**ELECTRIC POWER RESEARCH INSTITUTE
ENVIRONMENTAL CONTROL TECHNOLOGY CENTER**

REPORT TO THE STEERING COMMITTEE

Monthly Technical Progress Report

**US/DOE Patent Clearance is not Required
Prior to the Publication of this Document**

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EPRI/ECTC
Radian International
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EXECUTIVE SUMMARY

General Operations

Operations and maintenance continued this month at the Electric Power Research Institute's (EPRI's) Environmental Control Technology Center (ECTC). Testing for the month involved continued investigations into the Clear Liquor Scrubbing Process for the production of Anhydrous Calcium Sulfate (Anhydrite).

The 1.0 MW Cold-Side Selective Catalytic Reduction (SCR) unit and the Carbon Injection System (the Pulse-Jet Fabric Filter) remained idle this month in a cold-standby mode and were inspected regularly. From May 3 - 18, the NYSEG Kintigh Station and the ECTC were off-line for a two-week scheduled Station outage. During the ECTC outage, the major systems of the Center were inspected, and several preventive maintenance activities were completed. A listing of the major O&M outage activities completed during this period is presented in the Pilot/Mini-Pilot section of this report.

Pilot Testing Highlights

In May 1997, an extension to the Anhydrite Production test block was started following the NYSEG outage. The extension to the Anhydrite Production test block is being funded by the Electric Power Research Institute (EPRI) after promising results from the original test program. Both EPRI and the Department of Energy (DOE) funded the original test program as part of the DOE's Advanced Power Systems Program, whose mission is to accelerate the commercialization of affordable, high-efficiency, low-emission, coal-fueled electric generating technologies. While the pilot portion of the Anhydrite project was conducted on the 4.0 MW wet FGD pilot unit at EPRI's Environmental Control Technology Center (ECTC) in Barker, New York, the extension mainly used the 0.4 MW Mini-Pilot wet FGD unit to reduce operating costs. The project is designed to develop an advanced FGD process that produces a useable byproduct, anhydrite (anhydrous calcium sulfate).

The original CLS/Anhydrite process included three steps: chloride removal, clear liquor scrubbing, and anhydrite production. The final step in the process involved sending the calcium sulfite slurry from the sludge bed reactor to the anhydrite reaction tank for conversion to anhydrous calcium sulfate (anhydrite). The original objective in the PRDA project was to demonstrate all three areas of the integrated process. However, the primary focus has been on anhydrite production because:

- The anhydrite process is the least developed and potentially most valuable of the three proposed processes;
- The initial anhydrite tests on the pilot unit were encouraging; and,
- The DOE has placed emphasis on the reuse of byproduct materials.

The anhydrite process offers the following potential advantages:

- The solid byproduct differs from gypsum and is potentially more valuable;
- The solid byproduct is “reactive” without calcination;
- The material be used in other markets such as self-leveling floors, aggregate, or Portland cement; and
- The process is an attractive option for either new or existing inhibited oxidation systems as it produces a useful byproduct.

The objectives of the extension to the anhydrite test block are to:

- Produce anhydrite solids from FGD calcium sulfite slurry under the same chemistry conditions as the previous testing;
- Evaluate the effect of residence time, ionic strength, and temperature on anhydrite production; and
- Evaluate the effect of magnesium on anhydrite production.

FACILITY STATUS

General

The NYSEG Kintigh Station provided flue gas to the Center 45% of the time during this performance period. As the Kintigh Station operated with a variety of coals, fluctuations in the Center's inlet SO₂ concentrations were experienced and SO₂ spiking was initiated across the test unit as required.

Safety training for the month was conducted by the Operations Manager. A safety video entitled, "Chemical Burns" was reviewed by the staff. Inspections of the ECTC Facility and safety equipment (SCR air-packs, fire extinguishers, etc.) were completed and recorded this month. All systems were found to be in good condition. By continuing to emphasize safe work habits at the Center, we have raised the total number of days without a lost time injury to 1822 as of 5/31/97.

