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AIR EMISSIONS TESTS OF A DEUTSCHE BABCOCK ANLAGEN DRY SCRUBBER SYSTEM AT THE MUNICH NORTH REFUSE-FIRED POWER PLANT

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Scope Of Work

The testing protocol and scope of work was developed during the week of May 14, 1984, in Krefeld, West Germany, between the technical staffs of DBA, Belco, and Cooper Engineers. After a preliminary site visit on May 16, 1984, the testing protocol was revised to best meet the objectives of the testing. The testing was conducted at operating conditions which would be typical of operations at refuse-fired power plants in the U.S. The three major tasks were as follows:

Task 1 Two days of simultaneous testing for SO_x (SO_2 and SO_3), HCl, and Particulate Removal Across the Dry Scrubber - ESP during high removal efficiency operating conditions.

Task 2 On-site Laboratory Analysis.

Task 3 Particle Size Distribution, Selected Heavy Metals Emissions, and Distribution of Heavy Metals by Particle Size at the ESP Outlet.

The test methods were U.S. EPA approved or equivalent so that DBA and Belco could compare prior and future performance data taken using West German methods to data acceptable to U.S. regulatory agencies. Test arrangements were handled by the on-site DBA technical staff.

Plant Description

General

The Munich North Refuse-Fired Power Plant went on line in February 1984. This is the third block of a three-block installation located north of downtown Munich, West Germany. Blocks 1 and 2 are coal and mixed fuel fired, and are relatively old units.

Block 3 consists of two incinerator-boiler units, each designed to burn 22 tons per hour of municipal refuse and 12 tons per hour of clarifier sludge from the adjacent sewage treatment plant. Each boiler is rated at 110,000 pounds per hour steam production.

The entire plant, including the gas cleaning equipment, is enclosed by an architecturally pleasing building in keeping with the location of the plant in suburban Munich (Figure 1). Although the original facility was surrounded by farm land, most of this acreage has been displaced by urban expansion. On three sides of the plant, housing (both multiple and single family), shopping centers, and light commercial industries now abut the plant (Figures 2 and 3). On the fourth side (Figure 4), farming (mostly safflower) struggles to survive among single-family housing developments. Due to the proximity of housing (less than 500 feet), enclosure of the facility was necessary both for visual aesthetics and for noise control.

The continuing housing encroachment to the plant boundary and the lack of reported neighbor complaints or concerns indicate that this facility deserves the designation as a "good neighbor".

Plant Layout

Refuse is delivered to the plant six days a week (providing for continuous operation) mostly by enclosed packer trucks. The trucks are unloaded within an enclosed tipping hall with roll up doors for truck access. The refuse is stored within a concrete bunker and transferred to the incinerator feed chutes by means of overhead cranes.

The sewage sludge with a solids content of approximately 25% is delivered by pipeline from the adjacent sewage treatment plant. It is predried in an integral mill-dryer using recycled flue gas. The dried sludge is then blown into the fire chamber above the grate.

During the test period no sewage sludge was fired as the sludge delivery system between the sewage treatment plant and the Munich North plant was not complete.

Each incinerator is a mass-fired reciprocating grate with water-wall boiler above. The firing rate is controlled by O_2 and temperature monitors in the first boiler pass which regulate the refuse feed rate and combustion air flow. The refuse feed rate is determined by the stroke rate of a hydraulic feeder under the feed chute. Air flow is controlled by an inlet damper on the primary air fan.

The bottom ash falls off the end of the grate into a water quench ash extractor. A bar grizzly at the extractor discharge separates oversize materials (mostly metal) from the ash which is transported by belt conveyor to the ash bunker. The oversize material is manually removed to a dumpster.

Flue Gas Control System

The flue gas from the boiler (at about 500°F) discharges into a DBA dry scrubber reactor followed by a DBA electrostatic precipitator.

The lower inlet section of the dry scrubber reactor is a cyclonic preseparator where approximately 70% of the fly ash is removed from the flue gas and pneumatically transported to the ash bunker.

From the preseparator section the flue gas flows upward through a distribution grid and into 10 flow tubes arranged annularly on the reactor perimeter. Each tube contains a dual fluid nozzle used for spraying the lime slurry into the gas stream. The atomized lime slurry is a composite of concentrated lime slurry (200 g/l) and dilution water. Compressed air is used for atomization. The calcium component of the lime slurry droplet reacts with the flue gas components SO_x and HCL. The acid gases are removed from the flue gas by an absorption-reaction process while the water component of the droplet is evaporated. The result is a dry particulate which includes calcium salts and excess lime. The evaporation process lowers the temperature of the flue gas to approximately 300°F.

The solid reaction products from the dry scrubber reactor, together with the dust that has passed through the cyclone, are carried over into a two-field electrostatic precipitator and removed from the flue gas. The collected material is mechanically and pneumatically transported to the ash bunker. The cleaned flue gas exits through a concrete stack. Continuous emissions monitoring and control equipment are located near the base of the stack. Figure 5 is a process flow sheet.

