Furnace Injection of Alkaline Sorbents for Sulfuric Acid Control

Semi-Annual Technical Progress Report

October 1, 2002 – March 31, 2003

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Abstract

This document summarizes progress on Cooperative Agreement DE-FC26-99FT40718, Furnace Injection of Alkaline Sorbents for Sulfuric Acid Control, during the time period October 1, 2002 through March 31, 2003. The objective of this project is to demonstrate the use of alkaline reagents injected into the furnace of coal-fired boilers as a means of controlling sulfuric acid emissions. The coincident removal of hydrochloric acid and hydrofluoric acid is also being determined, as is the removal of arsenic, a known poison for NO_X selective catalytic reduction (SCR) catalysts. EPRI, the Tennessee Valley Authority (TVA), FirstEnergy Corporation, American Electric Power (AEP) and the Dravo Lime Company are project co-funders. URS Group is the prime contractor.

This is the seventh reporting period for the subject Cooperative Agreement. During previous reporting periods, two long-term sorbent injection tests were conducted, one on Unit 3 at FirstEnergy's Bruce Mansfield Plant (BMP) and one on Unit 1 at AEP's Gavin Plant. Those tests determined the effectiveness of injecting alkaline slurries into the upper furnace of the boiler as a means of controlling sulfuric acid emissions from these units. The alkaline slurries tested included commercially available magnesium hydroxide slurry (Gavin Plant), and a byproduct magnesium hydroxide slurry (both Gavin Plant and BMP). The tests showed that injecting either the commercial or the byproduct magnesium hydroxide slurry could achieve up to 70-75% overall sulfuric acid removal. At BMP, the overall removal was limited by the need to maintain acceptable electrostatic precipitator (ESP) particulate control performance. At Gavin Plant, the overall sulfuric acid removal was limited because the furnace injected sorbent was less effective at removing SO_3 formed across the SCR system installed on the unit for NO_X control than at removing SO_3 formed in the furnace. The SO_3 removal results were presented in the semi-annual Technical Progress Report for the time period April 1, 2001 through September 30, 2001. Additional balance of plant impact information for the two tests was reported in the Technical Progress Report for the time period October 1, 2001 through March 30, 2002. Additional information became available about the effects of byproduct magnesium hydroxide injection on SCR catalyst coupons during the long-term test at BMP, and those results were reported in the previous report (April 1, 2002 through September 30, 2002). During the current period, there was no technical progress to report, because all planned testing as part of this project has been completed. The project period of performance was extended to allow the conduct of testing of another SO_3 control technology, the sodium bisulfite injection process. However, these additional tests have not yet been conducted.

TABLE OF CONTENTS

Page

Introduction

This document is the semi-annual Technical Progress Report for the project "Furnace Injection of Alkaline Sorbents for Sulfuric Acid Control," for the time period October 1, 2002 through March 31, 2003. The objective of this project is to demonstrate the use of alkaline reagents injected into the furnace of coal-fired boilers as a means of controlling sulfuric acid emissions. The coincident removal of hydrochloric acid and hydrofluoric acid has also been determined, as has the removal of arsenic, a known poison for NO_X selective catalytic reduction (SCR) catalysts. The project is being funded by the U.S. DOE National Energy Technology Laboratory under Cooperative Agreement DE-FC26-99FT40718. EPRI, the Tennessee Valley Authority (TVA), FirstEnergy Corporation, American Electric Power Company (AEP), and the Dravo Lime Company are project co-funders. URS Group (formerly Radian International) is the prime contractor.

Sulfuric acid is present in most flue gases from coal combustion because a small percentage of the SO_2 produced from the sulfur in the coal (approximately 0.5% to 1.5%) is further oxidized to form SO_3. The SO_3 combines with flue gas moisture to form vapor-phase or condensed sulfuric acid at temperatures below 500°F. Because of this temperature effect, in this report sulfur in this oxidation state is generally referred to as "SO_3" in furnace gas or flue gas upstream of the boiler air heater, and "sulfuric acid" in flue gas downstream of the air heater.

Besides being a Toxic Release Inventory substance and a potential precursor to acid aerosol/condensable emissions from coal-fired boilers, sulfuric acid in the flue gas can lead to boiler air heater plugging and fouling, corrosion in the air heater and downstream, and the formation of a visible plume. These issues will likely be exacerbated with the retrofit of SCR for NO_X control on some coal-fired plants, as SCR catalysts are known to further oxidize a portion of the flue gas SO_2 to SO_3.

The project has tested the effectiveness of furnace injection of four different calcium- and/or magnesium-based alkaline sorbents on full-scale utility boilers for SO_3 control. These reagents have been tested during four one- to two-week tests conducted on two FirstEnergy Bruce Mansfield Plant (BMP) units. One of the sorbents tested was produced from a wet flue gas desulfurization (FGD) system waste stream, from a system that employs a modified Thiosorbic® Lime scrubbing process. The other three sorbents are commercially available.

After completing the four one- to two-week tests, the most promising sorbents were selected for two longer-term (up to 30-day) full-scale tests. The longer-term tests were used to confirm the effectiveness of the sorbent tested over extended operation, and to determine balance-of-plant impacts. Two longer-term tests were conducted, one on FirstEnergy's BMP Unit 3 and the second on AEP's Gavin Plant Unit 1.

The remainder of this report is divided into five sections: an Executive Summary followed by sections for Experimental procedures, Results and Discussion, Conclusions, and References.

