

AIR POLLUTION EMISSION TEST

TEXAS UTILITY COMPANY, INC.

Big Brown Station

Fairfield, Texas

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park, North Carolina

NITROGEN OXIDES EMISSION MEASUREMENTS
FROM LIGNITE-FIRED POWER PLANT

EMB Projects Report No.

75-LSG-3

Plant Tested

Texas Utility Company, Inc.
Fairfield, Texas

September 30 and October 1, 2, 3 and 4, 1974
October 10, 11 and 12, 1974

Prepared for

Environmental Protection Agency
Office of Air Quality Planning and Standards
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I. INTRODUCTION

Monsanto Research Corporation (MRC) was contracted under the Environmental Protection Agency's "Field Sampling of Atmospheric Emissions" program to provide emission data from the two lignite fired boilers at the Big Brown Station of the Texas Utility Company at Fairfield, Texas.

The field test work was directed by Joseph F. Peoples, Jr., Field Testing Section, Emission Measurement Branch. The sampling was performed by MRC with William R. Feairheller, Jr. as Team Leader. The sampling schedule was planned by Arthur D. Little, Inc. Robert Wilson and Keith O'Neal of A. D. Little, Inc. observed the testing and were responsible for ensuring that the process variables were changed according to their schedule. The results of the sampling program will be used in a study which is being conducted by A. D. Little, Inc. under contract to the EPA.

This report tabulates the data collected from Unit No. 1 and Unit No. 2, two identical 575 MW lignite fired boilers, at the Big Brown Station. Sampling was conducted on September 30 and October 1, 2, 3 and 4, 1974 on Unit No. 2. Unit No. 1 was tested on October 10, 11 and 12, 1974. The primary goal of this sampling program was to obtain nitrogen oxides (NO_x) data to develop standards of performance for new lignite fired steam generators. NO_x concentrations have been

determined by using Method 7, "Determination of Nitrogen Oxide Emissions from Stationary Sources" Federal Register, Vol. 36, No. 247, December 23, 1971, and by continuously monitoring the NO_x levels with a Dynasciences Air Pollution Monitor.

Sampling was performed on two similar exhaust stacks, each 121.92 meters (400 feet) tall. The exhaust gases from each unit passed through a Research-Cottrell electrostatic precipitator before entering the stack. The sampling was performed at the 82.30 meter (270 foot) level where a permanent platform was located. No modifications were necessary to prepare the stacks for sampling.

Along with the Method 7 tests (which were run every half hour) and the continuous monitoring of NO_x, the following EPA methods were also followed, as applicable, on each stack: Method 1 "Sample and Velocity Traverses for Stationary Sources;" Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)," performed every hour; Method 3, "Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight," performed every half hour; and Method 4, "Determination of Moisture in Stack Gases," performed three times a day. All of the above methods are given in the Federal Register, Vol. 36, No. 247, December 23, 1971.

Lignite samples were also collected from both units. The samples were brought to MRC laboratories for analysis of Btu content, sulfur and ash content, moisture, volatility and ultimate analysis for C, H, N and O content.

This report includes a summary of results, description of the process, location of sampling points and traverse data, process operating conditions, and sampling and analytical procedures. Appendices include all field and analytical data from this sampling project.

II. PROCESS DESCRIPTION AND OPERATION

Two similar units were tested during this test program. Each unit was a CE dual furnace steam generator with a 575 MW rated load. Each of the twin furnaces in each unit was fired by four vertical columns of eight burners. One column is placed in each corner in such a way that tangential flame motion is induced in the furnace.

Coal is carried from eight bowl mills by heated primary air to the 64 burners through a network of ducting as illustrated in Figure 1. The primary air makes up about 35% of total air at full load. Since each bowl mill feeds one level throughout the eight corners, it is possible to cut off the coal feed to any level by shutting down the mill. It is conventional procedure at Big Brown to fire with the uppermost level off. Since secondary air continues to flow through the idle burner level, a form of overfire air occurs under normal operations. Secondary air is preheated to 760°F to assist in lignite volatilization.

The excess air was normally set to give between 2.8 and 3.6% O₂ at the furnace exit. Values in the range 2.9 to 4.4% O₂ could be reached for limited duration.

Three basic parameters characterize furnace operation: the chemical energy feed rate, the overall air flow and the air distribution to active burners. Although gross load (MW)