The process control schematic (Figure 6) shows the two control loops of the DBA dry scrubber system. The lime slurry is prepared from CaO in a slaker. Lime slurry is

supplied to the spray nozzles by means of a ring manifold assuring uniform slurry distribution to each nozzle. The required amount of slurry delivered to the nozzles is determined by the HCl content measured in the clean gas. When the raw gas load changes, the lime slurry rate is adjusted accordingly by means of this feedback control loop, and hence the HCl emission rate remains relatively constant.

A second control loop maintains a constant temperature at the precipitator inlet by the addition of water to the lime slurry immediately before the nozzles. This operating temperature has been optimized for removal of both acid gases and dust.

Due to the combined action of the two control loops, the concentration of the slurry at the nozzles fluctuates between 20 and 100 g/l in accordance with the HCl concentration contained in the raw gas and its temperature.

If a spray nozzle has to be replaced, or rather if individual nozzles have been shut off, the required lime slurry rates are automatically distributed over the nozzles still in operation. Up to three of the 10 nozzles can be shut off at the same time without affecting the HCl emissions. Only the lime consumption will be increased. Here the marked advantage of a spray system consisting of several individual nozzles becomes obvious because the necessary servicing which is required for each spray nozzle can be carried out without any effect on the acid gas emission rates.

Air Emissions Testing Methodology

Sampling Locations

The dry scrubber inlet sampling location and the ESP outlet sampling location are shown in Figure 5. The ESP outlet sampling ports were located in a straight section of rectangular ducting that was approximately two and one-half equivalent diameters long. There were flow straightening vanes located upstream from the sampling ports. The ESP outlet sampling ports consisted of four 3-inch ports located in the duct according to the U.S. EPA Method 1. The dry scrubber inlet sampling ports were located in a straight section of ducting that was approximately one equivalent diameter long, with five 3-inch ports (only three ports were available for testing) that were located in the duct according to the U.S. EPA Method 1.

Sampling Methods

The sampling methods used to extract and analyze the gas samples from the dry scrubber inlet and the ESP outlet are detailed below. Described are sampling and analysis for initial molecular weight and percent water, velocity traverse and volumetric flow rate, particulate emissions, sulfur oxides, acid gas, and aerodynamic particle size by the Andersen Mark III Cascade Impactor and the Flowsensor Multiclone. The sampling methods, in general, followed the U.S. EPA test methods as given in the Code of Federal Regulations, Title 40, Part 60, Appendix A.

Parameter	Test Method
Gas analysis for molecular weight	U.S. EPA Method 3
Moisture in stack gases	U.S. EPA Method 4
Velocity traverse points	U.S. EPA Method 1
Velocity and volumetric flow rate	U.S. EPA Method 2
Particulate, SO_2, SO_3 emissions	U.S. EPA Method 5/8

The combination train, U.S. EPA Method 5/8, is a Method 5 train on the front half and a Method 8 on the back half of the train. This allows the determination of particulate, particulates with condensibles, SO_2 and SO_3 emissions with one train. Particle sizing was performed with a typical Andersen train: an Andersen Cascade Impactor connected via tubing to a condensing section and then a pump/meter set-up. The three-stage Flowsensor Multiclone was set up similarly but the cyclone allows for more sample to be collected, so heavy metals could be determined on the fractions collected.

Heavy metals were analyzed by atomic absorption by Brown and Caldwell Environmental Laboratory, Emeryville, California, from samples taken from the particulate catch of the Multiclone.

The "acid gas train" was a U.S. EPA Method 6 type train, except that distilled water was used in the impingers. The train was used to determine hydrogen chloride emissions.

Sampling Schedule

The final testing schedule is presented in Table I.

Air Emissions Test Data

General

The results of the air emissions testing, including plant process data, air pollutant emissions and the dry scrubber-ESP system efficiencies, are contained in this five-part section. Each part includes the presentation of the field data in discussion or tabular form.

Plant Process Data

The process requirements of the dry scrubber system during the test program were selected to meet the criteria listed in Table VIII. The emission values of importance were the guidelines on emission limits set forth by the California Air Resources Board (30 ppm dry volume @ 12% CO_2 for sulfur dioxide and hydrogen chloride).

The HCl feedback control mechanism required that outlet HCl concentration be used as the controlled variable. The SO_2 emissions were an uncontrolled variable.

Table II summarizes the desired HCl emission values at the ESP outlet and the flue gas temperature at the dry scrubber reactor outlet versus the actual recorded values during the test runs.

The HCl emissions strip chart from July 20, 1984, shown in Figure 7, shows the ability of the control system to maintain levelized HCl emissions with modulated lime slurry feed rates. The flue gas temperature strip chart for the same period, shown in Figure 8, indicates the constant dry scrubber reactor outlet temperature which is maintained by modulated dilution water flows.

