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Project Summary

Dual Alkali Acceptance Test at Louisville Gas and Electric Company

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This report discusses results of the recent acceptance test on the dual alkali system serving Louisville Gas and Electric Company's Cane Run Unit 6 boiler. The test was conducted to measure system performance with respect to the guarantees offered Louisville Gas and Electric by Combustion Equipment Associates. Testing results were:

- **SO_2 removal averaged 94% and 143 ppm outlet concentration.**
- **Lime consumption averaged 1.04 mole CaO/mole SO_2 removed.**
- **Power consumption averaged 1.05% of generation.**
- **Filter cake solids averaged 52.2 wt % insoluble solids.**
- **There was no net particulate matter addition.**

Various problems attributable to the boiler, the FGD system, and the quality and quantity of the carbide lime supplied to the system delayed acceptance tests until July 1980. The year-long demonstration officially started in May 1980. The problems experienced and their solutions are discussed.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Dual Alkali Demonstration Project is a joint effort by a number of organizations under the sponsorship of the U.S. EPA. The process is a sodium-based concentrated mode using carbide lime as a regenerant. Louisville Gas and Electric Company (LG&E) owns/operates the dual alkali system serving their Cane Run Unit 6 boiler, a nominal 280 MW high-sulfur-coal-fired boiler (3.5-4.0% S). The design was developed by Combustion Equipment Associates (CEA) and Arthur D. Little, Inc. (ADL). The system was erected by LG&E under the guidance of CEA/ADL at a cost of about $22 million (1976-1980 dollars) or about $79/kW installed generating capacity (including waste disposal).

Figure 1 is a process flow schematic of the dual alkali process at Cane Run 6. Flue gas from the boiler passes through electrostatic precipitators (ESPs) and is fed to two absorbers. A recycling sodium sulfite solution, flowing countercurrent to the flue gas across two stainless steel perforated plate trays, absorbs SO_2 according to the reaction:

$$SO_3^{=} + SO_2 + H_2O \rightarrow 2HSO_3^{-} \quad (1)$$

In addition, due both to the absorption of sulfur trioxide from the gas and to the oxidation of sulfite ion in solution, sulfate ($SO_4^{=}$) is formed in the absorbent liquor:

$$H_2 + SO_3 \rightarrow H_2SO_4 \rightarrow 2H^+ + SO_4^= \quad (2)$$

$$SO_3^= + \tfrac{1}{2}\, O_2 \rightarrow SO_4^= \quad (3)$$

The scrubbed flue gas is reheated by combustion gases from a direct oil-fired reheater and is ducted to the stack.

Sodium carbonate is added to either the thickener or the absorber to make up for losses of sodium in the system. Bleed streams of the spent absorbent solution from the absorbers are sent to the regenerator reactor trains where carbide lime is added to convert the bisulfite (HSO_3^-) in the spent absorbent to sulfite ($SO_3^=$) in the regenerated absorbent, precipitating a mixture of calcium sulfite and sulfate solids:

$$2HSO_3^- + Ca(OH)_2 \rightarrow CaSO_3\downarrow + SO_3^= + 2H_2O \quad (4)$$

$$SO_4^= + 2HSO_3^- + Ca(OH)_2 \rightarrow CaSO_4\downarrow + 2H_2O + 2\,SO_3^= \quad (5)$$

The mixed solids actually can be designated as:

$$x\,CaSO_3 \cdot y\,CaSO_4 \cdot z\,H_2O$$

where the ratio x:y is usually greater than 4 and z represents some amount of water of hydration. No pure gypsum phase is formed. The solids are separated from the liquor in a thickener and are removed from the system on washed vacuum filters. The filter cake is mixed with fly ash and quicklime in a system designed by I.U. Conversion Systems. After fixation the solids are trucked to a landfill site for disposal. The clear liquor overflowing from the thickener is returned to the absorber recycle loop.