Pilot/Mini-Pilot Wet FGD System

The equivalent and actual availability for the ECTC 4.0 MW Pilot/0.4 MW Mini-Pilot Wet FGD System was 100% and 41% respectively during this period. The Pilot/Mini-Pilot System was off-line during the ECTC outage period this month (5/3 - 5/18/97).

The Clear Liquor Scrubbing/Anhydrite production test block continued this month with test AEX-1. This test was designed to further characterize the production process for the anhydrous calcium sulfate (anhydrite) utilizing the Pilot scrubber unit and the process tanks and equipment from the 0.4 MW Mini Pilot System. The smaller tanks of the Mini-Pilot were used in conjunction with the Pilot system to reduce slurry residence time and temperature/oxidation demands for the testing. The operational parameters for the test block included: gas flow of 10,000 scfm; inlet SO₂ concentrations of 2000 ppm; and recycle slurry flows of 1700 gpm.

The Ball Mill operation at the ECTC continued this month providing process reagent for the Clear Liquor Scrubbing with Anhydrite Production test block. The Beachville limestone prepared for the testing was maintained at a grind of 88% passing 325 mesh screen.

The following maintenance work was completed on the ECTC facility and Pilot/Mini-Pilot Systems during the outage period this month:

- Scheduled maintenance was completed on the Pilot and ESP Booster fans. The Pilot booster fan VSD was repaired.
- Blanket heaters and insulation were installed on the Mini-Pilot First Loop Reaction Tank (FLRT).
- The modified oxidation air sparge ring was connected to the saturated air heater and installed in the Mini-Pilot Main Reaction Tank (MRT).

- The oxidation air piping was reconnected to the Mini FLRT.
- A new oxidation header was fabricated and installed in the Mini FLRT.
- The heated tank and slurry coils were inspected, cleaned and prepared for service.
- The Pilot scrubber HME, VME, inlet duct, and turning vanes inspected and cleaned.
- The Pilot MRT, FLRT, Dewatering and Recycle Systems were inspected and cleaned.
- All Pilot and Mini-Pilot slurry flow transmitters were inspected and cleaned.
- The hose was replaced in pump 9. The motor was replaced on pump 4.
- Several peristaltic pumps were repaired for use in the chemical addition system.
- The ECTC Power Distribution Center was inspected and all connections were checked and cleaned. This inspection included the substation, booster fan motors, transformers, cables, and motor control centers.
- The ESP rappers and fields were inspected and tested. No problems were noted.

Financial Report

The Financial Report for the four Operations and Maintenance contract tasks are summarized below for the month of May 1997, the year to date, and the contract total.

Task Definitions:

Task 100: Operations and Maintenance Labor

Task 200: Purchased Materials

Task 300: Engineering Support

Task 400: Training

Table i.
Monthly Operating Costs by Task

	May	Year to Date*	Contract Total*
Task 100	\$ 46,757	\$ 48,780	\$ 14,527,789
Task 200	\$ 10,411	\$ 17,482	\$ 8,528,677
Task 300	\$ 5,623	\$ 37,611	\$ 1,232,198
Task 400	\$ -	\$ 63	\$ 53,298
DOE Grant	\$ -	\$ 132,616	\$ 248,792
TOTAL	\$ 62,791	\$ 236,552	\$ 24,590,754

* 1997 Year to Date and Contract Totals were adjusted in the May report to correct previous errors in Task accounting.

The attached graph illustrates the budgeted and actual expenses for ECTC O&M activities through May 1997.

Figure i.
1997 Operation & Maintenance Costs

PILOT AND MINI-PILOT TEST ACTIVITY

Testing Overview

In May 1997, an extension to the Anhydrite Production test block was started following the NYSEG outage. The extension to the Anhydrite Production test block is being funded by the Electric Power Research Institute (EPRI) after promising results from the original test program. Both EPRI and the Department of Energy (DOE) funded the original test program as part of the DOE's Advanced Power Systems Program, whose mission is to accelerate the commercialization of affordable, high-efficiency, low-emission, coal-fueled electric generating technologies. While the pilot portion of the Anhydrite project was conducted on the 4.0 MW wet FGD pilot unit at EPRI's Environmental Control Technology Center (ECTC) in Barker, New York, the extension mainly used the 0.4 MW Mini-Pilot wet FGD unit to reduce operating costs. The project is designed to develop an advanced FGD process that produces a useable byproduct, anhydrite (anhydrous calcium sulfate).