Flue Gas Flow Rates During Testing

The flue gas flow data are shown in Table III as uncorrected flows and as SDCFM @ 7% O_2 and 12% CO_2. These data are calculated from the results of the U.S. EPA Methods 2, 3, and 4 runs concurrent with the Method 5/8 particulate runs.

Particulate Matter Emissions

Inlet and outlet particulate loadings and particle size distributions are shown in Tables IV and V, respectively. Table IV shows the U.S. EPA Method 5/8 results as gr/SDCF uncorrected and gr/SDCF @ 12% CO_2. The outlet particulate mass flow rate in lb/hr, also shown in Table IV, is a product of the gr/SDCF and the flue gas flow rates from Table III.

Table V shows the inlet and outlet particle size distributions as measured by Multiclone and by Andersen Cascade Impactor. The table also shows the total grain loadings obtained. It should be noted that these total grain loadings are for reference only and are obtained from the Andersen and Multiclone runs. These grain loadings are considered to be less accurate than the grain loadings measured by the U.S. EPA Method 5 because the Andersen and Multiclone measurements are made at a single point of average velocity in the duct, whereas Method 5 measurements are made by traversing the duct in accordance with the U.S. EPA Method 1 and with the filter outside the duct.

Heavy Metals Emissions

The outlet concentrations of selected heavy metals measured from the Multiclone particulate catch are summarized in Table VI. The results are expressed as percent by weight of the total particulate and as percent of each heavy metal in each particle size range. Also, total heavy metals emissions are expressed in pounds of heavy metal emitted per ton of MSW fuel fired.

HCl and SO_x Emissions and Control Efficiencies

The inlet and outlet HCl and SO_x concentrations are shown in Table VII. These data are expressed as ppmdv uncorrected and as ppmdv @ 12% CO_2. The calculated HCl and SO_x removal efficiencies are also shown. These data are discussed further with respect to process data and plant operation in the subsequent section on performance.

Performance Of The DBA Dry Scrubber - ESP

General

The intent of the Munich North Test Program was to establish the ability of the DBA Dry Scrubber - ESP system to maintain air pollutant emissions at levels acceptable in the United States. Table VIII lists the current guidelines and regulations for refuse-fired units in West Germany and several American states. Test conditions were selected to optimize the DBA system performance but were limited during the testing by certain plant operating requirements beyond DBA's control.

Presented below are the comparisons of the DBA system performance for HCl and SO_x removal, total particulate removal, and fine (<2 um) particulate removal against the levels presented in Table VIII. Also discussed are the heavy metals emissions.

HCl and SO_x Removal

The time-weighted average emission levels for HCl and SO_x during almost six hours of simultaneous inlet and outlet performance testing were 27.8 and 21.7 ppmdv at @12% CO_2, respectively, as shown in Table VII. These levels are below all the criteria given in Table VIII for these air pollutants. In addition, the average removal efficiencies for HCl and SO_x were 94.8% and 76.4%, respectively, yielding higher efficiencies than required in Table VIII.

SECTION VI

PERFORMANCE OF THE DEUTSCHE BABCOCK ANLAGEN DRY SCRUBBER - ESP AT THE MUNICH NORTH REFUSE-FIRED POWER PLANT

A. GENERAL

The intent of the Munich North Test Program was to establish the ability of the Deutsche Babcock Anlagen Dry Scrubber - ESP system to maintain air pollutant emissions at levels acceptable in the United States. Table 8 lists the current guidelines and regulations for refuse-fired units in West Germany and several American states. Test conditions were selected to optimize the DBA system's performance but were limited during the testing by certain plant operating requirements beyond DBA's control.

Presented below are the comparisons of the DBA system's performance for HCl and SO_x removal, total particulate removal, and fine (<2 μm) particulate removal against the levels presented in Table 8. Also discussed are the heavy metal emissions.

B. HCl AND SO_x REMOVAL

The time-weighted average emission levels for HCl and SO_x during almost six hours of simultaneous inlet and outlet performance testing were 27.8 and 21.7 ppmdv at @12% CO_2, respectively, as shown in Table 7. These levels are below all the criteria given in Table 8 for these air pollutants. In addition, the average removal efficiencies for HCl and SO_x were 94.8% and 76.4%, respectively, yielding higher efficiencies than required in Table 8.

Each test run had different operating conditions as dictated by the plant operators and DBA. Run 1 was a short outlet test only and is not included in the averages. Run 2 was performed during a period when the continuous HCl analyzer/controller was not operating and the reagent feed rate was held constant at a high level. The dry scrubber outlet controlling temperature was set lower than normal (130 vs 160°C). The stoichiometric ratio (α) for Run 2 was 7.1, and correspondingly, the HCl and SO_x emissions were the lowest.

