EXHIBIT F

2008 BACT Analysis Update

UPDATED BEST AVAILABLE CONTROL TECHNOLOGY ANALYSES
VULCAN CONSTRUCTION MATERIALS, L.P.
MANTENO, ILLINOIS

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1. INTRODUCTION

Vulcan Construction Materials, L.P. ("Vulcan") is submitting this updated Best Available Control Technology ("BACT") analysis for sulfur dioxide ("SO_2"), nitrogen oxides ("NOx"), carbon monoxide ("CO"), volatile organic compounds ("VOC"), PM_{10} particulate matter ("PM_{10}"), and lead control at the Manteno, Illinois Lime Plant. The Illinois Environmental Protection Agency ("IEPA") requested this updated analysis. This information submitted in November 2008 updates the BACT evaluation submitted to the IEPA first in February 2002 and updated on October 23, 2003, January 9, 2004, and July 6, 2006. This November 2008 analysis includes updates to the SO_2, NOx, VOC, and PM_{10} BACT reviews. In the November 2008 analysis, Vulcan has expanded the scope to include lead.

PM_{10} air quality modeling results are being provided as a separate submittal. The PM_{10} modeling results update Section 5 of the February 2002 dispersion modeling submittal. Information provided in Section 6 of the February 2002 submittal concerning soil and vegetation impacts remains correct and has not been updated. Due to the decreased emissions described in the November 2008 submittal, the impact of emissions on soil and vegetation will decrease from the levels considered in this previous evaluation. As stated in earlier submittals, there are no Class 1 areas within 100 miles of the Manteno plant; therefore, no analyses are needed concerning the impact of emissions on Class 1 areas.

1.1 Background Information Concerning BACT Evaluations

The regulatory requirements for BACT analyses are specified in Section 165 (a)(4) of the Clean Air Act as Amended in 1990 and in the Prevention of Significant Deterioration (PSD) Regulation 40 CFR 52.21(j). BACT is generally defined in the PSD regulations as:

> "... an emission limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Clean Air Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques..."[1]

Vulcan's BACT update is being conducted in accordance with U.S. EPA requirements stated in the PSD regulations and described in the document titled "New Source Review Workshop Manual."[2] Specifically, a "top down analysis" is being applied as described in the EPA

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[1] 1. U.S. EPA New Source Review Workshop Manual (Draft), October 1990, *available at* www.epa.gov.ttn. This definition expands the definition at 42 U.S.C. § 7479(3).

[2] *See id.*

document.. The basic purpose of the top down analysis is to select the most effective control technique available within the energy, environmental, and economic impact constraints of the specific emission unit evaluated. EPA has recommended a five-step process for BACT analyses.

Step 1 – Identify potential control technologies.

Step 2 – Eliminate technically infeasible options.

Step 3 – Rank remaining control technologies by control effectiveness.

Step 4 – Evaluate most effective controls and document results.

Step 5 – Select the BACT.

The first step in a BACT review is to identify control technologies for each pollutant. Once identified, controls are then evaluated to determine the control systems that are technically feasible for the application under consideration. Once the appropriate control alternatives have been identified, they are to be ranked in order of control effectiveness, with the most effective control alternatives considered first.

The most stringent technically feasible control system is the first to be considered for further evaluation in any "top-down" BACT. If the most stringent control technology is implemented, no further environmental, energy, or economic analyses are necessary. Alternatively, if the analysis determines that the selected alternative is not BACT for environmental, energy, or economic reasons, the next most stringent alternative is selected for review. This process is repeated until the appropriate BACT alternative is chosen.

The environmental analysis estimates the net impact associated with each control alternative. Both beneficial and adverse impacts are to be identified and discussed and, where possible, quantified. When weighing environmental impacts, the analysis considers all pollutants affected by the control alternative. This includes pollutants such as air toxics and carbon dioxide. In addition, the environmental analysis considers appropriate non-air effects, such as water pollution or solid/hazardous waste impacts.

The second impact analysis concerns energy impacts. The energy impact analysis estimates the direct energy effects of the control alternatives in units of energy consumption (Btus, KWh, barrels of oil, tons of coal, etc.) Where possible, the energy requirements of the control options are shown in terms of total and incremental energy costs (units of energy per ton of reduction).

The economic analysis involves assessing the costs associated with installation and operation of the various BACT alternatives. Examples of costs to be considered are:

- Capital and interest charges,
- Engineering and installation costs,
- Operation and maintenance labor and materials,
- Energy costs,
- Disposal costs, and
- Lost revenue due to equipment downtime.

Credits for tax incentives are also included along with credits for product recovery costs and by-product sales generated from the use of control systems. Where control alternatives have been applied in the same source category, the average and incremental cost effectiveness is a primary tool for determining if a control is viable. If there are significant cost differences between the use of that control technique on other sources in the same category as the source, the control technique may be rejected as not economically viable for the applicant. When a control technique has not been applied to other sources in the same category, alternative cost effectiveness ratios may be used, including:

- Ratio of total control costs to total investment costs,
- Unit production costs (for example dollars/ton of lime), and
- Percent cost increase per unit of product.

If the control technique alternative costs are disproportionately high when compared to the cost of control for other similar sources with the same pollutant in recent BACT determinations, the subject control technique may be rejected as not being economically viable.

1.2 Background Information Concerning the Vulcan Manteno Facility

The facility was issued a Construction Permit on October 28, 2002 (I.D. No.: 091806AAB). One of the permit conditions included the authorization for the installation of a wet scrubber to control SO_2 emissions. The wet scrubber was proposed to supplement SO_2 control provided by a fabric filter[3].

Since the February 2002 BACT evaluation, Vulcan has gained additional experience with the type of dual alkali wet scrubbing system that had been proposed for installation at Manteno. This type of wet scrubbing system proved to be unreliable at another Vulcan facility, so Vulcan stopped the installation of this scrubbing system at the Manteno plant to avoid similar problems.

The Manteno plant has a rotary kiln for processing dolomitic limestone. It produces metallurgical grade lime subject to low sulfur content limits. The chemical characteristics of dolomitic lime and limestone with respect to SO_2 adsorption are quite different from the characteristics of high calcium lime and limestone used in most of the lime industry. For these reasons, information concerning SO_2 control approaches applied to rotary kilns processing high calcium limestone is not relevant to this evaluation.

In 2008, Vulcan determined that a preheater tower could be installed at the plant without compromising the ability of the plant to produce commercial lime product having a maximum sulfur content of 0.05% by weight. This provides a modest reduction in SO_2 emissions and significantly reduces the fuel firing rate, the effluent gas flow rate, and the CO_2 emissions. As part of these upgrades, the kiln will be shortened from its present length of 236 feet to 175 feet.

1.3 Baseline Emissions

Sulfur Dioxide Emissions

The coal and coke combusted in the kiln are the primary sources of the SO_2 emissions. Some additional SO_2 forms due to the oxidation of pyritic sulfur in the limestone feed. When

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[3] A fabric filter used for particulate matter collection at lime kilns has a filter cake with a high limestone content. A portion of the SO_2 present in the gas stream being filtered can be adsorbed on the surfaces of the limestone particles in the filter cake.

combusting a sulfur containing fuel, each pound of sulfur in the fuel will convert to two pounds of SO_2[4] in the gas stream; however, some of the sulfur is retained in the lime product. Customer specifications limit the sulfur content of the product to a maximum of 0.05% by weight.

Based on the present BACT limit of 2.76 pounds of SO_2 per ton of kiln feed, the average hourly SO_2 emissions from the facility are 149 pounds of SO_2. This emission limit was to be achieved in accordance with the updated BACT evaluation submitted on January 9, 2004 and updated on July 6, 2006. This July 2006 BACT control included (1) a maximum fuel blend sulfur content of 3% by weight, (2) a lime product maximum sulfur content of 0.04 percent by weight, (3) a maximum limestone feed sulfur content of 0.15% by weight, (4) the use of a spray dryer system with an SO_2 removal efficiency of 89%, and (5) scrubbing SO_2 in a pulse jet fabric filter located after the dry scrubber. The BACT limit of 2.76 pounds of SO_2 per ton of kiln feed is the baseline for this November 2008 updated BACT evaluation. This is equivalent to an annual emission rate of 626 tons per year.

Nitrogen Oxides Emissions

Thermal formation of NOx (NO and NO_2) from molecular nitrogen (N_2) in the combustion air is the primary source of NOx emissions at the Manteno kiln. The oxidation of fuel nitrogen compounds and, to a much lesser extent, "prompt NOx" formation also contributes to the NOx emissions.

The present BACT limit for this facility is 4.5 pounds NOx (as NO_2) per ton of limestone feed. This emission limit is to be achieved by the use of good combustion controls including the use of oxygen control to values equal to or less than 1% by volume at the kiln outlet (feed end). This BACT limit is equivalent to 243 pounds of NOx (as NO_2) per hour.

Carbon Monoxide Emissions

Carbon monoxide is formed primarily due to the incomplete combustion of fuels in the kiln burner. The incomplete combustion of organic compounds volatilized from the kiln feed also contributes to the CO emission concentration.

The present BACT limit for this facility is 11.48 pounds CO per ton of limestone feed. This emission limit is to be achieved by the use of good combustion control practices. This emission limit is equivalent to 620 pounds CO per hour.

Volatile Organic Compounds

Volatile organic compounds (VOC) are formed primarily due to the incomplete combustion of fuels in the kiln burner. The thermal breakdown and volatilization of organic compounds in the kiln feed also contribute to the VOC emission concentration.

