

Table 1. Summary of Nitrogen Oxide Emissions from Coal-Fired Wet Process Cement Kilns.

Source of Emission Factor	Fuel	No. of Source Tests or CEM Data	Reference	Heat Input Rate (lb/MMBtu)	Clinker Production Rate (tons/hr)	NOx Emissions					
						lb/hr		lb/MMBtu		lb/ton clinker	
						Average	Range	Average	Range	Average	Range
Tarmac Kiln 2 NOx Limit	Coal	1	1	162.5	25	--	113.8, max	--	0.70, max	--	4.55, max
Tarmac Kiln 3 NOx Limit	Coal	1	1	417.5	88	--	592, max	--	1.42, max	--	6.77, max
Tarmac Source Tests: No. 2 Kiln, 1994 and 1995	Coal	6	2	115-138	19-26	308.8	205 - 417	2.50	1.67 - 3.78	8.1	6.24 - 10.94
Tarmac Source Tests: No. 3 Kiln, 1982 thru 1993	Coal	16	3	360-473	79-92	533.0	218 - 855	1.34	0.71-2.11	6.2	3.5 - 8.8
Rinker Source Tests: 2 Kilns	Coal	3	4	352.4	71.4	1,182.3	883 - 1431	3.36	2.5 - 4.08	16.6	12.25 - 20.14
1982 PCA Survey of Coal-fired Wet Process Cement Kilns (b)	Coal	8	5	--	--	--	--	--	--	5.0	1.69 - 8.25
Continental Cement Company: June 20, 1990	Coal	1	6	475.0 (a)	57.0	671.6	--	1.41	--	--	--
Holnam, Inc. CEM Data: July 16, 1992	Coal	1	7	--	--	--	--	--	--	12.50	--
Holnam, Inc. Source Test: October 24, 1991	Coal	1	8	--	--	--	--	--	--	5.80	--
Lehigh Portland Cement Company Source Test: May 22, 1990	Coal	1	9	162.5	--	--	--	1.12	--	5.90	--
AVERAGE						639.2		1.6		3.0	
RANGE						(113.8 - 1182.3)		(0.7 - 3.36)		(4.55 - 16.6)	

Footnotes

- (a) Heat input (Btu/hr) is based on burning 100% coal, and any supplemental fuel is added at a rate of 50% of the coal Btu load (i.e., 50% coal Btu/hr, 50% hazardous waste Btu/hr).
 (b) Emissions are based on a study of 8 wet process cement kilns firing 100% coal.

References

1. From Permit Allowables for Kiln 2 (AC13-169901 ;PSD-FL-142), and for Kiln 3.
2. Tarmac Source Tests - No. 2 Kiln: April 26-27, 1994, June 28-29, 1994, August 31, 1994, October 27-28, 1994, January 3, 1995, and May 31, 1995; Medley, Florida.
3. Tarmac Source Tests - No. 3 Kiln: April and May 1982, May 16, 24, 31, and August 1985, December 1986, April and December 1987, July and August 1988, May and August 1989, October 1990, August 1992, and September 1993; Medley, Florida.
4. Rinker Materials Corporation Source Tests: January 1993; Dade County, Florida. Fired with 100% Coal.
5. "An Overview of the Formation of SOx and NOx in Various Pyroprocessing Systems" by Peter Bechtolt Nielsen & Ove Lars Jepsen, F.L. Smidth & Co. A/S, Copenhagen, Denmark. Figure 8.1.
6. Continental Cement Company Source Test: June 20, 1990; Hannibal, Missouri. Fired with 100% Coal.
7. Holnam, Inc. CEM Data: July 16, 1992; Artesia, Mississippi. Fired with 100% Coal.
8. Holnam, Inc. Source Test: October 24, 1991; Florence, Colorado. Fired with 100% Coal.
9. Lehigh Portland Cement Company Source Test: May 22, 1990; Cementon, New York. Fired with 100% Coal.

