperatures, urea decomposes to produce ammonia, which is responsible for NO_x reduction. In cement kiln applications, ammonia typically has performed best as the reducing reagent. Because no catalyst is used to increase the reaction rate, the temperature window is critical for conducting this reaction. At higher temperatures, the rate of a competing reaction for the direct oxidation of ammonia, which actually forms additional NO_x, becomes significant. At lower temperatures, the rates of NO_x reduction reactions become too slow resulting in too much unreacted ammonia being released to the atmosphere (i.e., ammonia slip). The effective temperature window range can be lowered to about 700°C (1,300°F) by the addition of hydrogen along with the reducing agent.

The NO_x reduction efficiency of SNCR depends upon the temperature, oxygen, carbon monoxide, and residence time, as well as the ammonia and NO_x concentrations in the flue gas. Injection of ammonia at a NH_3:3 NO_x proportion of 1 to 1.5 will reduce NO_x emissions between 60 to 80 percent. Using a molar ratio of 0.5 will give NO_x reductions of approximately 40 percent. Work done by the German equipment supplier Polysius has shown that the optimum temperature for reduction of NO_x by ammonia is about 950ºC (1,740ºF), while for urea, the temperature increases to about 1,000ºC (1,830ºF).

Operating experience has identified several concerns with both ammonia and urea-based SNCR processes. The most frequently reported is the buildup of ammonium bisulfite or bisulfate scale, which is significant for sulfur-containing fuels. SNCR processes also appear to convert some NO_x to N_2O. The rate of N_2O formation is a weak function of both the reactant and the NO

concentration. However, N_2O formation seems to be inherently more prevalent in systems using urea than those using ammonia.

The NO_x destruction efficiency also depends upon the flue gas residence time in the appropriate temperature window. Unlike an SCR system where the reaction temperature is controlled in a dedicated reactor, an SNCR system relies on the existing gas temperature profile to provide an adequate residence time for a desired NO_x destruction. Maximum achievable NO_x reduction in a cement kiln may thus depend upon the gas temperature profile.

Based on the foregoing discussion and the potential for ammonia slip, the Division concludes that an assumed 45% NOx reduction (30-day rolling average) and 48.43% NOx reduction (annual average) from 2002 baseline is reasonable.

Step 5: Evaluate Visibility Results

An impact analysis was conducted to assess potential visibility improvements associated with SNCR. CALPUFF modeling was used as part of this analysis. The visibility improvement associated with various scenarios 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. Based upon the modeling, the addition of SNCR is projected to result in a 0.41 dv improvement.

Table 12: Visibility improvement for NOx Controls – Kiln Only

Control Method	98th Percentile Impact (Δdv)	98th Percentile Improvement (from 24-hr Max) (Δdv)	Cost Effectiveness ($/Δdv)
24-hr Maximum (≈ 656.9 lbs/hr))	0.760		
Revised Baseline (≈ 464.3 lbs/hr)*	0.572	0.188	
Original Baseline (≈ 446.8 lbs/hr)*	0.555	0.205	
Water Injection (≈ 431.8 lbs/hr)*	0.540	0.220	$198,174
Firing TDF (≈417.9 lbs/hr)*	0.526	0.234	$735,807
Indirect Firing with LNB (≈ 371.4 lbs/hr)*	0.481	0.279	$2,547,493
Original BART Limit – SNCR (≈ 268.0 lbs/hr)	0.380	0.380	
Proposed BART Limit (30-day) – SNCR (≈ 255.3 lbs/hr)**	0.368	0.392	$4,175,091
Proposed BART Limit (annual) – SNCR (≈ 239.0 lbs/hr)**	0.352	0.408	$4,011,363
SNCR w/LNB (≈208.9 lbs/hr) **	0.322	0.438	$3,850,217

* - *Visibility impacts interpolated from original BART CALPUFF modeling*
** - *Visibility impacts extrapolated from original BART CALPUFF modeling*

Step 6: Select BART Control

The Cemex – Lyons facility is a unique kiln system most accurately described as a modified long dry kiln, the characteristics of a modified long dry kiln system are not similar to either a long wet kiln or a multi stage preheater/precalciner kiln. The temperature profile in a long dry kiln system (>1500°F) is significantly higher at the exit than a more typical preheater precalciner kiln (650°F). This is a significant distinction that limits the location and residence time available for

an effective NOx control system. As discussed above, the combination of SNCR with LNB has an uncertain level of control due to unique nature of the Lyons kiln. Furthermore, the associated incremental reduction in NOx emissions associated with SNCR in combination with LNB would afford only a minimal or negligible visibility improvement (less than 0.03 delta deciview). Therefore, the Division believes that SNCR is the best NOx control system available for this kiln.