The present BACT limit for this facility is 0.146 pounds of VOC per ton of limestone feed. This emission limit is to be achieved by the use of good combustion control practices. This emission limit is equivalent to 7.9 pounds VOC per hour.

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[4] The molecular weight of SO_2 is 64; the molecular weight of sulfur is 32.

PM_{10}, Filterable and Total Particulate Matter

Particulate matter emissions from the Manteno kiln system are due to entrainment of kiln feed, formation of ash particles, and drying of calcium hydroxide particles from the dry scrubber system. The July 2006 BACT limit for PM_{10} particulate matter is 0.134 pounds per ton of kiln feed. The alternative BACT limit for total filterable particulate matter is 0.02 grains per dry standard cubic foot of gas. These BACT limits are to be achieved using a pulse jet fabric filter with a control efficiency for filterable particulate matter of 99.8%.

IEPA has also requested that Vulcan include a BACT limit for condensable particulate matter. Vulcan believes that all or most of the VOC emissions will be captured as condensable particulate matter. Accordingly, the proposed BACT limit for condensable particulate matter is identical to the 0.146 pounds per ton of stone feed BACT limit for VOC.

Lead

Lead has not been addressed in previous BACT analyses. It is included in this evaluation even though estimated emissions are below the threshold amount.

Summary of Recent BACT Determinations for Lime Kilns

A summary of the BACT determinations listed in the EPA BACT, RACT, LEAR Clearinghouse since Vulcan's February 2002 BACT analysis is presented Table 1.

2. SO_2 BACT EVALUATION

2.1 Identification of Potential SO_2 Control Technologies

Vulcan has compiled a list of all available control technologies that would be appropriate for the control of SO_2 emissions from the rotary lime kiln at Manteno. The scope of the information reviewed concerning available control techniques includes (1) published air pollution control equipment buyer's guides, (2) web-based information concerning air pollution control, (3) U.S. EPA Air Pollution Training Institute Course 415 Student Manual titled, "Control of Gaseous Emissions,"[5] (4) U.S. EPA's CHIEF AP-42 database,[6] and (5) U.S. EPA's RACT, BACT, LAER Clearinghouse (RBLC).[7]

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[5] Richards, J. "Control of Gaseous Emissions." U.S. EPA Air Pollution Training Institute Course 415. Student Manual. 2000.

[6] U.S. EPA AP-42, Section 11.6 Lime Kilns. January 1995.

[7] U.S. EPA RACT, BACT, LAER Clearinghouse. Available at www.epa.gov/ttn/catc.

Table 1. Recent BACT Determinations for Lime Kilns

Company	Location	Pollutant	Emissions, Lbs/Ton of Feed	Notes	Date
Vulcan	Manteno, IL	SO_2	2.76	Wet scrubber and use of natural gas during kiln start-up	2/02
		NOx	4.50	Good combustion practices and low excess air combustion	
		CO	43.2	Good combustion practices	
		VOC	ND	No Data	
		PM_{10}	0.134	Fabric filter and use of natural gas during kiln start-up	
Carmeuse Lime Co.	Maple Grove Facility, Bettsville, OH	SO_2	34.0	Coal and coke sulfur limited to 6.5%	7/05
		NOx	45.6	No controls	
		CO	ND	No controls	
		VOC	ND	No controls	
		PM	0.50	Fabric filter	
Western Lime Corporation	Schoolcraft County, MI	SO_2	0.83	Preheater tower and fabric filter adsorption of SO_2	9/07
		NOx	1.83	Low NOx burners and low excess air	
		CO	1.62	Efficient combustion and low excess air	
		VOC	ND	No control listed	
		PM	0.10	Fabric filters and propane or No.2 oil during start-up	
Greymont #6	Bellefonte, PA	SO_2	6.1	Low sulfur fuel	10/04
		NOx	ND	No control listed	
		CO	28.62	No control listed	
		VOC	0.118	No control listed	
		PM	0.10	No control listed	
Greymont #7	Bellefonte, PA	SO_2	2.12	No data in RBLC	10/04
		NOx	3.70	No control listed	
		CO	26.9	No control listed	
		VOC	0.118	No control listed	
		PM	0.10	No control listed	
Arkansas Lime Co.	Batesville, AR	PM	0.10	Fabric filter, includes filterable and condensable PM	11/05
		SO_2	ND	Inherent scrubbing by lime, fuel sulfur limited to maximum, value of 4%.	
		NOx	3.50	No controls	
		CO	3.00	No controls	
		VOC	ND	No controls	

Table 1. Recent BACT Determinations for Lime Kilns (Continued)

Company	Location	Pollutant	Emissions, Lbs/Ton of Feed	Notes	Date
Cutler-Magner	CLM-Superior, WI	SO_2	0.62	Preheater tower, and inherent scrubbing in fabric filter	12/06
		NOx	1.83	Good combustion, oxygen control	
		CO	1.56	Good combustion, oxygen control	
		VOC	1.56	Good combustion, oxygen control	
		PM	0.1	Fabric filter with membrane bags	
Chemical Lime Company, Kilns 1 and 2	O'Neal, AL Plant,	SO_2	2.05	No control listed	5/07
		NOx	ND	No information	
		CO	2.50	No control listed	
		VOC	ND	No Information	
		PM	0.1	No control listed	
Texas Lime Kiln 6	Johnson County, TX	SO_2	2.63	No control listed	1/05
		NOx	4.44	No information	
		CO	1.09	No control listed	
		PM	0.25	No Information	
		VOC	0.03	No control listed	
Austin White, Kilns 1, 2	McNeil, TX,	SO_2	11.78	No control listed	8/07
		NOx	10.61	No control listed	
		CO	4.41	No control listed	
		VOC	0.9	No control listed	
		PM	4.67	No control listed	
Austin White, Kiln 3	McNeil, TX	SO_2	2.84	No control listed	8/07
		NOx	11.83	No control listed	
		CO	3.83	No control listed	
		VOC	1.32	No control listed	
		PM	0.1	No control listed	

Based on this scope of review, Vulcan believes that the following categories of air pollution control systems should be included in the BACT analysis:

- Adsorption of SO_2 in fabric filter solids,
- Conventional spray dryer absorbers,
- Spray dryer absorbers using pulverized lime reagent,

- Dry lime injection,
- Dynawave® froth tower scrubbers,
- Tray tower wet scrubbers,
- Reduced sulfur coal/coke fuel blends,
- Use of low sulfur coal
- Use of a preheater tower, and
- Fuel switch to natural gas.

2.2 Elimination of Technically Infeasible SO_2 Control Options

After identifying potential control techniques, the second step of a BACT analysis is the elimination of air pollution control techniques that are infeasible based on well-established physical, chemical, or engineering principles. Vulcan evaluated the application of each of the categories of air pollution control systems listed in Section 2.1 with respect to technical feasibility. The results of this evaluation are described below.

Use of a Preheater Tower

The installation of a preheater tower would result in energy savings that reduce the fuel input requirements. This reduces the mass emission rates of SO_2 and the kiln effluent gas flow rate. This is a technically feasible control option. The preheater reduces the fuel requirements from the present level of approximately 7 MMBTU per ton of lime to a level of 5 MMBTU. This is an energy savings of 28%. This reduces SO_2 emissions by approximately 23% by reducing the amount of sulfur entering the kiln with the fuel. This approach does not affect the amount of sulfur released from the limestone feed stream.

The preheater tower will not provide any additional SO_2 control beyond the reduction in emissions due to reduced fuel use. With respect to SO_2 adsorption, the preheater tower installed on the shorter kiln will function in a manner similar to the last 100 feet of the existing kiln that is being removed.

Adsorption of SO_2 in Fabric Filter Solids

Vulcan has previously reviewed data indicating that high SO_2 removal efficiencies occur in fabric filters serving lime kilns. Emission tests conducted at the Manteno facility indicate that there are site-specific factors that minimize SO_2 removal to equal to or less than 20%. This is well below reported efficiencies in some other facilities. Due to this site-specific experience, Vulcan concludes that adsorption of SO_2 at efficiencies above 20% is not technically feasible at Manteno.

While absorption of SO_2 into fabric filter solids is not an adequate stand-alone control technique, limited quantities of SO_2 are removed in the fabric filter regardless of the BACT control technique applied to the system. This absorption is an inherent benefit of the fabric filter. A control efficiency of 20% in the fabric filter will be used in calculations of the overall control efficiency provided by the BACT control technique with the additional control inherent due to adsorption of SO_2 in the fabric filter solids.

Conventional Spray Dryer Absorbers

Conventional spray dryer absorbers are used on some coal-fired utility boilers and waste incinerators, sources with operating characteristics and gas stream characteristics quite different from the Manteno lime kiln. The transfer of this technology to the Manteno facility is technically feasible. Vulcan believes that an SO_2 control efficiency of 89% is technically feasible based on the literature concerning spray dryer absorbers and discussions with experienced vendors. This 89% efficiency includes the beneficial contribution of SO_2 adsorption in the fabric filter.

Spray Dryer Absorbers using Pulverized Lime Reagent

A spray dryer absorber using pulverized lime with a mass median diameter less than 10 micrometers has been tested on cement kiln applications, sources with operating characteristics and gas stream characteristics quite different from the Manteno lime kiln. The transfer of this technology to the Manteno facility is technically feasible. Vulcan believes that an SO_2 control efficiency of 89% is technically feasible based on the literature concerning spray dryer absorbers and discussions with experienced vendors. This 89% efficiency includes the beneficial contribution of SO_2 adsorption in the fabric filter.