Table 2. Nitrogen Oxide Emissions From Mixed-Fuel-Fired Wet Process Cement Kilns

Source of Emission Factor	Type of Fuel	No. of Source Tests or CEM Data	Reference	Heat Input Rate (MMBtu/hr)	Clinker Production Rate (tons/hr)	NOx Emissions				
						lb/hr	lb/MMBtu Average	Range	lb/ton clinker Average	Range
Holnam Source Tests: October 17-18, 1990	Coal/Coke/Tires	2	1	258.6	50.1	449.9	1.74	1.61 - 1.86	9.0	8.3 - 9.6
Blue Circle, Inc. CEM Data	Coal/Coke	1	2	162.5			1.91		9.38	
Holnam Source Test: October 16, 1990	Coal/Coke	1	3	258.0	50.0	529.2	2.05		10.6	
Holnam, Inc. CEM Data	Coal/Coke	1	4						6.80	
Holnam, inc. CEM Data: June 28 and July 9, 1992	Coal/Coke (Oil)	2	5						5.50	5.3 - 5.7
LaFarge Corporation Source Test: May 25, 1982	Coal/Coke/WDF	1	6	162.5			0.68		3.60	
Ash Grove Cement Company CEM Data: July 10, 1992	Coal/Coke/WDF/Gas		7	162.5			1.37		9.00	
Continental Cement Company: July 5-6, 1990	Coal/Diesel	2	8	475.0	75.9	218.9	0.46	0.3 - 0.61		
Holnam, Inc. Source Test: June 1992	Coal/Gas	2	9						17.70	15.9 - 19.5
Ash Grove Cement Company CEM Data: July 1992	Coal/LWDF/SWDF	3	10	162.5			2.26	1.97 - 2.58	15.83	13.51 - 18.34
Continental Cement Company: June 21, 1990	Coal/Waste	3	11	475.0	78.6	754.5	1.59			
Holnam, Inc. Source Test: November 21, 1991	Coal/Waste (Gas)	2	12						6.04	6.61 - 5.46
Lone Star Industries CEM Data	Coal/Waste (Oil/Waste)	1	13						5.0	
Holnam, Inc. Source Test: February 10, 1986	Gas (Coal)	1	14						11.60	
AP-42, Section 11.6	Various	6	15						7.4	
AVERAGE						488.1	1.5	0.3 - 2.58	9.0	5.3 - 19.5

Footnotes

(a) Heat input (Btu/hr) is based on burning 100% coal and a heating value of 12,500 lb/MMBTU. Any supplemental fuel is added at a rate of 50% of the coal Btu load (i.e., 50% coal Btu/hr, 50% hazardous waste Btu/hr).

References

- Holnam Source Tests: October 17-18, 1990; Seattle, Washington. Fired with 44% Coal, 32% Pet Coke, 11% Black Diamond (coal), and 11% tire derived fuel (TDF).
- Blue Circle, Inc. CEM Data; Ravens, New York. Fired with 40% Coal and 60% Coke.
- Holnam Source Test: October 16, 1990; Seattle, Washington. Fired with 50% Coal, 37% Pet Coke, and 13% Black Diamond (coal).
- Holnam, Inc. CEM Data; Artesia, Mississippi. Fired with Coal and Coke.
- Holnam, Inc. CEM Data: June 28 and July 9, 1992; Holly Hill, South Carolina. Fired with Coal/Coke (Oil).
- LaFarge Corporation Source Test: May 25, 1982; Paulding, Ohio. Fired with 45.3% Coal, 2.5% Coke, and 52.2% Waste-derived fuel (WDF).
- Ash Grove Cement Company CEM Data: July 10 & 18, 1992; Foreman, Arizona. Fired with 30% Coal, 7.1% Coke, 61.6% Waste-derived fuel (WDF), and 1.3% gas.
- Continental Cement Company Source Test: July 5-6, 1990; Hannibal, Missouri. Fired with 50% Coal and 50% diesel.
- Holnam, Inc. Source Test: June 1992; Ada, Oklahoma. Fired with Coal/Gas.
- Ash Grove Cement Company CEM Data: July 1992; Foreman, Arizona. Fired with 42% Coal, 42% Liquid waste-derived fuel (LWDF), and 16% Solid waste-derived fuel (SWDF).
- Continental Cement Company Source Test: June 21-23, 1990; Hannibal, Missouri. Fired with 50% Coal and 50% hazardous waste.
- Holnam, Inc. Source Test: November 21 and 27, 1991; Morgan, Utah. Fired with Coal/Waste (Gas).
- Lone Star Industries CEM Data; Greencastle, Indiana. Fired with Coal/Waste (Oil/Waste).
- Holnam, Inc. Source Test: February 10, 1986; Three Forks, Montana. Fired with Gas (Coal).
- AP-42, Table 11.6-8 Emission factor based on 8 stack tests (3 from Tarmac's Medley, Florida facility)

