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SUBJECT: Review and Analysis of NO_x Data for Four Cement Kilns

This memorandum reviews and analyzes nitrogen oxides (NO_x) emissions data from cement kilns at four plants: CEMEX in Santa Cruz, CA; Titan America – Pennsuco, in Medley, FL; the Giant Cement Company kiln in Harleyville, SC; and Suwannee American Cement in Branford, FL. The first three plants use F.L. Smidth kilns without selective non-catalytic reduction (SNCR). The fourth kiln (Suwannee American Cement) uses a Polysius MSC-CC kiln, with SNCR.

RTI previously performed an analysis of the effects of compliance averaging time on potential compliance values, based on NO_x continuous emissions monitoring (CEM) data from the CEMEX plant in Santa Cruz, CA.[1] RTI also summarized NO_x CEM data emissions for the Titan America Pennsuco plant in Medley, FL.[2] Both of these plants are considered important because they employ F.L. Smidth kilns thought to produce low NO_x emissions, but do not employ SNCR, which would further lower NO_x emissions. This memorandum will present NO_x data for the Giant Cement Company plant in Harleyville, SC, which also utilizes an F.L. Smidth kiln without SNCR. The fourth kiln for which data will be presented will be the Suwannee American Cement company kiln in Bradford, FL, which uses a Polysius MSC-CC kiln, with SNCR.

The effects of averaging time on potential compliance values for the CEMEX Santa Cruz plant are shown in **Table 1**. From Table 1, it can be see that averaging time has essentially no effect on the average (arithmetic mean) value, which stays at approximately 1.97 lb/ton, but averaging time does effect the maximum, 95th percentile, and 99th percentile values.

The effect of averaging time can be seen more clearly by calculating all values as a ratio to the average (arithmetic mean) value. This is done in **Table 2**. For example, in Table 2, the 99th percentile value, as expressed a ratio to the mean value, changes from 1.16 (i.e., 16 percent higher than the average) for a 24-hour averaging time, to 1.10 (i.e., 10 percent higher than the average) for a 30-day averaging time. Although the exact ratio of the 99th percentile value for a 30-day averaging time to the arithmetic mean value may vary somewhat from plant to plant, this memorandum will assume that the 99th percentile value for a 30-day average time will be 10 percent higher than the arithmetic mean value from any plant.

The data from the Titan America Pennsuco (Medley, FL) plant can be analyzed in light of this assumption. **Table 3** shows the results of 12 days of NOx readings from the Titan America Pennsuco plant. The arithmetic mean value for all 12 days was 1.62 lb/ton. If the 99th percentile value for a 30-day averaging time is assumed to be 10 percent greater than that, the 99th percentile value for a 30-day rolling average would be 1.78 lb/ton.

RTI has monitored emissions data reported by the Suwannee American Cement plant in Branford, FL. This monitoring consisted of recording live emissions data from the Suwannee American Cement website, 2-3 times a day during weekdays, for the period from February 18, 2008, to March 24, 2008. (On March 24, at 12:06 AM, the live emissions reports stopped, and have not restarted as of the date of this memorandum.) **Table 4** presents the resulting NO_x emissions data. The average NOx emission value is 1.44 lb/ton of clinker. If the 99th percentile value for a 30-day averaging time is assumed to be 10 percent greater than that, the 99th percentile value for a 30-day rolling average would be 1.58 lb/ton.

RTI received data for the Giant Cement Company kiln in Harleyville, SC, from the SC Department of Health and Environmental Control (DHEC). This is an F.L. Smidth kiln installed in 2005, without SNCR. The data consisted of two compliance tests for the kiln. **Table 5** presents the results of those compliance tests. The average NOx emission value is 1.88 lb/ton of clinker. If the 99th percentile value for a 30-day averaging time is assumed to be 10 percent greater than that, the 99th percentile value for a 30-day rolling average would be 2.07 lb/ton.

Table 6 presents a summary of the results for the four kilns. Average values are given, as well as 99th percentile values for 30-day rolling averages. Note that the 99th percentile values for three of the kilns are calculated, based on the results from the CEMEX, Santa Cruz, CA plant. That is, the 99th percentile 30-day rolling average values for those three plants are obtained by multiplying the average (arithmetic mean) reading for those plants by 1.10, which was the ratio between the 99th percentile 30-day rolling average value and the mean value for the CEMEX, Santa Cruz plant. The 99th percentile values for CEMEX in Santa Cruz, CA, Titan America-Pennsuco in Medley, FL, and Giant Cement in Harleyville, SC are 2.16, 1.78, and 2.07 lb/ton of clinker, respectively. The 99th percentile value for the Suwannee American Cement kiln in Bradford, FL, is 1.58 lb/ton, which reflects the fact that this kiln has SNCR, but that its Polynius MSC-CC kiln has higher uncontrolled NO_x emissions (the Suwannee American Cement kiln is thought to have emissions without SNCR in the range of 2.5 to 3.0 lb/ton of clinker).