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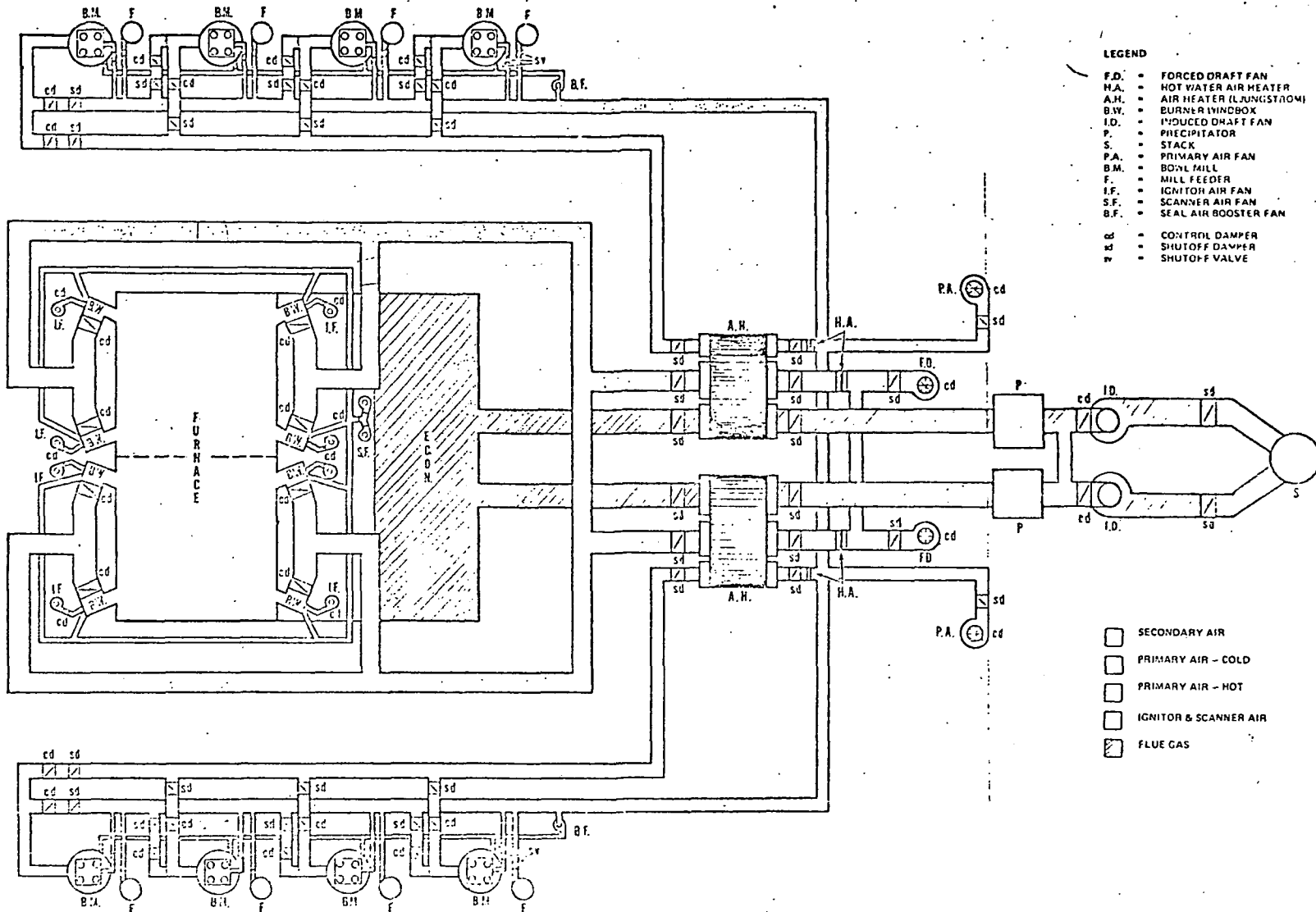


Figure 1. Air and Gas Flow Schematic for Furnaces

and excess O₂ are "output" variables, they were used as convenient and reliable indices for "input" chemical energy and overall air flow. This interchangeability is justified because combustion is essentially complete and boiler efficiency is nearly constant.

The air flow to active burners (as percent of stoichiometric) was controlled and estimated as follows: burner air flow was varied by withholding fuel (but not air) from the top burner level. Three conditions could be set up: no overfire with all burners operating, moderate overfire with secondary air to the top idled burner level, or maximum overfire with primary and secondary air to the top idled burner level. These air flows were recorded and estimated from the plant's instruments.

Additional variables known to affect NO_x were also recorded: windbox temperature and pressure, ambient humidity, and fuel nitrogen content. Sufficient steam cycle measurements were recorded to construct an energy balance and verify normal operation of each boiler. A copy of the process data collected can be found in Appendix D. Table 1 gives a summary of plant operating conditions.

Operating conditions during any of the identified test phases were subject to changes because of the nature of plant operation. For example, it was not unusual for excess oxygen to fluctuate between 2.7 and 3.3 percent within one-half hour when set at 3.0 percent. The reason for this drift is that electrical output and steam flow typically are maintained constant within about ±0.5 percent by continually adjusting excess air or burner tilt to compensate for transient slag buildup, coal heating value, or air flow variations. This drift contributes to the scatter in successive NO_x measurements

Table 1

SUMMARY OF PLANT OPERATING DATA (Big Brown Units 1 and 2)

	DATE	INTERVAL	CONDITION	GROSS LOAD(MW)	COAL FEED RATE (lbs/hr, as rec'd)	BURNER-AIR* (% Stoich)	
Big Brown Unit #2	9/30/74	1200-1545	Baseline (Moderate overfire)	601	839,000	105	
		1600-1630	Low load	483	666,000	105	
		1700-1800	Baseline	-	823,000	-	
10/1/74	0900-1045	0900-1045	Baseline	597	801,000	104	
		1100-1410	Low excess air	598	807,500	103	
		1430-1600	Baseline	599	825,000	105	
10/2/74	0800-0930	0800-0930	High excess air	593	801,000	111	
		0945-1300	No overfire (all burners on)	586	800,500	116	
		1315-1500	Baseline	595	810,000	104	
10/3/74	0700-0945	0700-0945	High excess air	601	827,500	109	
		1000-1100	Baseline	602	825,000	106	
		1120-1315	Max overfire (level-H primary air)	601	840,000	101	
		1330-1400	Baseline	600	828,000	104	
10/4/74	0900-0930	0900-0930	High excess air	595	840,000	107	
		0945-1230	Max overfire and low excess air	594	845,500	114	
		1245-1530	Baseline	592	831,500	104	
Big Brown Unit #1	10/10/74	1300-1800	Special test (level B off)	577	826,500	105	
		10/11/74	0945-1040	Max overfire	596	860,000	101
			1050-1345	No overfire (all burners on)	595	853,500	117
			1400-1600	Baseline	596	836,500	104
10/12/74	0900-1410	0900-1410	Baseline	598	866,000	108	
		1420-1600	Max overfire and high air	597	869,000	104	

*Estimated based on excess oxygen measurements before the air preheater and the number (and location) of inactive burners.

taken at one-half hour intervals. Therefore, the averaged NO_x data corresponds to an average condition representative of the range over which the boiler conditions drifted.

