

Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Bay Area 2010 Clean Air Plan
Stationary Source Control Measure SSM-9

BAAQMD Regulation 9, Rule 13:
***NITROGEN OXIDES, PARTICULATE MATTER, AND TOXIC AIR
CONTAMINANTS FROM PORTLAND CEMENT MANUFACTURING***

Workshop Report
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1.0 Introduction

The Bay Area Air Quality Management District (“BAAQMD” or “District”) will hold a public workshop to discuss and solicit input on proposed Regulation 9, Rule 13: *Nitrogen Oxides, Particulate Matter, and Toxic Air Contaminants from Portland Cement Manufacturing* (“Regulation 9-13” or “the rule”). In Stationary Source Control Measure SSM-9 of the Bay Area 2010 Clean Air Plan, the District identified Portland cement manufacturing as a potential source of emissions reductions of nitrogen oxides (NO_x), a precursor of ozone and secondary fine particulate matter. Additionally, the control measure sought to reduce emissions of sulfur dioxide (SO₂), a precursor of fine particulate matter, and particulate matter (PM) from the manufacturing of Portland cement. Reducing emissions would enable the District to make progress toward meeting federal and state ozone and particulate standards, for which the District is currently in a non-attainment status.

In August of 2010, the United States Environmental Protection Agency (EPA) issued final amendments to the National Emission Standards for Hazardous Air Pollutants (NESHAP) from the Portland Cement Manufacturing Industry. The revised NESHAP significantly reduces emissions of toxic air contaminants (TACs) from new and existing Portland cement kilns. Since adoption of the amended rule, individual Portland cement manufacturing companies along with the national industry association have petitioned EPA to reconsider these rules, and subsequently challenged them in Federal Court. In addition, legislation has been proposed in both the U.S. House of Representatives and Senate (H.R. 2681 and S. 1610, Cement Sector Regulatory Relief Act of 2011) to provide a legislative stay of EPA emissions standards that apply to cement manufacturing plants. Either of these efforts may delay or rescind the amended standards of the NESHAP. In order to ensure that emissions from the manufacture of Portland cement are significantly reduced in the Bay Area, the emission limits of the NESHAP are included in the proposed Regulation 9-13.

This report outlines and explains the proposed rule to the public, the affected facility, affected operators, and any other interested persons. This report includes a description of the Portland cement manufacturing process, the air emissions from that process, the regulatory background for emissions standards, and a technical discussion of the means of controlling those emissions. Following the technical review, the draft rule that staff is proposing is described and associated compliance costs are discussed.

District staff will hold a public workshop on December 12, 2011 to discuss the proposed rule. Staff invites participation in the workshop and submittal of written comments on any aspect of the proposal. Staff will then consider all comments, revise the proposed rule as needed, and present the proposed rule to the District’s Board of Directors for adoption at a public hearing.

2.0 Background

Portland cement is combined with water, gravel, sand, or other aggregate to form concrete, which is used in road building and a variety of other construction projects. Portland cement manufacture is a \$10 billion per year industry in the United States. In 2008, Americans consumed 104 million tons of cement nationally, or 675 pounds per person for the year. Between 85% and 90% of that is produced in the United States with the rest imported primarily from China, Canada, Colombia, Mexico and Korea. There has been a consistent decline in consumption for the past 5 years. Although the Portland Cement Association projected a small increase (3-5 million tons) in cement production in the US for 2010, this increase may be put in perspective by noting that this is still 60 million tons less than the peak consumption levels of 2005.

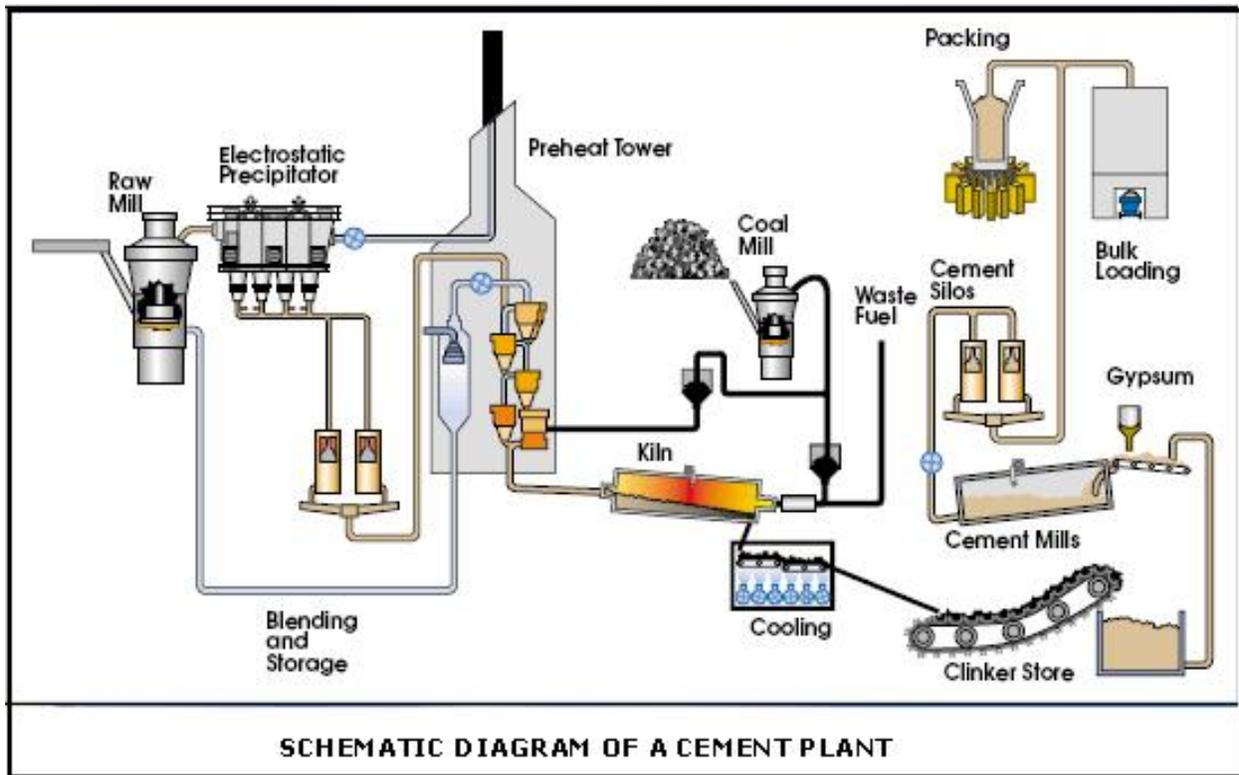
There are 108 Portland cement manufacturing plants operating in 36 states, with 11 in California, three in Northern California, and one in the Bay Area. Lehigh Southwest Cement Plant (Lehigh), located in unincorporated Santa Clara County, west of Cupertino, is the only cement manufacturing facility in the District. Consistent with national trends, Lehigh has reduced production annually since 2006. Their BAAQMD permit limits their production of clinker (a preliminary stage of cement) to 1.6 million tons per year, but in 2010 Lehigh produced 847 thousand tons of clinker, a little over half the permitted amount.