Dry lime injection

The injection of calcium hydroxide solids for the adsorption of SO_2 has been used on some coal-fired utility boilers and waste incinerators, sources with operating characteristics and gas stream characteristics quite different from the Manteno lime kiln. The transfer of this technology to the Manteno facility is technically feasible. Vulcan believes that a SO_2 control efficiency of 70% is technically feasible based on the literature concerning spray dryer absorbers and discussions with experienced vendors. This efficiency level could be achieved only by the use of evaporative cooling of the gas stream to a fabric filter inlet gas temperature of less than 300°F. This 70% efficiency includes the beneficial contribution of SO_2 adsorption in the fabric filter.

Dynawave® Froth Tower Scrubber

The Dynawave® froth tower wet scrubber is a conventional tower scrubber that relies on counterflow gas and liquid streams in a specially designed tray. Sulfur dioxide is absorbed during gas-liquid droplet mixing in the contact zone. Dynawave® scrubbers have been used successfully for the control of SO_2 in cement kiln applications.

Vulcan has contacted the supplier of the Dynawave® system to evaluate its technical suitability for use at Manteno. Vulcan has concluded that the characteristics of the gas-liquid contact combined with the inherent problems associated with mist elimination in all wet scrubbers indicate that the unit will contribute significant particulate matter emissions in the form of solids-containing droplets. Under some conditions, it is probable that particulate matter emissions in the form of solids-containing droplets would be at or above the applicable particulate matter emission limit. Accordingly, the Dynawave® wet scrubber is considered technically infeasible at Manteno.

Tray Tower Wet Scrubbers

Vulcan has contacted the supplier of a tray tower system to evaluate its technical suitability for use at Manteno. Vulcan has concluded that the characteristics of the gas-liquid contact combined with the inherent problems associated with mist elimination in all wet scrubbers indicate that the unit will contribute significant particulate matter emissions in the form of solids-containing droplets. Under some conditions, it is probable that particulate matter emissions in the form of solids-containing droplets would be at or above the applicable particulate matter emission limits. Accordingly, the tray tower wet scrubber is considered technically infeasible at Manteno.

Reduced Sulfur Coal/Coke Fuel Blends

Vulcan has previously considered the use of a coal/coke blend having a maximum sulfur content of 3% by weight instead of the initial BACT level of 4% by weight. This control approach precludes the use of Illinois coal, most of which has a sulfur content above 3% by weight. With the 3% coal/coke blend, the fuel costs increase significantly and the reduction in SO_2 emissions is very limited.

Low Sulfur Coal Fuel

Vulcan can fire the kiln with low sulfur fuel instead of a blended coal/coke fuel. This substantially increases fuel costs by eliminating the low-cost coke fuel and by incurring the additional costs associated with purchasing and shipping western low sulfur coal. The increased fuel nitrogen content of the western low sulfur coal as compared to a coal/coke blend will increase nitrogen oxide emissions. The high ash content per million Btu of western low sulfur fuel also reduces the quality of lime produced.

Fuel Switch to Natural Gas

Operation of the kilns on natural gas is technically feasible. While this approach reduces SO_2 emissions, it potentially causes a substantial increase in NOx emissions due to the more intense flame conditions formed in natural gas burner flames.

2.3 Rank Remaining SO_2 Control Technologies by Control Effectiveness

The technically feasible SO_2 control techniques discussed in Section 2.3 are ranked in Table 2. It is important to note that Vulcan proposes to use a preheater tower in conjunction with a spray dryer absorber. Furthermore, natural gas firing and the use of add-on control devices also benefit from the inherent SO_2 adsorption in the fabric filter. The overall efficiencies taking into account the combination of techniques to be provided is listed on the right side of Table 2.

2.4 Evaluate Most Effective SO_2 Controls

The technically feasible SO_2 control technologies ranked in Section 4.2.3 are evaluated in a top-down manner in this section. The factors considered in these analyses include (1) SO_2 removal efficiency, (2) energy requirements, (3) potential generation of secondary pollutants, and (4) generation of waste products.

Use of a Preheater Tower

Vulcan has determined that the use of a preheater tower is technically feasible and could reduce fuel requirements by 28% down to 5 MMBTU per ton of lime produced. This reduces the costs of all downstream SO_2 control equipment by reducing the kiln effluent gas flow rate and the mass of SO_2 that must be captured. The installation of a preheater tower would also reduce emissions of the greenhouse gas CO_2. This is a technically feasible control option. The use of a preheater tower is assumed in evaluating the costs of other possible SO_2 control options.

Table 2. Technically Feasible SO_2 Control Technologies

Rank	Description	Stand Alone Control Efficiency, %	Overall Control Efficiency, %	Overall Control Efficiency Notes
1	Conventional Spray Dryer Absorber	89	91.5	28% fuel use reduction due to preheater tower 4.0% maximum fuel sulfur
2	Spray Dryer Absorber with Pulverized Reagent	89	91.5	
3	Natural Gas Firing	80	84	28% fuel use reduction due to preheater tower, 20% adsorption in fabric filter
4	Dry Lime Injection	70	77	28% fuel use reduction due to preheater tower, 4.0% maximum fuel sulfur
5	Low Sulfur Fuel	68	73	28% fuel use reduction due to preheater tower, 20% adsorption in fabric filter
6	Use of a Preheater Tower	23	39	28% fuel use reduction due to preheater tower, 20% adsorption in fabric filter, 4% maximum fuel sulfur
7	Adsorption in Fabric Filter	20	39	

Conventional Spray Dryer Absorber

Vulcan representatives contacted Wheelabrator Air Pollution Control, Inc. ("WAPC") to provide budgetary cost data for a conventional spray dryer absorber using high-pressure, two-fluid nozzles. This type of system uses standard lime that is slaked and injected at a slurry density of 18% to 22% by weight. Lime produced on-site at the Manteno plant can be used for the spray dryer absorber ("SDA") reagent. There is no need for purchased pulverized lime.

The spray dryer system quoted by Wheelabrator is 20 feet in diameter and more than 100 feet high. Due to Vulcan's decision to use a preheater tower, the actual system installed would be slightly smaller (approximately 16 to 18 feet diameter) due to the reduced kiln effluent gas flow rate. The total gas residence time in this vessel would be 12 seconds. This is typical of other spray dryer absorbers having gas residence times of 8 to 20 seconds. This unit would be equipped with three high-pressure, two-fluid atomizing nozzles for dispersing the lime slurry into the gas stream. These nozzles would operate at liquid pressures of up to 90 psig. The compressed air pressure at the nozzle would be in the range of 100 psig. The two-fluid nozzles would be mounted downward from the top of the absorber vessel. The hopper for the spray dryer would have hopper heaters, hopper level detectors, a live bin bottom, anvil plates, poke holes, and access doors. These hopper design features would be used to facilitate cleaning on a routine basis.

A conventional SDA as proposed by WAPC would be able to achieve the 89% SO_2 control efficiency requirement with some contribution from dry scrubbing in the pulse jet fabric filter. This SDA system would generate solid wastes that include the lime reagent reaction products (calcium sulfate and calcium sulfite) and unreacted calcium hydroxide.

The capital and annualized costs for the conventional spray dryer absorber system are estimated to be 4.33 million installed cost and 2.01 million annual operating cost. This yields a cost per ton of lime produced of $9.61. These costs have been adjusted from the Wheelabrator budgetary cost estimate to take into account the reduced size of the preheater-controlled kiln and to account for the significant increase in metal costs since Wheelabrator provided the budgetary quote in 2004. These estimates are based on budgetary data supplied by the vendor and supplemental cost data obtained from the EPA cost models.

The major operating cost for the conventional spray dryer system is the waste disposal cost. The high cost is due to the high stoichiometric ratio of the reagent used in the system. The waste disposal costs have been estimated at $30 per ton of waste generated in the SDA and captured in the pulse jet fabric filter. The $30 per ton value is typical for coal-fired boilers and municipal waste incinerators.

Spray Dryer Absorber with Pulverized Lime Reagent

EnviroCare, International Inc. ("EnviroCare") was contacted by Vulcan representatives to obtain budgetary cost data and reagent requirements for a pulverized lime spray dryer absorber. This type of dry scrubber uses pulverized lime with a mass median diameter less than 10 micrometers in a slurry having 4 to 6 wt.% solids. The slurry is injected downward through a set of high-pressure, two-fluid nozzles into a small diameter vertical tower. The spray tower is smaller than other types of spray dryer absorbers due to (1) the use of pulverized lime particles and (2) effective atomization of the lime slurry.

EnviroCare has estimated that the pulverized lime feed rate necessary to achieve the desired SO_2 control efficiency is 1,800 pounds per hour. The reagent feed rate would actually be approximately 30% lower (1,260 pounds per hour) than this quoted value due to Vulcan's decision to use a preheater tower. The revised lime feed rate will remain equivalent to a $Ca(OH)_2/SO_2$ stoichiometric ratio of 1.82. The outlet gas temperature from the SDA is 285°F. EnviroCare has estimated the SDA control efficiency to be 89% under these conditions. This removal efficiency takes into account some additional SO_2 removal in the pulse jet fabric filter.

The reaction products generated in the system would include $CaSO_3 \frac{1}{2}H_2O$, unreacted lime, captured limestone feed, and flyash from the coal and coke fuels. Overall, the solids disposal requirements of the system would increase by slightly more than the 1,260 lb/hr pulverized lime feed rate.

The EnviroCare scrubbing system has been used in a number of industrial applications, including cement. The unit will be able to achieve the 89% SO_2 control efficiency with some contribution from dry scrubbing in the pulse jet fabric filter.