III. SUMMARY AND DISCUSSION OF RESULTS

The NO_x , CO_2 , O_2 and moisture content, and stack velocity and temperature were obtained at the stacks of the Big Brown steam plant during both normal operation and under various conditions of modified operation. A summary of the averaged results for Unit No. 1 with the corresponding run conditions is given in Table 2. The averaged results from Unit No. 2 are given in Table 3. The results of the sampling program on a day by day basis are given in Tables 4-11. The Method 7 NO_x data are given in ppm of NO_2 on a dry basis. The Dynasciences data recorded on a continuous basis was read from the chart every 10 minutes and the value obtained at a time corresponding to each EPA-7 result was recorded on the Table.

Emissions from Boiler No. 2 were measured during the first week of sampling (Sept. 30 to Oct. 4). The boiler was operated under normal conditions on the first day to provide baseline emission rate data. The initial samples, analyzed for CO_2 and O_2 content, indicated only air. The monitor values for NO_x were about 100 ppm rather than about 350 ppm as expected. The probe system, consisting of two stainless probes and one glass probe in a common sheath, was sealed around the probes and also between the sheath and port. The monitor and integrated gas samples were initially withdrawn at the rate required for each instrument. After it was found that the gas samples were contaminated with

Table 2

Summary of Averaged Test Results - Big Brown Station Steam Generating Plant - Unit No. 1

Date	Test Phase	Gas Flow DSCFM 10 ⁶	No. of Samples Averaged		ppm		lb/hr		kg/hr		lb/10 ⁶ Btu		gm/10 ⁶ cal.	
			EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.
10/10	Special Test (1300-1800)	1.44	10	11	301	389	3101	4007	1407	1818	.58	.75	1.04	1.35
10/11	Max Overfire (0945-1040)	1.24	4	4	295	310	2605	2738	1182	1242	.48	.51	.86	.92
	No Overfire (1050-1345)	1.26	6	6	337	368	3048	3334	1383	1512	.57	.63	1.03	1.13
	Baseline (1400-1600)	1.35	3	3	349	313	3375	3030	1531	1375	.65	.58	1.17	1.04
10/12	Baseline (0900-1410)	1.47	11	11	299	333	3159	3520	1433	1597	.57	.64	1.03	1.15
	Max Overfire and High Air (1420-1600)	1.49	3	4	268	317	2883	3390	1308	1538	.52	.61	.94	1.10

Table 3

Summary of Averaged Test Results - Big Brown Station Steam Generating Plant - Unit No. 2

Date	Test Phase	Gas Flow DSCFM 10 ⁶	No. of Samples Averaged		ppm		lb/hr		kg/hr		lb/10 ⁶ Btu		gm/10 ⁶ cal.	
			EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.	EPA-7	Dyna.
9/30	Baseline (1200-1545)	1.32	8	-	296	-	2803	-	1271	-	.54	-	.97	-
	Low Load (1600-1630)	1.32	2	-	334	-	2154	-	1431	-	.76	-	1.37	-
	Baseline (1700-1800)													
10/01	Baseline (0900-1045)	1.26	2	1	314	411	2816	3651	1277	1656	.58	.75	1.05	1.36
	Low Excess Air (1100-1410)	1.28	6	4	325	378	2957	3448	1341	1564	.61	.71	1.09	1.27
	Baseline (1430-1600)	1.28	3	4	370	376	3380	3430	1533	1556	.68	.69	1.22	1.24
10/02	High Excess Air (0800-0930)	1.38	1	1	268	225	2650	2224	1202	1009	.51	.43	0.92	.77
	No Overfire (0945-1300)	1.33	4	8	335	326	3189	3107	1447	1409	.61	.59	1.10	1.06
	Baseline (1315-1500)	1.32	2	5	307	316	2965	3062	1345	1389	.57	.58	1.02	1.04
10/03	High Excess Air (0700-0945)	1.56	3	-	305	-	3441	-	1561	-	.67	-	1.21	-
	Baseline (1000-1100)	1.39	1	2	267	403	2659	4008	1206	1818	.52	.79	.94	1.42
	Max Overfire (1120-1315)	1.42	2	2	252	200	2582	2006	1171	910	.90	.39	1.61	.69
	Baseline (1330-1400)	1.45	-	3	-	248	-	2580	-	1170	-	.51	-	.92
10/04	High Excess Air (0900-0930)	1.50	-	1	-	375	-	4029	-	1828	-	.82	-	1.48
	Max Overfire & Low Excess Air (0945-1230)	1.36	3	4	319	293	3330	1510	3196	1450	.68	.62	1.22	1.12
	Baseline (1245-1530)	1.40	2	1	273	55	2914	587	1322	266	.60	.12	1.07	.21

Table 4

Summary of Test Results - September 30, 1974

P.S. - 29.86 - Coal Heating Value - 6240 Btu/lb

Time	Moisture	Dry MW	DSCFM 10 ⁶	Nm ³ /sec.	Coal Feed Rate 10 ³ lb/hr	Method 7 NO _x				
						ppm	lb/hr	kg/hr	lb/10 ⁶ Btu	gm/10 ⁶ cal.
1200	12.5	30.3	1.31	620	839	254	2384	1081	.46	.82
1230						262	2459	1115	.47	.85
1300			1.32	625		299	2827	1282	.54	.97
1330						279	2638	1197	.50	.91
1400			1.34	631		309	2966	1345	.57	1.02
1430						338	3245	1472	.62	1.12
1500			1.32	624		314	2969	1347	.57	1.02
1530						310	2932	1330	.56	1.01
1611			1.32		666	331	3130	1420	.75	1.36
1613						336	3177	1441	.76	1.38