Table 1 compares the design basis and observed operation. The design basis is taken from the design manual produced during this project. Details can be found in References 1, 2, and 3. The system is designed to operate with a liquid/gas ratio of less than 10 gal./10^3 acf, including liquor feed to the tray and spray recycle (typical lime or limestone slurry processes are designed for about 50 gal./10^3 acf). The design flue gas pressure drop from the booster fan to the stack entrance is 8.5 in. H_2O.

Bechtel National, Inc. is under a separate contract with EPA to provide an independent test program to assess the operation of the system with regard to its performance guarantees, and to provide a demonstration program designed to characterize the system and monitor its performance over a year-long demonstration period.

Construction was completed in March 1979 and the system was initially charged and started up in April 1979. Various problems attributable to the boiler, the FGD system, and the quality and quantity of the lime supplied to the system delayed acceptance testing until July 1980. The year-long demonstration

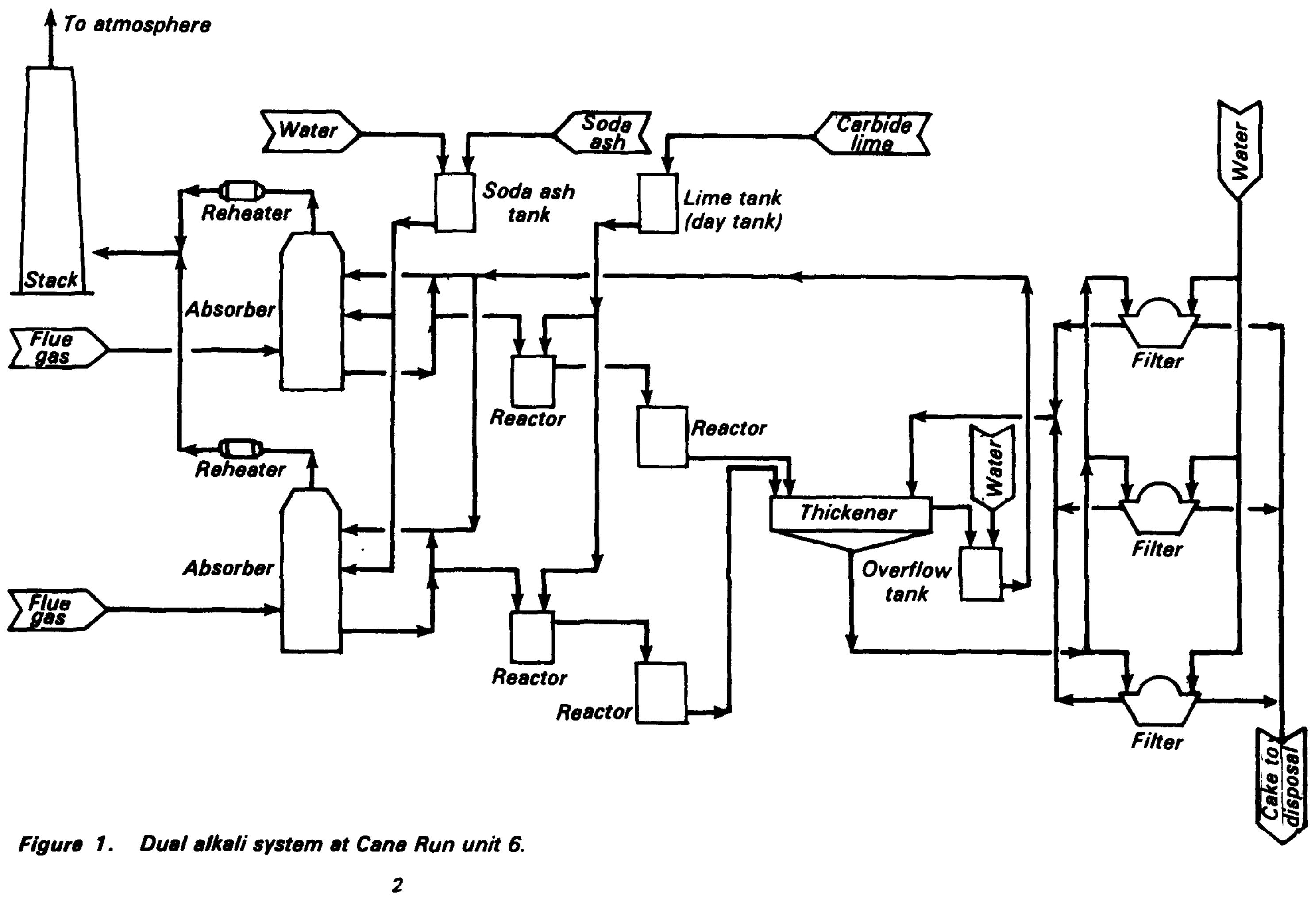

Figure 1. Dual alkali system at Cane Run unit 6.

period officially started in May 1980. The problems and solutions are discussed later.

The acceptance test was conducted from July 17 to July 28, 1980. With one minor exception (filter cake quality), the system proved to be capable of successfully meeting its performance guarantees.

Acceptance Test Results

The 12-day acceptance test was conducted to measure the performance of the dual alkali system with respect to the guarantees provided to Louisville Gas and Electric Company by Combustion Equipment Associates. The guarantees concerned operation in the following areas:

- SO_2 removal.
- Carbide lime consumption.
- Soda ash consumption.
- Particulate matter emissions.
- Power consumption.
- Filter cake quality.
- Year-long system availability.