The original CLS/Anhydrite process included three steps: chloride removal, clear liquor scrubbing, and anhydrite production. The final step in the process involved sending the calcium sulfite slurry from the sludge bed reactor to the anhydrite reaction tank for conversion to anhydrous calcium sulfate (anhydrite). The original objective in the PRDA project was to demonstrate all three areas of the integrated process. However, the primary focus has been on anhydrite production because:

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The objectives of the extension to the anhydrite test block are to:

- Produce anhydrite solids from FGD calcium sulfite slurry under the same chemistry conditions as the previous testing;
- Evaluate the effect of residence time, ionic strength, and temperature on anhydrite production; and
- Evaluate the effect of magnesium on anhydrite production.

Operating Summary

The mini-pilot activities began following a two-week NYSEG outage. The new process configuration is shown in Figure 1. During the outage, the process was reconfigured to include the m-ART as the anhydrite reactor (3.5-ft diameter mini-pilot first loop reaction tank) and the m-FGDRT as the sulfite slurry feed tank (6-ft diameter mini-pilot main reaction tank). The pilot wet scrubber was used with the pilot main reaction tank (MRT or FGDRT) to produce sulfite slurry. This slurry was then transferred to the m-FGDRT on a weekly basis, and the chemistry of the slurry in the m-FGDRT was controlled by adding soda ash, sodium sulfite, or magnesium hydroxide, depending on the test requirements. The m-ART was equipped with blanket heater around the tank walls that were capable of maintaining the desired temperature in the tank without sulfite slurry feed. This addition allowed for anhydrite slurry storage over the weekends when the process was not being operated. Also, as the height of the reaction tank is only 12 ft, a hydrogen peroxide feed was installed to allow for supplemental oxidation if the oxidation air rate was not sufficient.

Figure 1. Process Flow Diagram for Anhydrite Process Test Block Extension.

The initial testing focused on production of anhydrite at the same conditions tested in the previous test block. In May, operation of the ECTC pilot scrubber was limited to only a few days since the size of the anhydrite reaction tank was reduced significantly. In this operating mode, the FGD scrubber was in service only two to three days every three weeks, thus, reducing costs and extending the duration of the test period. During this time, enough sulfite slurry was produced to keep the anhydrite reactor operating continuously.

A summary of operating conditions in May is presented in Table 1.