The SDA outlet-pulse jet fabric filter inlet gas temperature of 285°F is appropriate. This temperature should provide for proper SO_2 removal without creating unnecessary risks of pulse jet fabric filter bag blinding, hopper plugging, and/or corrosion.

This dry scrubbing system would generate solid wastes that include the lime reagent reaction products (calcium sulfate and calcium sulfite) and unreacted calcium hydroxide. The quantities of these wastes would be similar to those formed in a conventional spray dryer absorber.

The capital and annualized costs of the EnviroCare system are estimated to be 2.4 million installed cost and 1.48 annualized operating cost. This is equivalent to $6.77 per ton of lime produced. These cost estimates are based on budgetary quotes from EnviroCare that have been adjusted for the expected gas flow rate from a preheater-equipped kiln and for the increased metal costs since this quote was received.

The major operating cost for the EnviroCare system is the pulverized lime reagent. This reagent would have to be purchased at a cost of approximately $120 per ton.

The waste disposal costs have been estimated at $30 per ton of sulfur dioxide removed in the SDA and captured in the pulse jet fabric filter. The $30 per ton value is typical of coal-fired boilers and municipal waste incinerators.

Other Control Techniques

The other technically feasible control techniques described in Section 2.3 have SO_2 reduction efficiencies below those available from (1) conventional spray dryer absorption and (2) spray dryer absorption with pulverized lime reagent. These less efficient control systems are not discussed further.

2.5 SO_2 BACT Determination

Vulcan concludes that BACT for SO_2 control at the Manteno facility is the use of a preheater tower with a spray dryer absorber. The conventional spray dryer and the spray dryer using pulverized lime reagent provide equivalent SO_2 control and have similar energy requirements and environmental impacts. The use of a conventional spray dryer or a spray dryer with pulverized lime reagent are both innovative technologies for lime kilns. The Manteno plant will have the first lime kiln in the U.S. with a spray dryer adsorber system.

Vulcan will use a blended coal/coke fuel having a maximum fuel sulfur content of 4.0%. The maximum SO_2 emissions using this BACT approach will be 2.2 pounds of SO_2 per ton of limestone feed. This level is similar to or below the BACT levels for all of the lime kilns summarized in Table 1 except Western Lime and Cutler Magner. However, both of these units are high-calcium lime-producing kilns that can achieve high SO_2 removal efficiencies in the preheater tower. Neither of these units use SO_2 control techniques that are relevant to the Manteno plant. Vulcan Manteno will be the first lime kiln to use a spray dryer absorber to control SO_2 emissions. The Manteno SO_2 BACT limit emission rate is consistent with recent BACT determinations summarized in the EPA RBL Clearinghouse. The SO_2 emission rate based on this BACT determination is 118 pounds per hour, a value well below the July 2006 BACT emission rate of 149 pounds per hour.

3. NOx BACT EVALUATION

Nitrogen Oxides (NOx) include nitric oxide (NO) and nitrogen dioxide (NO_2). These compounds form in the combustion process due to the following three mechanisms.

- Thermal NOx refers to the NOx generated in the high temperature oxidation of nitrogen (N_2) in the combustion air. It is minimized, to the extent possible, by reducing peak flame temperatures and reducing the effluent gas stream oxygen concentrations in the zone of peak temperature.
- Fuel NOx refers to emissions resulting from the oxidation of organically bound nitrogen. Such nitrogen appears in the fuel, not as N_2, but chemically bound to the fixed carbon and volatile constituents of the fuel. This fuel-bound nitrogen can be released as either a gas or a solid and is readily available for the formation of NOx. If the combustion occurs in a fuel rich environment with little or no excess oxygen, the nitrogen radicals combine to form N_2. If excess oxygen is present, NO_2 is formed.
- Prompt NOx formation contributes only a small fraction (generally much less than 1%) of the total NOx produced in a rotary lime kiln. This NOx reaction mechanism is believed to involve hydrocarbon radicals that combine with N_2 forming compounds that react with O_2 during the initial devolitization phase of combustion at flame fronts. Due to its limited contribution to the total NOx generated and a lack of specific prompt NOx control measures, prompt NOx will not be discussed further in this report.

3.1 Identification of NOx Control Techniques

Vulcan has compiled a list of all available control technologies that would be appropriate for the control of NOx emissions from the rotary lime kiln at Manteno. The scope of the information reviewed concerning available control techniques includes (1) published air pollution control equipment buyer's guides, (2) web-based information concerning air pollution control, (3) U.S. EPA Air Pollution Training Institute Course 418 Student Manual titled, "Control of Nitrogen Oxides,"[8] (4) U.S. EPA's CHIEF AP-42 database,[9] and (5) U.S. EPA's RACT, BACT, LAER Clearinghouse (RBLC).[10]

Potentially available alternatives to conventional burners to minimize NOx formation include the use of combustion related technologies similar to those used on utility boilers and the use of post-combustion controls. The use of NOx control technologies is not well documented for rotary lime kilns. The control technologies that are discussed in this document have been applied to other source categories but may not have applicability to NOx control in a rotary lime kiln and, therefore, are not considered demonstrated or proven for Manteno. The technologies considered include:

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[8] Richards, J. "Control of Gaseous Emissions." U.S. EPA Air Pollution Training Institute Course 415. Student Manual. 2000.

[9] U.S. EPA AP-42, Section 11.6 Lime Kilns. January 1995.

[10] U.S. EPA RACT, BACT, LAER Clearinghouse. Available at www.epa.gov/ttn/catc.

- Selective catalytic reduction (Never applied to a rotary lime kiln),
- SCONOx^{TM} catalytic absorption system (Never applied to a rotary lime kiln),
- Selective non-catalytic reduction (Applied to other rotary lime kilns with lower capacities. Technology has not been validated in that application.),
- Low NOx burners,
- Overfire air (Never applied to a rotary lime kiln),
- Flue gas recirculation (Never applied to a rotary lime kiln),
- Gas reburning (Never applied to a rotary time kiln), and
- Combustion controls and low oxygen firing (Currently applied to the Manteno kiln).

Currently, the plant has been subject to a BACT control technique based on the oxygen content of the effluent gas stream exiting the lime kiln. Vulcan had proposed a 1% oxygen concentration limit in the February 2002 BACT analysis. This evaluation will look at additional control technologies beyond those that are currently being implemented. When economic impacts are examined, incremental costs will be used to determine feasibility.

3.2 Elimination of Technically Infeasible NOx Control Options

Selective Catalytic Reduction (SCR)

SCR systems use a set of two or more stationary beds of catalyst usually formulated from vanadium pentoxide, tungsten oxide, and titanium dioxide. The catalysts and support ceramic material are extruded honeycomb beds or coated onto vertical plates that are installed in the gas stream. Ammonia injected upstream of the bed reacts with NOx on the catalyst surface to yield harmless diatomic nitrogen, N_2.

SCR is considered proven NOx control technology for (1) coal-, oil-, and gas-fired boilers and (2) gas turbines. SCR has been used extensively throughout the U.S. SCR has not been used for rotary kilns in the lime industry. The engineering problems that have precluded the use of SCR in lime kiln applications include, but are not necessarily limited to (1) gas stream particulate matter loadings that are a factor of 5 to 10 higher than those in boiler applications, (2) the potential for significant formation of sulfuric acid from high concentrations of sulfur dioxide in the gas stream, (3) poisoning of the vanadium pentoxide active ingredient in the catalyst by high alkali (mainly sodium and potassium) in the particulate matter, and (4) poisoning of the catalyst by other materials, such as arsenic.

Various regulatory agencies have pointed toward the demonstration scale cement plant in Solnhofen as proof that these technical problems have been overcome in cement kiln applications[11]. However, the Solnhofen plant apparently has unusually low alkali levels as

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[11] Samant, G., G. Sauter, and N. Haug. "New Development of High Dust-SCR Technology in the Cement Industry, Results of Pilot Tests in Solnhoffen and Development State of a Full Scale Unit". Paper presented at the Cement Industry Conference, Paris March 21-22, 2001.

compared to Manteno, extremely low sulfur dioxide concentrations, and possibly low arsenic levels. Accordingly, the Solnhofen SCR system has not been subject to the types of SCR operating problems that would occur in U.S. lime kilns. The sulfur dioxide levels at Manteno are higher than at other facilities because of the need to produce metallurgical grade lime with low sulfur content. The operation of the kiln under the conditions needed to make a pebble lime product at Manteo inherently increases the gas stream sulfur dioxide concentrations. Manteno will also have high alkali levels that could poison the SCR catalyst.

SCR costs are high. European organizations do not presently considered SCR as Best Available Technology ("BAT", a term similar to BACT in the U.S.) for cement kilns or lime kilns, in part because of the extreme cost. In the case of Manteno, the initial installed cost of an SCR system would probably be in the range of 4 to 10 million dollars. The operating costs would be prohibitively high due to (1) reagent costs, (2) catalyst replacement and regeneration costs, and (3) equipment maintenance and kiln downtime costs.

SCR has not been demonstrated for or applied to lime kilns. It is technically infeasible at Manteno primarily due to (1) the high sulfur dioxide concentrations that will result in sulfuric acid formation and (2) high alkali levels that will poison the catalyst.

It would be extremely costly to install an SCR system after the Manteno fabric filter due to (1) the extreme cost associated with the SCR reaction vessel and accessory systems and (2) the need to reheat the gas stream following fabric filtration. The exit temperature of the fabric filter is anticipated to be in the range of 350°-400°F, which is well below the required 575° to 800°F operating temperature of an SCR system.[12,13,14,15] Reheating the flue gas would require additional fossil fuel combustion, which would in itself generate NOx and would incur substantial energy penalties.

