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Project Summary

Source Test and Evaluation Report: Cane Run Unit No. 6, Louisville Gas and Electric Co.

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A comprehensive multimedia emissions assessment was performed on a coal-fired boiler equipped with electrostatic precipitators (ESPs) and a dual-alkali flue gas desulfurization systetem. Levels 1 and 2 sampling and analysis procedures were used to characterize pollutant emissions in gaseous, liquid, and solid waste streams. Flue gas pollutant concentrations were measured at the inlet and outlet of both control devices.

Flue gas emissions after scrubbing had the following criteria pollutant loadings: 273 ng/J So_2, 419 ng/J NO_x (as NO_x at 88 percent load), 39 ng/J CO, 7.46 ng/J total particulate, 3.8 to 4.3 ng/J total organics, and <0.3 pg/J lead. Scrubbing efficiency for SO_2 was 88 percent. Particulate removal efficiencies were 99.7 percent across the ESPs and 19 percent across the scrubbers for a total removal efficiency of 99.86 percent. Particulates (exclusive of sulfuric acid aerosol) less than 3 μm in diameter accounted for 59 percent by weight of total particulate emissions. Emissions of primary sulfates averaged 6.6 ng/J, or 2 percent of total sulfur species emitted. Primary sulfate removal efficiencies were 48 percent across the ESP and 77 percent across the scrubber. Particulate sulfate emissions after scrubbing accounted for approximately 50 percent by weight of total particulate emissions, with about 10 percent of this particulate sulfate ascribed to entrainment of scrubber liquor. Elements in stack emissions which may be of environmental concern include As, Cr, and Fe. Specific anion analyses for nitrate, chloride, and fluoride showed that these emissions averaged 0.0018, 0.175, and 0.122 ng/J, respectively. Neither chloride nor fluoride emissions appeared to pose a health hazard. Numerous compounds of polycyclic organic matter were identified in the air emission. Phenanthrene was present at the highest concentration, but was not deemed to pose a significant health hazard.

The two liquid streams discharged from the site showed concentrations of Al, Ca, Cd, Fe, Mn, Ni, P, and Pb at levels of potential environmental concern. However, in most cases, the levels discharged to the river were not significantly different from those found in makeup water obtained from the river. Only Ca content increased appreciably from makeup to discharge. Total organic content of the discharges ranged from 0.002 to 0.290 mg/l.

Waste solids consisted of three collected ash streams and scrubber filter cake. The ashes contained several elements of potential health and ecological concern including Al, As, Ca, Fe, and Mn, but few organics (0.04-0.48 mg/kg). Filter cake contained more organics (19.22 mg/kg), but fewer elements appeared to be of environmental concern.

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

Louisville Gas and Electric Co. owns and operates the Cane Run generating station, in Jefferson County, KY, about 13 km southwest of Louisville on the east bank of the Ohio River. The power station consists of six coal-fired generating units with a total peak capacity of 1040 MW. Unit No. 6, a tangentially fired dry-bottom boiler, equipped with electrostatic precipitators (ESPs) and a dual-alkali flue gas desulfurization (FGD) system, was tested in this program. Cane Run No. 6 is a 300 MW gross peak capacity boiler developed by Combustion Engineering. It was placed in service in 1969. It is nominally rated at 280 MW and has a continuous rating of 300 MW. Its minimum controllable rating is 60 MW, and its annual average load has been about 180 MW. The unit normally fires Western Kentucky No. 9, a high-slagging eastern bituminous coal, which limits the time the unit can operate at high load. The coal is quite variable in composition. Ash content varies from about 16 to 25 percent and fuel sulfur varies from 3.5 to 6.3 percent (dry bases). Particulate emissions are controlled by two single-stage Buell ESPs installed in parallel in a cold-side configuration. SO_2 emission control is provided by a dual-alkali FGD system developed by Combustion Equipment Associates, Inc., and Arthur D. Little, Inc.

The principal waste streams from the plant are flue gas, ash, scrubber filter cake, ash pond overflow, and discharge from a liquid sump in the scrubber circuit. Bottom ash, fly ash, and economizer ash are sluiced to an ash pond which also accepts ash and scrubber sludge from two other units at the site. Overflow from the pond and the liquid waste from the scrubber circuit are discharged into the Ohio River. Dewatered filter cake is sent to a separate on-site disposal area. Figure 1 is a simplified process flow diagram showing emission streams and sampling locations.