ATTACHMENT A

Attachment A. Literature Search Contacts and Results - Page 1 of 8

Firm/Agency	Contact	Telephone	Results of Conversation
U.S. Environmental Protection Agency; Research Triangle Park, NC	Jim Southerland OAQPS Section Chief	(919) 541-5523	Office closed due to government shutdown.
U.S. Environmental Protection Agency; Research Triangle Park, NC	Ron Myers Project Officer for AP-42, Portland Cement Manufacturing	(919) 541-	
U.S. Environmental Protection Agency; Research Triangle Park, NC	Kristen Roland Library Assistant	(919) 541-2777	She performed a search, but did not find anything. Faxed instructions for accessing On-Line Library System. However, KBN could not access, system error.
San Diego Air Pollution Control District (APCD), Air Permitting Section	Mike Lake Chief of Engineering Division	(619) 694-3313	1-9-96 Left Voice Mail message @ 2:30pm 1-10-96 He had Dan Speer return my call.
San Diego APCD, Air Permitting Section	Dan Speer Senior Engineer	(619) 694-3311	1-10-96 Mike Lake had Dan call me back. He knows of only one wet process cement kiln in California, Riverside Cement in the South Coast Air Quality Management District (AQMD). Also recommended contacting Fred Lettuce there if I cannot find anyone there to help me.
Santa Barbara County, Air Permitting Section	Jerry Scheibe Engineering Supervisor	(805) 961-8800	1-9-96 He will have someone search their database and get back to me. He also recommended contacting SCAQ; CARB, Bob Georges @ (916) 327-5601 for BACT Clearinghouse and Don Coberline @ (916) 327-1505 for BART Clearinghouse; and Bay Area for their BACT databases.
Santa Barbara County, Air Permitting Section	Frances Gilliland Air Quality Specialist	(805) 961-8800	1-9-96 Their district does not have any wet process cement kilns. Suggested contacting Bay Area for their BACT database for guidelines on cement kilns. Also suggested Kern County APCD (805) 861-2593 and South Coast AQMD (909) 396-2000. Faxed a copy of a BACT Guideline Table for Cement Kilns in the Bay Area Air Quality Management District.
South Coast AQMD	Richard Haurylew Air Permit Engineer	(909) 396-2657	1-9-96 Left Voice Mail message @ 4:00pm
South Coast AQMD	Sean Cullins Air Permit Engineer	(909) 396-2655	1-10-96 They have BACT guidelines on dry kiln fired with natural gas. Suggested contacting Jon Henninger, Air Quality and Analysis and Compliance Supervisor @ (909) 396-2278.

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Firm/Agency	Contact	Telephone	Results of Conversation
South Coast AQMD	Jon Henninger Air Quality & Analysis and Compliance Supervisor	(909) 396-2278	1-10-96 Riverside Cement (white cement) in Riverside @ (909) 683-3660 and Cal Portland Cement (grey cement) in Colton @ (909)... Recommended contacting Dixie Richards @ (909) 396-2395. Richard Thrash @ (909) 396-2397 for each plant, respectively. Also recommended contacting Doug Macauley in the Mojave Desert AQMD for two other cement kilns.
South Coast AQMD	Dixie Richards	(909) 396-2278	1-10-96 Out of office until 1-17-96. Call Hubert Wilson @ (909) 396-2496 for immediate assistance.
South Coast AQMD	Hubert Wilson Air Quality and Analysis Supervisor	(909) 396-2496	1-10-96 Neither Riverside Cement or Cal Portland Cement have wet process cement kilns in this area. He believes that Cal Portland is also in Mojave Desert, but it is a dry process cement kiln. Suggested that using natural gas (low N₂ content) or hydro-treated oil (removes excess H₂ and ammonia from the oil) in place of coal to reduce NO_x.
South Coast AQMD	Richard Thrash Air Quality Engineer II	(909) 396-2397	1-10-96 Cal Portland Cement is not a wet process cement kiln. Recommended contacting San Bernardino County APCD (619)...
Mojave Desert AQMD	Jim Lehmann Air Quality Engineer III	(619) 245-1846	1-10-96 6-15% reduction of NO _x on a BTU basis for dry cement kilns. Activated Sewage Sludge has reduced NO _x on a dry kiln. The Cement Industry Environmental Consortium, 1490 Rubidoux Blvd., Riverside, CA 92509 did research testing for sewage additions. Recommended contacting L.L. Afeild @ (909) 683-7349 Fax 686-05703. Marquet Cement Company (out of business, he thinks) in Madison, WI, Ashland, KY, Lone Star, TX (Midland, Dallas). There are only 5 cement kilns in CA, this district only has three. San Bernardino County APCD does not have any wet kilns.
Cement Industry Environmental Consortium	Stretch Mayfield Executive Director	(909) 683-7349	1-10-96 Mitsubishi precalciner (1.5 million ton) in Lucerne Valley added Biosolids to reduce NO _x about 40%. Low NO _x burners generally hurt the kiln more than helping reduce the NO _x .
Calif Air Resources Board (CARB)	Bob Georges BACT Clearinghouse	(916) 327-5601	1-9-96 Out of office until 1-26-96. Voice mail recommended contacting Lars Rydell @ (916) 327-7215.