Run 3 and Run 4 had the continuous HCl analyzer/controller in operation and set at one-half of the 1984 West German standard, 30 mg/NM^3 versus 60 mg/NM^3 at 11% outlet O_2 (wet). In addition, the dry scrubber outlet controlling temperature was raised from Run 2 to 145°C, still lower than the normal setting of 160°C, but requiring more reagent slurry to be fed to meet the lower HCl set-point instead of feeding dilution water. The α's for Runs 3 and 4 were 6.6 and 3.7, respectively. A lower SO_x inlet level affected Run 3's α, as only HCl was being used as a control variable, not SO_2 and HCl. According to the 1984 West German regulations, and thus the plant design, only HCl control is required. Run 5 saw the dry scrubber outlet controlling temperature raised to 160°C, dictated by the plant operators, while the HCl set-point was lowered to 15-20 mg/NM^3 (the lowest HCl control level possible at the plant). The use of reagent slurry based on the lowest HCl control setting in conjunction with the higher dry scrubber outlet temperature setting saw the α rise to 8.5 to produce the low HCl and SO_x emissions. The DBA dry scrubbing control system would be designed differently for operation in the United States, including control with SO_2 feedback and lower dry scrubber outlet temperatures.

C. TOTAL PARTICULATE REMOVAL

Based on the average of four of the U.S. EPA Method 5 ESP outlet grainloadings from Table 4, the performance of the dry scrubber - ESP equalled or was below all criteria for particulate emissions in Table 8. Where the inlet and outlet testing was performed simultaneously and under DBA observation and control, the average outlet grainloading was even lower, i.e., 0.0079 gr/DSCF @ 12% CO_2.

D. FINE (<2 μm) PARTICULATE REMOVAL

Using the particulate size distribution data obtained with the Andersen Cascade Impactor in Table 5, i.e., 45.6% less than 2 μm, the performance of the dry scrubber - ESP was well below the criteria for fine particulate emissions in Table 8, based on the total average outlet grainloading. Were the data on particle sizing to be compared to the average grainloadings of Runs 2, 3, and 4, the emission of fine particulate would be even less. The particle size data from the Multiclone was obtained during almost 40 hours of sampling required for heavy metal analysis. DBA had no control over plant operation during the majority of the test, as shown by the higher outlet grainloading, i.e., 0.031 gr/DSCF @ 12% CO_2, and the Multiclone data should only be used for a worst-case analysis.

Figure 1. Munich North Resource Recovery Facility.

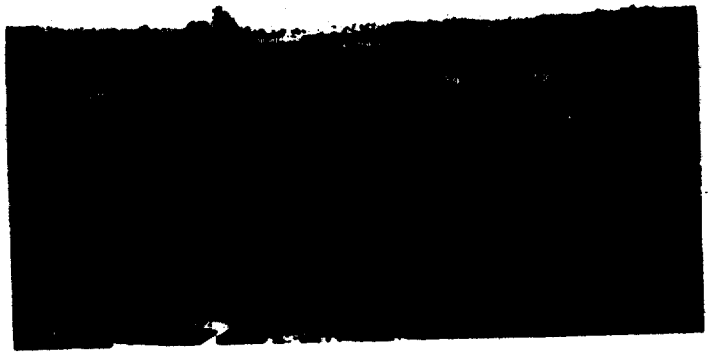

Figure 2. Munich North Resource Recovery Facility.

Figure 3. Munich North Resource Recovery Facility.

Figure 4. Munich North Resource Recovery Facility.

