RTP ENVIRONMENTAL ASSOCIATES, INC.®

March 11, 2008

Mr. Alan Newman
Senior Air Quality Engineer
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P. O. Box 47600
Olympia, WA 68504-7600

Subject: Proposed Best Available Retrofit Technology (BART) for the Lafarge Cement Plant in Seattle, WA – Response to Questions Dated January 23, 2008

Dear Mr. Newman,

Please find attached to this letter Lafarge North America's responses to the questions you raised regarding the December 2007 BART Report for Lafarge's Seattle Washington Plant. To facilitate your review, we have reproduced your questions and provide answers to each. Please contact me or Travis Weide of Lafarge if you have any additional questions regarding the analysis.

Sincerely,

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RTP Environmental Associates, Inc.

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Q1. One method to reduce emissions from an existing wet process cement plant is to convert or replace it with a modern pre-heater/pre-calciner system. There should be a short discussion of the viability of this process change.

A1. RTP did not evaluate replacing the existing wet kiln with a modern pre-heater/pre-calciner system because EPA specifically excluded this type of control from consideration in a BART analysis. For example, EPA states in Appendix Y to 40 CFR 51:

"We do not consider BART as a requirement to redesign the source when considering available control alternatives. For example, where the source subject to BART is a coal-fired electric generator, we do not require the BART analysis to consider building a natural gas-fired electric turbine although the turbine may be inherently less polluting on a per unit basis." [70 FR 39164]

Clearly, EPA did not intend Lafarge to consider retiring the existing kiln and replacing it with a completely new kiln as part of the BART analysis process. Nonetheless, given the space constraints at Lafarge's Seattle facility, this option is not technically feasible. There is simply no physical location where a new pre-heater/pre-calciner kiln system could be constructed on the existing site.

Q2. Section 3.2, SO_2 controls analysis. You evaluate the use of a limestone based wet flue gas desulphurization process. As part of available SO_2 controls review for a coal fired power plant, an ammonia-based wet flue gas desulphurization process was identified as having an equivalent removal capability and cost as the limestone based control. Please evaluate the technical feasibility of an ammonia based SO_2 control system, and if technically feasible, please complete the BART analysis for that process.

A2. Lafarge agrees that an ammonia-based FGD process would be expected to provide a similar level of SO_2 control at costs that are similar to those of a wet limestone system. An ammonia-based system was not considered more specifically in the BART analysis because it offers no advantages over the limestone-based system but it has the following disadvantages:

- A limestone system uses limestone as the scrubbing reagent. This material is already on-site at the Seattle plant as it is the primary raw material for the cement kiln. An ammonia-based system would require a completely new material handling infrastructure and would require handling of a potentially hazardous material (anhydrous ammonia).
- A limestone FGD system produces gypsum as a byproduct. This gypsum can be used in the cement manufacturing process, eliminating costs and issues

associated with waste management and disposal. An ammonia-based FGD system produces ammonium sulfate as a byproduct. When properly processed, this material can be used as a fertilizer. However, Lafarge is not in the fertilizer business at the Seattle plant, and there can be no assurances that ammonium sulfate produced at the Seattle location could be marketed as a fertilizer on a consistent basis. This situation creates a significant waste management risk for Lafarge that is avoided by use of a limestone system.

- An ammonia-based FGD system has the potential to create additional particulate emissions due to ammonia emissions from the scrubber system. This problem is avoided with a limestone system.

For these reasons, Lafarge concludes that an ammonia wet scrubber is a technically inferior choice for application to the Seattle kiln. Thus, all other factors being equal, these disadvantages make the limestone-based FGD system the most appropriate wet FGD system for consideration in the BART analysis.

Eliminating ammonia scrubbing from further consideration based on these factors is also generally consistent with U.S. EPA's top-down approach for conducting a BACT analysis. The 1990 Draft NSR Workshop Manual states:

"A possible outcome of the top-down BACT procedures … is the evaluation of multiple control technology alternatives which result in essentially equivalent emissions. It is not EPA's intent to encourage evaluation of unnecessarily large numbers of control alternatives for every emissions unit. Consequently, judgment should be used in deciding what alternatives will be evaluated in detail in the impacts analysis (Step 4) of the top-down procedure"

Lafarge feels that the qualitative disadvantages of ammonia scrubbing (and other types of wet scrubbing) relative to limestone scrubbing remove them from potential consideration as control options for the Seattle kiln.