Portland cement manufacturing is the third largest industrial source of emissions of NO_x and SO₂ in the nation at 180 thousand tons per year. Lehigh is the Bay Area's largest source of NO_x emissions without modern add-on NO_x controls. This facility emitted 1,798 tons of NO_x and 181 tons of SO₂ in 2008. The plant has been in operation since 1939, and is subject to a variety of District, State, and federal air quality rules and regulations. District staff initiated rule development on a proposed cement kiln rule and has evaluated more stringent standards for NO_x, PM, and SO₂. In addition, U.S. EPA has adopted amendments to federal rules affecting this facility, with compliance due in September of 2013. Staff has evaluated the standards and compliance deadlines of these federal rules to ascertain their application to this facility and to determine what additional technologies and/or methodologies could be employed to reduce emissions of air pollutants in a cost effective manner.

Portland Cement Kiln Overview

Portland cement is a fundamental ingredient of concrete, consisting of calcium, silicon, aluminum, and iron. These materials are combined in a number of steps requiring careful control to ensure that the final product meets specific chemical and physical specifications required for building and construction needs. Figure 1 shows a schematic diagram of Portland cement manufacturing.

Figure 1 – Schematic of Cement Manufacturing Process



Manufacturing Steps

Portland cement manufacturing is a series of steps which take place at a large industrial facility usually located adjacent to a source of raw materials. Raw materials consist of limestone, shells or chalk, clay, sand, alumina and iron ore. The bulk of these are mined at a quarry, blended, and ground to a powder. This blended material is subjected to intense heat in a kiln to cause a series of chemical reactions, transforming the powdered raw materials into something called cement clinker. Cement clinker consists of grayish-black pellets the size of marbles or golf balls, which is cooled, ground and mixed with gypsum and other additives to form powdered Portland cement.

In the initial manufacturing step, limestone is mined from a quarry near the plant. At the quarry, the material is reduced to a manageable size (from chair or desk size to softball size) by a two-stage primary crusher before stockpiling and transport to the kiln. The limestone is crushed for a third time and then pre-blended to homogenize the quality of the limestone. It is then mixed with bauxite (a source of alumina) and iron ore before being ground inside a ball mill and further blended to create the required proportions necessary for the desired end product.

In older cement manufacturing plants water is added to the raw materials to form a slurry, and grinding and mixing operations are completed in a slurry form. This aids in conveying the

material, but the dry method is ultimately more energy efficient. The Lehigh facility converted from wet to dry process in 1981. In order to produce clinker the material must be heated to at least 2400 degrees Fahrenheit and this is much easier when the raw materials are dry. At modern plants, the materials are preheated before entering the kiln and at many facilities the process of making cement is begun at this stage in a process called precalcining. A preheater/precalciner tower is utilized at the Lehigh facility to heat the material to approximately 1650 degrees F, and begin the cement manufacturing process prior to the material entering the rotary kiln.

At the heart of the manufacturing process is the cement kiln. The blended mixture of raw material is fed from the preheater/precalciner into the upper end of a tilted rotating cylindrical kiln where it will reach temperatures of 2400 to 3000 degrees F. This intense heat causes the material to fuse and undergo chemical reactions to create cement clinker. The clinker is discharged from the lower end of the kiln where it is cooled and then ground into a fine powder. Some of this heat is recovered at this stage and routed to the preheater. The ground clinker is mixed with gypsum and ground one final time to make the final product.

Emissions

Emissions to the atmosphere from the manufacture of cement primarily come from combustion of fuel to heat the kiln, with additional point source particulate emissions from the kiln, grinding and mixing operations, and fugitive particulate emissions from transport of materials. Choice of fuel can impact combustion emissions, whether it is natural gas, coal, petroleum coke, or tires. Currently no cement kiln in the US is fired by natural gas due to cost and availability. Lehigh uses 100% petroleum coke, having switched from a mixture of coal and petroleum coke in 2007. Generally, emissions of concern from cement manufacture are the criteria pollutants (NO_x, SO₂, PM, and VOCs) and toxic air contaminants (TACs) from combustion. TACs include benzene, hydrochloric acid, dioxins and furans, as well as trace metals such as mercury, cadmium, arsenic, nickel, chromium, and manganese. In addition, cement kilns generate large amounts of greenhouse gases, primarily carbon dioxide (CO₂).