Table 5

Summary of Test Results - October 1, 1974

P.S. - 29.48 - Coal Heating Value - 6040 Btu/lb

Time	Moisture	Dry MW	DSCFM		Coal Feed Rate 10 ³ lb/hr	Method 7 NO _x				Dynascience Continuous Monitor									
			10 ⁶	Nm ³ /sec.		ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.
945	16.0	30.4	1.27	602	801														
1010						289	2629	1192	.54	.98									
1045			1.24	585		338	3003	1362	.62	1.12	411	3651	1656	.75					1.36
1120					807.5	345	3114	1192	.64	1.15	370	3340	1515	.68					1.23
1145	14.9	30.2	1.26	595		335	3024	1372	.62	1.12									
1200						317	2861	1298	.59	1.06									
1245			1.27	599		328	2984	1354	.61	1.10	390	3548	1609	.73					1.31
1330						346	3148	1428	.65	1.16	385	3503	1589	.72					1.29
1345			1.30	614		280	2608	1183	.53	.96	365	3399	1542	.70					1.25
1430					825						365	3321	1506	.67					1.20
1445	16.0	30.4	1.27	598															
1500						357	3248	1473	.65	1.17	372	3385	1535	.68					1.22
1530						413	3758	1705	.75	1.36	385	3503	1589	.70					1.27
1545			1.29	608															
1600						339	3133	1421	.63	1.13	380	3512	1593	.70					1.27

Table 6

Summary of Test Results - October 2, 1974

P.S. - 29.60 - Coal Heating Value - 6480 Btu/lb

Time	Moisture Dry	MW	DSCFM		Coal Feed Rate			Method 7 NO _x			Dynascience Continuous Monitor							
			10 ⁶	Nm ³ /sec.	10 ³ lb/hr	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶
915	13.4	30.4	1.38	650	801	268	2650	1202	.51	.92	225	2224	1009	.43	.77			
1015					807.5	334	3158	1432	.60	1.09	350	3310	1501	.63	1.14			
1030	14.5	30.5	1.32	625		307	2903	1317	.55	1.00	380	3593	1630	.69	1.24			
1050											370	3499	1587	.67	1.20			
1115			1.33	629							320	3049	1383	.58	1.05			
1130						354	3373	1530	.64	1.16	310	2954	1340	.56	1.02			
1215			1.34	634							315	3024	1372	.58	1.04			
1230											315	3024	1372	.58	1.04			
1300						346	3322	1507	.63	1.14	250	2400	1089	.46	.83			
1340	15.6	30.4	1.34	634	810						280	2688	1219	.51	.92			
1400						304	2918	1324	.56	1.00	320	3072	1393	.59	1.05			
1420			1.36	642							320	3118	1414	.60	1.08			
1440						309	3011	1366	.57	1.03	325	3166	1436	.60	1.09			
1515			1.36	642							335	3264	1481	.62	1.12			

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Table 7

Summary of Test Results - October 3, 1974

P.S. - 29.60 - Coal Heating Value - 6190 Btu/lb

Time	Moisture	Dry MW	DSCFM		Coal Feed Rate 10 ³ lb/hr	Method 7 NO _x					Dynascience Continuous Monitor							
			10 ⁶	Nm ³ /sec.		ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶
725	4.9	30.4	1.57	741	827.5	306	3442	1561	.67	1.21								
800						300	3374	1530	.66	1.19								
820			1.59	752		308	3508	1591	.68	1.23								
900																		
940			1.53	723														
1000					825						370	3684	1671	.72	1.30			
1020	18.2	30.3	1.39	655							435	4332	1965	.85	1.53			
1100											267	2659	1206	.52	.94			
1125	16.2	30.4	1.43	673	840	295	3022	1371	.58	1.05								
1200						209	2141	971	.41	.74								
1215			1.40	661							200	2006	910	.39	.69			
1300											200	2006	910	.39	.69			
1340	14.1	30.5	1.45	684	828						220	2285	1036	.45	.80			
											250	2597	1178	.51	.91			
											275	2857	1296	.56	1.00			

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Table 8

Summary of Test Results - October 4, 1974

P.S. - 29.53 - Coal Heating Value - 5820 Btu/lb

Time	Moisture	Dry MW	DSCFM		Coal Feed Rate 10 ³ lb/hr	Method 7 NO _x				Dynascience Continuous Monitor								
			10 ⁶	Nm ³ /sec.		ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶
915	11.7	30.3	1.50	707	840					375	4029	1828	.82	1.48				
1015	12.1	30.4	1.47	695	845.5					500	5264	2388	1.07	1.93				
1030						358	3769	1710	.77	1.38								
1115			1.45	684		288	2991	1357	.61	1.09								
1130						311	3230	1465	.66	1.18	310	3219	1460	.65	1.18			
1215			1.44	679						275	2836	1286	.58	1.04				
1230										85	877	398	.18	.32				
1310	12.4	30.3	1.49	703		275	2935	1331	.60	1.07	55	587	266	.12	.21			
1320						271	2892	1312	.59	1.06								

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Table 9

Summary of Test Results - October 10, 1974

P.S. - 29.37 - Coal Heating Value - 6450 Btu/lb

Time	Moisture	Dry MW	DSCFM		Coal Feed Rate		Method 7 NO _x				Dynascience Continuous Monitor								
			10 ⁶	Nm ³ /sec.	10 ³	lb/hr	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶
1300						862.5							380	3947	1790	.74			1.33
1330	12.8	30.4	1.45	684			342	3553	1612	.67	1.20		375	3895	1767	.73			1.32
1400							318	3303	1498	.62	1.12		375	3895	1767	.73			1.32
1430			1.42	668			197	2004	909	.38	.68		365	3713	1684	.70			1.25
1500							180	1831	831	.34	.62		390	3967	1799	.74			1.34
1540			1.43	674			278	2848	1292	.53	.96		380	3893	1766	.73			1.31
1600							337	3452	1566	.65	1.17		400	4098	1859	.77			1.38
1630			1.45	684			357	3708	1682	.70	1.25		405	4207	1908	.79			1.42
1700							314	3252	1480	.61	1.10		395	4103	1861	.77			1.39
1740			1.44	679			305	3146	1427	.59	1.06		405	4178	1895	.78			1.41
1750							378	3900	1769	.73	1.32		405	4178	1895	.78			1.41