Q3. Section 3.2, SO_2 controls analysis. There is no discussion of the sulfur content of the current fuels used by the plant. As EPA Region 8 has noted in its comment letters on the BART analyses developed by Ash Grove Cement in Clancy, MT, and Holcim in Three Forks MT, changing to a lower sulfur content fuel is a reasonable SO_2 emission reduction option that should be evaluated. Thus, there should be a discussion of changing fuel to a lower sulfur fuel as a SO_2 reduction process for this report.

A3. SO_2 emissions from a cement kiln derive from two sources – the raw material and the fuel. Sulfur, in the form of pyrite, sulfate, or organic compounds, is often found in the raw materials used to manufacture cement clinker and in the fuels

used to fire cement kilns. The raw materials and fuels used in Lafarge's Seattle plant are no exception. Sulfur dioxide is generated by the oxidation of sulfur compounds in the raw materials and fuels during pyroprocessing.
The cement kiln system itself acts as a control device for SO_2 due to its highly alkaline internal environment, the normal presence of SO_2 absorbing reagents, and the inherent process conditions that enhance absorption reactions. This situation provides a direct means of removing potential SO_2 emissions from process gases before they are exhausted to the atmosphere. This "inherent" scrubbing has been known in the industry for years. Inherent scrubbing is also discussed in U. S. EPA's AP-42 emissions factors section covering the Portland cement industry[1]:

"the alkaline nature of the cement provides for direct absorption of SO_2 into the product, thereby mitigating the quantity of SO_2 emissions in the exhaust stream. Depending on the process and the source of the sulfur, SO_2 absorption ranges from about 70 percent to more than 95 percent."

AP-42 goes on to state:

"Cement kiln systems have highly alkaline internal environments that can absorb up to 95 percent of potential SO_2 emissions. However, in systems that have sulfide sulfur (pyrites) in the kiln feed, the sulfur absorption rate may be as low as 70 percent without unique design considerations or changes in raw materials."

This statement indicates that SO_2 emissions derived from raw-material sources of sulfur can have a larger influence on emissions than SO_2 derived from the fuel sources and that fuel-derived SO_2 emissions are attenuated by up to 95% in a cement kiln. Thus, changes in fuel sulfur content may have only a minimal effect on kiln SO_2 emissions. The SO_2 absorption capacity of a kiln depends, in part, on the excess alkali compounds available for absorption. If the kiln is operating with excess absorption capacity, then reductions in sulfur content of the fuel would do little to reduce SO_2 emissions. Lafarge believes this to be the case at the Seattle plant. For this reason, changing fuels to reduce SO_2 emissions is not a feasible option for the Seattle kiln because it would have little effect on actual SO_2 emissions. Additionally, the raw material is low in pyritic sulfur, so changes to raw material would not be expected to influence SO_2 emissions to any measurable extent.

Q4. Section 3.2, SO_2 controls analysis, Step 1, Duct Sorbent Injection. What is the dry reagent proposed for use? In the text on page 3-4, you note that hydrated lime

[1] AP-42 Fifth Edition - Compilation of Air Pollutant Emission Factors; Chapter 11.6 – Portland Cement Manufacturing; January 1995; U.S. EPA; OAQPS; Research Triangle Park, NC.

is a typical reagent used in this process. Sodium bicarbonate (also known as nahcolite) is an alternate reagent that is commonly used by facilities in Washington. Some of my research (and Appendix B to your report) indicates that it is advantageous to include some sulfate (gypsum) in the final cement product. Will the collected reagent be incorporated into the cement product or otherwise disposed of? What reagent is proposed for use?

A4. Lime will be used as the reagent in the duct sorbent injection system. The use of sodium-based reagents is not acceptable for use at the Lafarge Seattle plant because Lafarge does plan to reuse some of the kiln dust collected in the baghouse in the cement manufacturing process. Sodium salts have adverse effects on cement properties and cannot be reused.