Emissions Inventory

Table 1 shows the average daily emissions from the cement kiln at Lehigh according to BAAQMD records for 2010. These values are determined by emission factors assigned by District permit engineers, stack testing, mass balance estimates, and the annual throughput of fuel used and clinker produced as reported by the facility. Lehigh reported that they produced 847 thousand tons of clinker in 2010, a little over half the permitted amount of 1.6 million tons per year.

Table 1 – Lehigh Southwest Cement Company Kiln Emissions (2010)		
Pollutant	Average emissions in pounds	Average emissions in

	per day	pounds per ton of clinker
Particulate Matter (PM)	32.62	1.40E-02
Precursor Organics (POC)	59.2	2.55E-02
Oxides of Nitrogen (NO _x)	9,290	4.00E+00
Sulfur Dioxide (SO ₂)	2,665	1.15E+00
Carbon Monoxide (CO)	5,435	2.34E+00
Benzene	16.1	6.84E-03
Hydrochloric Acid (HCL)	179	7.63E-02
Mercury	0.72	3.05E-04
Total Equivalent CO ₂	4.08E+06	1.76E+03*

**NOTE: Total equivalent CO₂ value calculated based on 2008 inventory scaled by the ratio of reported clinker produced for 2010 and 2008.*

Federal Regulations

Two federal rules address air emissions from the manufacture of Portland cement: New Source Performance Standards (NSPS) and National Emission Standard for Hazardous Air Pollutants (NESHAP). EPA generally promulgates NSPS for specific industrial operations to address emissions of criteria pollutants from new, modified, and reconstructed sources. NESHAP addresses emissions of TACs (also known as hazardous air pollutants) from both new and existing sources, and may have separate standards for each case.

The NSPS for Portland cement manufacture was originally promulgated in 1971, and has been amended many times. Clean Air Act amendments of 1977 require a quadrennial review of all NSPS and, if deemed appropriate, EPA revises the standard. The most recent amendments to the NSPS were proposed in June of 2008 and finalized in August of 2010. The previous standard remains in effect for all sources constructed after 1971. For facilities constructed, modified or reconstructed after June 6, 2008, emissions standards have been made more stringent, and the monitoring methodology has been modified. EPA is requiring continuous emission monitoring systems (CEMS) for each of the three pollutants covered under this rule (PM, NO_x, and SO₂).

EPA initially issued the NESHAP for Portland cement manufacture in 1999 to limit emissions of PM as a surrogate for certain toxic metals contained in cement kiln and clinker cooler PM, to limit dioxin/furan emissions, and to set a hydrocarbon limit for new kilns. Several organizations filed petitions for judicial review of that rule. In 2000, the US Court of Appeals remanded parts of the 1999 standard and instructed EPA to consider standards for hydrochloric acid (HCL), mercury, total hydrocarbons, and metallic hazardous air pollutants. In December of 2006, EPA issued final amendments to the NESHAP to set limits for mercury and total hydrocarbons for kilns built after December 2, 2005 and to require that existing kilns meet “work practice” standards to reduce emissions of mercury and hydrocarbons. In a separate December 2006 action, EPA announced that it would reconsider the emission limits for mercury and total hydrocarbons for new cement kilns. Prior to that action, EPA had been sued by the cement industry, environmental groups, and state environmental agencies on the final amendments, and

also received petitions to reconsider the existing source standards for mercury, hydrocarbons, and the decision not to regulate HCl. On April 21, 2009 EPA proposed to amend the NESHAP to reduce emissions of mercury, total hydrocarbons, HCl, and PM from both new and existing cement kilns.

On August 6, 2010, EPA issued final amendments to both rules. The revised NESHAP significantly reduces emissions from new and existing Portland cement kilns, and the NSPS further limits emissions from new and modified operations. Table 2 illustrates the standards in the federal NSPS for NO_x, SO₂, and PM; and Table 3 shows the NESHAP limits.

Table 2 – 2010 New Source Performance Standards	
Pollutant	Emission Limit
Oxides of Nitrogen (NO _x)	1.5 lb/ton of clinker, averaged over 30 days
Sulfur Dioxide (SO ₂)	0.4 lb/ton of clinker, averaged over 30 days
Particulate Matter (PM)	0.01 lb/ton of clinker, averaged over 30 days

Table 3 – 2010 National Emission Standards for Hazardous Air Pollutants		
Pollutant	Existing Facilities	New and Modified Facilities
Mercury	55 lbs/million tons of clinker, averaged over 30 days	21 lbs/million tons of clinker, averaged over 30 days
Dioxins/Furans*	0.2 nanograms/dry standard cubic meter (ng/dscm)(TEQ), averaged over 24 hours	0.2 ng/dscm (TEQ)*, averaged over 24 hours
Total Hydrocarbons	24 parts per million by volume (ppmv), averaged over 30 days	24 ppmv, averaged over 30 days
Total Organic HAP*	9 parts per million by volume (ppmv), averaged over 30 days	9 ppmv, averaged over 30 days
Particulate Matter (PM)	0.04 lb/ton of clinker, averaged over 30 days	0.01 lb/ton of clinker, averaged over 30 days
Hydrochloric Acid (HCL)	3 ppmv, averaged over 30 days	3 ppmv, averaged over 30 days

**NOTES: The Total Organic HAP standard is an alternative to the Total Hydrocarbon Standard. The Dioxin/Furan standard is unchanged from the previous NESHAP standard. Toxic Equivalent (TEQ) weighs the toxicity of less toxic compounds as fractions of the most toxic compound of the group.*

The amended NESHAP will reduce emission of mercury, total hydrocarbons, HCl, and PM from both new and existing kilns. The amended NSPS will reduce emissions of NO_x, SO₂, and PM from “new” kilns (those constructed, modified, or reconstructed after June 6, 2008). Facilities are given three years to meet these limits as the deadline for full implementation of these rules is September 9, 2013. EPA estimates that by that date the NESHAP will result in national

emissions reductions of 92% for mercury, 83% for total hydrocarbons, and 97% for HCl. EPA estimates that implementation of the NSPS will result in national emissions reductions of 78% for SO₂, 5% for NO_x, and 92% for PM, although PM is addressed in both the NESHAP and the NSPS. The federal regulations would reduce emissions at the Lehigh facility by approximately the following amounts: 93% for mercury; 91% for total hydrocarbons; and 70% for HCl. The Lehigh facility is not “new or modified” and so only the amended NESHAP limits would apply and not the amended NSPS limits. As previously stated, legislation pending in the US House of Representatives and Senate could stay or rescind these federal regulations.