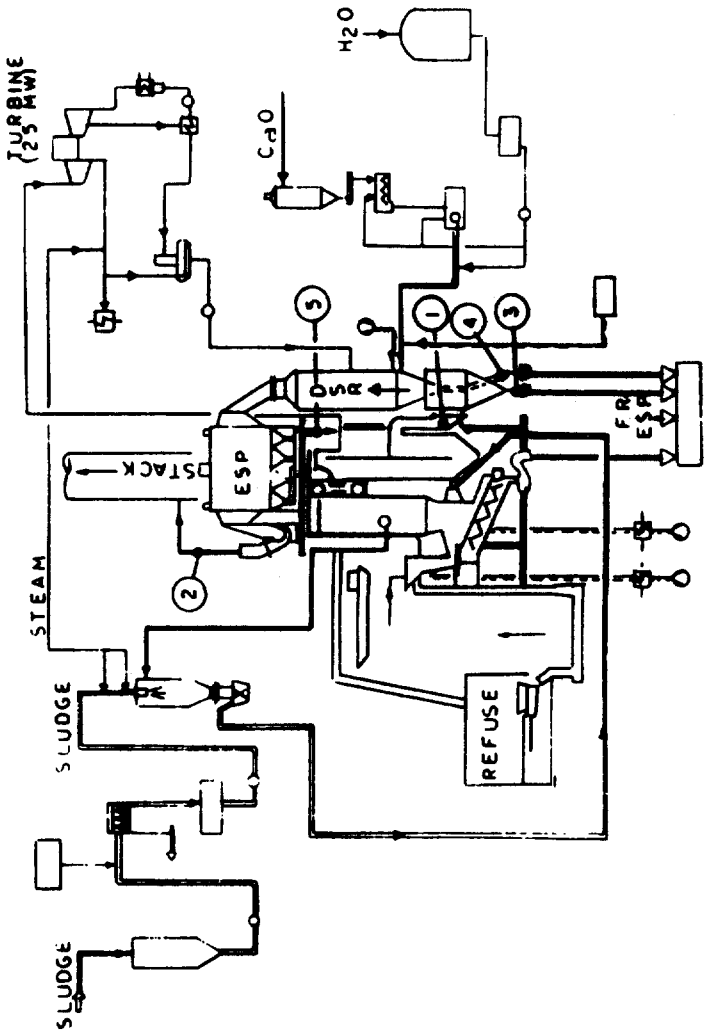

Figure 5. Munich North process flow sheet.

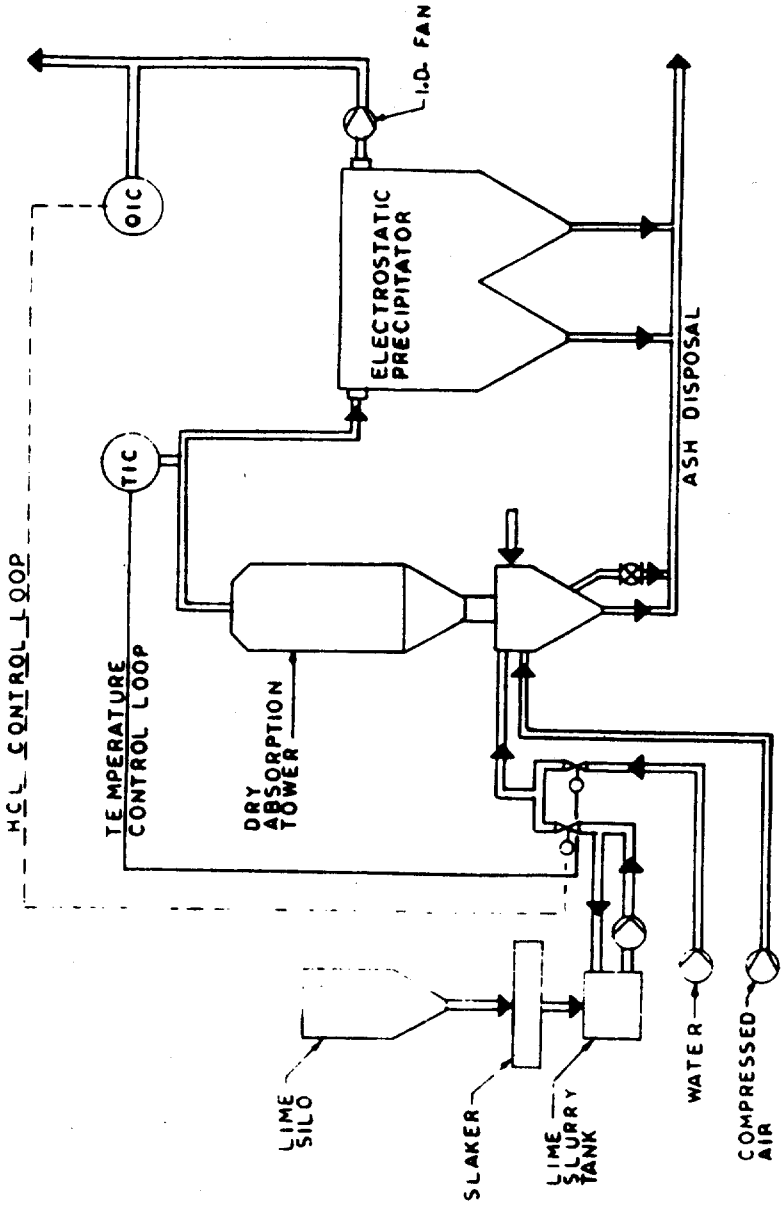

Figure 6. Process control schematic.

Table 1. Final testing schedule.

