



Project Summary

Investigation of the Formation of a Portland Cement Plant Detached Plume

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Gaseous and particulate source emission samples were collected at a Portland cement production plant to determine the cause of a detached high-opacity plume. During this sampling program, gas and solid samples were taken from the various stages of the cement plant process to determine the source of potential plume reactants.

The results of the source and process sample analyses indicated that the cause of the visible plume was ammonium chloride, formed from gas-phase ammonia and hydrochloric acid as the plume cooled.

Results from the source sampling indicated a significant part of the collected particulate sample was ammonium chloride. In-stack particulate sampling showed that at stack temperatures, the ammonia and hydrochloric acid reactants were in the gas phase in the stack but formed ammonium chloride particles in the extractive sampling probes.

Analysis of the process solid samples indicated no significant ammonia was emitted from the kiln or derived from the limestone feed. However, analysis of the shale feed indicated the presence of ammonium that is released upon heating. The hydrochloric acid is probably formed from the chloride ion content of the coal, limestone, and feed material.

This Project Summary was developed by EPA's Atmospheric Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This project summary discusses the results of a study conducted to determine

the cause of the formation of a highly visible detached plume at a Portland cement production plant. The study was initiated in response to a Technical Assistance request from EPA's Region VIII. A two-week source and process sampling study was conducted at the Portland cement production plant, located in Rapid City, South Dakota. Along with three wet process kilns, the plant has a dry-process, coal-fired, clinker production facility. The dry process involves pulverizing limestone and shale into blend silos which are subsequently fed into the kiln. The kiln feed is introduced into the kiln through a four-stage heat exchanger, where the solids are preheated by the flow counter to the coal-fired kiln emissions level. Within this heat exchanger the kiln gases are cooled from a nominal 2000 °F to 700 °F and the solids are heated to a nominal 1500 °F at the feed entrance of the kiln.

After preheating the kiln feed solids, the kiln emissions can proceed out the 100-ft stack by either of two routes. One route is through the Loesch Mill, which pulverizes the raw feed. The other route bypasses the mill while it is not operating. The operation mode when the mill is running is designated the mill on mode (MON) and when not, the mill off mode (MOF). Emissions then pass through a baghouse and exit the stack. During both these modes, opacity within the stack is a nominal 10%. Just subsequent to stack exit, the emissions become highly visible by some particle-forming mechanism. The purpose of this study was to determine the nature and cause of the visible detached plume. The source sampling was conducted by the personnel and in-house contractor support of the Stationary Source Emissions Research Branch of EPA at Research Triangle Park, NC.



Sampling Methods

The sampling involved seven days of operation; four in the MOF mode, and three in the MON mode. Particulate and gaseous emissions were measured with a variety of in-stack and extractive sampling methods including; a modified version of the EPA Reference Method 5 (MM5); prototype particulate gaseous systems (PAGS); a seven-stage particle sizing impactor; and various filter medium samples for particulate characterization. The MM5 train was used to measure gaseous sulfur dioxide, ammonia, chloride, and fluoride by various impinger solutions. The PAGS systems were run in simultaneous pairs and were used to measure particulate and gaseous ammonium, chloride and fluoride components of the emissions.

The particle-sizing samples were taken with a seven-stage, University of Washington, Mark IV impactor with either steel plates or quartz filter plates for particle collection. Samples were taken both in and out of the stack by an extraction probe.

Glass fiber, Teflon and quartz characterization filter samples were collected with an extraction system. The plant process was sampled extensively during both operation modes, and samples of solids from the mill, kiln, baghouse, and heat exchanger were collected.

Results

A total of 11 MM5, 21 PAGS, 14 impactor, and a large number of characterization filter samples were collected during the sampling period. Six sets of simultaneous MM5 and PAGS samples were collected during the MOF mode and five sets were collected during the MON. A white precipitate in the probes, which was difficult to recover quantitatively with acetone and brush washings, was recovered from the particulate sampling systems. Nearly all of the particulate mass recovered by the MM5 sampling systems was located in these probe wash fractions. Filters showed insignificant weight gains and many showed weight losses. For the MM5 samples, chemical analysis of the probe wash residues indicated that from 4 to as much as 83 percent of the residue was NH_4Cl . Probe washes also composed a significant fraction of the mass collected with the PAGS systems. As with the MM5 samples, a large part of some of the PAGS probe washes was NH_4Cl .

Emission rates of particulate matter were calculated for both MOF and MON modes of operation from the MM5 and PAGS samples. Table 1 provides the total mass emission rates (lb/h) of particulate matter and

Table 1. Summary of MM5 and PAGS Emission Rates (lb/h) *

Mode	Total Particulate			Adjusted Particulate		
	MM5	PAGS-A	PAGS-B	MM5	PAGS-A	PAGS-B
MOF	36.2(4)	23.1(4)	30.7(4)	17.3(4)	17.4(6)	18.0(5)
MON	18.2(4)	14.7(1)	20.4(2)	12.4(4)	12.5(2)	13.8(3)

*Numbers in parentheses indicate the number of measurement results used to determine the accompanying average.

the emission rates adjusted to show the absence of the NH_4Cl detected in the residues.

The large variations observed between the sampling methods for the unadjusted rates (total particulate) are due to the sporadic formation of NH_4Cl in the sampling probes. The larger contribution of probe NH_4Cl during the MOF mode is due in part to the higher temperature of the baghouse, which was 480 °F in contrast to the 342 °F temperature of the MON mode.

Only a limited amount of information could be derived from the impactor and characterization samples since in-stack sampling did not collect the gas phase NH_3 or HCl, and the extraction collection lacked the NH_4Cl lost in the sampling probe.

Process samples were collected for subsequent composition studies. Analysis of the Loesch Mill, kiln feed, and baghouse return confirmed the presence of NH_3 in the emissions and indicated less particulate-phase NH_4Cl in the baghouse solids during the high temperature MOF mode than during the MON mode. These samples, along with raw product feed samples, were analyzed for NH_3 by washing and filtering with 0.1N H_2SO_4 . Very little NH_3 was detected for the raw feed by washing; however, heating the raw feeds in an apparatus custom built to collect emitted gases resulted in the liberation of NH_3 from the shale. It was determined that heating the shale to a minimum temperature of 900 °F for 1 h would liberate the NH_3 in the shale. The shale liberated an average potential of 51.4-ppm NH_3 based on a wt/wt basis of undried shale. Assuming a raw feed rate of 224,000 lb/h, there is a potential for an emission of 4.1 lb/h of NH_4Cl if all NH_3 is emitted as NH_4Cl .

Conclusions

Two approaches to solving the detached plume problem are suggested as a result of this study: (1) the raw shale should be heated prior to its milling to liberate the NH_3 or (2) the baghouse temperature should be lowered such that particulate NH_4Cl would form and be collected with the other baghouse solids, and this material should be returned to a wet process system instead of the dry process system.

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The complete report, entitled "Investigation of the Formation of a Portland Cement Plant Detached Plume," (Order No. PB 86-194 420/AS; Cost: \$16.95, subject to change) will be available only from:

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