California Regulations

All cement kilns operating in California are subject to permitting by the local air district. Major sources of air pollution like the Lehigh facility are required to obtain Title V operating permits which incorporate the applicable NESHAP, NSPS and District regulations. There are currently no State rules that specifically regulate cement manufacture, other than greenhouse gas emissions reporting requirements and those rules governing the use of scrap tires as fuel. Several air districts (Antelope Valley, Amador, Kern, Mojave, and Monterey Bay Unified) with cement kilns operating within their jurisdiction have adopted regulations to address emissions of NO_x and/or PM from these sources. South Coast Air Quality Management District has adopted several cement manufacturing regulations addressing emissions of NO_x, PM, CO, as well as hexavalent chromium and fugitive dust. At least two of these regulations were adopted to address specific conditions at individual cement manufacturing facilities.

Applicable BAAQMD Regulations

While there is currently no BAAQMD rule which specifically addresses cement manufacturing operations, these operations are subject to a number of District regulations that govern permitting (e.g., Regulation 2-1, 2-2), emissions of toxic or hazardous compounds (Reg. 2-5), and some general or miscellaneous regulations for individual pollutants (Reg. 6-1 for PM, Reg. 8-2 for VOCs, Reg. 9-1 for SO₂, and Reg. 11-1 for lead). Requirements for these rules are incorporated into the Title V permit for Lehigh along with the applicable federal requirements of the NESHAP and NSPS.

3.0 Technical Review

Controlling Emissions from Cement Manufacturing

The manufacturing of cement requires the movement and processing of many tons of material as well as the combustion of large amounts of fuel in order to heat that material to extremely high temperatures. Emissions of pollutants are directly attributable to both the fuel combustion and materials processing. Any improvements to the efficiency of the material handling processes as well as the delivery of heat can result in a reduction in emissions to the atmosphere. Over many years of operation Lehigh has implemented efficiency related modifications to their process as the state-of-the-art of cement manufacturing has developed. The facility has switched from a wet to a dry process, introduced heat recovery methods, and installed a precalcining tower. The driving force behind these modifications has been financial, but the improved efficiency has also reduced emissions. Staff is continuing to evaluate potential efficiency improvements, but there do not appear to be any obvious additional modifications of this type that might be undertaken at this time. Add-on emissions control or improvements to existing emissions control devices hold far greater potential to reduce emissions in a cost effective manner.

NO_x Emissions Control

The formation of NO_x during the manufacture of cement is due to the high temperature, oxidizing atmosphere necessary for clinker formation. NO_x is primarily formed by two mechanisms: the oxidation of molecular nitrogen in the combustion air or “thermal NO_x”; and the oxidation of nitrogen compounds in the fuel or “fuel NO_x”. Although the contribution of fuel NO_x cannot be discounted, in the high temperature zone of cement kilns, thermal NO_x is the dominant contributor to NO_x formation. Additionally, some NO_x may be formed by oxidation of nitrogen compounds from the raw materials or “feed NO_x”, and a small amount of NO_x is formed instantaneously at the flame surface or “prompt NO_x.” The predominant nitrogen species in cement kiln exhaust gas is NO, at typically up to 90-95%, with NO₂ accounting for the remainder.

Emissions of NO_x from cement manufacture come primarily from the manner in which fuel is combusted to heat and chemically formulate the cement clinker. As such, these emissions may be reduced by control of the combustion zone temperature and excess air, as well as combustion modifications. These modifications include low NO_x burners in both the kiln and precalciner, mixing air systems, fuel addition systems, and staged combustion. In addition, post-combustion controls involving the use of chemical additives to the pollutant stream can further reduce emissions of NO_x to the atmosphere. Many of these methods may be used in combination and some preclude one another or have operational constraints due to the design of the kiln that may limit their efficacy.

A number of post-combustion or add-on control techniques have proven successful at removing NO_x in exhaust streams from a variety of industrial combustion sources. These include scrubbing technology utilizing various chemical additives, oxidation technology utilizing

hydrogen peroxide, and selective reduction technology utilizing ammonia or urea injection either with or without a catalyst present. The applicability of these add-on NO_x controls to the exhaust from cement kilns is somewhat limited by high temperature, high flow rate, and high level of particulate in the exhaust. The cost, availability, and handling requirements of the chemical additives can further restrict their usefulness in this application. The two post-combustion techniques that present the greatest likelihood of successful NO_x reduction from cement kiln exhaust are selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR).

Both SNCR and SCR utilize a nitrogen based reducing agent (usually ammonia or urea) to convert NO_x into molecular nitrogen (N₂) and water vapor (H₂O). The chemical reactions that accomplish this conversion depend on the reducing agent and the presence of a catalyst. However, the catalyst and the temperature at which the reactions occur is the main difference between SNCR (1600-2000°F) and SCR (570-700°F). Ammonia may be obtained as either anhydrous (dry) or aqueous (mixed with water). Anhydrous ammonia is the most efficient form because it is 100% ammonia, but there are significant issues with the transport, handling and storage of anhydrous ammonia. Both EPA and OSHA classify anhydrous ammonia as a hazardous material. Aqueous ammonia is not a hazardous material but is usually available in concentrations of 19% or 29% by weight, so a greater amount is required to achieve the same benefit. Urea is perhaps a safer alternative than anhydrous ammonia, but is about 46% nitrogen, so it takes about twice as much mass of urea to provide the same NO_x control. Urea is available in dry form or mixed with water at 40% to 50% by weight urea solution. Urea solutions are also more viscous than aqueous ammonia so delivery systems must account for this.