References:

1) Memorandum, M. Bahner, RTI, to K. Barnett, EPA/OAQPS/SPPD/MMG, Averaging Time Analysis, Using Data from CEMEX – Santa Cruz, CA.

2) Memorandum, M. Bahner, RTI, to K. Barnett, EPA/OAQPS/SPPD/MMG, March 5, 2008, Nitrogen Oxides (NO_x) Data for Titan America - Pennsuco, FL.

Table 1. NO_x Averaging Time Analysis for the CEMEX Plant in Santa Cruz, CA (lb/ton at 110 tph)

Parameter	Averaging Time				
	24-hour	48-hour	7-day	30-day	90-day
Average	1.96	1.96	1.97	1.97	1.98
Maximum	2.34	2.30	2.25	2.17	2.06
Minimum	1.21	1.31	1.57	1.80	1.89
Standard Deviation	0.18	0.16	0.12	0.08	0.05
99th Percentile	2.27	2.24	2.22	2.16	2.06
95th Percentile	2.21	2.18	2.15	2.13	2.06

Table 2. NO_x Averaging Time Analysis for the CEMEX Plant in Santa Cruz, CA, Expressed as Ratios

Parameter	Averaging Time				
	24-hour	48-hour	7-day	30-day	90-day
Average	1.00	1.00	1.00	1.00	1.00
Maximum	1.19	1.17	1.14	1.10	1.04
Minimum	0.62	0.67	0.80	0.91	0.95
Standard Deviation	0.09	0.08	0.06	0.04	0.03
99th Percentile	1.16	1.14	1.13	1.10	1.04
95th Percentile	1.13	1.11	1.09	1.08	1.04

Table 3. Summary of NO_x CEM Data for Titan America - Pennsuco, FL.

Date	Emissions (lb/ton of clinker)			Possible readings [1]	Actual Readings
	Average	Maximum	Minimum		
10/17/2007	1.45	2.19	0.61	1440	1393
10/18/2007	1.83	2.54	1.08	1440	1393
10/19/2007	1.47	2.32	0.35	1440	1393
10/20/2007	1.1	3.69	-0.04	1440	1347
10/21/2007	1.12	31.54	0.18	1440	918
2/11/2008	2.1	3.14	1.2	1440	1361
2/12/2008	1.46	2.33	0.56	1440	1392
2/13/2008	1.81	3.86	0.68	1440	1370
2/14/2008	1.78	3.6	0.05	1440	1349
2/15/2008	1.7	5.39	0.61	1440	1387
2/16/2008	2.16	3.28	1.05	1440	1391
2/17/2008	1.45	2.19	0.61	1440	1393
Number	12	12	12	12	12
Average	1.62	5.51	0.58	1440	1341
Minimum	1.10	2.19	-0.04	1440	918
Maximum	2.16	31.54	1.20	1440	1393
Standard Deviation	0.33	7.90	0.38	0	129

[1] Minute-by-minute readouts, with a maximum of 1440 data points in 24 hours.

Table 4. Reported NOx Emissions for the Suwannee American Cement Plant (Branford, FL)

Record #	Date and Time	NOx Emissions (lb/hr – 24 hr)	NOx Emissions (lb/ton of clinker – 24 hr)	Clinker Production (tons/hr)
1	2/18/2008 16:06	157.63	1.90	82.95
2	2/18/2008 17:30	155.26	1.87	82.92
3	2/20/2008 9:36	124.19	1.43	87
4	2/20/2008 15:54	124.19	1.43	87.84
5	2/20/2008 13:48	145.92	1.66	87.56
6	2/21/2008 10:24	144.47	1.60	90.01
7	2/21/2008 16:48	141.67	1.65	90.8
8	2/25/2008 8:48	80.55	0.96	86.47
9	2/25/2008 14:36	86.22	1.03	86.49
10	2/25/2008 17:06	88.76	1.05	86.94
11	2/26/2008 9:06[1]	78.33	0.86	91.5
12	2/26/2008 13:18[1]	81.05	0.89	91.71
13	2/26/2008 17:48[1]	80.55	0.89	91.28
14	2/26/2008 20:06[2]	87.20	0.99	87.88
15	2/27/2008 9:36	81.20	0.95	82.97
16	2/27/2008 13:48	109.64	1.26	82.95
17	2/27/2008 17:06	132.92	1.48	84.48
18	2/28/2008 8:48	194.77	1.97	97.87
19	2/28/2008 13:00	190.20	1.89	101.43
20	2/28/2008 16:48	190.20	1.89	101.47
21	2/28/2008 18:36	191.40	1.90	101.5
22	2/28/2008 23:06	160.30	1.58	101.6
23	2/29/2008 8:48	108.50	1.07	100.47
24	2/29/2008 11:54	100.57	1.00	100.04
25	3/3/2008 11:06	160.16	1.50	107.23
26	3/3/2008 17:18	203.77	1.98	104.44
27	3/4/2008 17:36	88.16	0.89	100.16
28	3/5/2008 8:48	54.77	0.57	99.41
29	3/5/2008 13:06	64.91	0.67	99.58
30	3/5/2008 17:24	70.87	0.72	100.23
31	3/6/2008 8:24	73.40	0.73	100.48
32	3/6/2008 12:18	75.49	0.75	100.6
33	3/6/2008 16:54	75.31	0.75	100.23
34	3/7/2008 8:54	95.64	0.92	104.49