SCONOx™

The SCONOx™ catalyst works by simultaneously oxidizing CO to CO_2 and NO to NO_2 and absorbing NO_2 onto its surface through the use of a potassium carbonate absorber coating. The SCONOx™ system is designed to control CO, NOx, and VOC compounds for natural gas fired utility boilers.[16]

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[12] Durilla, M., J.M. Chen, B.K. Speronello and R.M. Heck. "Composite SCR Catalysts for NOx Reduction." Undated publication of the Engelhard Corporation, Iselin, NJ.

[13] Beckmann, G. T. Maghom, and W. Schreier. "NOx Removal for Combustors, L&C Steinmuller's Operating Experience in the Post-Combustion Technologies High Dust and Tail End SCR" Presented at the Institute of Clean Air Companies Forum '98, Cutting NOx Emissions. Durham, NC March 18-20, 1998.

[14] Czarnecki, L.J. C., Libanati, and J.S. Rieck. "Camet ST Metal Monolith Catalyst for NOx Emission Control." Paper 94-RP131.06 presented at the 87th Annual Meeting and Exhibition of the Air & Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

[15] Hoenig, V., H. Hoppe, and N. Bodendiek. "Möglichkeiten und Grenzen der NOx – Minderrung in der Zementinindustrie, Teil 2." ZKG International, Volume 54, No. 7, 2001.

[16] McDonald R.J. and T. Girdlestone. "The SCONOx™ Catalytic Absorption System, Implications for the New $PM_{2.5}$ and Ozone Standards." Presented at the Institute of Clean Air Companies Forum '98, Cutting NOx Emissions. Durham, NC, March 18-20, 1998.

These reactions are shown below and are referred to as the " Oxidation/Absorption Cycle."

$$CO + 0.5O_2 \rightarrow CO_2$$

$$NO + 0.5O_2 \rightarrow NO_2$$

$$2NO_2 + K_2CO_3 \rightarrow CO_2 + KNO_2 + KNO_3$$

The CO_2 formed in the above reactions is exhausted. The potassium carbonate coating reacts to form potassium nitrites and nitrates, which are then present on the surface of the catalyst. This reaction can be compared to a sponge absorbing water. The SCONOx^{TM} catalyst becomes saturated with NOx and must be regenerated. When all of the carbonate absorber coating on the surface of the catalyst has reacted to form nitrogen compounds, NOx will no longer be absorbed, and the catalyst must enter the regeneration cycle.

The regeneration of the SCONOx^{TM} catalyst is accomplished by passing a dilute hydrogen reducing gas across the surface of the catalyst in the absence of oxygen. The hydrogen in this gas reacts with nitrites and nitrates to form water and elemental nitrogen. Carbon dioxide in the regeneration gas reacts with potassium nitrites and nitrates to form potassium carbonate, which is the absorber coating that was on the surface of the catalyst before the oxidation/absorption cycle began. This cycle is referred to as the "Regeneration Cycle", and the relevant reaction is shown below.

$$KNO_2 + KNO_3 + 4H_2 + CO_2 \xrightarrow{\text{catalyst}} K_2CO_3 + 4H_2O + N_2$$

Water (as steam) and elemental nitrogen are exhausted to the stack instead of NOx, and potassium carbonate is once again present on the surface of the catalyst, allowing the oxidation/absorption cycle to begin again. There is no net gain or net loss of potassium carbonate after the oxidation/absorption cycle and the regeneration cycle have been completed.

Because the regeneration cycle must take place in an oxygen-free environment, a section of catalyst undergoing regeneration must be isolated from exhaust gases. This is accomplished using a set of louvers: one upstream of the section being regenerated and one downstream. During the regeneration cycle, the louvers are closed, and a valve allowing regeneration gas into the section is opened. Stainless steel sealing strips on the isolation louvers provide a durable and effective barrier against leaks during operation. A typical SCONOx^{TM} system has four to sixteen sections of catalyst. This number can vary depending on the size and special design requirements of the individual system.

At any given time, three quarters of these rows are in the oxidation/absorption cycle, and one quarter is in the regeneration cycle. Because the same number of rows is always in the regeneration cycle, the production of regeneration gas always proceeds at a constant rate. The regeneration cycle is typically set to last for three to five minutes; therefore, each section is in the oxidation/absorption cycle for nine to fifteen minutes.

SCONOx^{TM} is not technically feasible for the Manteno lime kiln due to the high solids loading in the effluent gas stream. This would coat the potassium carbonate and prevent NOx control. SCONOx^{TM} has not been applied to any rotary lime kiln due to the same problems that preclude its use at Manteno.

Selective Non-Catalytic Reduction (SNCR)

Selective Non-Catalytic Reduction (SNCR) of NOx is similar to SCR in that both use a nitrogen-bearing compound to reduce NOx to its elemental components. In the SNCR process, NOx reacts with ammonia (NH_3) or urea ($CO(NH_2)_2$) and, under appropriate conditions, is reduced in a set of gas-phase homogeneous reactions to form nitrogen (N_2) and water. SNCR reactions take place in the 1600° to 1900°F temperature range.[17,18,19] At gas temperatures less than 1600°F, high levels of unreacted ammonia are emitted due to incomplete reaction with NOx compounds. At gas temperatures above 1900°F, the efficiency of NOx control decreases rapidly. At gas temperatures exceeding approximately 2000°F, a fraction of the ammonia or urea reagent oxidizes to form additional NOx rather than participating in the intended reactions to chemically reduce NOx to N_2. This critical temperature range exists only within the mid-section of the rotary lime kiln. Injection of ammonia or urea in a rotating combustion unit has not been attempted.

The equipment necessary for an SNCR system at a lime kiln includes reagent (urea or ammonia) storage and handling systems, atomizing systems, injection nozzles (either mounted or retractable) and controls. Anhydrous ammonia storage requires extra permitting (most notably § 112(r) emergency release permitting) and safety precautions.

As part of this BACT update, the characteristics of SNCR systems to be applied to three different cement kilns have been evaluated. The purpose of this evaluation is to determine if the SNCR systems proposed for these new facilities would be technically feasible at Manteno. These plants include the Seattle plant operated by Ash Grove Cement Company, the St. Genevieve plant to be operated by Holcim, and the Greenport plant that was proposed by St. Lawrence Cement.

SNCR was tested as part of a week-long program at the Ash Grove plant in Seattle.[20] The urea solution for the SNCR system was injected into multiple ports located in the stationary precalciner vessel. The gas temperatures were in the appropriate range for SNCR reactions in the upper portions of the precalciner. However, the pyroprocessing system at Ash Grove is entirely different from the rotary kiln at Manteno.

The St. Genevieve Cement Plant will be a state-of-the-art preheater-precalciner cement plant. Cement clinker will be produced in a rotary kiln equipped with a four-stage preheater and precalciner. NOx will be controlled initially by multi-stage combustion controls ("MSC") on the precalciner combustion chamber. MSC uses staged combustion technology to suppress NOx formation due to high gas temperature thermal formation mechanisms that occur in the peak temperature-peak oxygen concentration zones of burner flames. This combustion modification

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[17] Sun, W.H. and J.E. Hofmann. "Post Combustion NOx Reduction with Urea: Theory and Practice." Paper presented at the Seventh Annual International Pittsburgh Coal Conference, September 10-14, 1990.

[18] Jones, D.G. et al. "Urea Injection NOx Removal in European Coal-Fired Boilers and MSW Incineration Plants." Paper presented at the 83rd Annual Meeting & Exhibition of the Air & Waste Management Association, Pittsburgh, Pennsylvania, June 24-29, 1990.

[19] Schreiber, R.J. Jr., A. Lauf, D. Carney, and M. Terry. "Selective Non-Catalytic Reduction and the Low NOx Precalciner Kiln: Limitations on NOx Control." Presented at Annual Exhibition & Meeting of the Air & Waste Management Association. 2000.

[20] Steuch, H.E., J. Hille, W.H. Sun, M.J. Bisnett and D.W. Kirk. "Reduction of NOx Emissions from a Dry Process Preheater Kiln with Calciner Through the Use of the Urea Based SNCR Process." Paper presented at the IEEE Cement Conference, 1995.

type control technique is similar to off-stoichiometric combustion techniques applied to coal-fired boiler flames. MSC has been developed recently for precalciner (stationary) combustion chambers.

The St. Genevieve Cement Plant will phase in the use of selective non-catalytic reduction ("SNCR") controls for NOx. The use of SNCR is very new in the cement industry and has not been used extensively at plants also applying MSC control technology. Accordingly, some engineering development work might be necessary to integrate MSC and SNCR at a cement kiln.

St. Lawrence Cement, Inc., a subsidiary of Holcim (US), was proposing to construct a state-of-the-art cement plant to replace an existing facility near Albany, NY. This application has been withdrawn. St. Lawrence proposed the use of MSC with phased-in SNCR to control NOx emissions at this facility. The SNCR system was to be installed in the precalciner and preheater tower.

The use of SNCR technology at Manteno is <u>not</u> technically feasible. Both the St. Genevieve plant and the proposed Greenport facility have precalciner vessels and large diameter cyclone preheater towers having zones where the gas temperature remains in the 1600°F to 1900°F range. Accordingly, it is conceivable that these facilities will be able to operate SNCR systems to reduce NOx emissions by 20% to 30%. The Manteno lime kiln does not have a preheater tower, and there are no SNCR accessible portions of the lime kiln system in the critical temperature range. In fact, the gas temperature exiting the lime kiln at Manteno is approximately 1200°F. Gas temperatures above 1200°F are only available in the kiln, and no SNCR technology has been applied on a commercial scale inside a rotary kiln.