Table 1. May 1997 Anhydrite Operating Summary

Date	Test Description	Operating Summary
Thu, 5/1-Mon, 5/19	NYSEG Outage	The facility was prepared for the NYSEG outage that started on 5/2. During the outage, the facility was reconfigured for the extended testing using the mini-pilot tanks. NYSEG started up on oil on 5/19. The ECTC began pulling gas at 9:00 and the scrubber was started at 12:00.
Tue, 5/20	Start-up	Building solids using the pilot scrubber using ECTC baseline chemistry. Building solids in FGDRT to store for a few weeks of testing. Sulfuric acid addition and hydrogen peroxide addition were installed on the m-ART.
Wed, 5/21	AEX-0: Start-up	Scrubber was taken off-line after reaching desired solids concentration. Sulfite slurry was transferred to the m-FGDRT and the m-ART to reach 9 ft in both tanks. Sodium sulfite was added to both tanks to increase sodium concentration to baseline concentration. At 10:00, the heated blankets around the m-ART were started and began recirculating slurry through the heated coils. Problems with mini-pilot oxidation air system required the use of the pilot oxidation air system at much higher air rates than desired. Oxidation air started at 12:00. Sulfuric acid addition started at 15:25 to bring pH closer to the desired pH. Temperature was 20°F below desired temperature. Feed to the reactor started at 17:30. Lost acid addition overnight and high air rate coupled with acid addition problems led to overflowing the m-ART and electrically shorting the heated blankets.
Thu, 5/22	AEX-0: Start-up. incomplete oxidation	The level in the m-ART was lowered to 7 ft to accommodate high air rate. The pH in the m-ART was 0.9 pH units above the desired pH by 10:00 and 0.4 by 12:00 with sulfuric acid addition. Slurry temperature was up to 2°F below desired temperature and pH at 0.26 above desired pH by afternoon. Still had incomplete oxidation. At 13:00, Mechanism B1 was implemented to the m-ART to start the reaction.
Fri, 5/23	AEX-0: Start-up	Increased oxidation air rate. At 14:00, began adding peroxide to help oxidize the sulfite while keeping the air rate low—temperature increased by 3°F after starting the peroxide. NYSEG tripped off-line at 14:10—does not affect process. Temperature up to 5°F above desired temperature—probably indicating complete oxidation—when unit was taken off-line. At 22:00, the process was stopped and contents in the m-ART kept heated for the weekend.
Sat, 5/24	Unit off-line	Process stopped. Tanks kept heated.

Table 1. May 1997 Anhydrite Operating Summary (cont.)

Date	Test Description	Operating Summary
Sun, 5/25	Unit off-line.	The m-ART was at 2°F above the desired temperature when facility was inspected. No problems noted.
Mon, 5/26	Unit off-line.	The m-ART was at 2°F above the desired temperature when facility was inspected. The pH in the m-ART was 1.2 pH units below desired pH. The process was restarted at 23:30.
Tue, 5/27	AEX-1A: Mechanism B2 for surface area control, baseline chemistry.	At 7:00 the temperature in the m-ART was at 4°F above the desired temperature and the pH was at the desired pH. The peroxide was started at 100 ml/min at 7:45. At 11:30, Mechanism B1 was implemented and began using Mechanism B2 for surface area control. Solids showed 100% oxidation. Anhydrite crystals were noticed under the microscope. Mechanism B3 was implemented at 22:00 for surface area control.
Wed, 5/28	AEX-1B: Mechanism B3, baseline chemistry.	The temperature in the m-ART was 1°F above the desired temperature at 7:00 with a pH of 0.1 pH units below the desired pH. Both peroxide and oxidation air were being used to oxidize the sulfite. The pH was being controlled with soda ash addition. By 22:30, the temperature was at 3°F above the desired temperature.
Thu, 5/29	AEX-1B: Mechanism B3, baseline chemistry.	Feed to the anhydrite reactor stopped when the pump failed. A new pump was installed with a recirculation loop to maintain the very low flows being used. Solids improving somewhat over the last few days. The copper coil failed at 10:20 and the copper concentration in the m-ART increased from 0.1 to 28 ppm from morning to afternoon. A blue tint was noticed in the slurry. The air rate was lowered from 2.7 to 1.8 scfm overnight with 50 ml/min peroxide to give 1.5 O:SO ₂ ratio.
Fri, 5/30	AEX-1B: Mechanism B3, baseline chemistry.	The temperature in the m-ART was 3°F below the desired temperature. Peroxide addition was increased to 100 ml/min and air at 1.8 (2.0 total). When this was done, the temperature increased to 2°F above the desired temperature. Lost another heated coil at 22:30. After 22:00 the surface area control mechanism was changed from B3 to B4.
Sat, 5/31	AEX-1C: Mechanism B4, baseline chemistry.	Lost the feed pump at 4:00 and had no back up. Lost 2 feet of slurry level from the m-ART when two fittings failed on the heated coil and pH tree loop. Unit was off-line until 15:00 when repairs could be completed. The one sample taken in the morning showed some improvement in the anhydrite content (from 54 to 63%).

