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High SO_2 Removal Efficiency Testing

DE-AC22-92PC91338

Technical Progress Report - March - May 1996

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DISCLAIMER

1.0 INTRODUCTION

This document provides a discussion of the technical progress on DOE/PETC project number DE-AC22-92PC91338,·"High Efficiency SO_2 Removal Testing," for the time period 1 April through 30 June 1996. The project involves testing at six full-scale utility flue gas desulfurization (FGD) systems, to evaluate low capital cost upgrades may allow these systems to achieve up to 98% SO_2 removal efficiency. The upgrades being evaluated mostly involve using performance additives in the FGD systems.

The "base" project involved testing at the Tampa Electric Company's Big Bend Station. All five potential options to the base program have been exercised by DOE, involving testing at Hoosier Energy's Merom Station (Option I), Southwestern Electric Power Company's Pirkey Station (Option II), PSI Energy's Gibson Station (Option III), Duquesne Light's Elrama Station (Option IV), and New York State Electric and Gas Corporation's Kintigh Station (Option V). The originally planned testing has been completed for all six sites.

The remainder of this document is divided into four sections. Section 2, Project Summary, provides a brief overview of the status of technical efforts on this project. Section 3, Results, summarizes the outcome from technical efforts during the quarter or results from prior quarters that have not been previously reported. In Section 4, Plans for the Next Reporting Period, an overview is provided of the technical efforts anticipated for the first quarter of calendar year 1996. Section 5 contains a brief acknowledgment.

2.0 PROJECT SUMMARY

On the base program, testing was completed at the Tampa Electric Company (TECo) Big Bend Station in November 1992. The upgrade option tested was DBA additive. Base project efforts during the second quarter of calendar year 1996 consisted only of project management and reporting activities. Additional testing is planned at this site during the latter half of calendar year 1996. During the current quarter, a Test Plan Addendum for the planned testing was approved by DOE, and an Environmental Questionnaire for the planned testing was prepared.

For Option I, at the Hoosier Energy Merom Station, results from another program co-funded by the Electric Power Research Institute (EPRI) and the National Rural Electric Cooperative Association have been combined with results from DOE-funded testing. Three upgrade options have been tested: DBA additive, sodium formate additive, and high pH set-point operation. All testing was completed by November 1992. There were only reporting activities for this site during the current quarter.

Option II involved testing at the Southwestern Electric Power Company Pirkey Station. Both sodium formate and DBA additives were tested as potential upgrade options. All of the testing at this site was completed by May 1993. There were only reporting activities for this site during the current quarter.

On Option III, for testing at the PSI Energy Gibson Station, testing with sodium formate additive was completed in early October 1993, and a DBA additive performance and consumption test was completed in March 1994. There were only reporting efforts for this site during the current quarter.

Option IV is for testing at the Duquesne Light Elrama Station. The FGD system employs magnesium-enhanced lime reagent and venturi absorber modules. An EPRI-funded model evaluation of potential upgrade options for this FGD system, along with a preliminary

economic evaluation, determined that the most attractive upgrade options for this site were to increase thiosulfate ion concentrations in the FGD system liquor to lower oxidation percentages and increase liquid-phase sulfite alkalinity, and to increase the venturi absorber pressure drop to improve gas/liquid contacting. Parametric testing of these upgrade options was conducted in March 1994. There were only reporting activities for this site during the current quarter.

Option V is for testing at the NYSEG Kintigh Station. Baseline testing was conducted in July 1994. Parametric testing at this site was conducted in late August, and a sodium formate additive consumption test was conducted in September 1994. There were no significant activities related to this site during the current quarter other than management and reporting efforts.

3.0 RESULTS

Results from the base program (at the TECo Big Bend Station) and the first optional site (Hoosier Energy Merom Station) were presented in detail in the April 1993 quarterly Technical Progress Report, and updates were included in the July 1993 and October 1993 reports. For the second optional site (the Southwestern Electric Power Company Pirkey Station), results were presented in the July 1993 quarterly Technical Progress Report and updated in the October 1993 report.

For the third optional site (the PSI Energy Gibson Station), baseline testing was conducted in May 1993, and those results were presented in the July 1993 quarterly report. Parametric testing at this site was completed in early October of 1993, and these results were discussed in the January 1994 Technical Progress Report. A DBA performance and consumption test was conducted in February and March of 1994. Preliminary results from this test were discussed in the April 1994 Technical Progress Report. An update of the results from this site was presented in the April 1995 quarterly report.