Record #	Date and Time	NOx Emissions (lb/hr – 24 hr)	NOx Emissions (lb/ton of clinker – 24 hr)	Clinker Production (tons/hr)
35	3/10/2008 10:06	140.66	1.31	107.47
36	3/10/2008 14:48	140.66	1.31	107.89
37	3/10/2008 15:18	135.71	1.26	108
38	3/11/2008 8:36	114.87	1.06	108.26
39	3/11/2008 12:36	111.76	1.02	109.46
40	3/11/2008 16:06	106.58	0.98	109.43
41	3/11/2008 17:06	174.44	1.64	109.41
42	3/12/2008 8:36	174.44	1.64	107.97
43	3/12/2008 13:06	180.67	1.69	107.73
44	3/12/2008 17:06	185.76	1.74	107.85
45	3/13/2008 8:54	141.01	1.3	108.93
46	3/13/2008 14:36	178.60	1.66	108.48
47	3/14/2008 9:54	171.51	1.56	109.61
48	3/14/2008 12:24	171.51	1.56	110.49
49	3/17/2008 8:36	245.62	2.32	105.99
50	3/17/2008 14:48	247.60	2.34	106.28
51	3/17/2008 17:06	247.60	2.34	106.49
52	3/18/2008 9:18	237.84	2.22	107.26
53	3/18/2008 13:36	239.10	2.23	107.48
54	3/18/2008 17:18	239.10	2.23	107.85
55	3/19/2008 14:36	252.57	2.34	110.2
56	3/20/2008 9:18	221.24	2.09	106.09
57	3/21/2008 10:48	163.66	1.50	109.29
58	3/21/2008 12:48	146.90	1.34	109.47
59	3/24/2008 0:06	145.93	1.35	107.65
Number of Records		59	59	59
Average		144.30	1.44	100.14
Minimum		54.77	0.57	82.92
Maximum		252.57	2.34	110.49
Standard Deviation		54.61	0.49	9.01

Notes: 1) Emissions data for these times included the notation, “Kiln startup.” However, it may have actually been the raw mill that was starting up.
2) Emissions data for this time included the notation, “Kiln process down.” However, it may have actually been the raw mill that was down.

Table 5. NO_x Emission Tests for Giant Cement Company (Harleyville, SC)

Test Date	Run Number	Emissions (lb/hr)	Production (tons/hr)	Emissions (lb/ton)
September 26, 2006	1	203	121.2	1.67
	2	188	122.4	1.54
	3	318	119.0	2.67
September 25, 2007	1	238.1	127.8	1.86
	2	239.7	127.9	1.87
	3	216.2	128.4	1.68
Average (all tests)		233.8	124.4	1.88

Table 6. Summary of NO_x Data for Four Kilns

Kiln (Location)	Emissions (lb/ton of clinker)		Comments
	Average	99th Percentile[1]	
CEMEX (Santa Cruz, CA)	1.97	2.16[2]	F.L. Smidth low-NOx kiln, without SNCR
Titan America – Pennsuco (Medley, FL)	1.62	1.78[3]	F.L. Smidth low-NOx kiln, without SNCR
Giant Cement Company (Harleyville, SC)	1.88	2.07[3]	F.L. Smidth low-NOx kiln, without SNCR
Suwannee American Cement (Branford, FL)	1.44	1.58[3]	Polysius MSC-CC kiln, with SNCR[4]

Notes

1) The "99th Percentile" values are 99th percentile for 30-day rolling averages.
2) The 99th percentile value for CEMEX Santa Cruz is observed, based on 13 months of CEMs data.
3) The values for the other three kilns are calculated, based on multiplying the average values for those kilns by 1.10, which is the ratio of the 99th percentile 30-day rolling average to the average value for the CEMEX Santa Cruz kiln.
4) The Suwannee American Cement plant is thought to have NO_x emissions in the range of 2.5 to 3.0 lb/ton of clinker without SNCR.