Table 2 summarizes the guarantees offered and corresponding results of the acceptance test. A brief discussion of each guarantee test performed during the acceptance test follows.

Table 1. *Performance Conditions*

	Design	Observed
Coal (Dry Basis)		
Sulfur, %	5.0	3.7 (ave.)
Chloride, %	0.04	0.02 (ave.)
Heat Content, Btu, lb	11,000	10,650 (ave.)
Inlet Gas:		
Flow Rate (Volumetric), acfm	1,065,000	1,045,000 (max.)
Temperature, °F	300	280 (max.)
SO_2, ppm	3471	2323 (ave.)
O_2, %	5.7	6.7 (ave.)
Particulate, lb/10^6 Btu	0.10	0.84 (ave.)
Outlet Gas:		
SO_2, ppm	<200	143 (ave.)
Particulate, lb/10^6 Btu	0.10	0.10 (ave.)
Boiler Operation:		
Generation, MW	280	240 (max.)

Table 2. *Performance Guarantees and Acceptance Test Results*

Guarantee	Test Results
SO_2 Removal	
220 ppm dry basis (D.B.) without additional air dilution	*143 ppm (D.B.) without additional air dilution*
Calcium Consumption	
1.05 moles available CaO/mole SO_2 removed	*1.04 moles available CaO/mole SO_2 removed*
Soda Ash Consumption	
0.045 moles Na_2CO_3/mole SO_2 removed	*0.042 moles Na_2CO_3/mole SO_2 removed*
Net Particulate Addition	
No net particulate addition by FGD system	*Net particulate removal averaging 88% efficiency*
Power Consumption	
System will consume (excluding reheat) not more than 1.2% of power generated at peak capacity	*System consumed 1.05% of power generated*
Filter Cake Properties	
Filter cake will contain a minimum of 55 wt % insoluble solids	*Filter cake averaged 52.2 wt % insoluble solids*

SO_2 Removal

The primary method of determining SO_2 removal relied on a continuous Lear Siegler monitor in the stack. This analyzer was certified in December 1979 by an outside contractor according to the procedure specified in the Federal Register. During the acceptance test, as a backup to the continuous monitor and as an ongoing confirmation of the analyzer accuracy, wet-chemical EPA Method 6 tests of the stack effluent were also performed daily, in conjunction with the particulate tests.