Summary and Conclusions

Level 1 flue gas sampling was conducted with the boiler operating at a constant load of 265 MW (gross), 88 percent of maximum capacity. Subsequent tests were performed while the boiler operated at lower loads, fluctuating from 170 to 249 MW. Approximately 30 percent excess air was used to combust the coal which, based on several analyses, was quite variable over the course of the test program. Coal ash and sulfur contents averaged 16 and 3.8 percent, respectively, during the test period. During Level 1 tests, one of the oil reheaters in the scrubber system was not in operation. Observations indicated that poor combustion conditions were common in one of the reheaters during the entire test period. On some

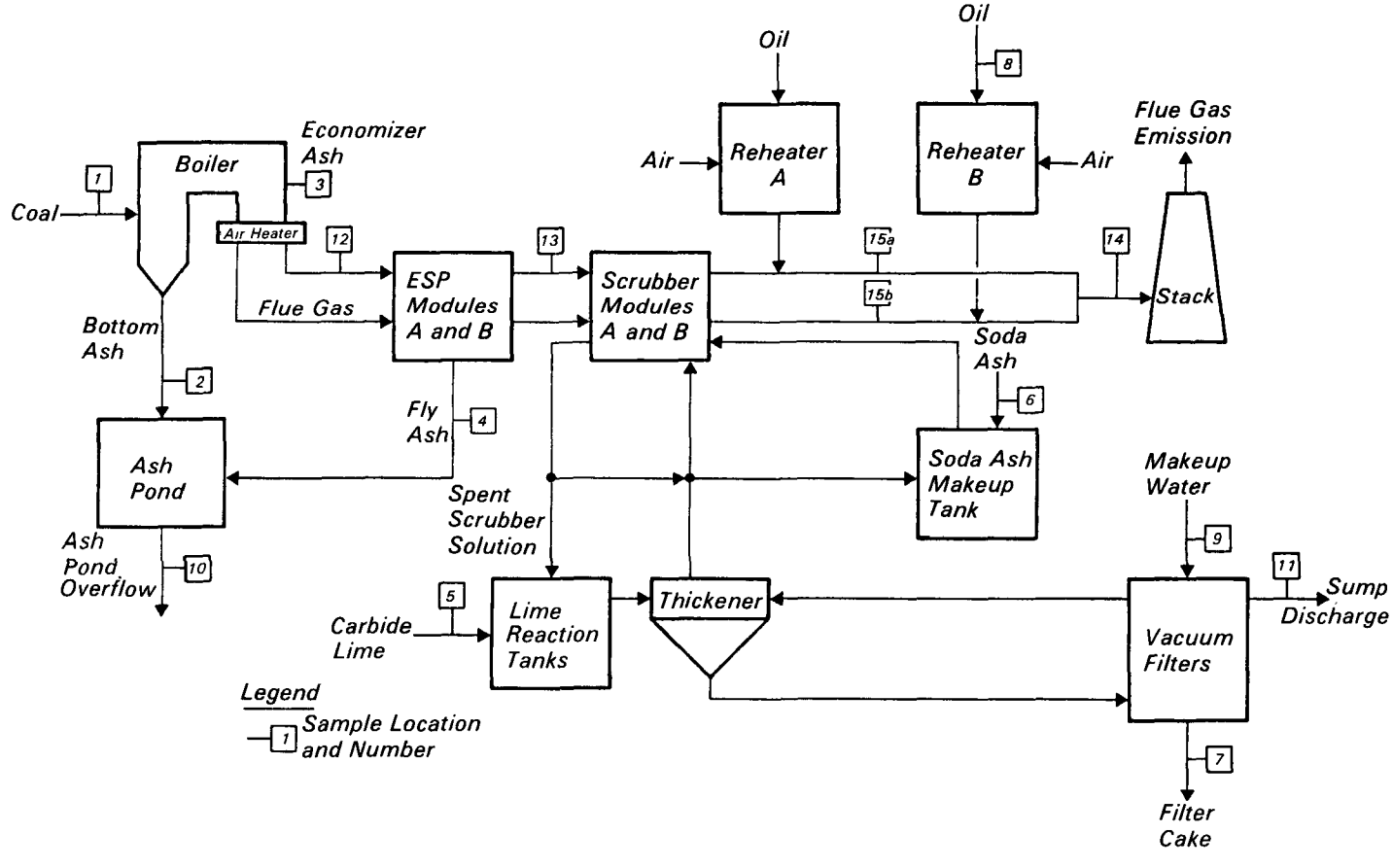

Figure 1. *Simplified process flow diagram of Cane Run No. 6.*

Level 2 test days, the scrubber system was operated in an "acid cleaning" mode which resulted in reduced SO_2 removal. This clouded interpretation of Level 2 sulfur species analyses.

Flue gas emissions are summarized in Table 1. Sulfur emissions data indicate an SO_2 scrubbing efficiency of 88 percent. Primary sulfate removal efficiencies were 48 percent across the ESP and 77 percent across the scrubber. Particulate sulfate emissions after scrubbing accounted for approximately 50 percent by weight of total particulate emissions, with about 10 percent of this particulate sulfate ascribed to entrainment of scrubber liquor.

NO_x was determined at 88 percent boiler load. These emissions averaged over 400 ng/J, which is considered high relative to other sources of this type.

CO data showed high variability. A 100 percent increase in average emissions (from 19 to 39 ng/J) was experienced across the scrubber. The increase can be attributed to poor combustion conditions in the oil reheaters.

