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ASSEMENT OF TOXIC EMISSION FROM A LIGNITE-FIRED POWER PLANT UTILIZING AN ESP/WET FLUE GAS DESULFURIZATION SYSTEM

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PARTICIPANTS

Sponsors	**Cost Shares**
Cooperative Power Association	$55,000
U.S. Department of Energy	890,919
ND Industrial Commission	55,000
Total	$1,000,919

Project Schedule – Eight Months
Contract Date – 12/6/93
Start Date - 6/21/93
Completed – 2/94

Projects Deliverables
Status Report – 11/93 ✓
Status Report – 12/93 ✓
Draft Final Report – 1/94 ✓
Final Report – 2/94 ✓

OBJECTIVE / STATEMENT OF WORK

This project is a comprehensive assessment of toxic emission from the Coal Creek Station Unit No. 1 near Underwood, North Dakota owned by Cooperative Power Association and United Power Association. This study was one of a group of assessments of toxic emissions from coal-fired power plants conducted for the Department of Energy Pittsburgh Energy Technology Center during 1993. The two principal objectives of the project are:

1. To collect and analyze representative solid, liquid, and gas samples from input and output streams of the Coal Creek Station for hazardous air pollutants and to assess the emission level of the pollutants;
2. To determine the removal efficiencies of the electrostatic precipitator and a wet flue gas desulfurization (FGD) system at the Coal Creek Station for toxic substances and to develop material balances for these control systems and the overall unit.

The Coal Creek Station is equipped with an electrostatic precipitator and a wet flue gas desulfurization unit. This study involves the analysis of solid, liquid, and gaseous samples from input, output, and process streams to determine a variety of toxic chemicals. Coal Creek Station is a two-unit, zero discharge, 1,100-megawatt, mine-mouth plant burning North Dakota lignite from the Falkirk Mine located adjacent to the plant.

STATUS

Measurements were taken and samples collected at the Coal Creek Station on June 21-24, 26 and 27, 1993. The samples were analyzed for the following:

1. Five major and 16 trace elements, including mercury, chromium, cadmium, lead, selenium, arsenic, beryllium, and nickel;
2. Acids and corresponding anions (HCI, HF, chloride, fluoride, phosphate, sulfur);
3. Ammonia and cyanide;
4. Elemental carbon;
5. Radio nuclides;
6. Volatile organic compounds (VOC);
7. Semi-volatile organic compound (SVOC) including polynuclear aromatic; Hydrocarbons (PAH), and polychlorinates, dioxins and furans; and
8. Aldehydes.

Some or all of these constituents were measured in solid, liquid, and gaseous input and output streams of the plant, and in the flue gas at key points within the plant. In addition, particle size distributions were determined for flue gas particulate matter and for collected ESP ash.

Emission for the various species were calculated based on stack gas flow rate and concentration measurements. Not unexpectedly, emission rates differ widely. Emission rates are presented in the final report in terms of pounds per 10 Btu (lb. 10 Btu) (Curies/10 Btu for radio nuclulide) and the total uncertainty (+). The main results of this study are summarized below.

Removal efficiencies and mass balances were calculated for the major and trace elements and ESP were greater than 99 percent for most of the elements.
Notable exceptions were cadmium and selenium with removal efficiencies of about 80-87 % and mercury, with an efficiency of less than 50 percent, consistent with its presence predominantly in the vapor phase removal. Removal efficiencies calculated for the absorber and scrubber showed wide variability, due to very low concentrations in the inlet and outlet flows.

Mass balances were calculated across individual plant components and groups of components for major and trace elements. Mass balance closure values (i.e., sum of outputs/inputs) were within + 50 percent of balance for most elements.

Particle size distributions of elements in the flue gas particulate matter were evaluated. For most elements the majority of the mass of the element in the gas occurs in the size range greater than 10 micrometers aerodynamic diameter, which comprised the bulk of the flue gas particulate. For a few elements, notably cadmium, selenium, vanadium, and lead, a substantial portion of the total flue gas loading is present in the size range less than 5 microns diameter.

Vapor/particle phase distributions of elements, PAH/SVOC, and dioxins/furans were determined. Most of the elements measured exist entirely in the particle phase under all flue gas conditions encountered at Coal Creek Station. Antimony, arsenic, lead, sodium, potassium, manganese, and boron, were distributed between the vapor and particle phase, in proportions that depend on the flue gas particulate loading temperature. At the stack, nearly all elements were found exclusively in the particle phase. Mercury alone was found almost entirely in the vapor phase at all flue gas locations where measured. Most PAH and SVOC compounds were found almost exclusively in the vapor phase, consistent with their volatility and the flue gas temperatures. Benzo- (a)-pyrene and other PAHs having five or more aromatic rings in their molecular structure were found only in the particle phase. A few PAH and SVOC of intermediate characteristics were distributed between the vapor and particle phases. Relatively few dioxins/furan compounds could be detected in flue gas.

This was an extensive study. The final report consists of three volumes containing a great deal of detail, data, statistical analysis, conclusions, and recommendations.