Preliminary wet-chemical test results showed a discrepancy between these measurements and the continuous monitor readout. An extensive check of the system revealed a burned ground wire in the signal line of the Lear Siegler monitor. Data on the calibration sequences of the analyzer prior to, during, and after elimination of the grounding problem, indicated that the signal from the analyzer was offset 30 ppm on the low side by the malfunction.

Therefore the continuous stack SO_2 monitor readings for the first 7 days of the tests were corrected by 30 ppm. 'ith this correction applied to the early ɔdings, and subsequent to the repairs to the ground in the analyzer, the two techniques were in good agreement.

Both measurements showed that the system could meet the 200 ppm SO_2 outlet concentration guarantee. Table 3 summarizes the 24-hour average SO_2 results for the 12-day acceptance test. Table 4 summarizes the simultaneous wet chemical and continuous monitor measurements (the Method 6 tests were conducted only for the first 10 days).

Lime Consumption Guarantee

The lime consumption guarantee was specified as "not [to] exceed 1.05 moles of available CaO in the lime per mole of SO_2 removed from the flue gas." Lime consumption was determined by analyzing representative samples of filter cake collected as the cake was discharged from the filters prior to fixation. The cake was analyzed for total calcium and total sulfur. The total calcium represented the lime used, and the total sulfur represented SO_2 removed from the flue gas. A portion of the calcium entering the system with the carbide lime is present as carbonate and therefore does not represent alkalinity available for regeneration. Each time the lime day tank was filled, a sample of time was analyzed for available alkalinity and total calcium. From these results, a correction factor was developed to account for unreactive calcium in the carbide lime feed. During the 12-day acceptance test, the calcium consumption, corrected for available alkalinity as described above, averaged 1.04 moles of available CaO/mole of SO_2 removed, thus meeting the guarantee which required less than 1.05 moles/mole of sulfur removed. Table 5 summarizes the analyses of the filter cake.

Table 3. *Acceptance Test Continuous SO_2 Analysis*

Acceptance Test Day	24 Hour Continuous SO_2 Analyzer Results (ppm, dry basis)				L/G gal.	Act. Na
	A Inlet	B Inlet	Stack	% Removal	10^3 acf	(M)
1	2444	2418	130	94.7	9.5	0.42
2	2674	2570	129	95.0	8.7	0.40
3	a	2390	130	94.6	9.4	0.42
4	a	2290	152	93.4	9.2	0.44
5	2265	2315	157	93.1	9.1	0.54
6	2567	2515	140	94.5	7.8	0.52
7	2113	2021	132	93.6	8.3	0.49
8	2116	2088	124	94.1	8.9	0.49
9	2395	2339	146	93.8	8.2	0.49
10	2372	2315	171	92.7	8.7	0.49
11	2292	2233	156	93.1	9.6	0.43
12	2167	2166	130	94.0	9.8	0.43
Average	2340	2305	141	93.9	8.9	0.46

[a]Analyzer printout malfunction

Table 4. *Acceptance Test Continuous Monitor and EPA Method 6 Analysis*

Acceptance Day	Hours	SO_2 Concentration, ppm, dry basis					
		A Inlet		B Inlet		Stack	
		Dupont Analyzer	Method 6	Dupont Analyzer	Method 6	LSI Analyzer[a]	Method 6
1	1400-1700	2434	2330	2516	2330	119	124
2	1100-1300	2434	2150	2423	2180	122	163
3	1000-1300	2592	2210	2670	2290	117	154
4	1200-1500	2836	2390	2674	2480	155	159
5	1000-1300	2656	2330	2606	2410	136	137
6	1000-1300	2716	2350	2418	2480	184	212
7	1600-1900	2337	2040	2250	2030	b	137
8	1100-1300	2395	2120	2330	2100	113	130
9	1100-1400	2864	2530	2721	2450	122	133
10	0900-1200	2690	2410	2624	2360	160	137

[a] Lear Siegler analyzer readings for days 1-6 corrected for the effect of the burned out ground wire

[b] Analyzer out of service for repairs to ground wire

Soda Ash Consumption

Soda ash consumption was determined by analysis of total sodium and total sulfur in the filter cake. According to this analysis, consumption of soda ash averaged 0.042 moles of Na_2CO_3/mole of SO_2 removed, meeting the guaranteed requirement of 0.045.