The Division has considered the five factors and has thoroughly reviewed the data supplied by Cemex to determine that SNCR represents Best Available Retrofit Technology for control of NOx emissions from the kiln. Table 13 specifies the Division NOx BART determination of 255.3 pounds per hour (30-day rolling average) and 901.0 tons per year (12-month rolling average). The Division considered establishing a NOx emissions limit based on clinker production, however, the Cemex-Lyons facility does not have the capability to weigh clinker product upon exiting the kiln. Consequently, compliance with the NOx BART limits will be determined by a continuous emissions monitor system (CEMS).

Table 13: NOx Emission Limits on the Kiln

Subject Unit	NOx Control Technology	NOx Emission Limits
Kiln System	Selective Non-Catalytic Reduction (SNCR)	255.3 lbs/hour (30-day rolling average)
		901.0 tons/year (12-month rolling average)

The Division has reviewed the analysis provided by Cemex and agrees that SNCR is the appropriate NOx control technology. In reviewing the proposed emission rate of 255.3 lbs/hour (approximately equal to 4.06 lb/ton of clinker), the Division also looked at the RACT/BACT/LAER clearing house (see Table 14 below). The NOx rate of 4.06 lb/ton clinker is consistent with determinations made in Iowa and Missouri, but is about double the proposed limits for the newer Florida kilns. The Cemex – Lyons facility is an older modified long dry kiln and does not have the precalciner systems developed for newer facilities specifically to reduce the temperatures for clinker formation. The use of lower temperatures also reduces the formation of thermal NOx.

Table 14: RACT/BACT/LAER data for NOx emissions from Portland Cement Kilns

RBLC ID	NOx Control	NOx Limit	Units	Year
FL 0297	SNCR	1.5	lb/ton clinker	2007
FL-0271	SNCR	1.95	lb/ton clinker	2006
FL-0268	SNCR	1.95	lb/ton clinker	2004
FL-0267	SNCR	1.95	lb/ton clinker	2004
SD-003	Preheater/calciner	2267	tons/yr	2003
MO-0059	SNCR	8	lb/ton clinker	2002
IA-0052	Process	4	lb/ton clinker	2002
TX-0355	Process	660	lb/hr	2001
FL-0139	Process	2.9	lb/ton clinker	2000

The Division also reviewed the *U.S. v. Lafarge* Consent Decree, dated January 21, 2010. In that recent action, the NOx reduction requirements established under the kiln retrofit options require

SNCR with a 12-month rolling emission limit of 4.89 lbs NOx/ton of clinker. The BART Regulations do not require the demolition and reconstruction of any facility that is subject-to-BART. The proposed Cemex BART limit compares favorably to similar units addressed by the *Lafarge* Consent Decree and the RACT/BACT/LAER clearinghouse. While determinations made by other states do not dictate the emissions rate choice made by the Division, they do provide information on the range to validate the emissions rate chosen by the Division. Because the Cemex kiln is a modified long dry kiln and is not directly comparable to the reported limits listed in the RACT/BACT/LAER clearinghouse, the Division finds that requiring an emission rate that falls into the range for modern sources that are more thermodynamically efficient (produce less NOx) helps to further validate the stringency of the NOx emissions rate selection.

The Division is aware that Cemex may be able to do better than a 45% reduction, and will require that 48.43% reduction on an annual basis (901.0 tons per year, 12-month rolling average). This limit results in reductions that are 68% lower than the current allowable NOx limit (2,649 tpy) contained in the operating permit.