Baseline testing at the fourth optional site (Duquesne Light's Elrama Station) was completed in July 1993. Those results were discussed in the October 1993 quarterly report. The results of EPRI-funded FGDPRISM modeling and preliminary economic evaluations of potential upgrades for this FGD system were discussed in the January 1994 Technical Progress Report. In March of 1994, parametric testing of the most promising upgrade options was conducted. The preliminary results of these tests were discussed in the April 1994 Technical Progress Report. A draft Technical Note for this site was submitted to DOE in January 1995. An overview of new results presented in this draft Technical Note was included in the Technical Progress Report for the time period October through December 1994, dated 3 February 1995.

For the fifth optional site, at the New York State Electric and Gas Corporation's (NYSEG's) Kintigh Station, baseline, parametric, and additive consumption tests were completed during the third quarter of 1994. Results from the baseline testing at this site were discussed in

the Technical Progress Report for the third quarter of calendar year 1994, dated December 1994. The parametric and additive consumption tests at this site were also completed late in the third quarter. These results were discussed in the April 1995 quarterly Technical Progress Report. Late in the fourth quarter of calendar year 1994, FGDPRISM modeling of the Kintigh FGD system was completed, as were the economic evaluations of potential upgrade options for this site. A draft report discussing these results was submitted to DOE and to NYSEG in the first quarter of calendar year 1995. These results were discussed in the quarterly Technical Progress Report dated July 1995.

There are no new project results to present this quarter. However, the following subsection provides a brief overview of the test plan for the testing scheduled at TECo's Big Bend Station later this year.

3.1 Ultra-High Velocity Testing at the TECo Big Bend Station

In 1995, subsequent to the DOE-funded testing described in previous Technical Progress Reports, TECo modified the FGD system on the 450-MW Unit 4 to add dibasic acid (DBA) on a continuous basis and to also scrub flue gas from the adjacent Unit 3. While treating flue gas from both units at full load, the packed, dual-loop absorbers now operate at a superficial gas velocity of about 12 ft/sec, which is 60% greater than the original design.

With the success of this conversion, TECo is investigating the ability to operate the absorbers at even higher velocity and scrub part or all of the flue gas from a third unit at the Big Bend Station. This would involve operating the FGD absorbers at superficial gas velocities as high as 18 ft/sec, or almost 2-1/2 times their design velocity. The ability to scrub flue gas from up to three units with one FGD system is potentially very cost effective, particularly when evaluated in terms of incremental costs per additional ton of SO_2 removed (beyond the tons/yr scrubbed from one or even two units).

The technical and economic feasibility of scrubbing this quantity of flue gas with the existing FGD system is being evaluated in two phases of testing in one absorber module that has been retrofitted with a larger flue gas fan. During this testing, the Unit 4 FGD system will continue to treat only flue gas from Units 3 and 4, but the test module will be operated at gas velocities equivalent to treating flue gas from three units (up to 18 ft/sec), while the other modules operate at lower velocities (less than 12 ft/sec).

Phase 1 of the testing involves short-term tests to determine the practical upper limit for flue gas velocity through the absorbers. Avoiding excessive slurry carryover from the absorber mist eliminators, producing wallboard-grade gypsum, and avoiding excessive gypsum-scale formation are the primary performance criteria for Phase 1. Phase 1 will be conducted over a three-week period in August 1996.

Table 1 summarizes the planned Phase 1 test conditions and sequence. The test series begins with two days of mist eliminator (ME) performance measurements. ME performance is expected to be the limiting factor in high-velocity absorber operation. At high velocity, mist droplets collected on the chevron-type ME can be reentrained by the flue gas before they drain back into the absorber. Mist reentrainment will be measure by Koch Engineering Company using their Phase Doppler Particle Analyzer (PDPA). This device measures mist droplet size and velocity using an optical laser technique. The measurements are made by traversing the absorber cross section with the PDPA at a location above the second ME stage. The PDPA is supported by test tracks installed at the very top of the absorber, above the ME.

The first day of ME testing will be used to determine the maximum velocity at which the absorber can operate without significant ME reentrainment. The test absorber will be operated for two hours each at three to four increasing levels of gas velocity. The PDPA will be used to detect droplets in the 50+ μm size that is characteristic of reentrained droplets.