Particulate Emission

The system was guaranteed not make any net addition of particulate the gas stream prior to discharge. EP Method 5 particulate tests were co ducted at the inlets to the absorber mo ules and in the stack (downstream of r heaters) during the acceptance test. Th results of 10 simultaneous tests showe convincingly that there was no net add tion of particulate across the systen Actually, the absorber performed as particulate removal device, averagin 88% net removal of incoming particulat Table 6 shows results of particulat tests during the test program.

Although the FGD system met guarar tee requirements, the test was not ver stringent due to the low level of perfo mance by the ESPs during the acceptanc test. The FGD system was originally de signed to process an incoming flue ga stream containing the equivalent of 0. lb of particulate/10^6 Btu or less. Durin the acceptance test, however, the leve of incoming particulate matter was al most an order of magnitude higher. Thus it is not surprising that the absorber removed particulate even at the relative ly low pressure drop at which they oper ated. The particulate emissions from th stack, however, were on the order of 0.1 lb/10^6 Btu as required for the Cane Rur Unit 6 FGD system under the appropriate requirements to control particulate emissions.

Power Consumption

The system, excluding reheat, was guaranteed not to use more than 1.2% of the total power generated by the boiler/turbine unit at gross peak load. During the acceptance test, peak generation was 240 MW. Correspondingly, power consumed during peak generation was 2.5 MW, or 1.05%. The guarantee was met, based on both peak generation and average generation during the test. During the 12-day test, the average load was 178 MW and the average power consumption by the FGD system was 2.05 MW, or 1.15%.

Waste Filter Cake Properties

The system was guaranteed to produce a waste filter cake containing a minimum of 55 wt % insoluble solids. The filter cake averaged 52.2 wt % insoluble solids during the acceptance test. While this fell slightly short of guarantee, the product discharged to the IUCS process was uniform in moisture content a was suitable for working into a stab

Table 5. *Acceptance Test Daily Average Filter Cake Analysis*

Test Day	As Received Basis: Na wt %	Ca wt %	Total Sulfur as SO_4 wt %	Insoluble Solids wt %	$\frac{\text{Mole } Na_2CO_3}{\text{Mole } SO_2}$	$\frac{\text{Mole } CaO^a}{\text{Mole } SO_2}$
1	0.55	14.88	31.35	52.65	0.037	1.139
2	0.58	14.60	31.58	52.20	0.038	1.109
3	0.70	15.64	32.60	52.60	0.045	1.151
4	0.48	15.72	32.68	53.72	0.031	1.154
5	0.45	15.15	31.92	53.92	0.029	1.139
6	1.11	15.20	33.20	51.90	0.070	1.099
7	0.58	14.35	31.80	50.70	0.038	1.083
8	0.50	14.44	32.32	51.40	0.032	1.072
9	1.07	14.05	32.58	51.00	0.068	1.035
10	0.45	14.43	33.07	52.43	0.028	1.047
11	0.77	14.85	33.48	52.82	0.047	1.064
12	0.62	13.74	31.64	50.58	0.041	1.042
Average				52.16	0.042	1.095

[a]*Calcium consumption corrected for available alkalinity (1.095 × 0.95 = 1.040). Correction factor of 0.95 was developed from analysis of incoming carbide lime for mole of available alkalinity/mole of total calcium.*

Table 6. *Acceptance Test Particulate Test Results*

Acceptance Test Day	Particulate, lb/10^6 Btu: A Inlet	B Inlet	Stack	% Removal
1	0.5320	0.7120	0.0895	85.6
2	0.6590	0.3620	0.0932	81.7
3	0.9470	1.0700	0.1110	89.0
4	0.9440	0.8060	0.1030	88.2
5	1.1100	0.9200	0.1020	90.0
6	0.9900	1.4900	0.1020	91.8
7	0.5890	0.8470	0.1020	85.6
8	0.6250	0.6490	0.0893	86.0
9	0.7890	1.2000	0.1100	88.9
10	0.9620	0.5930	0.1020	86.9
Average	0.8147	0.8649	0.1004	88.0

and manageable product through the fixative process. Optimization of filter cloth selection and filter cycle will continue, with the goal of showing that compliance with this guarantee can be met during the demonstration year.