Use of either SNCR or SCR would require substantial equipment upgrades as well as operational modifications to any cement manufacturing plant. Operational plans and equipment are required for the delivery, storage, mixing and delivery of the reagent. The complexity of this depends on the form of the reagent used. The performance of these systems is highly dependent on temperature, residence time, and concentration of the applied reagent. Control systems to monitor these variables as well as CEMS for NO_x and ammonia are required to determine the optimum conditions to maximize NO_x control and minimize emissions of unreacted ammonia. Emissions to the atmosphere of unreacted ammonia resulting from the use of SNCR and SCR are referred to as “ammonia slip” and can result in odor concerns, stack plume visibility problems and secondary PM formation. Additional issues associated with poorly managed SNCR systems at cement plants include the potential for increased emissions of CO, and N₂O (more likely when using urea as a reagent).

SNCR has proven an effective means of NO_x control at a number of cement kilns across Europe, Japan, and the United States. The first trial use of this technology in cement manufacturing occurred in Europe in 1979, with further trials carried out at cement plants in Europe and Japan throughout the 1980s. As of 2007, over 60 cement plants across Europe utilized SNCR for the control of NO_x emissions achieving control efficiencies in excess of 50%. Higher NO_x reduction efficiencies are possible when SNCR is paired with staged combustion or some other combustion modification. In the United States, the application of SNCR to cement kilns is more recent and initially only proved successful on preheater/precalciner kilns. However, there are currently several cement plants across the country utilizing SNCR including wet kilns, long kilns

and those using waste derived fuels. Reported NO_x control efficiencies for the US applications run from 12% to 65%. Higher efficiencies are generally associated with higher concentrations of ammonia added to the flue gas, and this often results in greater ammonia slip (emissions of unreacted ammonia).

SCR has proven an effective means of NO_x control for a variety of combustion sources, from gas turbines at power plants to industrial boilers to diesel locomotives and even automobiles. The application of this technology to cement kilns is much more limited. Primarily, this is due to the high levels of dust in cement kiln gas at the temperature favorable for SCR use. It is possible to utilize SCR after the PM control device, but the exhaust gases would need to be reheated. SCR requires a catalyst bed, catalyst cleaning system, bypass ducting and periodic replacement of the catalyst, and a significantly higher capital investment over SNCR. There are three known cement plant SCR installations worldwide, all in Europe, and another is due to be installed in the US in Illinois in 2013. The first SCR system on a cement plant began operation in 2001 at the Solnhofer cement plant in Germany. In 2006 and 2007 two cement plants in Italy began operation of SCR systems. All of these are high dust applications. It is worth noting that the Solnhofer plant in Germany employs both SCR and SNCR technology, to avoid downtime during cleaning of the catalyst bed. The NO_x emission limit applied to that plant under permit is such that it can be met by the less efficient SNCR technology. The system to be installed in Illinois is by consent decree as part of a Clean Air Act Settlement between EPA and Lafarge North America.

In determining emissions levels for the NSPS, EPA considered lower NO_x levels based on performance of SCR, but determined that SCR was not “sufficiently demonstrated technology for this industry.” This determination was made with full knowledge of the three facilities in Europe, the successful demonstrations of SCR for control of other source categories, and the proposed installation in Illinois as part of a settlement agreement. EPA is concerned about the potential for dust buildup on the catalyst, which can be influenced by the site specific raw material characteristics of the facility’s quarry. Dust buildup on the catalyst can reduce the effectiveness of the SCR and cleaning the catalyst can result in significant downtime. EPA has based its NSPS NO_x emission limit of 1.5 lbs. per ton of clinker on a well-designed preheater/precalciner kiln (i.e. with staged combustion) and 50% control obtained by SNCR.

PM Emissions Control

Particulate emissions arise from a variety of activities at cement manufacturing facilities, some of which are amenable to collection and control by add-on systems and some of which are fugitive in nature but which may be nevertheless reduced by mitigation methods. Dust sources amenable to collection and control include crushing, mixing and storage of raw materials, clinker production and cooling, finish grinding, and packaging. Of these sources, the largest single point of emissions are the stack emissions from the kiln including the feed system, fuel firing, and clinker cooling and handling systems. Fugitive emissions come from quarrying and primary crushing of raw materials, storage and handling of raw materials, fuel, clinker, and finished product, and from vehicle traffic.

Fugitive dust emissions are best controlled by efficient site design and lay-out as well as proper maintenance and operation of equipment to reduce spillage and air leakage from collection systems. These can be addressed appropriately in a dust mitigation plan and operation and maintenance plan. Plan elements may include open pile wind protection, use of water spray or chemical dust suppressors, paving, road wetting, and housekeeping requirements, and humidification of stockpiles. Additional measures may include enclosing or encapsulating dusty operations such as grinding, screening and mixing, covering conveyors and elevators, vacuum systems to prevent formation of diffuse dust from spillage during maintenance operations, and flexible filling pipes for dispatch and loading processes. Particularly dusty operations may require ventilation and collection by a control device similar to that for stack emissions.

Various systems have been employed in the cement industry to control point source or stack emissions in the past, but the predominant means of add-on particulate control currently in use are either fabric filtration (bag houses), electrostatic precipitation (ESP) or a combination of the two (hybrid filters). Hybrid filters are often ESP systems that have been modified to include a bag house in order to extend the useful life of the control device. In some cases a cyclonic separator may be used to remove larger particulate matter upstream of these fine particulate control devices.