Q5. Section 3.2, SO_2 controls analysis, Step 4, Evaluate feasible control options. While it is important to know what the cost and cost effectiveness of the wet FGD system is, we also need to know what the cost analysis and cost effectiveness of the duct sorbent injection technology proposed as BART to compare with the control costs for other cement plants and other BART facilities. Please provide this information.

A5. In the BART analysis, wet scrubbing was determined to be economically infeasible. This determination left dry injection as the top-performing feasible technology. An economic impact analysis for a duct injection system applied to the Seattle kiln has not been completed. Instead, Lafarge has elected to propose this technology as BART based on its engineering judgment that the process will be economically feasible. This approach is generally consistent with U.S. EPA guidance which does not require additional analysis when the top performing feasible technology is selected as the basis for a BACT limit. As a consequence, Lafarge has not prepared a cost analysis for applying duct injection to the Seattle kiln.

Q6. Section 3.3, NOx BART analysis. I need a discussion of combining compatible NOx controls; i.e., combining the use of low NOx burners with mid-kiln fuel firing or SNCR, or combining mid-kiln fuel firing with SNCR. Note, that EPA Region 8 identified this same lack in the BART analysis referenced above.

A6. SNCR involves injection of aqueous or anhydrous ammonia (NH_3), or urea (urea is composed of two attached ammonia molecules) into the kiln. At the proper temperature, the injected ammonia is converted by OH* radicals (present in the kiln gases under oxidizing conditions) to ammonia radicals (i.e., NH_2*), which then react with NOx to form N_2, CO_2, and H_2O. Thus, SNCR requires an

oxidizing or fuel-lean atmosphere to reduce NOx emissions. In a fuel-rich environment, partially combusted fuel (e.g., CO) will compete with NH_3 for OH* radicals, thereby reducing the NOx control effectiveness of SNCR.

Mid-kiln firing reduces NOx emissions by burning some of the required fuel at a lower temperature. Injection of whole tires is the most common form of mid-kiln firing. Mid kiln firing also creates a fuel-rich environment in the same part of the kiln where NH_3 would be injected in a SNCR application. The reducing atmosphere created by mid-kiln firing helps reduce NOx formation by staging fuel combustion. However, the reducing atmosphere created by mid-kiln firing would interfere with the SNCR reactions making SNCR much less effective. Because SNCR is the more effective NOx control technology, the combination of mid-kiln firing combination with SNCR is not expected to result in any improvement in NOx control, thus the combination of these technologies provides no significant advantage over the use of SNCR alone.

The use of low-NOx burners is a possible option for reducing NOx emissions in combination with SNCR. For the Seattle kiln, this control option requires conversion from direct to indirect firing to facilitate the addition of low-NOx burners. This control option is compatible with SNCR and, when combined with SNCR would be expected to reduce overall NOx emissions by approximately 50 to 55%. Attachment A contains a revised impact analysis that addresses this combination of technologies.

Q7. Section 3.3, NOx BART analysis, mid-kiln fuel firing. The discussion on the value of mid-kiln firing is fuel neutral through most of this paragraph. My review of the literature on the process indicates petroleum coke, biomass, or even coal should be equally effective for mid-kiln firing. The only fuel specific sentences in this discussion address the use of whole tires. Without any supporting evidence or discussion, the last sentence in the paragraph on mid-kiln firing dismisses the control option stating that mid-kiln firing with whole tires is not considered a viable NOx control because a supply of whole tires cannot be assured. This simple statement is not adequate to discount this viable, proven NOx control technique. You need to supply better justification of why the technique is not technically viable, or carry the technique forward to steps 2, 3, and 4 of the analysis.

A7. Mid-kiln firing requires the use of slow-burning fuels such as whole tires.[2] The use of coal or coke is not effective because these fuels will burn too quickly,

[2] "NOx Control Technologies for the Cement Industry"; EC/R Incorporated; Chapel Hill, NC; September 19, 2000; page 65.

raising temperatures and limiting NOx reductions. Additionally, injection of such fuels could easily damage the kiln due to localized overheating in the mid-kiln area. Because Lafarge's Seattle facility cannot ensure that it has a long-term reliable supply of whole tires, mid-kiln firing is determined to be technically infeasible as a NOx control strategy for application to the Seattle kiln. Additionally, the use of SNCR is expected to be more effective than mid-kiln firing might be, making mid-kiln firing a lower performing technology which need not be evaluated further once SNCR is selected. Lastly, as discussed above, the combination of these technologies (mid-kiln firing plus SNCR) is not expected to improve NOx control beyond what can be obtained with SNCR alone.