Total particulate data indicated an ESP removal efficiency of 99.7 percent. A further reduction of 19 percent is made by scrubbing. At the ESP inlet, 53 percent by weight of the particulate was larger than 10 μm, 29 percent was 3-10 μm, 17 percent was 1-3 μm, and 1 percent was smaller than 1 μm. At the ESP outlet, 9 percent of the particulate was larger than 10 μm, 15 percent was 3-10 μm, 49 percent was 1-3 μm, and 27 percent was smaller than 1 μm. Of the particulate emissions to the atmosphere, 41 percent were larger than 3 μm, while 59 percent were less than 3 μm in diameter. Size distribution data obtained with an MRI impactor indicate that about 70 percent of the particulate (including H_2SO_4 aerosol) emissions to the atmosphere were less than 1 μm in diameter and capable of deep lung penetration.

Total organic emissions at the scrubber outlet ranged from 3.8 to 4.3 ng/J, and were composed primarily of C_1-C_6 organics. As with some other pollutants, organic emissions increased across the scrubber, most likely due to inputs from the oil-fired reheaters. Polycyclic organic matter (POM) was found to some extent in all three flue gas streams, but was by far most prevalent at the scrubber outlet. Phenanthrene had the highest concentration (37 $\mu g/m^3$) of the 17 POM compounds found at the scrubber outlet, and had the highest discharge severity, 0.023.

Table 1. Average Flue Gas Emissions

Pollutant	Emission Factor, ng/J		
	ESP Inlet	ESP Outlet	Scrubber Outlet
SO_2[a]	2270 ± 250[h]	2250 ± 240	273 ± 75
Primary Sulfate[b]	56	29	6.6
NO_x (as NO_2 at 88% load)[c]	408 ± 25	404 ± 13	419 ± 25
CO[d]	19 ± 20	19 ± 20	39 ± 15
Total Particulate[e]	3260	9.20	7.46
Total Organics[f]	0.87 - 1.4	1.8 - 2.3	3.8 - 4.3
NO_3^- [e]	0.0126 - 0.0359	0.0016	0.0018
Cl^- [g]	2.88	2.98 ± 0.60	0.175 ± 0.065
F^- [g]	4.26	3.37 ± 0.81	0.122 ± 0.017

[a] *Determined by pulsed fluorescence* (Level 2).
[b] *Best estimates based on combined data obtained with the CCS, SASS, and MRI impactor.*
[c] *Determined by chemiluminescence (Level 1).*
[d] *Determined by non-dispersive infrared (NDIR) analysis (Level 1).*
[e] *Determined with the SASS (Level 1). Nitrate was determined by extraction of the SASS particulate catch (Level 2).*
[f] *C_1-C_{16} fractions were determined by gas chromatography; $>C_{16}$ fraction was determined gravimetrically (Level 1).*
[g] *Determined with the CCS (Level 2).*
[h] *Data expressed as $\bar{x} \pm s$ are mean ± 1 standard deviation.*

Inorganic elemental analyses indicated that at least 17 elements exceeded their respective Discharge Multimedia Environmental Goal (DMEG)* levels at the ESP inlet, while only 4 elements exceeded their DMEG levels at the ESP outlet. Scrubber outlet data showed that only As, Cr, and Fe exceeded their DMEG values, and may be of environmental concern.

Specific anion analyses indicated emission levels of NO_3^-, Cl^-, and F^- were 0.0018, 0.175, and 0.122 ng/J, respectively. DMEG values have not been established for NO_3^-. Concentrations of Cl^- and F^- did not exceed their respective DMEG values at the scrubber outlet. Hence, these specific anions did not appear to pose a health hazard with short-term direct exposure.

Liquid streams analyzed included two streams which were discharged to a river: ash pond overflow and liquid from a sump in the scrubber circuit. In general, the elements posing the greatest environmental concern in these discharges (Al, Ca, Cd, Fe, Mn, Ni, P, and Pb) are all present at similar concentrations in makeup water from the river. Ca concentration increased in the pond discharge relative to the makeup because lime scrubber wastes from other units at the generating station were also disposed of in the ash pond. Organic content of the sump discharge was 0.283-0.290 mg/l and of the ash pond overflow, 0.002 to 0.011 mg/l. Traces of naphthalene were also found in the sump discharge.

Solid wastes include fly ash, economizer ash, bottom ash, and scrubber filter cake. The ashes contained three or four elements at concentrations exceeding health-based DMEG values and numerous elements exceeding ecology-based DMEG values. Elements of primary concern from a health standpoint included Al, As, Ca, Fe, and Mn. Filter cake exceeded health-based DMEG values for Ca and Fe, and numerous ecology-based DMEG values. Organics were present at the highest concentration in the filter cake (19.22 mg/kg), and included naphthalene, phenanthrene, and 11 other POM compounds.

*For background and charts for DMEGs, see EPA-600/7-77-136a/b (NTIS PB 276 919 and PB 276 920) and EPA-600/7-79-176a/b (NTIS PB 80-115 108 and PB 80-115 116).

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The complete report, entitled "Source Test and Evaluation Report: Cane Run Unit No. 6, Louisville Gas and Electric Co.," (Order No. PB 81-238 644; Cost: $11.00, subject to change) will be available only from:

National Technical Information Service
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