System Availability

System availability, as defined by the Edison Electric Institute (available hours divided by the total hours in the period under construction), was guaranteed to be greater than 90% for the demonstration year. While it is too early to report such a figure, through the first 4 months of the demonstration year (May-August), system availability has averaged 99.8%.

Operating and Maintenance Problems

Up to the time of acceptance testing, a number of mechanical problems and a few chemical problems affected system performance and led to cumulative delays in executing the program. None of the problems were insurmountable; but their solutions were time consuming. It is important to report the nature of these obstacles so that future installations of this or similar technology can benefit from the experience.

Recycle and Thickener Return Pumps

There were two major problems with the high-capacity low-speed pumps for recirculation of absorbent liquor to the trays, and return of thickener overflow liquor to the absorbers. The first problem was the mechanical shearing of the impellers at the hub. The original pump impellers were manufactured in two parts: a body and a separate hub for attachment to the shaft. The hub was welded to the body. All of the impeller failures were at this welded seam. This problem was eliminated when the pump vendor supplied a one-piece molded impeller body.

The second major problem involved the rapid failure of the suction side of the pump liner. As a result of close tolerances between the casing liner and the impeller, the two surfaces were rubbing; the resulting abrasion destroyed the liner. After completely dismantling the pumps, it was discovered that a finishing step appeared to have been omitted at the factory, leaving about ¼-in. excess length on each shaft. Milling each shaft to its design size eliminated this problem.

Mist Eliminator Collapse

Within a few months after start-up, both absorber modules experienced high pressure drop problems. Inspection of the internal structure revealed that the mist eliminator sections had sagged or collapsed structurally. The problem was solved by replacing the mist eliminator sections with those of a different manufacturer. Since the replacement, in August 1979, there has been no further problem with the mist eliminators.

Tray Pluggage

One of the most perplexing problems was the pluggage of the absorber trays due to deposition. At first the observed deposit was thought to be carbonate scale resulting from pH upsets in the modules. Careful analysis showed the precipitate to be an aluminum-hydroxy-silicate complex. The mechanism of dissolution and subsequent deposition was traced to the operating pH of the reaction train. Aluminum was entering the system with the carbide lime. At the above-11.5 operating pH in the reactor, the aluminum compound is soluble in the liquor. When the thickener overflow recycle combined with the recirculating absorbent, the resultant drop in pH caused the aluminum to precipitate on the absorber trays.

Reducing the operating pH of the reactor to between 10.0 and 10.8 reduced the solubility of the aluminum with the reactor and thickener. This change ahead of the absorber minimized pluggage. At the reduced pH set point, however, there is less buffering and control of reactor pH is more difficult.

Water Balance

The system initially experienced a severe water imbalance. This was partly due to a lack of familiarity with the system, and partly because of low-solids concentration in the carbide lime feed. The other lime slurry systems at Cane Run can tolerate an occasional open-loop excursion. However, the dual alkali process must operate in a closed-loop at all times, since the high concentration of solubles in the scrubbing liquor makes disposal unacceptable for both environmental and economic reasons. The system was designed to accommodate 70% water (30% solids) in the incoming carbide lime slurry. Initially the water content was consistently 82-85%. At this concentration, the system was receiving twice the design input water flow. After only a few hours of operation, the volume of water in the system had accumulated to the point where the lime feed had to be cut off. The absorbers continued to function as evaporators until the water level dropped low enough to resume normal operation.