Q8. Section 3.3, NOx BART analysis, SNCR. The references I have reviewed indicate that removal efficiencies of SNCR can be on the order of 30 – 50+% rather than the 30 – 40 % indicated in your report. Please supply information detailing why a 30 – 40% removal rate is more appropriate than the 30 – 50+% removal rate indicated in the literature (see EPA's Draft Alternative Control Techniques document update – NOx emissions from new cement kilns, June 2007, or the Texas, France, and Florida cement plant NOx emission control reports for example).

A8. Virtually all of the SNCR applications cited in the references you mention are modern pre-heater/pre-calciner (PH/PC) kilns. For example, the draft ACT update deals only with new PH/PC kilns. Thus, the elevated levels of performance cited are for a completely different kiln configuration with more favorable SNCR operating conditions (i.e., PH/PC kilns provide more opportunity for good residence time and mixing in the proper temperature range).

To Lafarge's knowledge, SNCR has only been applied to one facility in Europe with wet kilns for any extended period of time. Lafarge is also aware that Ash Grove Cement has installed SNCR on its wet kilns in Midlothian, Texas, but has only operated them for a short period of time. The Midlothian kilns are similar to the Seattle kiln, and Ash Grove has reported achieving reductions of 35-40% which is consistent with the range of NOx reductions cited in the Seattle plant's BART analysis. Thus, the range of expected reductions (30 to 40%) resulting from retrofit of SNCR to the Seattle kiln is consistent with the limited experience of SNCR applied to other long wet kilns.

Q9. Section 3.3, NOx BART analysis. There are 2 controls not mentioned or discussed in your analysis that must be included, the use of an expert system to optimize fuel usage and emissions, and the CemStar process from TXI. Both of these technologies are available and have been used on cement kilns to reduce

NOx emissions.

While I don't request that you provide an evaluation, both Montana cement plant BART reports discuss changes to the kilns to reduce NOx emissions.

A9. The Seattle plant already has an expert system installed, and thus this technology was not considered in the evaluation of retrofit options.

In the CemStar^{sm} process, crushed air-cooled slag (not ground granulate) is added directly into the kiln, typically in lumps from 18 – 25 mm. The result is an increase in clinker production up to 15% with no net increase in emissions. More specifically, CemStar^{sm} involves the addition of slag into the back or feed end of the kiln. Slag is essentially proto-clinker containing dicalcium silicates. As slag does not require any further calcination, the bulk of the thermal work having been completed in the steelmaking furnace, it requires little additional fuel to convert it into cement clinker. Fuel consumption avoided by the pre-calcined slag results in net reduction in the fuel consumption per ton of clinker. NOx emissions may be reduced because the slag addition may allow operation of the kiln at slightly lower temperatures.

The CemStar^{sm} process is not applicable to the Seattle kiln. This process requires a supply of crushed air-cooled slag and there is no source of this material in the Seattle area.[3] Lafarge does not believe it is appropriate to install a technology that relies on a raw material that is not readily available for use in the Seattle plant.

Note that the Seattle plant already uses ground granulate blast furnace slag (GGBFS) to produce several products. However, according to TXI, GGBFS is not used in the CemStar^{sm} process.[4]

Q10. Section 3.3, NOx BART analysis, Step 2 on page 3-18. As noted above mid-kiln firing has not been demonstrated to be technically infeasible. This technology along with any others in a revised technical feasibility analysis need to be retained for ranking and determination of feasible control options. The opportunity to pair control options such as low NOx burner technology with SNCR needs to be evaluated.

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[3] USGS Minerals Yearbook: Slag – Iron and Steel; December 2007. Nucor Steel produces a mill-scale byproduct, but this is not suitable for use in the CemStar^{sm} process.