The Division also notes that the flash vessel at Cemex - Lyons is unique and may affect how well SNCR will perform at the plant. Because of this uncertainty the Division will not specify the ammonia injection or slip rate but will allow Cemex - Lyons to meet the NOx limits through SNCR technology and process controls. Improving process controls may allow Cemex - Lyons to limit formation of NOx in the kiln and thus meet the NOx limits while reducing ammonia use. By requiring a 48.43% reduction on an annual basis, the Cemex BART determination almost matches the reductions achieved for both SCR and SNCR at the Solnhofen facility.

Accordingly, based upon its analysis and consideration of the five factors, the Division has determined that the higher NOx emission rate is reasonable for the older cement kiln process, and that SNCR control at 255.3 lb/hr NOx on a 30-day rolling average (which is about 4.06 lbs of NOx per ton of clinker) is NOx BART for the Cemex – Lyons facility. This BART determination will remove 45% of the NOx emissions averaged over 30 days, and is projected to result in about 0.39 Δ dv in visibility improvement.

III.C. Review of Particulate Matter Controls on the Kiln and Dryer

PM emissions from the kiln are currently controlled by fabric filter baghouse and wet dust suppression techniques. Emission testing from the kiln has demonstrated compliance with the National Emission Standards for Hazardous Air Pollutants for Source Categories; Portland Cement Manufacturing Industry, 40 CFR Part 63 Subpart LLL. The NESHAP standard applies the kiln and establishes PM emissions limits.

During development of the NESHAP standard, EPA was not able to identify any technologies for existing or new kilns that would consistently achieve lower emissions than the New Source Performance Standards (NSPS). Consequently, the level of the NESHAP standard is the same as NSPS and requires compliance with certain particulate emission limits and opacity limits. The NESHAP standard also includes emission limits for HCl and other hazardous pollutants; however these are not considered for their impact on visibility. The provisions of the NESHAP standard are already contained in the operating permit issued to Cemex – Lyons. For sources already regulated by a NESHAP standard, EPA stated the following in the BART guidelines:

"We believe that, in many cases, it will be unlikely that States will identify emission controls more stringent than the MACT standards without identifying control options that would cost many thousands of dollars per ton. Unless there are new technologies subsequent to the

MACT standards which would lead to cost effective increases in the level of control, you may rely on the MACT standards for purposes of BART." [70 FR 39163]

The Division has reviewed the requirements of the NESHAP (MACT) for Portland cement production and evaluated the RACT/BACT/LAER clearinghouse database for other available particulate control options (see Table 15). The Division has determined that no new particulate control methodologies are identified that would improve upon the PM controls required in the NESHAP.

Table 15: RACT/BACT/LAER data for PM emissions from Portland Cement Kilns

RBLC ID	PM Control	PM Limit	Units	Year
FL 0297	Fabric Filter	0.1	lb/ton clinker	2007
MO-0072	Baghouse	0.516	lb/ton clinker	2006
FL-0271	Baghouse	0.1	lb/ton clinker	2006
FL-0268	Baghouse	0.2	lb/ton clinker	2004
FL-0267	ESP	0.2	lb/ton clinker	2004
SD-003	Fabric Filter	0.13	lb/ton	2003
MO-0059	Fabric Filter	99%		2002
IA-0052	Baghouse	0.5160	lb/ton clinker	2002
TX-0355	ESP	40	lb/hr	2001
FL-0139	Baghouse	0.11	lb/ton clinker	2000

Therefore, the Division is establishing the following PM and opacity limits as BART for particulate matter control that is based on the NESHAP 40 CFR Part 63 Subpart LLL:

Table 16: Particulate Matter Emission Limits on the Kiln and Dryer

Subject Unit	Control Technology	PM Limits from 40 CFR Part 63 Subpart LLL	BART PM Emission Limits
Kiln System	Fabric Filter Baghouse	0.30 lb/ton of dry feed 20% opacity	0.275 lb/ton of dry feed 20% opacity
Dryer	Fabric Filter Baghouse	10% opacity	22.8 tons/year* 10% opacity

* Current emission limitation from Operating Permit (95OPBO082)

The Division has established a PM limit on the kiln system that is more stringent than the NESHAP, which is already in the Cemex – Lyons Operating Permit. Because the current NESHAP limits constitute the most stringent level of control, the State does not need to provide a five-factor analysis for PM for these units.