Test No.		
	Monday, July 16, 1984	
	1800-2000	1. Flue gas velocity profile and initial moisture analysis. 2. Locations - Dry Scrubber inlet and ESP outlet.
	Tuesday, July 17, 1984	
1	1431-1501	1. U.S. EPA Methods 2, 3, and 4. 2. U.S. EPA Method 6 for SO_x. 3. U.S. EPA Method 6 (modified) for HCl. 4. Location - ESP outlet.
2	1739-1922	1. U.S. EPA Methods 2, 3, and 4. 2. U.S. EPA Method 5/8 for particulate (including condensibles) and SO_x. 3. U.S. EPA Method 6 (modified) for HCl. 4. Locations - Dry Scrubber inlet and ESP outlet.
	Wednesday, July 18, 1984	
3	0942-1113	1. U.S. EPA Methods 2, 3, and 4. 2. U.S. EPA Method 5/8 for particulate (including condensibles) and SO_x. 3. U.S. EPA Method 6 (modified) for HCl. 4. Locations - Dry Scrubber inlet and ESP outlet.
4	1515-1641	1. U.S. EPA Methods 2, 3, and 4. 2. U.S. EPA Method 5/8 for particulate (including condensibles) and SO_x. 3. U.S. EPA Method 6 (modified) for HCl. 4. Locations - Dry Scrubber inlet and ESP outlet.
	1700	1. Multiclone for heavy metals emissions and particle size distribution - start of run. 2. Location - ESP outlet.
	Thursday, July 19, 1984	
	0500-1600	1. Andersen Cascade Impactor for particle size distribution. 2. Location - ESP outlet.
	0927-0932	1. Andersen Cascade Impactor. 2. Location - Dry Scrubber inlet.
	1141-1146	1. Andersen Cascade Impactor. 2. Location - Dry Scrubber inlet.
	1245-1345	1. Multiclone. 2. Location - Dry Scrubber inlet.
	1612-1712	1. Multiclone. 2. Location - Dry Scrubber inlet.

Table I. continued

Test No.		
	Friday, July 20, 1984	
	0900	1. Multiclone for heavy metals emissions and particle size distribution - end of run. 2. Location ESP outlet.
5	0938-1105	1. U.S. EPA Methods 2, 3, and 4. 2. U.S. EPA Method 5/8 particulate (including condensibles) and SO_x. 3. U.S. EPA Method 6 (modified) for HCl. 4. Location - Dry Scrubber inlet and ESP outlet. (Note: The U.S. EPA Method 6 was used for SO_x only at the Dry Scrubber inlet)

Table II. Operating parameters of the Deutsche Babcock Anlagen Dry Scrubber - ESP System.

Test No.	Date	HCl Emissions ppmdv @ 12% CO_2 Setpoint	HCl Emissions ppmdv @ 12% CO_2 Actual	Dry Scrubber Reactor Outlet Temperature (°F) Setpoint	Dry Scrubber Reactor Outlet Temperature (°F) Measured	Lime Slurry lb/min	Lime Slurry Wt %
1	7/17/84	Variable	24.5	266	295	18.5	18.0
2	7/17/84	Variable	4.5	266	300	22.6	22.0
3	7/18/84	30	35.5	293	330	21.1	18.0
4	7/18/84	30	45.9	293	330	14.9	18.0
5	7/20/84	15-20	25.2	300	314	19.5	17.5
						avg. 19.3	18.7

SPS Calculations for reagent feed rate (RFR):

RFR = Slurry feed rate × wt %

= (19.3 lb/min)(0.189) = 3.61 lb/min

= 217 lb/hr

Calculation for H_2O quench rate (HQR):

HQR = Slurry feed rate (1 - wt%)

= 19.3 lb/min (0.813) = 15.7 lb/min

∴ = 15.7 lb/min $\frac{1 \text{ gal.}}{8.33 \text{ lb}}$ = 1.88 gpm

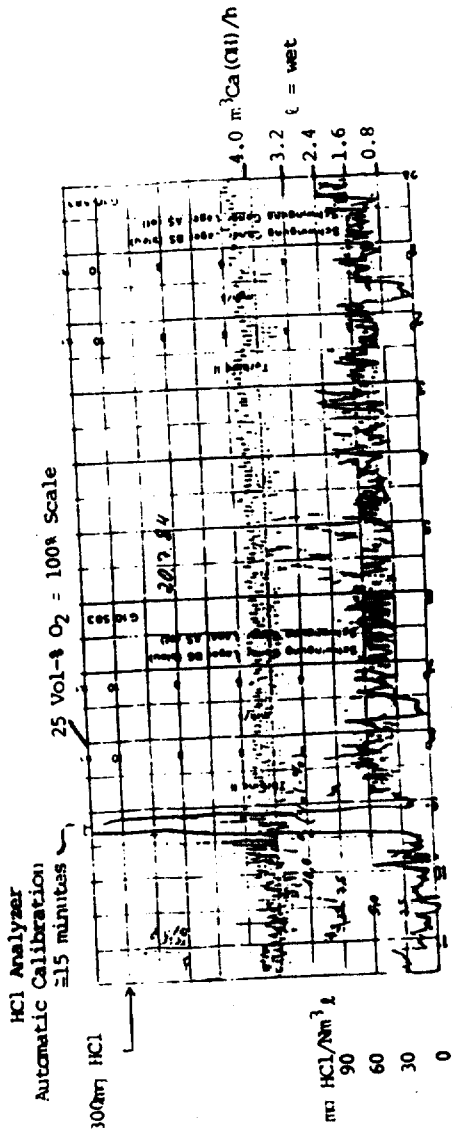

Figure 7. HCl emissions strip chart, July 20, 1984.