Electrostatic precipitators (ESPs) generate an electrostatic field across the path of particulate matter in the air stream. The particles become negatively charged and then migrate to positively charged collection plates downstream of the electrostatic field. The plates are vibrated, tapped or shaken periodically to remove the collected material on a cycle optimized to minimize re-entrainment of the particulate matter. ESPs can operate effectively in conditions of high temperature (up to 750°F) and high humidity. Performance is impaired by particulate build-up on the electrodes forming an insulating layer and thereby reducing the electric field. This is most likely to happen with high chlorine or high sulfur fuel or raw materials forming alkali metal chlorides and sulfates. Explosion risks may also arise in conditions of high CO concentrations in exhaust gas.

Fabric filters are very efficient at dust collection, with the basic principle of a fabric membrane that allows the gas to pass but retains particulate. The most common large scale systems use hanging bags arranged geometrically across the top of a box or chamber, hence the name “bag house.” Dust is deposited both on the surface and within the fabric, and in time the dust itself becomes the dominant filtering medium. Periodic cleaning of the fabric membrane is required as dust builds up and resistance to gas flow increases. The most common cleaning methods are compressed air pulsing, reverse airflow, mechanical shaking or vibration. Usually baghouses have multiple chambers that can be isolated in case of bag failure, and to maintain efficiency during the cleaning cycle. Filter bags are available in a variety of woven and nonwoven fabrics with some synthetic fabrics that can operate effectively at temperatures above 500°F.

TACs Emissions Control

The TACs addressed in the proposed regulation as well as the federal NESHAP come in a variety of forms, so that control thereof is equally varied. The addition of adsorptive materials to the production process can be utilized to adsorb organic compounds, ammonia and ammonium compounds, HCl and mercury. The removal of toxic compounds that are emitted in solid form such as lead, beryllium and chrome is also increased slightly by the use of activated carbon. Acidic compounds can be removed through use of scrubbers which either spray caustic liquid into the kiln itself or into a separate reaction chamber downstream of the kiln. Alternatively, dry lime can be utilized in place of the caustic solution. Dioxins and furans are controlled by activated carbon or through operational controls such as maintaining a lower inlet temperature to the baghouse or other particulate abatement device.

Adsorption addition refers to adding lime or activated carbon to the cement manufacturing process in either a wet or dry form when raw materials are mixed prior to entering the kiln, or directly incorporated into the clinker formation process. The lime may be calcium oxide (CaO) or any of the various chemical and physical forms of quicklime, hydrated lime, or hydraulic lime. Dry scrubbing is another term for the addition of dry CaO and this has already been implemented to a degree at Lehigh. Two raw mills are situated immediately prior to final mixing of the raw materials and test results show a decrease in emissions when these are operating due to the increased addition of pulverized limestone into the flue gas. A suspension of hydrated lime in water may be sprayed into the cement kiln flue gas to reduce emissions and is called lime slurry injection (LSI). Lehigh obtained a permit from the District in 2010 to add LSI to their process (injection point at the last stage of the preheater/precalciner) and the system has been installed and used on a trial testing basis. The facility is awaiting county approval before beginning full scale operation.

Organic compounds, ammonia and ammonium compounds, HCl, mercury, SO₂, and to a lesser extent, residual dust can be removed by adsorption by activated carbon. As stated above, activated carbon can be injected into the cement manufacturing process (ACI), or alternatively the kiln gases can be routed to packed beds or filters. In both cases, the saturated carbon is then added to the fuel mix in the kiln. Lehigh applied for a permit from the District to install ACI primarily to reduce emissions of mercury. The installation was completed and ACI was fully operational beginning in May 2011.

SO₂ Emissions Control

Similar to NO_x, the formation of SO₂ is a product of the chemical make-up of the raw materials and fuel, as well as the high operating temperatures and oxygen concentration in the kiln. The production of SO₂ is more dependent on the sulfur content of fuel and raw materials however, whereas NO_x formation is more dependent on combustion effects. Emissions of the two pollutants are interrelated due to the overlap of contributing factors. Process optimization measures are the first step towards reducing SO₂ emissions, including smoothing of kiln operation, choice and homogenization of the raw materials and fuel, and prevention of reducing conditions in the burning process by controlling the amount of available oxygen. When these optimization measures prove insufficient, add-on controls such as adsorption addition, carbon filtration, and wet scrubbing may be employed to further reduce emissions of SO₂.

Wet scrubbing is another means of controlling SO₂ emissions which involves spraying a mixture of calcium carbonate and water countercurrent to the exhaust gas in a tower as an add-on control device. The calcium carbonate reacts to form calcium sulfate dihydrate, which is then separated and can replace gypsum as a modulating agent in the finished cement depending on the properties required. The liquid is recovered and reused in the wet scrubbing tower. Wet scrubbing also removes HCl, residual dust and to a lesser extent metal and ammonia emissions. This is the most commonly used method of desulfurization in coal fired power plants and its use is also well established in cement manufacturing, although more often at facilities where sulfur levels are high in the fuel or raw materials. Limitations on the use of this means of control would be increased energy consumption, increased CO₂ emissions, increased water consumption and risk of water contamination, and increased operational costs.