Executive Summary

Summary of Progress

The current reporting period, October 1, 2002 through March 31, 2003, is the seventh technical progress reporting period for this project. October 1, 1999 was the start date for this Cooperative Agreement.

In 2001, a long-term slurry injection test was conducted at BMP Unit 3. The sorbent was a byproduct magnesium hydroxide (byproduct Mg) produced at Allegheny Energy's Pleasants Power Station. The long-term injection test began the second week of May and continued into the first week of June 2001. The primary measure of the success of the slurry injection tests was the reduction in flue gas SO_3 concentration in the electrostatic precipitator outlet flue gas. After the test was complete, samples collected during the test were chemically analyzed, and data collected were organized, reduced and analyzed. Results from this testing were presented in a previous Technical Progress Report for this project (April 1, 2001 through September 30, 2001). The test at BMP included an evaluation of the impacts of byproduct Mg injection in the furnace on SCR catalyst coupons inserted into the flue gas stream at the economizer outlet duct. Analyses and reporting on these coupons were completed during the previous reporting period, and these results are summarized in the Technical Progress Report for the period April 1, 2002 through September 30, 2002.

In July 2001, AEP joined the project as a new team member, co-funder, and host site. Their Gavin Plant started up new SCR units for NO_X control on both Units 1 and 2 (both 1300-MW coal-fired units) in May 2001. As might have been expected, a portion of the SO_2 produced from the high-sulfur coal fired there was oxidized to SO_3 across the SCR catalysts. This conversion essentially doubled the amount of SO_3 in the flue gas going to the units' air heaters, and correspondingly increased sulfuric acid concentrations at the ESP outlet and FGD outlet (stack). The increased sulfuric acid concentrations in the stack flue gas caused increased plume opacity, and appeared to contribute to the occurrence of plume "touch downs" at ground level near the plant. AEP joined the project to test magnesium hydroxide injection as a means of controlling stack sulfuric acid concentrations, and TVA agreed to forego testing on one of their units for the opportunity to test sorbent injection on a unit with an operating, full-scale SCR system.

Because the supply of byproduct Mg in the quantities required to treat two 1300-MW units was in question, AEP also wanted to test commercial magnesium hydroxide (commercial Mg), so that sorbent was used for a portion of the test. The testing at Gavin Plant was conducted from the middle of August through the first week of September. SO_3 removal results from this test were reported in a previous Technical Progress Report for this project (April 1, 2001 through September 30, 2001). Balance-of-plant results from the testing at Gavin Plant were presented in a later Technical Progress Report (October 1, 2001 through March 31, 2002). There are no additional results from the Gavin testing to report for the current period.

During the current quarter, plans were made to conduct full-scale testing of another SO_3 control technology, the sodium bisulfite (SBS) injection process, as part of this project. The testing was to be conducted at Hoosier Energy's Merom Station. However, an extended turbine-generator

outage on one of the units there adversely affected the utility's budget for conducting such a test, so the test program was called off.

A draft final report was submitted during the current reporting period, covering the results of the short-term sorbent injection tests conducted at BMP and results from the long-term sorbent injection tests conducted at BMP and at Gavin Plant. A section was added comparing the economics of byproduct Mg or commercial Mg injection in the furnace as an SO_3 control technology compared to a number of other potential SO_3/sulfuric acid control technologies.

No subcontracts were issued or completed during the current reporting period.

Problems Encountered

There were no problems encountered during the current reporting period.

Plans for Next Reporting Period

The next reporting period will cover the time period April 1, 2003 through September 30, 2003. The project period of performance was recently extended through December 31, 2003 to allow the conduct of tests of another SO_3 control technology, the sodium bisulfite (SBS) injection process. Originally, these tests were to be conducted at Hoosier Energy's Merom Station. However, mechanical problems with the turbine generator on one unit at that plant adversely affected the utility's budget for conducting the planned SO_3 control technology demonstration. Instead, two sites that are installing commercial versions of the SBS process are being considered as process demonstration sites as part of this DOE project. These two sites include the Tennessee Valley Authority's Widows Creek Unit 7 and FirstEnergy's BMP Units 1 and 2. If this demonstration testing can be arranged, it will take place during the next reporting period, as these commercial installations are only planned for operation during the ozone season of May 1 through September 30.

Prospects for Future Progress

Since the new end date for the Cooperative Agreement is December 31, 2003, the subsequent reporting period will just cover three months. During that reporting period, the final report for any testing of the SBS process will be prepared and submitted.

Experimental

The experimental apparatus used in the conduct of the project has been previously described in a number of previously published reports[1,2].

Results and Discussion

There was no technical progress on this project during the current reporting period other than preparation of a draft final report for the furnace injection tests conducted in 2000 and 2001[3]. Consequently, there are no results to present in this section.

Conclusion

Since there was no technical progress during this period there are no results to summarize and no conclusions to be made.

References

1. *Sulfuric Acid Removal Process Evaluation: Short-Term Results*, EPRI, Palo Alto, CA, and the U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA: 2001. EPRI 1003980.

2. *Sulfuric Acid Removal Process Evaluation: Long-Term Results*, EPRI, Palo Alto, CA, the U.S. Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA, TVA, Chattanooga, TN, American Electric Power, Columbus, OH, and FirstEnergy, Shippingport, PA: 2002. EPRI 1004165

3. Blythe, Gary. *Furnace Injection of Alkaline Sorbents for Sulfuric Acid Removal*, Draft Final Report, U.S. Department of Energy National Energy Technology Laboratory Cooperative Agreement DE-FC26-99FT40718, URS Group, Austin, TX. December 2002.