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Firm/Agency	Contact	Telephone	Results of Conversation
CARB	Lars Rydell BACT Clearinghouse	(916) 327-5601	1-9-96 Does not have any information on wet process cement kilns. He will double check. Also suggested contacting San Joaquin Valley Unified APCD Seyed Sedredin @ (209) 497-1000 and Ruppie Gil @ (209) 545-7000. Also stated that Don Coberline only works with internal combustion engines and turbines and recommended not contacting for the cement industry.
Bay Area AQMD, Permitting Section	Barry Young Supervising Engineer	(415) 771-6000	1-9-96 He will fax me the Cement Kiln section of the BAAQMD Clean Air Plan which provides the background information for the BACT Guideline Table Frances Gilliland faxed earlier. Also recommended contacting Bobby Nishimura, Supervising Air Quality Engineer @ (415) 749-4679.
Bay Area AQMD, Permitting Section	Bobby Nishimura Supervising Air Quality Engineer	(415) 749-4679	1-9-96 5-10% of kilns may use radioaxial burner (low NOx burners) but do not work well because of the temperatures required for reactions to be completed. There are other EPA documents. Book/Encyclopedia from Portland Cement Association which covers the cement process including control methods, Critical Evaluation of Potential Impacts of Emissions from Midlothian Industries, Summary Report from Texas Natural Resources Conservation Commission. Methanol added with urea to change temperature
Kern County APCD	Mary Flynn Air Quality Engineer	(805) 861-2593	1-9-96 Their district only has dry process cement kilns. She did not know of any wet process cement kilns in use currently. They are not used very much because they are inefficient with fuel usage. She will fax me a list of all the Air Districts in California so I can contact them if necessary.

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Firm/Agency	Contact	Telephone	Results of Conversation
Portland Cement Association; Skoakie, IL	Ann Dougherty Program Mgr. of Environmental Process Technology	(708) 966-6200 Ext. 363	1-8-96 Ann will be out of the office until Thursday, 1-11-96. Her secretary, Flo Redman, referred me to Greg Miller of Construction Technologies Laboratory.
			1-16-96 Have presentation papers on NOx reductions, but only dry process, not wet process kilns. She recommended contacting Greg Miller at Construction Technologies Laboratory for additional information.
			1-31-96 Left voice mail message @ 10:30am. I would like to get the 1982 PCA survey of NOx emissions from coal-fired cement kilns.
Portland Cement Association; Skoakie, IL	Corinne Guth	(708) 966-6200 Ext. 378	1-8-96 The publication, <i>U.S. And Canadian Portland Cement Industry Plant Information Summary</i> , is available for \$100 to nonmembers, and Tarmac is not a member. It provides a list of cement plants, location, type of cement kiln located at each plant, type of fuel, but not types of control devices or methods. There are approx. 73 wet process cement kilns presently operating. Suggested contacting Cheryl Solomon, U.S. Bureau of Mines for similar information.
			1-9-86 Ordered the publication listed above and had shipped for overnight delivery
Construction Technologies Laboratory; Skoakie, IL	Greg Miller Senior Principal Scientist	(708) 965-7500 Ext. 522	1-8-96 Write up a fax with my questions and he will get back to me. Probably not by tomorrow.
			1-9-86 Faxed a list of questions and requested the information by Thursday.
			1-16-96 Left voice mail message @ 4:30pm
U.S. Bureau of Mines; Washington, DC	Cheryl Solomon	(202) 501-9393	1-9-96 hours 7:30-5:00, LM @ 11:25am. Offices may be closed due to government shutdown.
Armstrong Cement & Supply Corporation; Cabot, PA	Rick Smith Plant Manager	(412) 352-4471	1-10-96 They have two coal fired wet process cement kilns.
			1-12-96 Left message @ 2:00pm
Armstrong Cement & Supply Corporation; Cabot, PA	Dan Coggins Quality Control Director	(412) 352-4471	1-15-96 Left message @ 11:45am
			1-16-96 Left message @ 4:15pm