4.0 Rule Under Consideration

Requirements

The District is considering adoption of Regulation 9, Rule 13 to achieve the maximum feasible, cost effective emissions reductions of NO_x and PM in concert with efforts to bring the Lehigh facility into compliance with limits for TACs consistent with the federal NESHAP. As an existing facility, Lehigh is not subject to the criteria pollutant emissions standards of the amended NSPS. Significant modifications will be required to reduce TAC emissions, including additional controls such as LSI and ACI, as well as enhanced monitoring requirements. The emission limits proposed in Regulation 9, Rule 13 represent the maximum feasible NO_x and PM controls as applied to an existing unmodified source. The equipment modifications necessary to meet the proposed NO_x emission limit may result in some excess ammonia emissions. Ammonia is a TAC and a precursor to secondary particulate matter formation, for this reason an ammonia emission limit is included in the proposed rule. Additional requirements of the proposed rule address concerns over the present configuration of the emission point from the kiln, and the need for an enforceable fugitive dust control plan. The proposed effective date of September 9, 2013 corresponds with that of the amended NESHAP and NSPS.

Criteria Pollutant Emissions Limits

The District proposes the following emission limits for Portland cement manufacturing kilns:

- 2.3 pounds NO_x per ton of clinker produced averaged over 30 days
- 0.04 pounds PM per ton of clinker produced averaged over 30 days
- 10 ppmv ammonia above baseline, dry at 7% oxygen averaged over 24 hours.

Where possible, limits and averaging times are expressed to maintain consistency with federal standards and represent the most stringent limits that Lehigh can achieve for these pollutants in a cost-effective manner. Staff has evaluated the controls required by the federal standards and has proposed these standards based on reasonably achievable emission rates for this facility. These emission limits will require the use of a continuous emission monitoring system (CEMS) or parametric monitors, as well as a means of monitoring and recording the production rates. CEMS, parametric monitors, and production monitoring requirements are detailed in the monitoring and records section of the rule. There is currently no commercially available CEMS for PM; however, there is a reasonable expectation that parametric monitoring equipment will become available before the federal standards requiring CEMS for PM go into effect in 2013. Lehigh has already installed a parametric monitor to measure ammonia and is currently calibrating and testing this equipment for quality assurance of the measurements. All CEMS and parametric monitors are required to comply with the provisions of the District Manual of Procedures, federal requirements, and to maintain records as provided in District Regulation 1.

An initial demonstration of compliance with these emission limits must be performed within 90 operating days of the effective date of the rule and repeated annually thereafter.

TAC Emissions Limits

The following emission limits are proposed to address TACs:

- 0.2 nanograms Dioxins/Furans (TEQ) per standard cubic meter, dry at 7% oxygen averaged over 24 hours
- 55 pounds Mercury per million tons of clinker produced averaged over 30 days
- 9 ppmv Total Organic HAP, dry at 7% oxygen averaged over 30 days
- 3 ppmv HCl, dry at 7% oxygen averaged over 30 days.

The proposed emissions limits are consistent with the federal NESHAP and will provide protection to nearby communities should the federal rules be delayed or overturned either through legislative efforts or pending litigation. Lehigh has already installed control equipment (LSI and ACI) and monitoring equipment (CEMS and parametric monitors) in order to meet the compliance date of the federal rules.

Opacity Standard

District staff proposes an opacity limit of 10 percent opacity lasting for no more than three minutes in any one hour period from any emission point or miscellaneous operation. Compliance with this standard will be facilitated through the implementation and maintenance of a Fugitive Dust Control Plan (FDCP). Elements of the FDCP include:

- List of potential emission sources
- Mitigation measures to minimize fugitive dust emissions
- Personnel training procedures
- Operation and maintenance procedures to minimize fugitive dust emissions

As part of Lehigh's recent Title V permit renewal, the District required Lehigh to develop and implement a FDCP to reinforce the facility's commitments to mitigate emissions of fugitive dust. Provisions for the submittal, public comment procedures, District review, and potential modifications to the FDCP are included in the proposed regulation to strengthen the enforceability of the measures contained in the plan. Under the terms of the proposed regulation,

the FDCP must be submitted to the District for review within 90 days of the effective date of the rule, and once deemed complete will be available for a 30 day public comment period. Within 30 days of completion of the public comment period, the District will approve the plan or notify the facility should the plan be deemed to be inadequate. In this latter event, the notification will identify any inadequacies and recommend corrections. Additionally, the District may determine that the FDCP be modified at a subsequent date should physical alterations, changes in throughput, or a recent history of exceedences of opacity standard dictate such a change.

Emission Point Requirements

District staff is proposing that emissions from the kiln enter the atmosphere not less than 300 feet above grade. This will aid in dispersion of pollutants and facilitate more accurate and less costly monitoring of emissions. A Health Risk Assessment performed for Lehigh determined that the concentration of pollutants at the maximally exposed receptor would be greatly reduced by increasing the stack height to 300 feet. This was confirmed by preliminary modeling of SO₂ emissions as described in the following paragraph. In general, a higher emission point allows emitted pollutants to be transported over a longer distance before reaching ground level. The concentration of pollutants decreases as the plume travels from the point of release and is dispersed by wind and other natural forces, greatly reducing health impacts. Structural constraints, dynamic back pressure on the plume, as well as aesthetics and compliance with local building codes place constraints on the actual height of the stack.

Sulfur Dioxide

On June 2, 2010, EPA established a new one-hour SO₂ ambient air quality standard which became effective on August 23, 2010. The new national standard, 0.075 ppmv, is considerably more stringent than the existing California ambient air quality standard, 0.25 ppmv. District staff is examining whether existing sources of SO₂, including Lehigh, have emissions sufficient to trigger an exceedance of the new ambient standard. Based on preliminary dispersion modeling according to EPA specified methodology, Lehigh may trigger an exceedance; however, these modeling results do not correlate well with local monitoring data. This is likely due to the complex terrain surrounding the Lehigh facility, which is not adequately accommodated by the AERMOD model. District staff is evaluating the potential of other models to more closely corroborate with existing monitoring and improve the accuracy of the modeled results. Currently Lehigh is limited by permit condition to SO₂ emissions of 481 pounds per hour.