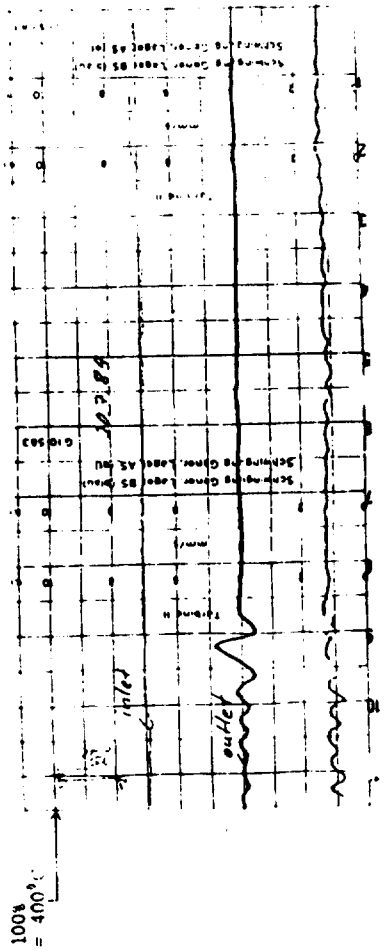

Figure 8. Flue gas temperature strip chart, July 20, 1984.

Table III. Velocity and volumetric flow data summary.

Run ID	Time	Average Velocity ft/sec	Gas Composition, %			Temp.	Volumetric Flow				
			O_2	CO_2	H_2O	°F	ACFM	SCFM	SDCFM	SDCFM @ 7% O_2	SDCFM @ 12% CO_2
Run 2 Inlet 7/17/84	1739 - 1922	27.4	12.2	6.3	16.0	516	155,400	77,700	65,300	40,900	45,200
Run 2 Outlet 7/17/84	1727 - 1854	43.5	13.0	7.5	24.0	300	150,000	96,500	73,300	41,700	45,800
Run 3 Inlet 7/18/84	0942 - 1113	25.8	11.2	8.0	11.1	515	146,400	73,300	65,200	45,500	43,500
Run 3 Outlet 7/18/84	0944 - 1107	42.2	12.5	7.8	14.0	330	145,600	90,000	77,400	46,800	45,200
Run 4 Inlet 7/18/84	1515 - 1641	27.3	11.3	8.0	15.8	500	154,800	78,700	66,300	45,800	44,200
Run 4 Outlet 7/18/84	1506 - 1635	42.5	12.1	7.3	16.8	330	146,500	90,700	75,500	47,800	45,900
Run 5 Outlet 7/20/84	0938 - 1105	42.0	12.5	7.0[a]	15.0	314	144,900	91,900	78,100	47,200	45,600

[a] Estimated from the plant oxygen monitor located at the ESP outlet.

Avg:
- Inlet 8.1 510 152,200 65,600
- Outlet 7.2 319 76,100

TABLE IV. Particulate data - Method 5/8.

Run ID	Inlet Concentration gr/SDCF (uncorrected)					Outlet Concentration gr/SDCF (uncorrected)					Outlet lb/hr		
	Time	% CO_2	Front	Back	Total	Time	% CO_2	Front	Back	Total	Front	Back	Total
2 7/17/84	1739 - 1922	8.3	1.890	0.125	2.015	1727 - 1854	7.5	0.0056	0.0065	0.0121	3.53	4.09	7.62
3 7/18/84	0942 - 1113	8.0	1.478	0.070	1.548	0944 - 1107	7.0	0.0038	0.0099	0.0137	2.52	6.58	9.10
4 7/18/84	1515 - 1641	8.0	2.482	0.004	2.486	1506 - 1635	7.3	0.0050	0.0012	0.0062	3.23	0.78	4.01
5 7/20/84			1.950	0.066	2.016	0938 - 1105	7.0[a]	0.0102 / 0.0062	0.0020 / 0.0049	0.0122 / 0.0111	6.83 / 4.03	1.33 / 3.19	8.16 / 7.22

Run ID	gr/SDCF @ 12% CO_2			gr/SDCF @ 12% CO_2		
2 7/17/84	2.730	0.101	2.916	0.0090	0.0104	0.0194
3 7/18/84	2.217	0.105	2.322	0.0065	0.0170	0.0235
4 7/18/84	3.725	0.006	3.729	0.0082	0.0020	0.0102
5 7/20/84	2.892	0.097	2.989	0.0175 / 0.0104	0.0034 / 0.0082	0.0209 / 0.0185

[a] Estimated from plant oxygen monitor located at ESP outlet.

Table 5. Particulate data - Multiclone and Andersen Cascade Impactor.