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Firm/Agency	Contact	Telephone	Results of Conversation
Essroc Materials; P.O. Box 779 Bessemer, PA 16112	Alan Fay Process Engineer, E.I.T.	(412) 667-7702 Ext. 311	1-10-96 They have two coal fired wet process cement kilns.
			1-12-96 He returned my call, but I was not available.
			1-12-96 Left voice mail message @ 2:00pm
			1-15-96 Do not have a limit at the present time, but will by the end of the year. Are putting NOx CEMS on per state request by the end of the year to measure the emissions in order to set limits. Recommended contacting Ann Dougherty at Portland Cement Assoc. for more information.
Essroc Materials; Frederick, MD 21702	Lisa Environmental	(301) 662-8244 Ext. 6	1-18-96 They have two coal (waste) fired wet process cement kilns.
			1-18-96 Left voice mail message @ 5:10pm
Holnam Inc.; Florence, CO	Leo Jurjovec Plant Manager	(719) 784-6325	1-10-96 They have three coal-fired wet process cement kilns.
			1-12-96 Recommended contacting Mark Johnson @ (313) 529-4344 at their corporate office in Dundee, MI.
Holnam Inc.; P.O. Box 122 Dundee, MI 48131	Mark Johnson Manager of Environmental Affairs	(313) 529-4344	1-12-96 Left voice mail message @ 2:00pm
			1-16-96 He returned my call, but I was not in. I left voice mail message @ 4:00pm
			1-17-96 Mark requested that I fax (313) 529-2719 a letter to request all the information I need.

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Firm/Agency	Contact	Telephone	Results of Conversation
Holnam Inc.; Dundee, MI	Rex Jameson Senior Environmental Project Manager	(313) 529-4352	1-19-96 Mark had Rex respond to my fax. European kilns may have NOx control techniques, but they are mostly dry kilns. Flame temperature reduction to get same heat transfer without as much thermal NOx. Holnam is adding tires with injection with the coal blown in 2-inch chunks in some of their wet kilns, but probably won't reduce NOx unless added mid-kiln. Also recommended contacting two of their facilities: Steve Otto in Mason City, IA @ (515) 421-3308 and Conrad Fzymczak in Seattle, WA @ (206) 937-8025. Both facilities are firing tires and have NOx permit limits. The Mason City facility only has dry cement kilns. Ash Grove Cement Co. in Foreman, AR is injecting tires into its wet process kiln (mid-kiln). Call to see if they are reducing their NOx levels. Also contact Doug Sweeney (913) 451-8900 in Ashgrove's Corporate office in Kansas City, KS to see if they have any other similar sources.
Holnam Inc.; Seattle, WA	Conrad Fzymczak Environmental Engineer	(206) 937-8025	1-19-96 They have one coal/tire (oil, gas, coke) fired wet process cement kiln. They do not have a permit for NOx. Chipped tires blown in with coal in front of kiln, not specifically for NOx reduction. Recommended contacting Angela Blaisdell at AMTest Air Quality (206) 222-7746 for looking at their test results with and without firing tires. Holnam has two other facilities with wet kilns firing tires. Contact: Kevin Ovard @ (801) 829-6821 in Devil's Slide, UT and Eric Ervin @ (719) 784-6325 in Portland, CO.
AMTest Air Quality; Preston, WA	Angela Blaisdale Vice President	(206) 222-7746	1-19-96 Left message @ 11:00am
AMTest Air Quality; Preston, WA	Jim Guenthoer Senior Air Quality Specialist Jan Alden Senior Technical Writer	(206) 222-7746	1-19-96 Left message @ 11:00am. He returned my call at 12:00pm, but I was not available. I returned call, and spoke with Jan Alden. She will contact Conrad to determine which source test I need and then fax the summary page to our Jacksonville office. She will also mail me a copy.