Table 10

Summary of Test Results - October 11, 1974

P.S. - 29.64 - Coal Heating Value - 6250 Btu/lb

Time	Moisture	Dry MW	DSCFM		Coal Feed Rate		Method 7 NO _x				Dynamicscience Continuous Monitor									
			10 ⁶	Nm ³ /sec.	10 ³	lb/hr	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.
900						860	274	2414	1095	.45	.81	295	2599	1179	.48	.87				
930	11.6	30.4	1.23	580			288	2538	1151	.47	.85	285	2511	1139	.47	.84				
1000							301	2652	1203	.49	.89	300	2644	1199	.49	.89				
1030			1.24	587			317	2816	1277	.52	.94	360	3198	1451	.59	1.07				
1100						853.5	349	3150	1429	.59	1.06	370	3340	1515	.63	1.13				
1130	12.0	30.4	1.26	596			368	3322	1507	.62	1.12	375	3385	1535	.63	1.14				
1200							361	3259	1478	.61	1.10	370	3340	1515	.63	1.13				
1230			1.27	601			327	2975	1349	.56	1.00	365	3321	1506	.62	1.12				
1300							295	2684	1217	.50	.91	370	3366	1527	.63	1.14				
1330			1.26	594			321	2898	1315	.54	.98	360	3250	1474	.61	1.10				
1400						836.5	420	4062	1842	.78	1.40	310	2998	1360	.57	1.03				
1430	11.2	30.5	1.35	635			335	3240	1470	.62	1.12	310	2998	1360	.57	1.03				
1500							292	2824	1281	.54	.97	320	3095	1404	.59	1.07				

Table 11

Summary of Test Results - October 12, 1974

P.S. - 29.64 - Coal Heating Value - 6390 Btu/lb

Time	Moisture Dry	MW	DSCFM		Coal Feed Rate			Method 7 NO _x				Dynamics Continuous Monitor				
			10 ⁶	Nm ³ /sec.	10 ³ lb/hr	ppm	lb/hr	kg/hr	lb/10 ⁶	Btu	gm/10 ⁶	cal.	ppm	lb/hr	kg/hr	lb/10 ⁶
900	14.7	30.4	1.47	693	866	290	3054	1385	.55	.99	330	3475	1576	.63	1.13	
930						294	3096	1404	.56	1.01	315	3317	1505	.60	1.08	
1000			1.48	697		294	3117	1414	.56	1.01	328	3478	1578	.63	1.13	
1030						308	3266	1481	.59	1.06	330	3499	1587	.63	1.14	
1100			1.48	697		255	2704	1227	.49	.88	334	3541	1606	.64	1.15	
1130						321	3403	1544	.62	1.11	323	3425	1554	.62	1.11	
1200			1.44	680		309	3188	1446	.58	1.04	335	3456	1568	.62	1.12	
1230						313	3229	1465	.58	1.05	325	3353	1521	.61	1.09	
1300			1.51	711		245	2650	1202	.48	.86	345	3732	1693	.67	1.21	
1330						329	3559	1614	.64	1.16	350	3786	1717	.68	1.23	
1400			1.46	689		333	3483	1580	.63	1.13	350	3661	1661	.66	1.19	
1430	12.5	30.4			866	316	3396	1540	.61	1.10	330	3546	1608	.64	1.15	
1500			1.50	706		191	2052	931	.37	.67	320	3439	1560	.62	1.12	
1530						298	3202	1452	.58	1.04	305	3278	1487	.59	1.07	
1600			1.47	694							313	3296	1495	.60	1.07	

ambient air, the sampling interface was modified by connecting the probes to metal bellows pumps operated at maximum capacity and samples were then withdrawn from "T"s in these lines at flow rates comparable to those of the monitor (28 l/hr) and the integrated gas sampler (28 l/min.). After this correction, reasonable values were obtained from the monitor and the gas sampler.

Numerous problems were encountered with the monitor. It was observed that the indicated value increased rapidly with increasing ambient temperature and that low ambient (10°C and below) temperature prevented stabilization on the calibration gas. This effect was observed on both Oct. 3 and Oct. 4. According to the literature supplied with the monitor, operation is possible from +5 to 49°C. However, if the ambient temperature varies, the calibration will change. For the second week the monitor was heated to about 40°C to maintain a constant sensor temperature and thus eliminate major drifts. Operation during the second week was reliable and valid data were obtained.

The results obtained from the Method 7 NO_x determinations are quite varied and indicate that the scatter of data during an operating condition is greater than the variation in NO_x due to changes in the operating conditions. The procedures used were as specified in the Federal Register. Identical techniques were employed for sampling and the analysis of all samples with one exception. During the analysis of one group of samples, representing for the most part baseline conditions from Oct. 1 to Oct. 4, it was found that the hood fan ceased operation and condensate from the hood dripped into the samples, giving invalid high NO_x results. The data for these samples are shown in parentheses on the data sheets in the appendices but have been omitted from the summary tables in this section as they do not represent actual stack emissions.