As mentioned previously, the LSI and ACI systems recently installed at Lehigh will reduce SO₂ emissions and the elevated stack will greatly reduce ground level concentrations of this pollutant. No SO₂ emissions standard is being proposed in this rule at this time; however, should future modeling or monitoring results indicate the need for SO₂ reductions from the facility, an emissions standard will be proposed that ensures that Lehigh does not cause an exceedance of the new standard.

Potential Emissions Reductions

The proposed rule would limit emissions of NO_x to 2.3 pounds per ton of clinker produced. This translates to a reduction in NO_x emissions from the kiln of two tons per day or a 58% reduction over current levels. Lehigh is subject to the NESHAP emission limits and has already taken steps to meet these limits through application of the LSI and ACI systems detailed in the Technical Review section of this report. Operation of this equipment will have a side-benefit of reducing emissions of SO₂ over previous levels, although it would be difficult to estimate the exact reduction in SO₂ emissions.

Reductions in particulate matter emissions are more difficult to quantify. The Lehigh kiln currently emits at a rate only slightly above the proposed standard for PM which is consistent with the NESHAP standards for existing sources. Both the NESHAP and NSPS require CEMS or parametric monitors for particulate emissions and there is a reasonable expectation that this equipment will become available before the standards go into effect in 2013. Compliance with the FDCP provisions of the rule will also help to ensure the continued minimization of fugitive dust emissions. The proposed limit for NO_x will decrease the potential for secondary particulate formation, and the proposed standard for ammonia emissions will limit potential secondary particulate formed by increased ammonia emissions resulting from NO_x control.

As part of the 2010 Clean Air Plan, District staff developed a multi-pollutant evaluation method (MPEM) to evaluate the benefits of the proposed control measures contained in the plan. This MPEM can be used to calculate the emissions equivalence for NO_x, SO₂, and ammonia to that of directly emitted PM_{2.5} in terms of the effect on the average increase in PM_{2.5} concentration in the air. The emissions reduction of NO_x combined with the proposed ammonia emission standard would be equivalent to a PM_{2.5} emission reduction of 8.7 tons per year. This number would be slightly increased by the side-benefit reduction in SO₂ emissions mentioned previously.

Cost of Controls

Lehigh is undergoing major modifications at their facility to meet the federally-imposed NESHAP requirements. Regulation 9, Rule 13 is being proposed at this time to integrate controls to reduce NO_x into Lehigh's planning process, as well as provide a backstop in the event that amendments to the NESHAP are delayed or rescinded. Some of the cost impacts are a result of the EPA mandates and some are the result of the District proposal. EPA evaluated the cost impacts of the final amendments to the NESHAP and NSPS in a document issued at the same time as those final documents. The costs are nationwide estimates, based on 140 existing and 16 new kilns, and actual costs may vary at individual facilities.

Using the EPA estimates for a similarly sized and configured kiln as exists at Lehigh, NO_x control utilizing SNCR would have a capital cost of \$2.3 million, and an annual operating cost of \$700 thousand. Lehigh has provided an estimated capital cost consistent with this estimate that would result from the District proposal. Lehigh estimates that it will cost \$2.5 million for

modifications necessary to meet the stack requirements of this rule. However, these modifications are being undertaken to reduce health risks sufficient to avoid notification requirements for Lehigh should production levels return to maximum capacity. Therefore, this cost should not be attributed entirely to the proposed rule. Ammonia emissions can be controlled by controlling the feed into the SNCR at no additional cost. Although an excess of ammonia may result in incrementally lower NO_x emissions, excess ammonia may also result in secondary PM formation and higher costs.

In order to meet the NESHAP emission limits, Lehigh will need to install control equipment as well as CEMS or parametric monitors for each emission point from the kiln and clinker cooler. The baghouses at Lehigh are compartmentalized and have multiple emission points, so Lehigh plans to manifold these to allow individual monitoring points. Lehigh has installed a hydrated Lime injection system (LSI) as well as activated carbon injection (ACI) in order to meet the NESHAP emission limits. Both of these systems will have the side benefit of reducing SO₂. In addition to the control equipment, there are costs associated with monitoring and testing to verify compliance with the rule. CEMS will be required for NO_x, and either O₂ or CO₂, although these are already in place by permit condition. Additional parametric monitors will be required for PM, ammonia, D/F, mercury, total organic hydrocarbons, and HCl, as well as installation of continuous flow rate monitors and production monitoring systems.

Costs of control equipment and monitoring to meet the NESHAP requirements are estimated to be \$27-\$32 million. Costs of control equipment and monitoring for elements of the proposed District rule not already required by the NESHAP would amount to \$5 million.

Costs for implementation of the Fugitive Dust Control Plan are considered to be minimal. Most provisions are already in place as a condition of Lehigh's Title V permit. The requirements of the proposed rule are meant to codify the FDCP and improve enforceability. However, it is possible that the existing dust mitigation plan would be revised, and there may potentially be costs associated with modifications to the Permit to Operate for the facility.

5.0 Rule Development / Public Consultation Process

The District has developed rule language and it is attached to this workshop report. The proposal is based in part on federal regulations and existing regulations in other air districts in California. Staff has consulted with officials from Lehigh Southwest Cement Company, Portland cement industry experts, California Air Resources Board staff, and EPA staff during the preparation of this document.

A public workshop is the next step in the rule development process. The purpose of the workshop is to solicit comments from the public on the District's proposed Regulation 9, Rule 13. During the workshop, District staff will seek comments on issues discussed in this workshop report and will respond to questions about information set forth in this report. Staff will review and consider all comments received at the public workshop and revise the proposal as appropriate.

In addition, staff will prepare an analysis of environmental impacts under the California Environmental Quality Act, a socioeconomic analysis, and a final proposed rule and staff report that will be available for public review and comment prior to a public hearing before the District's Board of Directors.

6.0 References

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