Strict control of the incoming lime concentration from the supplier and the addition of a ball-mill/hydroclone system to remove oversize particles alleviated the problem.

Soda Ash Silo Pluggage

Soda ash is added to the system by a dry weigh feeder which feeds dry solids from a storage silo to a mix tank where it is mixed with absorbent liquor. Vented moisture vapor from the hot mix tank backs up into the weigh feeder screw conveyor and causes the soda ash to form lumps which prevent the smooth flow of feed to the system. The system's small fan, used to blow the moisture-laden air back into the mix tank, proved to be under-designed. Although a larger fan improved the situation, the soda ash feed system still remains a relatively high maintenance item.

Thickener Blockage

In mid-January 1980, the thickener rake seized during a boiler outage for repair and ultimately required a shutdown and major overhaul of the thickener. This did not occur during normal operation, but rather during the transient period in which the boiler and FGD were being shut down for maintenance. The stoppage was postulated to have resulted from an overloading of the thickener with washings of accumulated solids (including fly ash) from the bottom of the absorber. Lacking a bottom drawoff, the absorber allowed fly ash to be trapped and accumulated in its lower portion. The problem could apparently have been avoided if the solids from the bottom of the absorber had been slowly pumped to the thickener while the thickener and filters continued in operation until the absorber bottom was purged of solids.

Correction of the problem took about 3 weeks, during which about 2 million gal. of liquid and solids had to be removed from the thickener (liquid was temporarily stored, and solids were impounded off site). To accomplish this, large holes were cut in the thickener sides to allow entry by personnel and equipment to dig out the compacted solids.

Overloading of the thickener has not recurred. The solids in the bottom of the absorbers are still not subjected to mechanical agitation, but are no longer washed into the thickener in large slugs.

SO_2 Monitoring

SO_2 in the inlet to and outlet from the absorbers is measured by continuous DuPont UV Model 460 SO_2 analyzers. In the stack, SO_2 concentration of the scrubbed gas is measured by a Lear Siegler SO_2 analyzer.

Three problems have occurred in the measurement of SO_2 using the DuPont analyzers supplied with the dual alkali system:

- Plugging of the sample probe.
- Maintaining a steady calibration of the instruments.
- Stratification of scrubbed gas across the absorber exit duct.

The first two problems were minimized by daily inspections to determine if the probes need to be calibrated or cleaned. An attempt to alleviate the last problem will be made by moving the SO_2 probes downstream of the reheaters, which should also help reduce the first two problems.

Failure of FRP Piping

The FRP (fiberglass reinforced plastic) piping in slurry service (i.e., thickener underflow and filter feed) has been a major maintenance item. Some failures have been major, others minor. Late in the fall of 1979, a flush connection on the underflow line snapped off. Slurry from the thickener flooded the access tunnel below the thickener before the break could be isolated. Routinely, elbows in the line from the thickener to the filter have required repairs because of erosion damage and failure of the connection bond. Gradually all underflow FRP piping is being replaced with mild steel. While mild steel has a limited life span in this service, failures will be less catastrophic.

pH Control

Reliable and accurate pH measurement for pH control in the reactors and in the scrubber bleed stream have been particularly bothersome. The pH related problems are attributed to:

- Inability to keep the probes clean.
- Poor responsiveness of the probes
- Pluggage of the sample lines.
- Poor calibration techniques.

Experiments with different instrument designs and sampling methods are gradually alleviating the first three problems. Detailed calibration instructions and cross checking of the results have minimized the last. On-line pH readings are compared daily with pH measurements taken with a portable pH meter by LG&E scrubber laboratory personnel. If these readings are in disharmony by more than 0.3 pH units, the on-line probes are recalibrated.

All the original L&N pH probes have been replaced with Great Lakes models. To measure the pH of the primary and secondary reactors, a Great Lakes Model 60 submersible probe was placed in the overflow chute from the primary to the secondary reactor, and in the secondary reactor below the liquid level near the overflow. The pH of the bleed and thickener return streams was measured by Great Lakes Model 60 flow-through pH probes with ultrasonic cleaners.