Table 1

Preliminary High Velocity Test Schedule for Big Bend

Test Order	Objective	Performance Indicators	Duration (Days)	Upper pH	Lower pH	DBA (mg/L)	Gas Velocity
ME-1	Find maximum velocity	50+ micron drops	1	Normal	Normal	Normal	Various
ME-2	Measure carryover	Total carryover	1	Normal	Normal	Normal	Maximum
1	Characterize effect of velocity on performance	SO_2 removal, utilization, oxidation, gypsum R.S., chloride balance, solids dewatering	2	Normal	Normal	Normal	Normal
2			2	Normal	Normal	Normal	Medium
3			2	Normal	Normal	Normal	High
4	Characterize effect of pH at high velocity	SO_2 removal, utilization, gypsum R.S.	1/2	High	Low	Normal	High
5			1/2	High	Normal	Normal	High
6			1/2	Low	Low	Normal	High
7			1/2	Low	Normal	Normal	High
8	Characterize effect of DBA	SO_2 Removal, utilization	1	Best	Best	Higher	High
9	at high velocity		1	Best	Best	Highest	High
10			1	Best	Best	Best	High

Based on the results of the first day of ME tests, the absorber module will be operated at a single high-velocity condition during the second day of ME tests. The selected velocity will be the highest at which excessive reentrainment does not occur. The PDPA will be used on the second day to obtain quantitative mist carryover measurement at this high-velocity condition.

Each remaining test is 1/2-day to 2-days in duration. Tests 1 through 3 in Table 2 are 2-day tests to determine the effect of velocity on absorber SO_2 removal performance, limestone utilization, sulfite oxidation percentage, gypsum scaling potential, chloride carryover into the upper loop, and byproduct solids dewatering properties. Tests 4 through 10 will be shorter duration tests, where only SO_2 removal and limestone utilization are measured. These tests will be used to determine optimum pH set points and DBA performance additive concentrations at the highest achievable velocity conditions.

The results of Phase 1 will be used to set conditions for long-term operation during Phase 2. This testing will confirm successful operation according to the Phase 1 criteria and allow measurement of steady-state conditions such as DBA consumption and gypsum-scale formation rates. Phase 2 will be completed in approximately January 1997.

During Phase 2, the performance of the test absorber will be tracked for up to six months. Performance indicators will include SO_2 removal, sulfite oxidation, upper-loop chloride concentration, and gypsum scaling potential in the absorber recirculating slurry liquor. At regular intervals, the test absorber will be inspected for gypsum scale formation in each absorber loop, in the ME, and in the absorber outlet duct. These inspection results will be compared to those for the other absorbers, which will operate at lower velocity (about 12 ft/sec), to determine any longer term effects of the higher velocity (up to 18 ft/sec) operation on absorber-scale build up. DBA additive concentrations will also be measured for the test absorber and the other operating absorbers. Material balance calculations will be conducted to compare DBA consumption as a function of flue gas velocity through the absorbers.

4.0 PLANS FOR THE NEXT REPORTING PERIOD

Scheduled efforts during the third quarter of calender year 1996 will consist of project management and reporting and the additional testing at the TECo Big Bend (base program) site. As described in the previous section, there is a plan to demonstrate high-efficiency SO_2 removal operation for a longer period of time (up to six months) at that site beginning in the next quarter. A three-week intensive test period will likely be completed in August, and longer term monitoring of the system performance should continue into early 1997.

Options I and II (Hoosier Energy's Merom Station, SWEPCo's Pirkey Station, respectively) are in final reporting phases. No efforts are expected for these options during the next quarter.

For the PSI Energy Gibson Station (Option III), a Technical Note summarizing results from both the sodium formate and DBA performance and additive consumption tests were revised and resubmitted as a final report to DOE during the current quarter. A draft Topical Report for this site was also submitted. This draft Topical Report will be revised as necessary and reissued in final form during the next quarter.

A draft Technical Note for the Duquesne Light Elrama site (Option IV) was submitted to DOE and to Duquesne Light early in 1995, and review comments on this Technical Note have been received. A revised Technical Note and a draft Topical Report for this site will be prepared during the next quarter.

For Option V, testing at the NYSEG Kintigh Station, a draft Technical Note summarizing these results was submitted early in 1995. Review comments on this draft have been received, and a revised Technical Note was prepared and submitted as a final report in the current quarter. A draft Topical Report for this site will be prepared and submitted during the next quarter.