Results Summary

Several analytical methods have been used to determine the phase of the calcium sulfate being produced in the anhydrite reactor including:

- % Bound Water (measure solid weight loss at about 180°C)—provides an estimate of anhydrite concentration (wt%) assuming solids are a mixture of only anhydrite and gypsum;
- X-ray Diffraction (XRD)—indicates the presence of gypsum, hemihydrate, and/or anhydrite;
- Visual Microscope and Scanning Electron Microscope (SEM)—indicates changes in particle size and shape; and,
- ORTECH Measurements—differential scanning calorimetry, gravimetric hydration phase analysis, and temperature setting characteristics.

Of these analyses, the % bound water and visual microscope measurements were made on site. These measurements, coupled with the subjective observations about the reactivity of the centrifuge or vacuum belt product, were used to make the daily decisions concerning modification of the test conditions.

Test conditions in May included a sodium-based chemistry with solids residence times similar to those in the Anhydrite Process Test Program completed last month. Figure 2 summarizes the solid-phase anhydrite content in the byproduct solids produced during May. The results in Figure 2 are based on the % bound water measurement and the assumption that all of the solids were either anhydrite or gypsum. Note that the first few days of testing are not included since the oxidation of the solids was incomplete. The figure shows that the anhydrite content rose from less than 5% on May 23 to almost 60% on May 27. During this period, the feed to the reaction tank was stopped and the slurry was kept heated in the m-ART. Shortly after restarting the feed to the reaction tank, the concentration of anhydrite began to fall slightly, indicating that Mechanism B2 was probably not sufficient to maintain the high anhydrite concentrations desired.

Figure 2. May 1997 Anhydrite Concentration Results Summary

On May 28, the surface area control mechanism was switched from B2 to B3. Over the next few days, the anhydrite concentration appeared to increase slightly but leveled off at approximately 54%. Consequently, the mechanism for surface area control was changed once more from B3 to B4. After this adjustment, the anhydrite concentration increased by almost 10% and appeared to be moving in the right direction at the end of the month.

Future Testing

Testing in June will investigate the effect of solids residence time and magnesium concentration. The extended test program will conclude on July 2 when the unit will be taken out of service and preparation will begin for the Dry Sorbent Injection (DSI) test block for Mercury Removal and ESP Performance studies (due to begin July 8).

APPENDIX A
TEST SCHEDULE(S)

4.0 MW Pilot FGD Unit	1 9 9 6											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	EPRI Wet FGD Toxics Testing		DOE/PRDA Phase I - Mercury and HAPs Control with Wet FGD			EPRI Wet FGD Toxics Testing		Third party Testing - Rotorfilter Technology		EPRI Toxics Removal Testing	EPRI SOx/NOx Process Testing	ECTC Fall Outage
0.4 MW Mini-Pilot FGD Unit	UNIT DOWN		DOE/PRDA Phase I - Multiple Pollutant Removal Using the Condensing Heat Exchanger (CHX)									

1 9 9 7											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4.0 MW Pilot FGD Unit	DOE/PRDA Phase I - Clear Liquor Scrubbing (CLS) with Anhydrite Production			NYSEG Spring Outage	CLS Anhydrite extension testing	Dry Sorbent Injection for Hg Removal and ESP performance studies			EPRI ECTC Testing		ECTC Fall Outage
									DuPont FGD Additives Study		API Process Additives Study
ECTC Bench-scale FGD Unit (proposed)	DOE/PRDA Phase I - Condensing Heat Exchanger (CHX) Testing			Reconfigure Mini-Pilot Scrubber		Unit Available for EPRI / Third-Party Testing					
0.4 MW Mini-Pilot FGD Unit											

4.0 MW Pilot Wet FGD Unit	1 9 9 8 (proposed)											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	DOE/PRDA Phase II Clear Liquor Scrubbing with Anhydrite						DOE/PRDA Phase II Condensing Heat Exchanger (CHX) Testing			EPRI / Third-Party Testing		
	EPRI / Third-Party Testing											
0.4 MW Mini- Pilot FGD Unit												

ECTC Test Schedule ('96 - '98)

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