Line voltage variations were a major problem during the testing of Unit No. 2. At the times when the sampling equipment was in operation, the line voltage was observed to drop as low as 92 volts. In order to lessen the problem of voltage drop, the various pieces of sampling equipment were not run simultaneously. The digital thermometer was only used when the other equipment was not being used. The calibration of the thermometer was checked at least twice a day to insure that the voltage drop was not affecting the temperature readout. The Dynascience monitor and the recorder seemed to be noticeably affected. The continuous readout from the recorder was noticeably lower when other equipment or heaters were running. When values were read from the chart paper, they were adjusted to account for sudden drops due to a lower voltage. An additional power line was used for the Dynascience monitor and recorder on October 3 and 4. A battery powered recorder was also used to help alleviate the problem of changing voltage.

The test data from September 30 indicate the following NO_x baseline data: an average of 303 ppm, a moisture level of 12.9%, and gas emissions contents of 6.3% O₂ and 12.9% CO₂. On successive days the baseline data vary greatly. The studies on Boiler No. 1 indicate less variation in the NO_x baseline data, especially as measured with the monitor, but even on this unit the variation is significant. As a result, it is necessary to observe the baseline data obtained before and after an operating parameter was changed in order to evaluate the change in NO_x concentration resulting from that change.

The problems encountered during the first week of sampling were corrected before the program began on Boiler No. 1. As a result, the data obtained from the second week are more reliable, and the effects of process variables can be observed.

During the sampling program coal samples were gathered for proximate and ultimate analysis and BTU content to be completed at the laboratory. The proximate analysis included percent moisture, volatile, ash and fixed carbon. The ultimate analysis included percent carbon, hydrogen, nitrogen, sulfur and ash. These samples were gathered from the conveyors feeding the silos above the pulverizers at one half-hour intervals. The samples were composited on site to provide a single sample daily and a portion of this daily sample was returned to Dayton in a sealed plastic bottle for analyses. All analyses were performed on a sample ground to pass a 60 mesh sieve. The results are shown in Table 12. All the results are reported on the as determined basis except the BTU value. The BTU samples were oven dried and analyzed and the results were calculated to the as determined basis using the percent moisture figure.

In reviewing the sampling program, there are three recommendations we feel are important to future programs of this type:

1. The monitor should be heated and maintained at a constant temperature above ambient temperature to prevent calibration drift.

Table 12

	Lignite Analysis							
	<u>9-30-74</u>	<u>10-01-74</u>	<u>10-02-74</u>	<u>10-03-74</u>	<u>10-04-74</u>	<u>10-10-74</u>	<u>10-11-74</u>	<u>10-12-74</u>
% Moisture	30.53	33.45	33.09	32.47	33.86	32.75	31.77	30.67
% Volatile	11.49	11.15	10.07	4.82	12.18	8.67	20.96	5.43
% Ash	13.16	11.41	10.35	12.64	14.01	10.93	10.81	12.74
% Fixed Carbon	44.82	43.99	46.49	50.17	39.95	47.65	36.46	51.16
BTU/lb (Oven-dried)	8980	9060	9680	9160	8810	9600	9160	9230
BTU/lb (As Determined)*	6240	6040	6480	6190	5820	6450	6250	6390
% Carbon	52.66	46.16	55.13	49.80	53.08	49.53	51.76	50.90
% Hydrogen	4.07	3.82	4.16	4.22	4.14	4.18	4.19	4.13
% Nitrogen	1.01	2.60	0.84	0.89	0.95	1.05	1.14	1.27
% Oxygen	28.23	35.24	28.74	31.70	27.01	33.57	31.17	30.37
% Sulfur	0.87	0.77	0.78	0.75	0.81	0.74	0.93	0.59

*All results are as determined basis and this BTU value was calculated from the oven-dried results.

2. All electronic instrumentation including the continuous NO_x monitor and recorders should have a power circuit isolated from that for instrument heating and other fluctuating sources. When fluctuating and/or reduced line voltage can be expected, a portable power supply is suggested.

3. Consideration should be given to the design of an adequate sample probe collection system to interface the analyzer to the stack to eliminate ambient air being drawn into the system and contaminating the sample. Drawing a large volume of sample into the probe and then removing a portion of this sample for analysis is recommended when high stack velocity situations are encountered. This method reduces the response time of the system and also assures that adequate stack gas will be supplied to the instrument provided there are no leaks in the sampling system.

IV. SAMPLING POINTS

Sampling was conducted on the outlet stacks of both units. Unit No. 2 was tested Sept. 30-Oct. 4 and Unit #1 was tested Oct. 10-12. The combustion gases from each unit passed through an electrostatic precipitator (ESP) before being exhausted out the stack. Method 1, 2, 3, 4, and 7 tests were performed on each stack. (NO_x concentrations were continuously monitored with a Dynasciences Air Pollution Monitor) during the time the EPA Method 7 testings was being performed.

Sampling was done through 4 ports, 90° apart from each other. The ports were located 73.2 meters (240 feet) above the inlet to the stack (approximately 9.9 stack diameters) and 39.6 meter (130 feet) upstream of the outlet (approximately 5.4 stack diameters). EPA Method 1 criterion was satisfied by using a total of 12 traverse points.

