ULTRA-HIGH VELOCITY TESTING ON THE TECO BIG BEND UNIT 4 FGD SYSTEM

GARY BLYTHE AND JIM PHILLIPS
Radian International LLC
P.O. Box 201088
Austin, TX 78720-1088,U.S.A.

JOHN SMOLENSKI
Tampa Electric Company
P.O. Box 111
Tampa, FL 33601-0111,U.S.A.

ABSTRACT

During 1995, Tampa Electric Company (TECo) modified the flue gas desulfurization (FGD) system on the 450-MW Big Bend Station Unit 4 to allow that system to also scrub flue gas from the adjacent Unit 3. 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 packed, dual-loop FGD absorbers at almost 2-1/2 times their design velocity.

The 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. TECo is conducting these tests with assistance from the U.S. Department of Energy=s Pittsburgh Energy Technology Center and their contractor, Radian International LLC, as part of the project "High-Efficiency SO_2 Removal Testing."

This paper discusses the plan for both phases of testing. The presentation in September will include the results of the first phase of testing, which is to be completed in August.

INTRODUCTION

In a project funded by the U.S. Department of Energy (DOE), Radian has conducted full-scale testing, process modeling, and economic evaluations of six existing utility FGD systems. The project objective is to evaluate low capital cost upgrades for achieving 95 to 98% sulfur dioxide (SO_2) removal efficiency in a variety of FGD system types. The first system tested was at TECo=s Big Bend Station. This system employs dual-loop, packed absorbers, uses limestone reagent, and operates in a forced oxidation mode to produce wallboard-grade gypsum. Other systems tested include cocurrent, packed absorbers at Hoosier Energy's Merom Station; dual-loop absorbers with perforated-plate trays at Southwestern Electric Power Company's Pirkey Station; horizontal spray absorbers at PSI Energy's Gibson Station; venturi scrubbers at Duquesne Light's Elrama Station; and open spray absorbers at NYSEG's Kintigh Station.

The program was conducted to demonstrate that upgrades such as performance additives and/or mechanical modifications can increase system SO_2 removal at low cost. The cost-effectiveness of each upgrade has been evaluated on the basis of test results and/or process model predictions for upgraded performance and utility-specific operating and maintenance costs. Results from this program will provide information for utilities that may consider SO_2 removal upgrades to existing FGD systems as an approach for compliance with Title IV of the Clean Air Act Amendments (CAAA) of 1990.

The originally planned testing, modeling, and economic evaluations for all six sites have been completed; Table 1 summarizes these previous results. The performance goals for the project were met or exceeded at five of the six sites. At those five sites, 95 to 99% SO_2 removal was achieved at estimated costs of $39 to $76 per ton of additional SO_2 removed. At the sixth site, the most cost-effective upgraded SO_2 removal efficiency was only 92 percent. However, the upgrades tested at this site resulted in an estimated operating cost *savings* equivalent to $94 per additional ton of SO_2 removed.

In 1995, subsequent to the DOE-supported testing summarized in Table 1, TECo modified the FGD system on Unit 4 to add dibasic acid (DBA) on a continuous basis and to also scrub flue gas from the adjacent Unit 3. Figure 1 is a process flow diagram for one absorber of four absorbers used in the system. While treating flue gas from both units at full load, the absorbers now operate at a superficial gas velocity of about 12 ft/sec, which is 60% greater than the original design velocity.

With the success of this conversion, TECo is investigating the ability to operate the absorbers at even higher velocity and scrub 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.

TEST DESCRIPTION

The 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 FGD system will continue to treat only flue gas from Units 3 and 4. The test module will operate 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). Radian will support these tests as part of the DOE High-Efficiency SO_2 Removal Testing project.

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.

Phase 2 involves operating the test module for up to six months at the highest velocity conditions practically achievable. This testing will confirm successful operation according to the Phase 1 criteria, and allow measurement of other conditions such as DBA consumption, recirculating liquor compositions, and module scale formation rates.

TEST PLAN

Table 2 summarizes the planned Phase 1 test conditions. Phase 1 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 that are collected on the chevron-type ME can be reentrained by the flue gas before they drain back into the absorber. Mist reentrainment will be measured by Koch Engineering using their Phase Doppler Particle

Analyzer (PDPA), which measures mist droplet size and velocity by 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 first day of ME testing will be used to determine the maximum velocity at which the absorber can operate without significant droplet reentrainment. The test absorber will be operated at increasing levels of gas velocity, and the PDPA will be used to detect the relative quantity of droplets in the 50+µm size that is characteristic of reentrainment.

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. 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 velocity.

The remaining test durations are 1/2-day to 2-days each. Three 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. The final seven tests in Phase 1 will be shorter in duration; only SO_2 removal and limestone utilization will be 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. 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 recirculating slurry liquor. At regular intervals, the test absorber will be inspected for gypsum scale formation. These inspection results will be compared with 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) on absorber scaling. 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.

RESULTS

Phase 1 testing is scheduled to begin in July of this year. As such, no results are available to include in this paper. It is expected that Phase 1 results will be available by the time of this presentation in September. Phase 2 will be conducted from August through approximately the end of 1996.

Figure 1

TABLE 1

Summary of SO_2 removal upgrade project results

Utility	Station (Unit)	Absorber Type	Reagent	Oxidation Mode	Observed Base SO_2 Removal	Upgrade Options	Optimum SO_2 Removal	Est. Incremental Cost of Add'l SO_2 Removed, $/ton	Add'l SO_2 Removed, tons/year
Tampa Electric	Big Bend (#4)	Dual-loop, packed	Limestone	Forced	94	DBA additive	99	65	4,400
Hoosier Energy	Merom (#1 & #2)	Co-current, packed	Limestone	Inhibited	83[1]	DBA additive	97	61	15,100
SWEPCo	Pirkey	Dual-loop, Tray	Limestone	Inhibited	80[2]	DBA additive	99	39	21,200
PSI Energy	Gibson (#5)	Horizontal spray tower	Limestone	Inhibited	80[3]	Sodiumformate, DBA additive[4]	95	63	15,100
Duquesne Light	Elrama	venturi	Mg-Lime	Inhibited	86 to 89	Increase in thiosulfate level, venturi pressure drop	92	-94[4]	1,500
NYSEG	Kintigh	Vertical spray tower	Limestone	Inhibited	86[5]	Sodiumformate additive	98[5]	76	10,600

[1] Includes the effects of flue gas bypass; SO_2 removal across the test module was measured at 86 to 90%.
[2] Includes the effects of flue gas bypass; SO_2 removal across the test module was measured at 97%.
[3] Includes the effects of flue gas bypass; SO_2 removal across the test module was measured at 86%.
[4] The most cost effective upgrade option actually resulted in a net <u>decrease</u> in system operating costs, with a modest increase in SO_2 removal capability.
[5] Assumes no flue gas bypass.

Portions of the data obtained at Hoosier Energy's Merom Station are the result of an effort that has been jointly sponsored by the Rural Electric Research Program of the National Rural Electric Cooperative Association and EPRI. Funding for the FGDPRISM portion of this program was provided by EPRI.

TABLE 2

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, gypsumR.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

Figure 1 = Figure 1 from July 1993 paper (may also be the same as Figure 2-1 in the TECo Topical Report, let's check)

Table 2 = Table 1 in the Draft Test Plan for TECo Big Bend Station High Velocity Tests, dated March 4, 1996, although correct "SO2" in the column labeled "Performance Indicators" to make the "2" a subscript.