[4] "CemStar^{sm} Process and Technology for Lowering Greenhouse Gases and Other Emissions while Increasing Cement Production"; Yates, J. R., et al.; April 2003.

A10. Lafarge has completed an evaluation of LNB/IDF economic feasibility. The results show that the costs for installation of an LNB/IDF system are excessive at approximately $8,400 per ton. See Attachment A for details. There are no other technically feasible options that have been identified for additional consideration. As discussed above, the use of mid-kiln firing and CemStar^{sm} are not feasible options for the Seattle kiln as these technologies require specific fuels or raw materials whose availability cannot be assured.

Q11. Section 3.3, NOx BART analysis, Step 4. While SNCR is being proposed for installation, a cost analysis is still required; if for no other purpose than to be able to compare your proposed NOx controls to those proposed for (or rejected at) other wet process cement plants subject to BART.

A11. In the BART analysis, SNCR was determined to be the top-performing feasible technology. An economic impact analysis for an SNCR system applied to the Seattle kiln has not been completed. Instead, Lafarge has elected to propose this technology as BART based on its engineering judgment that the process will be economically feasible. This approach is generally consistent with U.S. EPA guidance which does not require additional analysis when the top performing feasible technology is selected as the basis for a BACT limit. As a consequence, Lafarge has not prepared a cost analysis for applying SNCR to the Seattle kiln.

Q12. Section 4, BART modeling procedures. We note that you properly used the high 24-hour actual emissions during the baseline period [and] applied the proposed emission control system's removal rate to that maximum 24-hour rate to model the post control impacts.

A12. We assume this requires no response.

Q13. Appendix A, Wet FGD annualized cost estimate. I have a number of concerns about your assumptions in the annualized cost estimate.

a. You need to justify 3 operators/shifts for the Wet FGD system. This is high for equipment that exhibits stable operating characteristics and can be operated from a central control room. Note that the CUECost spreadsheet used to estimate costs estimated 6 operators per week (less than 1 per shift) and the 1995 EPA Control Cost Manual estimates ½ hour/shift for wet FGD operation.

b. $.08/kWh is not a realistic Seattle power cost. Based on the Seattle City light rate charge tables, it looks like you should be paying on the order of $0.06/kWh during peak demand time and almost $0.02/kWh less during off demand times.

A13a. Wet limestone FGD systems designed to produce gypsum are complex. The system envisioned for Seattle plant is more akin to an electric utility FGD system than the type of industrial FGD system envisioned by the Control Cost Manual. For a system designed to produce gypsum, typical staffing includes one control room operator, one outside operator for the scrubber area and one outside operator for the gypsum processing area. This staffing results in 3 operators per shift as was used in the cost estimate.

A13b. Lafarge has revised the cost estimate for the wet FGD system to use an electric power cost of $0.06/kWh. The resultant changes in control costs are summarized below:

- Annualized costs reduced from $15,340,911 to $15,198,999.
- Cost effectiveness reduced from $33,227/ton to $32,920/ton.

Q14. Appendix B, Emission calculations. The printed table and the spreadsheet "Seattle BART Model Input.xls". For the SO_2 modeling, why was the second high concentration value selected rather than the high value? Please explain why the second high SO_2 emission concentration was used as the basis for the emissions modeling and cost analysis.

As part of the same series of calculations, why was the second high concentration's lb/hour rate then applied against the high SO_2 concentration day's production rate to generate a pounds SO_2/thousand tons clinker emission factor?

A14. The second high concentration value for SO_2 was used instead of the high value because the high value is a statistical outlier. The high SO_2 concentration value is over 2 times the standard deviation plus the average, which is commonly employed as representative of 95% confidence interval. The second high value was statistically shown not to be an outlier because it lies within the 95% confidence interval. The maximum NOx value was also demonstrated to be within the 95% CI.

The second high concentration lb/hr rate was mistakenly applied against the high concentration value in calculating the lb SO_2/ton of clinker value. However, the lb SO_2/ton of clinker value was not used in any subsequent emission calculation and is therefore an irrelevant mistake.