Filter Operation

There have been two major concerns with the rotary vacuum drum filters. First, the cake quality has varied between 45% and 55% solids. Second, it has not always been possible to properly wash the cake to meet sodium consumption guarantee.

Prior to the acceptance test, experiments with different filter cloths led to installation of a new filter cloth. The original cloth was a polypropylene cloth supplied by National Filter Media of Hamden, CN. During the acceptance test this cloth was replaced with a multifilament nylon cloth supplied by Thoerner Products Corp., of Pittsburgh, PA. The new cloth produced a more consistent quality cake but had a tendency to blind. During the acceptance test, cake washing was sufficient to meet the soda ash consumption guarantee, but the blinding detrimentally affected the percent solids of the filter cake. There is also some concern that poorer quality solids may be produced in the reactors at the lower pH levels required to control dissolution of aluminum and silicon compounds.

Proper cake washing on the filters is subject to a number of considerations. The wash water rate (as limited by the water balance), the quality of solids produced, the thickness of the cake (controlled by drum angular velocity), the wash spray configuration, and the quality of the filter cloth (blinding characteristics) are all important. Therefore, experiments with different filter cloths and varying operating parameters are continuing.

Conclusions to Date

As indicated by operation since March 1980, and the successful completion of the acceptance test in July, the dual alkali process can achieve greater than 90% SO_2 removal with an availability of more than 99% while processing a flue gas generated in a high-sulfur (>3.5%) coal-fired full-size (280 MW) utility boiler. Consumption of raw materials and power was less than expected (guaranteed) while the SO_2 removal average was over 94% for the 12-day acceptance test.

Most of the problems initially encountered were mechanical and have been solved or greatly reduced in the operation at Louisville Gas & Electric's 280 MW Cane Run Unit 6.

Further investigation of filter operation, reactor operation, filter cloths, materials of construction, and major process component characterization is underway.

Units of Measure

EPA policy is to express all measurements in Agency documents in metric units. When implementing this practice will result in undue cost or difficulty in clarity, IERL-RTP provides conversion factors for the non-metric units. Generally, this paper uses British units of measure.

The following equivalents can be used for conversion to the metric system:

British	*Metric*
5/9 (°F−32)	°C
1 ft	0.3048 m
1 ft²	0.0929 m²
1 ft³	0.0283 m³
1 gr	0.0648 g
1 in.	2.54 cm
1 in.²	6.452 cm²
1 in.³	16.39 cm³
1 lb (avoir.)	0.4536 kg
1 ton (long)	1.0160 m tons
1 ton (short)	0.9072 m tons
1 gal.	3.7854 liters
1 Btu	252 calories

References

1. Van Ness, R.P. et al., "Full-Scale Dual-Alkali Demonstration System at Louisville Gas and Electric Co.—Final Design and System Cost," EPA-600/7-79-221b, NTIS No. PB80-146715, September 1979.
2. Van Ness, R.P., et al., "Project Manual for Full-Scale Dual-Alkali Demonstration at Louisville Gas and Electric Co.—Preliminary Design and Cost Estimate," EPA-600/7-78-010, NTIS No. PB278722, January 1978.
3. Kaplan, N., "Summary of Utility Dual Alkali Systems," in Proceedings: Symposium on Flue Gas Desulfurization—Las Vegas, Nevada, March 1979, Volume II, EPA-600/7-79-167b, NTIS No. PB80-133176 (pp 888-958), July 1979.

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The complete report consists of three volumes, entitled "Dual Alkali Acceptance Test at Louisville Gas and Electric Company,"

"Volume I. Acceptance Test and Appendices A-C," (Order No. PB 82-231 267; Cost: $12.00, subject to change)

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"Volume III. Appendices G-J," (Order No. PB 82-231 283; Cost: $27.00, subject to change)

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