Attempts to inject ammonia or urea into one or more points in a rotary lime kiln would create numerous engineering problems involved with protecting the materials of construction, preventing reaction of the reagents while in transit through the extremely hot delivery pipe, and movement of the injection pipe as needed to adjust for kiln gas temperature. Due to the extreme sensitivity of the SCNR reactions to gas temperature, injection of a portion of the reagent at temperatures less than 1,600°F would result in ammonia slip and odor problems in the areas around the plant. Injection of a portion of the reagent stream at temperatures above 2,000°F will result in the conversion of some or all of the reagent to form additional NOx. In this application, it would be possible to operate an SNCR system that generates more NOx than it eliminates. SNCR systems are not technically feasible for the Manteno lime kiln.

Low NOx and Advanced Burners

Combustion modifications limit the amount of thermal NOx produced during the combustion process. Low NOx burners are designed to reduce NOx production by creating off-stoichiometric combustion conditions within zones of the burner flame. This fundamental design change results in lower peak flame temperatures and longer burner flames. Low NOx burners reduce both thermal and fuel NOx formation rates.

Controlled air/fuel mixing is accomplished by using separate air registers within the burner. Part of the air enters with the fuel, while another part of the air enters through an annulus surrounding the central fuel/air stream. The remaining air is injected through a second, outer annulus. By partially separating the air and fuel, the combustion reactions are completed in stages, and peak gas temperatures are reduced.

Low NOx burners of the type used in gas-, oil-, and coal-fired boilers are not applicable to rotary kilns due to the orientation of a burner pipe extending well within the rotary kiln instead of the wall-mounted arrangement of burners used in utility and industrial boilers. Modified burners have been installed for lime and rotary kilns; however, this configuration is inherently limited to less complete off-stoichiometric combustion conditions and less effective suppression of peak flame temperatures due to the placement of the burner within the refractory-lined kiln. These burners are better termed "advanced burners" or "multi-channel burners" rather than "low NOx burners" due to these inconsistencies with the large number of low NOx burner designs in commercial use in the industrial and utility boiler industries. These burners require the conversion of the fuel handling system to an indirect firing mode in order to control the primary air-fuel feed rate. This would require the installation of new fuel silos, blending equipment, fuel feeding equipment, and an advanced burner. The use of advanced burners and the associated indirect firing systems at Manteno is not economically feasible. The NOx reduction efficiency is in the range of 0 to 30%.[21] However, there are concerns that these advanced burners might have a negative efficiency in some circumstances.[22]

Overfire Air (OFA)

Overfire Air (OFA) is a NOx control technique that has been applied to fossil fuel-fired boilers to achieve off-stoichiometric combustion.[23] A portion of the total combustion air (usually 15 to 20 percent) is diverted from the burners to overfire air ports located on the boiler wall above the burners. The burners operate under slightly fuel-rich conditions so that the temperature of the air/fuel combustion gas mixture and the yield of NOx are reduced. Both thermal and fuel NOx formation mechanisms are suppressed. The unburned fuel, which exits the fuel-rich zone, is combusted in the upper region of the boiler with the injected overfire air. Using overfire air delays the completion of the oxidation reactions. An overfire air system requires overfire air ports, additional ductwork, a separate fan, and overfire air flow controls.

OFA has not been applied to rotary lime kilns. There are no technically feasible means to install overfire air injection nozzles at positions downstream[24] from the burner flame.

Flue Gas Recirculation (FGR)

In utility boilers, flue gas recirculation (FGR) reduces the formulation of the thermal and fuel NOx by diluting the combustion gases with a low oxygen-containing gas stream. A portion of the flue gas is returned to the boiler furnace through the draft fan. FGR reduces the peak flame temperature through the absorption of the combustion heat by the flue gas.

With respect to lime kilns, recirculation of the low-oxygen containing kiln effluent gas stream back to the kiln burner is prohibitively difficult due to the high particulate matter loading in the gas stream. These solid loadings can be a factor of 10 to 50 times higher than those present in coal-fired boilers that have applied FGR. Damage to the burner caused by the high solids

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[21] Conroy, G.H. "LowNOx PYRO-Systems, Design and Operation." Paper presented at the 34th IEEE Cement Industry Technical Conference, Dallas, Texas May 10-14, 1992.

[22] Penta Engineering Corporation.

[23] Makansi, J. "Reducing NOx Emissions from Today's Power Plants." Power, May 1993, pages 11-28

[24] A rotary lime kiln operates with the effluent gas stream and the solid material being processed moving in a counter-flow orientation. With respect to OFA, the term downstream is used with respect to the gas stream moving from the firing end to the feed end of the kiln.

loadings could cause burner instability and safety problems. FGR is not technically feasible for lime kilns. Furthermore, the reduction in gas temperatures and oxygen concentrations in the firing end of the kiln will contribute to excessive formation of CO. This control technique is not compatible with low oxygen firing practices in-use in Manteno.

Gas Reburning

Gas reburning continues to be in the demonstration phase for utility fossil-fuel fired boilers.[25] A reburning system has not been applied to lime kilns. The reburning process divides the combustion chamber into three combustion zones.[26] The main supply of the fuel is burned under near stoichiometric conditions. Above the main burner zone, a second fuel such as natural gas, No. 2 fuel oil, or micronized coal is injected, often using high pressure recirculated flue gas. Natural gas is preferred for NOx reduction because it has a high hydrogen-to-carbon ratio and contains no organically-bound nitrogen.

NO is chemically reduced to N_2 by free radical reactions in the fuel-rich portion of the combustion zone. The balance of the combustion air is introduced above both combustion zones in order to complete the combustion process. This remaining air is introduced through the openings in the upper walls in a manner typical of overfire air. Overall, excess air is maintained at usual levels for efficient operation.

Gas reburning has not been applied to rotary lime kilns. Mid-kiln injection of a portion of the kiln fuel would create localized reducing conditions that would potentially affect the quality of the dolomitic limestone produced. Furthermore, this control technique is not compatible with the low O_2 firing condition in use at Manteno. This control technique is not considered technically feasible at Manteno.

Combustion Controls and Low Excess Air

NOx emissions can be reduced by means of advanced combustion controls. These combustion controls are designed to optimize air-fuel ratios, to optimize fuel blending and pulverization, and to ensure proper burner tube alignment. These control techniques can reduce NOx emissions by 5% to 15% and are technically feasible at Manteno.[27] It is important to use advanced combustion controls to minimize problems associated with carbon monoxide formation during transient combustion conditions in the kiln.

In its original BACT submittal in 2002, Vulcan proposed the use of combustion controls with low oxygen firing conditions to minimize NOx emissions. This use of low oxygen firing is consistent with combustion modifications used at a large number of coal-, oil-, and gas-fired boilers to suppress NOx formation. This type of NOx control technology is compatible with the advanced lime kiln burner to be used at Manteno. Low oxygen firing suppresses high gas

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[25] Bionda, J.P., B.P. Breen, G.F. Gretz, and J.M. Pratapas. "Application of the Fuel-Lean Gas Reburn NOx Reduction Process on a Roof-Fired Utility Boiler." Paper presented at the Institute of Clean Air Companies, Forum '98, Durham, NC, March 18-20, 1998.

[26] U.S. EPA Center for Environmental Research Information. "Summary Report, Control of NOx Emissions by Reburning." U.S. EPA Publication EPA/625%-96/001.

[27] Penta Engineering Corporation. "Report on NOx Formation and Variability in Portland Cement Kiln Systems, Potential Control Techniques and Their Feasibility and Cost Effectiveness." Portland Cement Association R&D Seriel No. 2227. 1999.

temperature related thermal NOx formation by minimizing the peak oxygen concentration available in the peak temperature zone of the burner flame.

Vulcan believes that the level of oxygen necessary to minimize NOx formation at Manteno is less than 1.25%. This is slightly higher than the original BACT determination of 1% oxygen. This slightly higher value provides for the normal spatial variability in oxygen levels in the effluent gas stream exiting the kiln. Often the spatial variability in oxygen levels is plus or minus 0.2%. This means that when the average oxygen concentration is 1%, there are portions of the gas stream at 0.8% and at 1.2%. When the kiln is operated at an average of 1%, there is very little operating margin for this normal variability. Localized conditions in the gas stream below 1% oxygen exiting the kiln can contribute to the formation of low concentrations of odorous compounds. By operating at a maximum of 1.25% oxygen, Vulcan can continue to minimize NOx concentrations without the risk of the formation of some odorous compounds in areas of the gas stream 0.2% oxygen below the average value.

3.3 Ranking Technically Feasible NOx Control Technologies

The only technically feasible NOx control techniques at Manteno are (1) the use of combustion control with low excess air firing and (2) advanced burners.

Alternative 1, the use of combustion controls with low excess air has been used at Manteno. This approach could be updated at Manteno by (1) improving the coal and coke blending operation, (2) improving the storage silos for coal and coke fuel, (3) upgrading the blended fuel pulverizer, and (4) improving kiln effluent gas stream monitoring and associated burner control. Based on these improvements, the NOx emissions will be maintained at or below 4.5 pounds per ton of limestone feed.

An indirect-fired burner system could be installed at Manteno. This would require an extensive modification to the fuel handling and preparation system in order to use indirect firing practices. This approach would provide a NOx reduction of 0% to 30% beyond that provided by combustion controls and low excess air operation.

3.4 NOx Economic, Energy, and Environmental Evaluation

The budgetary capital cost associated with the extensive modifications needed for an advanced burner and indirect firing system is 8 million dollars. This is not cost effective considering the very low NOx emission reduction of 0% to 30% that is provided by this control approach.