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Firm/Agency	Contact	Telephone	Results of Conversation
Holnam Inc.; Devil's Slide, UT	Kevin Ovard Environmental Manager	(801) 829-6821	1-19-96 They have two coal/waste/tire (gas) fired wet process cement kilns. Left message @ 11:55am
Holnam Inc.; 3500 Highway 120 Florence, CO 81226	Eric Ervin Environmental Engineer	(719) 784-6325	1-19-96 They have three coal fired wet process cement kilns. Permitted to burn tires. Fire with coal at front-end of kiln. NOx emissions caused primarily from the coal firing. Firing mid-kiln may or may not make a difference in NOx emissions. Tires have much less nitrogen content; however, lower Tires are used primarily for a less expensive fuel, not NOx reduction. Have stack tests 1. Reduce NOx by flame reduction. Not at this facility. 2. Lowering Nitrogen content. Decrease in nitrogen input of fuel by adding tires. Yes at this facility. 3. Thermal NOx is the major constituent of the NOx production. Recommended contacting Doug Sweeney at Ashrove Cement. He will know much more about wet process kilns with tire injection mid-kiln. Similar kilns, even with same dimensions can behave very differently in relation to process characteristics, including NOx emissions. Recommended obtaining "Burning Tires for Fuel and Tire Pyrolysis: Air Implications", EPA-450/3-91-024 does include NOx reduction summary from Holnam's, Seattle, WA wet process cement kiln.
Independent Cement Corporation; Catskill, NY	Charlie Klotz Environmental Manager	(518) 943-4040	1-10-96 They have one coal fired wet process cement kiln. 1-12-96 Left voice mail message @ 2:15pm. He returned my call, but I was not available. 1-15-96 He is out of office until Wednesday. Call Wed.
Medusa Cement Company; Clinchfield, GA	Randy Stillwell Environmental Engineer	(912) 987-2121	1-10-96 They have one coal fired wet process cement kiln. 1-15-96 Have not operated their wet kiln since 1979.

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Firm/Agency	Contact	Telephone	Results of Conversation
Tarmac Florida; Deerfield Beach, FL	Scott Quass Environmental Manager	(800) 226-8167	1-9-96 He will get existing burner system specs and their suppliers of coal burners. 1-15-96 Left voice mail message @ 4:00pm.

Attachment B. Literature Search Articles

Publication	Authors	Recommended NOx Control Techniques
<p>"Alternative Control Techniques Document - NOx Emissions from Cement Manufacturing"; EPA-453/R-94-004</p>	<p>U.S. EPA, OAQPS, ESD</p>	<p>1) Combustion Modifications - Normal operational practices; therefore, not considered a NOx control technique, 2) Low NOx burners, 3) Staged Combustion - May be achieved using Low NOx burners, 4) External Flue Gas Recirculation - Has not been demonstrated for NOx reduction in cement kilns, 5) "Mid-Kiln" Firing of Tires/Waste - Difficult in Wet process kilns, 6) Selective Non-Catalytic Reduction (SNCR) - Preheater/Precalciner kilns only, 7) Selective Catalytic Reduction (SCR) - Limited Pilot plant data available.</p>
<p>Cement Kiln NOx Control</p>	<p>A.T. McQueen, S.J. Bortz, M.S. Hatch, J.J. Buening, D.E. Shore, R.L. Leonard, E.F. Bouse; Radian Corporation.</p>	<p>Low NOx burners may be used to control the available oxygen and temperature of the kiln burning zone which can reduce NOx formation.</p> <p>No flue gas treatment is used in any U.S. cement plant to reduce NOx emissions.</p> <p>1) Combustion Modifications, 2) Low NOx burners, 3) Staged Combustion, 4) Selective Non-Catalytic Reduction (SNCR), 5) Selective Catalytic Reduction .</p>
<p>"An Overview of the Formation of SOx and NOx in Various Pyroprocessing Systems"</p>	<p>Peter Bechtolt Nielsen, Ove Lars Jepsen; F.L. Smidth & Co. A/S, Copenhagen, Denmark.</p>	<p>NOx emissions from wet process kilns are determined exclusively by the conditions in the kiln burning zone. Factors which determine NOx formation in the kiln burning zone:</p> <p>1) Max. theoretical (adiabatic) flame temperature, 2) Flame shape (burner type), 3) Excess air rate, 4) Max. necessary material temperature, 5) Material retention time in burning zone, and 6) Gas retention time in burning zone.</p> <p>High specific combustion air consumption, low secondary air temperature, and long material retention time in the burning zone should reduce NOx concentration in the exhaust gas of the kiln burning zone. Low NOx burners may be used to control these conditions as well as an automatic kiln control system to maintain constant burning conditions.</p> <p>A 1982 PCA survey of eight wet process coal-fired cement kilns is referenced. The average emission factor from this survey is 4.97 lbs (NOx)/ton (clinker) with a standard deviation of 3.28.</p>