RESULTS OF FGD UPGRADE PROJECTS ON LOW-RANK COALS

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ABSTRACT

This paper describes the approaches used to successfully implement flue gas desulfurization (FGD) upgrade projects at three power generating stations. Specifically, the FGD projects consisted of:

- Upgrades of the wet scrubber at American Electric Power/Southwestern Electric Power Company's (AEP/SWEPCO) Pirkey Unit 1.
- Upgrades of the wet scrubber at San Miguel Electric Cooperative, Inc.'s (SMEC) San Miguel Unit 1.
- Increase of dry scrubber capacity at Tucson Electric Power's (TEP) Springerville Units 1 and 2.

Impetus for these upgrades was the following, either singly or in combination:

- Tightening of emission regulations
- Increase in SO_2 emission allowance prices
- Degradation of coal quality over time.
- Need to reduce emissions to allow expansion
- Desire for improved reliability

The design alternatives and the challenges encountered on each of these projects, as well as their results, are presented below.

SPRINGERVILLE GENERATING STATION

TEP's Springerville Unit 1 commenced operation in 1985, with Unit 2 following in 1990 (on the right in Figure 9). These are replicate units, each with gross capacity of 425 MW and firing a New Mexico (Lee Ranch) sub-bituminous coal (analysis summarized in Table 1). Both units are equipped with Combustion Engineering (now Alstom Power) tangentially fired boilers and with Joy Manufacturing-Niro (now B&W) spray dryers with reverse air fabric filters (dry FGD system).

The planned construction of the new Springerville Units 3 and 4 units (approximately equivalent in size to Units 1 and 2) required an offset in the emissions by reducing the NO_X and SO_2 emissions from Units 1 and 2. The original and revised emissions limits are noted in Table 3.

Table 3. Springerville Units 1 and 2 Emission Rates

Parameter	Prior to Unit 3 Operation	Post-Unit 3 Operation
SO_2, lb/mmBtu	0.60	0.24
NO_X, lb/mmBtu	0.45	0.20

Figure 9. Springerville Generating Station

The dry FGD system for each unit comprises three spray dryer absorbers (SDA) with rotary atomizers and a reverse-air fabric filter. The Springerville Station receives high-calcium pebble lime via rail, and a pneumatic system transports the lime to a day bin located at each unit. Horizontal ball mill slakers convert the pebble lime to lime slurry, which is combined with a slurry of recycled material from the fabric filter just prior to being fed to the rotary atomizer. When the units were constructed, the dry FGD systems were built with a partial bypass, the result of which is that 75% of the flue gas is treated in the spray dryers and the bypassed flue gas is recombined with the scrubbed stream before entering the fabric filter.

TEP, with S&L as Owner's Engineer, implemented the following modifications to reduce NO_X and SO_2 emissions:

- Installation of low-NO_X burners and overfire air (NO_X).
- Installation of a fourth spray dryer and elimination of the flue gas bypass (SO_2).

Based on an evaluation of proposals received, B&W was selected as the turnkey contractor for the FGD upgrade.

To complete the upgrade, two infrastructure upgrades were necessary:

- Relocation of the cooling tower water blowdown tank for each unit (cooling tower blowdown is used to make up the recycle slurry for the dry FGD system).
- Installation of a new 10-ton/hour lime slaker to accommodate the increased lime usage.

Both upgrades were successfully completed and the gas path tie-ins coordinated with the scheduled unit outages. The new spray dryers were installed just outside the building housing the existing spray dryers (Figure 10 and Figure 11) with access to the new spray dryer penthouses at the existing SDA penthouse level.

Figure 10. Springerville Unit 1 Spray Dryer

The performance testing of the upgraded Springerville Unit 1 FGD system was done during April 29, 2005 through May 3, 2005, and consisted of tests at low-load (140 MW gross), medium-load (250 MW gross), and high-load (420 MW gross).

Figure 11. Springerville Unit 2 Spray Dryer Installation

For the low-load testing, the entire flue gas flow was directed through the new spray dryer chamber (Module D). Consequently, approximately 33% of the total design flue gas flow rate was channeled through 25% of the total spray dryer capacity.

During the medium-load testing, approximately 65% of the total design flue gas flow rate was directed through 50% of the operating spray dryer modules.

In the high-load testing, the entire flue gas flow was sent through all four spray dryer modules. The purpose of the high-load testing was not only to confirm that the SO_2 emission rate was in accordance with the contract between TEP and B&W, but also that the flue gas flows were properly balanced between modules. The full-load testing on May 2 also had the purpose of acquiring data on the lime slurry feed to the FGD system, pressure drop across the modules, and electrical power consumption by the new module to determine contract compliance with these values.

The objective of the performance testing was to validate the guarantees provided by B&W in the contract with TEP. Flue gas flow and SO_2 measurements were performed by a third-party testing company, METCO, out of Dallas, Texas. These measurements were taken at the inlets of each module's central gas disperser (CGD) and roof gas disperser (RGD). Similar measurements were taken in the exit duct of each spray dryer module. Summaries of the Springerville Unit 1 test results are provided in Table 4 and Table 5.