3.5 NOx BACT Determination

In conclusion, combustion control with a conventional burner is considered BACT because it is the only control option that is considered technically and economically feasible. Therefore, no additional BACT top-down analysis is necessary or required. The NOx emissions from the Vulcan Material Manteno lime kiln will be 4.5 lb/ton of stone feed, 243 pounds per hour, or 1,064 tons per year.[28] An equivalent alternative emission limit is to control the level of excess air so that the oxygen content in the kiln flue gases is less than 1.25 percent. That will maintain low nitrogen oxide emissions and substantially reduce vulnerability to the formation of low concentrations of odorous compounds. These NOx emissions limitations and the conventional

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[28] These emission estimates are based on kiln feed of 1,296 tons per day to produce 600 tons of lime per day.

burner are consistent with BACT for lime kilns based on a search conducted in the BACT/LAER Clearinghouse.

4. CARBON MONOXIDE CONTROL TECHNOLOGIES

Carbon monoxide (CO) is the product of incomplete combustion of carbon containing materials in fuels and raw materials. It is generally controlled by good combustion practices providing adequate gas residence time at temperatures exceeding 1800°F and with sufficient oxygen. It may also be controlled by the use of add-on control equipment.

No CO control technologies other than good combustion practices have been identified based on an evaluation of information provided in (1) the EPA's RBLC database for permits listed from January 2002 through July 2006, (2) published technical literature, and (3) information available from the National Lime Association.

Potentially available alternatives to conventional burners to control CO emissions include the use of post-combustion controls. The use of CO control technologies is not well documented for lime kilns. The control technologies that are discussed in this document have been applied to other source categories but do not have applicability to CO control in a rotary lime kiln and therefore, are not considered demonstrated or proven for a rotary lime kiln. The technologies considered as potential control technologies include:

- Use of excess air (Used in rotary lime kilns),
- Thermal oxidizer (Never applied to lime kilns),
- Catalytic oxidizer (Never applied to lime kilns), and
- Proper kiln design and operation (currently implemented at the Manteno kiln).

Currently, the plant is operating under BACT limits, which consists of proper kiln design and operation. This determination will look at additional control technologies beyond those that are currently being implemented. This analysis examines economic impacts using incremental costs to determine feasibility.

4.1 CO Control Techniques

Excess Air

This technology introduces a large amount of excess air in the kiln at the combustion zone. The excess air reduces CO emissions up to 95% by oxidizing CO to CO_2. It also has the effect of:

- Introducing large amounts of nitrogen (N_2) to the kiln,
- Lowering the temperature in the kiln by introducing cold air,
- Requiring a larger baghouse fan to move the additional air through the system,
- Requiring additional fuel to be burned per ton of limestone calcined to overcome the cooling effect of the excess air, and
- Increasing the ability of the pebble lime product to capture SO_2 from the air stream, which will increase the SO_2 levels in the product.

These additional effects on the kiln will be further discussed in the technical feasibility section.

Thermal Oxidizer

A thermal oxidizer reduces CO emissions by supplying adequate heat and sufficient oxygen to ensure that the CO converts to CO_2. Thermal oxidation generally requires temperatures of 1,800°F to 2,000°F to achieve 95% conversion of the CO to CO_2.

Catalytic Oxidizer

A catalytic oxidizer is designed to reduce the emissions of CO by passing combustion gases over a noble metal catalyst where the CO is converted to CO_2. The process can achieve 90% to 95% conversion of CO at a lower temperature (700°F to 1,000°F). This technology requires the removal of particulate matter and sulfur compounds before use to prevent fouling, clogging, and poisoning the catalyst bed.

Proper Kiln Design and Operation

A properly designed and operated kiln effectively functions as a thermal oxidizer. Carbon monoxide formation is minimized when the kiln temperature and oxygen availability is adequate for complete combustion. The design and operation of the kiln also has to account for SO_2 and NOx emissions and controls.

4.2 Technical Feasibility of CO Controls

Excess Air Injection

Excess air injection following the main combustion zone has been used in other industries. A review of the technical literature and BACT/RACT/LAER Clearinghouse information demonstrates that this control technique has not been included in permits or installed on lime kilns.

Injection of air into the portion of the kiln where the gas temperature is above 1800°F is extremely difficult in a rotary kiln. The kiln would be vulnerable to additional NOx formation due to the presence of high oxygen concentrations in incompletely mixed areas of the effluent gas stream within the kiln.

The addition of excess air to the system will cause a larger amount of sulfur in the gas stream to be scrubbed out by the pebble lime being produced. That will, in turn, cause the sulfur content of the lime to exceed the required product sulfur specification of 0.04% by weight. Accordingly, the pebble lime will not be saleable. This technology is not technically feasible and will not be considered further.

Thermal Oxidizer

Thermal oxidizers have been used as add-on CO control equipment in industries other than the lime industry. Thermal oxidizers have not been installed on lime kilns or included on permits for new lime kilns. The gas stream exiting the lime kiln would have to be reheated from a temperature range of 1,000°F to 1,200°F to a minimum operating temperature of 1,800°F. Thermal oxidation is technically feasible and will be considered further.

Catalytic Oxidizer

Catalytic oxidizers have not been installed on rotary lime kilns. A catalytic oxidizer system is designed so that combustion gases must pass through a noble metal catalyst bed (i.e. honeycomb bed) where the CO is converted to CO_2. The high levels of SO_2 in the gas stream would poison the catalyst.

The use of a catalytic oxidizer in the hot gas stream prior to the SO_2 scrubbing system would be infeasible due to the presence of a high concentration of particulate matter in the effluent gas stream. The catalyst would be rendered ineffective in a few minutes due to fouling of the catalyst bed. This would prevent contact of CO molecules with the noble metal catalyst. The use of a catalytic oxidizer following a pulse jet fabric filter would require reheating the gas stream from a filtered temperature of 350°F to 500°F up to the necessary preheat temperature of 700 to 1,000°F necessary for catalytic oxidization of CO.

The use of a catalytic afterburner as add-on CO control is not considered technically feasible on a rotary lime kiln as BACT for CO and will not be considered further.

Proper Kiln Design and Operation

A properly designed and operated lime kiln effectively operates as a thermal oxidizer. There are no incremental costs associated with optimal operation of the kiln becuase it has been proposed that this method of operation is BACT for NOx. This method of control is supported by recent entries in the BACT/RACT/LAER Clearinghouse, which lists "proper kiln operation" and "kiln design and operation" as the BACT of CO in lime plant operations. The proper kiln design and operation is technically feasible.

Vulcan is upgrading the lime kiln combustion control by (1) upgrading the equipment used to blend the coal and coke fuel, (2) upgrading the fuel pulverizer, and (3) modifying the kiln burner to improve combustion conditions. As part of this work, Vulcan is also installing an advanced combustion control system to control fuel/air ratios.

4.3 Ranking Technically Feasible CO Control Technologies

Table 3 ranks the technically feasible control technologies by control efficiency.

Table 3. Technically Feasible CO Control Technologies

Rank	Description	Control Efficiency, %
1	Fume Afterburner	96%
2	Good Combustion Practices	30% to 80%

4.4 CO Control Economic, Energy, and Environmental Evaluation

The technically feasible control technologies will be evaluated for economic and environmental feasibility in this section. When a control technology is being considered in addition to inherent controls associated with the kiln's design, an incremental cost will be used to determine the cost of the additional control compared to the additional pollution reduction realized by the additional control.

Incremental costs for the system will be presented in two ways. The first will be the traditional cost per ton of pollutant reduced.[29] The second will be in terms of cost of the control system per ton of lime produced.[30]

Thermal Oxidizer

The thermal oxidizer will consume 3,394,000 gallons of propane fuel per year and 198,000 kWh of electricity per year. This will result in the emission of over 32 tons of NOx per year. The formation of this additional NOx poses a serious adverse environmental impact.

The additional cost of the control equipment per ton of lime is greater than all of the pre-tax profit that Vulcan realizes on every ton of lime produced (see Appendix C). Vulcan would lose money on every ton of lime produced using this control system.

The prohibitive capital and operating costs on a per ton of lime basis for a thermal oxidizer as well as the adverse environmental and energy impacts render the use of this technology not feasible.

Properly Designed and Operated Lime Kiln

This control has been implemented at the kiln and has no further adverse economic, energy, or environmental affects.

4.5 CO BACT Determination

Vulcan proposes that BACT for the lime kiln be considered as proper design and operation of the kiln because it is the only control option that is considered to be feasible. The CO emissions from the Vulcan Manteno lime kiln will be 11.48 pounds per ton of stone feed or 620 pounds CO per hour.

5. VOLATILE ORGANIC COMPOUND CONTROL TECHNOLOGIES

Volatile organic compounds are formed as products of incomplete combustion of burned fuel well as organic compounds vaporized from the limestone feed. No control technologies other than good combustion practices have been identified based on an evaluation of information provided in (1) the EPA's RBLC database for permits listed from February 2002 through November 2008, (2) published technical literature, and (3) information available from the National Lime Association.

Potentially available alternatives to conventional burners to control VOC emissions include the use of post-combustion controls. The use of VOC control technologies is not well-documented for lime kilns. The control technologies that are discussed in this document have been applied to other source categories but do not have applicability to VOC control in a rotary lime kiln and, therefore, are not considered demonstrated or proven for a rotary lime kiln. The technologies considered as potential control technologies are identical to those discussed with respect to CO and include:

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[29] USEPA Draft New Source Review Manual, October 1990, page B.31.