ANDERSEN

Run ID	Time	Microns	Particle Size Distribution, % <0.6[a]	0.6	0.9	1.5	3.1	4.9	7.3	10.8	17.3	>17.3	Front Half Total Particulate[b] gr/SDCF	gr/SDCF @ 12 CO_2
Run 1 Inlet 7/19/84	0927 - 0938		4.7	5.9	1.9	1.4	3.1	2.5	6.0	8.0	32.5	>32.5	1.182	1.755
Run 2 Inlet 7/19/84	1141 - 1146		4.9	5.7	5.9	1.1	2.6	2.7	6.2	11.7	29.4	29.9	0.941	1.393
		Microns	<0.4[a]	0.4	0.7	1.1	2.3	3.7	5.4	8.0	12.9	>12.9		
Run 1 Outlet 7/19/84	0500 - 1600		9.1	10.1	16.2	10.1	8.1	6.0	4.8	7.4	9.1	19.1	0.0065	0.0096

MULTICLONE

		Microns	Particle Size Distribution, % <1.9[a]	1.9	>10.5		
Run 1 Inlet 7/19/84	1245 - 1345		14.1	9.3	76.6	1.050	1.526
Run 2 Inlet 7/19/84	1613 - 1712		17.7	10.5	71.9	0.954	1.398
		Microns	<1.3[a]	1.3	>8.3		
Run 1 Outlet 7/18 - 7/20	39.67 hrs.		71.4	25.4	3.2	0.019	0.031

[a] Aerodynamic particle size with mean cut diameter in microns (typical).

[b] Multiclone and Andersen particulate data are single point samples.

Table VI. Heavy metals emission factors and weight percent on particulate.

ESP OUTLET TEST
(% wt by cut diameter)

Cut Diameter	>8.3u	1.3u	<1.3u	% wt of total particulate	Emissions[a] Factors lb/ton
Element					
Cd	14	68	18	0.036	6.58×10^{-5}
Tl	ND	ND	100	6.9×10^{-6}	1.26×10^{-8}
Be	ND	ND	100	2.1×10^{-6}	3.86×10^{-9}
As	10	14	76	0.0019	3.56×10^{-6}
Cr	<1	18	82	4.3	8.04×10^{-3}
Co	<1	23	77	0.07	1.28×10^{-4}
Ni	<1	21	79	2.0	3.73×10^{-3}
Se	ND	ND	ND	—	—
Te	ND	ND	ND	--	--
Sb	30	39	31	0.011	2.01×10^{-5}
Pb	25	46	29	0.37	6.85×10^{-4}
Cu	22	50	28	0.025	4.57×10^{-5}
Mn	<1	23	77	0.48	8.95×10^{-4}
V	5	16	79	0.011	2.01×10^{-5}
Ba	19	34	47	0.027	4.94×10^{-5}
Zn	16	52	32	1.7	3.06×10^{-3}
Sn	5	8	87	0.15	2.70×10^{-4}
Sc	ND	ND	ND	--	--

[a] Based upon the design MSW feed rate of 22 tons/hr.
u = micron (micrometer).
<1 = Less than one percent.
ND = Below the level of detection.
Metals in the impinger solution were included with the metals on the filter to give a total for the <1.3u value fraction.

NOTE TO EDITORS

Table VII. HCl and SO_x emissions and removal efficiencies.

		Dry Scrubber Inlet		ESP Outlet			
	Test	HCl ppmdv Uncorrected	SO_x ppmdv Uncorrected	HCl ppmdv Uncorrected	SO_x ppmdv Uncorrected	Removal Efficiency, %	
Date	No.	(@ 12% CO_2)	(@ 12% CO_2)	(@ 12% CO_2)	(@ 12% CO_2)	HCl	SO_x
7/17/84	1	NR (—)	NR (—)	13.3 (24.5)	11.1 (22.2)	NR	NR
7/17/84	2	368 (531)	65.8 (95)	2.8 (4.5)	7.3 (11.7)	99.2	87.7
7/18/84	3	434 (651)	36.0 (54)	20.7 (35.5)	8.9 (15.3)	94.5	71.7
7/18/84	4	453 (680)	85.0 (128)	27.9 (45.9)	23.1 (38.0)	93.3	70.3
7/20/84	5	219 (324)	60.3 (89)	14.7 (25.2)	12.3 (21.1)	92.2	76.4
Average of Runs 2, 3, 4, and 5		368 (546)	61.8 (92)	16.5 (27.8)	12.9 (21.7)	94.8	76.4

NR = Not Reported.

Table VIII. 1984 Air emission guidelines and regulations.

	Sulfur Dioxide	Hydrogen Chloride	Solid Particulate	Correction Gas Percentage
West Germany	100 mg/Nm^3 (38 ppm)	60 mg/Nm^3 (~~39.5~~ 36.9 ppm)	75 mg/Nm^3 (0.03 gr/SDCF)	11% O_2, wet basis
California	30 ppm	30 ppm	0.01 gr/SDCF & 0.008 gr/SDCF for < 2 micron	12% CO_2, dry basis
New Jersey	100 ppm or 70% wt. reduction	50 ppm or 90% wt. reduction	0.02 gr/SDCF	7% O_2, dry basis
Connecticut	0.32 lb/10^6 Btu	50 ppm or 90% wt. reduction	0.015 gr/SDCF	12% CO_2, dry basis