Attachment A

Assessment of Low-NOx Burner Retrofit to Lafarge Seattle Kiln

The Lafarge Seattle kiln is a direct-fired long wet kiln. An integral requirement of a low NOx burner (LNB) system is conversion of a direct-fired kiln to an indirect-fired (IDF) one to allow using a much smaller proportion of combustion air as primary air. The low-NOx burner itself is only one small part of the changes that are required to install a low-NOx burner on the Seattle kiln. This is particularly true for the Seattle plant because:

- Installation of LNB/IDF will require substantial reconfiguration of the existing equipment on the burner floor to make room for the new configuration;
- Due to limited space, equipment will have to be installed on the roof above the kiln;
- Structural changes to accommodate the installation of LNB/IDF will require upgrade of the entire building conform to modern earthquake codes; and
- Installation of LNB/IDF has the potential to restrict or eliminate the ability to use certain high-volatile fuels (e.g., PRB coal) which could adversely affect production costs at the Seattle plant.

Conversion of the Seattle kiln to LNB/IDF in combination with SNCR is estimated to increase the potential NOx control efficiency from 40% (SNCR only) to 55% (SNCR plus LNB/IDF).[5] Thus, an increase in NOx reduction of 15% will result from this combination. Applied to the baseline NOx emissions from 2003/2004, this increased control efficiency would reduce NOx emissions by about 326 tons per year. The estimated annualized cost of the LNB/IDF system is approximately $2.74 million (see attached cost estimate for details). Thus, the LNB/IDF system has a control cost effectiveness of approximately $8,400 per ton. This cost is excessive for BART, and therefore, the retrofit of an LNB/IDF system combined with an SNCR system is economically infeasible for the Lafarge Seattle plant.

[5] (100%-25% for LNB) x (100%-40% for SNCR) = 45% uncontrolled emissions from LNB/SNCR combination or a 55% overall control efficiency.

Annulized Cost Estimate for LNB/IDF Retrofit to Lafarge Seattle Kiln.

Parameter		Value	Units	Basis
Input Data				
Baseline NOx (as NO2)	=	2,172.5	tpy	2003/2004 Average Emissins
Annual Average NOx Removal Efficiency	=	15.0%	%	Increased removal in combination with SNCR at 40% efficiency.
Operator / Maintenance Labor Hours	=	1,095	hr/yr	1 hour per 8 hour shift (2000 Cement NOx ACT, p. 6-27)
Operating Labor Cost	=	40	($/hr)	Unburdened cost.
Supervisory Labor Cost	=	45	($/hr)	Unburdened cost.
Maintenance Labor Cost	=	40	($/hr)	Unburdened cost.
Annual Intrest Rate	=	10%	%	2000 Cement NOx ACT, p. 6-14
Capital Recover Period	=	15	yrs	2000 Cement NOx ACT, p. 6-14
Capital Recovery Factor	=	13.15%		2000 Cement NOx ACT, p. 6-14
Total Capital Investiment				
Total Capital Investiment	=	15,000,000	$	Estimate based on retrofit of similar kiln plus costs to address structural / earthquake requirements in Seattle area.
Annual Cost Estimate				
Operating Labor	=	43,800	$/yr	= (Operator / Maintenance Labor Hours) x (Operating Labor Cost)
Maintenance Labor	=	43,800	$/yr	= (Operator / Maintenance Labor Hours) x (Supervisory Labor Cost)
Maintenance Materials	=	43,800	$/yr	100% of Manitenance Materials Costs (2000 Cement NOx ACT; p. 6-27)
Overhead Costs	=	78,840	$/yr	60% of Maintenance Materials and Labor (2000 Cement NOx ACT; Table 6-3).
Administrative Costs, Taxes, & Insurance	=	600,000	$/yr	4% of TCI - 2000 Cement NOx ACT; Table 6-3.
Capital Recovery Cost	=	1,972,107	$/yr	= (Total Capital Investiment) x (Capital Recovery Factor)
Total Annual Costs	=	2,738,547	$/yr	=sum of above items
Cost Effectiveness Assessment				
NOx Reductions		325.9	tpy	= (Baseline NOx (as NO2)) x (Annual Average NOx Removal Efficiency)
NOx Control Cost-Effectiveness		8,404	$/ton	= Total Annual Costs / NOx Reductions