[30] USEPA Guidelines for Determining Best Available Control Technology, December 1978, page 14.

- Use of Excess Air (Used in rotary lime kilns),
- Thermal Oxidizer (Never applied to lime kilns),
- Catalytic Oxidizer (Never applied to lime kilns), and
- Proper Kiln Design and Operation (currently implemented at the Manteno kiln).

Currently the plant is operating under a BACT, which consists of proper kiln design and operation. This determination will look at additional control technologies beyond what is currently being implemented. The analysis of economic impacts will use incremental costs to determine feasibility.

5.1 Volatile Organic Compounds Control Techniques

Excess Air

This technology introduces a large amount of excess air into the kiln at the combustion zone. This excess air reduces VOC emissions up to 95%. It also has the effect of:

- Introducing large amounts of nitrogen (N_2) to the kiln,
- Lowering the temperature in the kiln by introducing cold air,
- Requiring a larger baghouse fan to move the additional air through the system,
- Requiring additional fuel to be burned per ton of limestone calcined to overcome the cooling affect of the excess air, and
- Increasing the ability of the pebble lime product to capture SO_2 from the air stream, which will increase the SO_2 levels in the product.

These additional affects on the kiln will be further discussed in the technical feasibility section.

Thermal Oxidizer

A thermal oxidizer reduces VOC emissions by supplying adequate heat and sufficient oxygen to ensure that the VOCs convert to CO_2. Thermal oxidation generally requires temperatures of 1,200°F to achieve 95% conversion of the VOCs to CO_2.

Catalytic Oxidizer

A catalytic oxidizer is designed to reduce the emissions of VOCs by passing combustion gases over a noble metal catalyst where the VOCs are converted to CO_2. The process can achieve 90% to 95% conversion of VOCs at a lower temperature (600°F to 1,000°F). This technology requires the removal of particulate matter and sulfur compounds to prevent fouling, clogging, and poisoning the catalyst bed.

Proper Kiln Design and Operation

A properly designed and operated kiln effectively functions as a thermal oxidizer. VOC formation is minimized when the kiln temperature and oxygen availability are adequate for complete combustion. The design and operation of the kiln also has to account for SO_2 and NOx emissions and controls.

5.2 Technical Feasibility of VOC Controls

Excess Air Injection

Excess air injection following the main combustion zone has been used in other industries. A review of the technical literature and BACT/RACT/LAER Clearinghouse information demonstrates that this control technique has not been included in permits or installed on lime kilns.

The injection of air into the portion of the kiln where the gas temperature is above 1800°F is extremely difficult in a rotary kiln. The kiln would be vulnerable to additional NOx formation due to the presence of high oxygen concentrations in incompletely mixed areas of the effluent gas stream within the kiln.

The addition of excess air to the system will cause a larger amount of sulfur in the gas stream to be scrubbed out by the pebble lime being produced. That will in turn cause the sulfur content of the lime to exceed the required product sulfur specification of 0.04% by weight. Accordingly, the pebble lime will not be saleable. This technology is not technically feasible and will not be considered further.

Thermal Oxidizer

Thermal oxidizers have been used as add-on VOC control equipment in industries other than the lime industry. Thermal oxidizers have not been installed on lime kilns or included on permits for new lime kilns. The gas stream exiting the lime kiln would have to be reheated from a temperature range of 1,000°F to 1,200°F to a minimum operating temperature of 1,800°F. The thermal oxidizer is technically feasible and will be considered further.

Catalytic Oxidizer

Catalytic oxidizers have not been installed on rotary lime kilns. A catalytic oxidizer system is designed so that combustion gases must pass through a noble metal catalyst bed (i.e. honeycomb bed) where the VOCs are converted to CO_2. The high levels of SO_2 in the gas stream would poison the catalyst.

The use of a catalytic oxidizer in the hot gas stream prior to the SO_2 scrubbing system would be infeasible due to the presence of a high concentration of particulate matter in the effluent gas stream. The catalyst would be rendered ineffective in a few minutes due to fouling the catalyst bed. This would prevent contact of VOC molecules with the noble metal catalyst. The use of a catalytic oxidizer after the pulse jet fabric filter would require reheating the gas stream from a filtered temperature of 350°F to 500°F up to the necessary preheat temperature of 600°F to 1000°F necessary for catalytic oxidization of VOCs.

The use of a catalytic afterburner as add-on VOC control is not considered technically feasible on a rotary lime kiln as BACT for VOC and will not be considered further.

Proper Kiln Design and Operation

A properly designed and operated lime kiln effectively operates as a thermal oxidizer. There are no incremental costs associated with optimal operation of the kiln because it has been proposed that this method of operation is BACT for NOx. This method of control is supported by recent entries in the BACT/RACT/LAER Clearinghouse, which lists "proper kiln operation" and "kiln design and operation" as the BACT for VOC in lime plant operations. The proper kiln design and operation is technically feasible.

Vulcan is upgrading the lime kiln combustion control by (1) upgrading the equipment used to blend the coal and coke fuel, (2) upgrading the fuel pulverizer, and (3) modifying the kiln burner to improve combustion conditions. As part of this work, Vulcan is also installing an advanced combustion control system to control fuel/air ratios.

5.3 Ranking Technically Feasible VOC Control Technologies

Table 4 ranks the technically feasible control technologies by control efficiency.

Table 4 Technically Feasible VOC Control Technologies

Rank	Description	Control Efficiency, %
1	Fume Afterburner	96%
2	Good Combustion Practices	30% to 80%

5.4 VOC Control Economic, Energy, and Environmental Evaluation

The technically feasible control technologies will be evaluated for economic and environmental feasibility in this section. When a control technology is being considered in addition to inherent controls associated with the kiln's design, an incremental cost will be used to determine the cost of the additional control compared to the additional pollution reduction realized by the additional control.

The potential VOC emissions associated with the lime kiln after controls are 32 tons per year. This will be the baseline potential emission rate used to calculate the incremental costs of any additional controls for the system.

Incremental costs for the system will be presented in two ways. The first will be the traditional cost per ton of pollutant reduced. The second will be in terms of cost of the control system per ton of lime produced

Thermal Oxidizer

The thermal oxidizer will consume 3,394,000 gallons of propane fuel per year and 198,000 kWh of electricity per year. This will result in the emission of over 45 tons of NOx per year. The formation of this additional NOx poses a serious adverse environmental impact.

The additional cost of the control equipment per ton of lime is greater than all of the pre-tax profit that Vulcan realizes on every ton of lime produced. Vulcan would lose money on every ton of lime produced using this control system. The prohibitive capital and operating costs on a per ton of lime basis for a thermal oxidizer as well as the adverse environmental and energy impacts render the use of this technology not feasible.

Properly Designed and Operated Lime Kiln

This control has been implemented at the kiln and has no further adverse economic, energy, or environmental affects.

5.5 VOC BACT Determination

Vulcan proposes that BACT for the lime kiln be considered as proper design and operation of the kiln because it is the only control option that is considered to be feasible. The VOC emissions from the Vulcan Manteno lime kiln will be 0.146 pounds per ton of limestone feed.

6. PM$_{10}$, FILTERABLE AND CONDENSABLE PARTICULATE MATTER AND LEAD

Vulcan has previously installed a pulse jet fabric filter. This unit will be replaced with a unit that operates with a gross air-to-cloth ratio of 2.9 $(ft^3/min)/ft^2$ and is equipped with state-of-the-art membrane coated felted fiberglass bags. This unit will ensure emissions equal to or less than 0.100 pounds per ton of stone feed. Furthermore, the solids handling system will be upgraded to handle the additional material load created by the installation of the spray dryer absorber between the kiln outlet and the inlet to the fabric filter.

IEPA has requested that Vulcan include a condensable particulate matter emission limit. The condensable particulate matter is due primarily to the volatilization of ammonia and organic compounds present in the limestone feed. Vulcan has calculated the achievable condensable emission limit based on the assumption that all of the VOC emissions will be captured as condensable particulate matter. Accordingly, the BACT emission rate for condensable particulate matter has been taken to be 0.146 pounds per ton of stone feed. This results in a total particulate matter (filterable and condensable particulate matter) limit of 0.246 pounds per ton of stone feed.

The pulse jet fabric filter with membrane bags will provide for exceptionally low emissions of lead. The emissions of lead will be less than 0.001 pounds per tons of stone feed. At this emission rate, the annual lead emissions from the kiln will be less than 0.24 tons per year.

7. SUMMARY OF UPDATED BACT EVALUATION

Table 5 provides the associated emission levels for the BACT determinations listed in the above sections. The table also lists the emission limits in the last construction permit application.

Table 5. Summary of BACT Limits

Pollutant	BACT Limits, Pounds per Ton of Limestone Feed				Changes Since October 2003
	October 2003	January 2004	July 2006	November 2008	
SO_2	2.76	2.66	2.66	2.20	Reduced due to preheater
NOx	4.50	N/A	4.50	4.50	Unchanged
CO	43.2	N/A	11.48	11.48	Improved combustion controls
VOC	0.146	N/A	0.146	0.146	None
PM$_{10}$	0.134	N/A	0.134	0.100	Reduced due to membrane bags and larger fabric filter
Total Filterable PM	0.02 gr/DSCF	N.A	0.100	0.100	Reduced due to membrane bags and larger fabric filter
Condensable PM	N/A	N/A	0.146	0.146	Added requirement
Total PM	N/A	N/A	0.280[1]	0.246	Added requirement
Lead	N/A	N/A	N/A	0.001	Added requirement

1. Measured as total PM$_{10}$ (filterable and condensable)