Flow measurements were taken in accordance with U.S. EPA Methods 1 and 2. SO_2 and oxygen measurements were taken in accordance with U.S. EPA Methods 1, 6c, and 3a, respectively. All concentrations determined by METCO were source-gas-sampled, with the moisture removed, and therefore measured on a dry basis. The design coal for the upgrade project had a calculated SO_2 emission of 2.6 lb SO_2/mmBtu. The SO_2 emissions from the coal being fired at Springerville during the performance tests were lower than would have been measured if the design coal had been available. TEP expressed concern that if a coal with an SO_2 content equal to the design coal is fired in the boilers at the Springerville, there might be difficulty in achieving an emissions rate of 0.24 lb SO_2/mmBtu. Consequently, TEP requested that the testing demonstrate the capability of the system to achieve a minimum of 91% SO_2 removal (the removal required to meet the required emissions rate while firing the design coal) during the full-load tests. The results of the testing demonstrated that indeed the system was capable of achieving the desired 91% removal requested by TEP.

Table 4. Springerville Unit 1 SO_2 Removal

Run	SO_2 Inlet (lb/mmBtu)	SO_2 Outlet (lb/mmBtu)	Percent Removal
Low-load	1.870	0.206	89
Medium-load	1.887	0.196	89.6
High-load, May 5, 2005 (Note 1)	2.086	0.113	94.6
High-load, May 3, 2005 (Note 1)	1.792	0.145	91.9

Note:

1. Based on inlet SO_2 measurements taken by METCO.

Similar to the concentration measurements, the flow measurements at the inlets to the spray dryer modules were analyzed. It was determined that the distribution, calculated from the measured inlet flows to the modules, was balanced to within approximately 5% of the average module gas flow. Consequently, based on the flow and emissions measurements, TEP and S&L concluded that the upgrade of the FGD system at Springerville Unit 1 had met all of its requirements.

Table 5. Springerville Unit 1 Flow Distribution (Note 1)

Run	Module A	Module B	Module C	Module D
Medium-load	--	45%	--	55%
High-load	24.3%	23.3%	26.3%	26.1%

Note:

1. Distribution percentages are based on total flow to the module at the time of the test.

The performance testing of the upgraded Springerville Unit 2 FGD system was done during June 9 through June 10, 2005, and consisted of tests at high-load (420 MW gross). Similar to the Unit 1 testing, the purpose of the high-load testing was not only to confirm that the SO_2 emission rate was in accordance with the contract between TEP and B&W, but also that the flue gas flows were properly balanced between modules.

Due to operating problems on June 9, SDA Module A was isolated and the entire flue gas flow was directed through Modules B, C, and the new SDA Module D. On June 10, Module A was returned to service and a series of gas flow measurements performed to determine flue gas distribution. Consequently, and with B&W's concurrence, the official performance test for Unit 2, with regard to SO_2 removal and lime consumption, was performed on June 9. As indicated in Table 6, the system achieved emissions well below the 0.24 lb SO_2/mmBtu permit value and nearly achieved the 91% removal efficiency attained by Unit 1 during its performance testing. Since, during the SO_2 removal tests, Springerville Unit 2 was operating at 100% MCR with all of the flue gas being sent through 75% of the modules, it was concluded that this demonstrated satisfactory operation of the upgraded FGD system. The testing on June 10 was used to determine the flue gas distribution within the four Unit 2 SDA modules. Both in the three-module and four-module cases, the flow distribution was within 3.5% of the average gas flow through each module.

Table 6. Springerville Unit 2 SO_2 Removal

Inlet Measurement	SO_2 Inlet (lb/mmBtu)	SO_2 Outlet (lb/mmBtu)	Percent Removal
SO_2 inlet monitor	1.90	0.195	89.7
Coal analysis	2.105	0.195	90.7

Table 7. Springerville Unit 2 Flow Distribution (Note 1)

Run	Module A	Module B	Module C	Module D
June 9, 2005	Offline	32%	32%	36%
June 10, 2005	28.4%	23.9%	22.1%	25.6%

Note:

1. Distribution percentages are based on total flow to the module at the time of the test.

CONCLUSIONS

Many of the FGD systems installed in the 1980s were designed for SO_2 collection efficiencies of between 75% and 90% to meet the then current emission limits (typically 1.2 lb SO_2/mmBtu). Upgrading these FGD systems to achieve 95% or more SO_2 removal presents an opportunity to generate SO_2 allowances for sale or to offset the emissions of new units. Upgrades to the existing equipment of that vintage, i.e., 20 years old, also is typically required to restore the original design function, improve operability and maintainability and ensure unit availability.

The three FGD upgrade projects described in this paper posed unique requirements and challenges, and all were successfully upgraded to meet the Owners' needs.