Both stacks have inside diameters of 7.39 meters (291 inches). However, Unit No. 1 has an outside diameter of 10.23 meters (403 inches) and Unit No. 2 has an outside diameter of 10.11 meters (398 inches) at the sampling location. Figure 2 shows the location of the ports on both stacks, while Figures 3 and 4 show the location of the 12 traverse points. The ports consisted of a large square door on each outer stack and a 0.15 meter (6 inches) cylindrical port in the stack of Unit No. 2. A 0.1 meter (4 inches) cylindrical port was

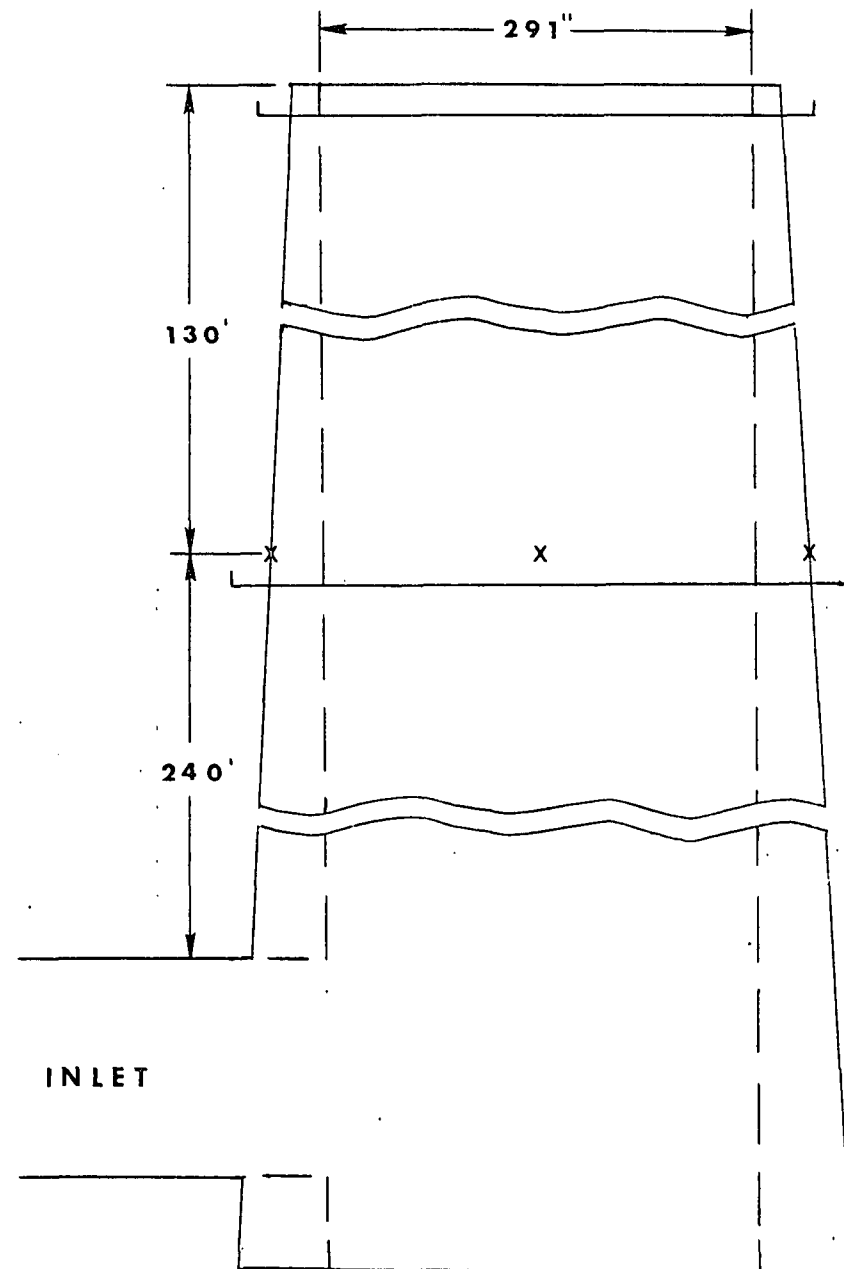


Figure 2. Sample Port Locations

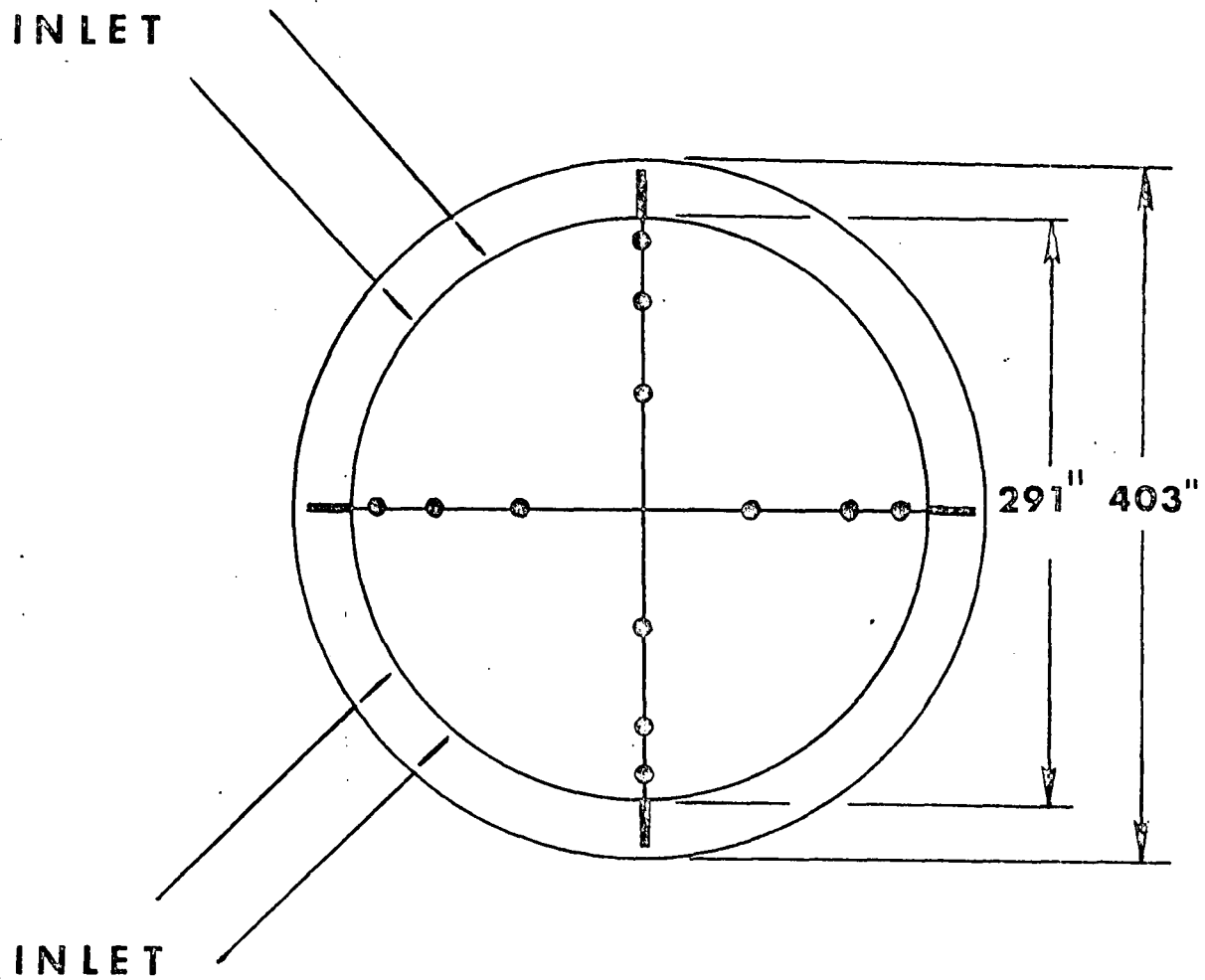


Figure 3. Traverse Locations Unit No. 1

INLET

INLET

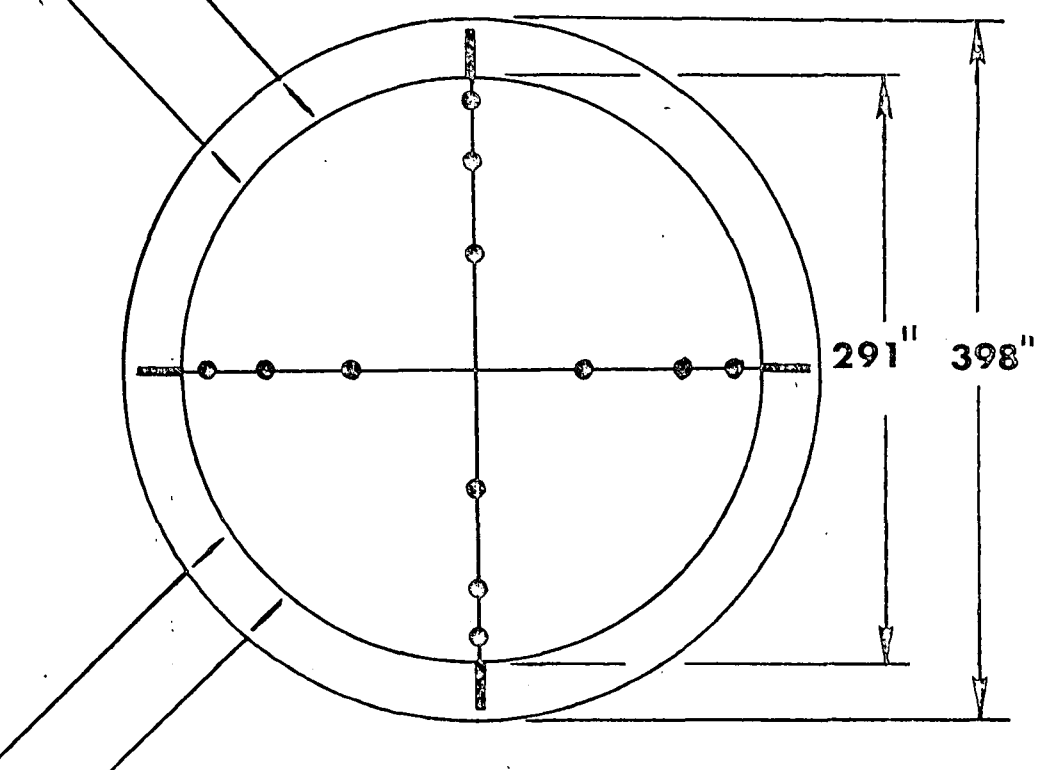


Figure 4. Traverse Locations Unit No. 2

located in the stack of Unit No. 1. A pipe the same dimension as the port extended from each inner wall to within .31 meter (1 foot) of the outer wall.

Lignite samples were collected at the inlet of the storage silos from the conveyor which feeds the silos.

V. SAMPLING AND ANALYTICAL PROCEDURES

SAMPLING PROCEDURES

The exhaust stacks of both Unit No. 1 and Unit No. 2 were generally sampled in accordance with the Federal Register methods. Some exceptions to these methods were used and they are listed below:

1. The Type S pitot tubes used to determine the stack gas velocity were calibrated at the same velocity as the stack being measured. Four pitot tubes were used to determine the velocity, one per port. The pitot tube coefficients were averaged for the four tubes and the average was used in the calculation of the stack velocity.
2. Two heated glass probes and a stainless steel probe were used to extract the exhaust gases from the stack. One glass probe with a glass wool filter was used for continuous monitor. Another probe without the filter was used for the Method 7 NO_x samples and the Method 3 gas analysis. The stainless steel probe was used for Method 4.
3. The Method 4 moisture samples were collected in two midget impingers, each containing 10 ml of distilled water. Sampling was conducted at a continuous rate of approximately 4 ft³ per hour until the dry test meter registered 0.06 cubic meter (2 cubic feet) of dry gas sampled.

4. The guidelines proposed in the Federal Register September 11, 1974, Vol. 39, No. 177, entitled "Performance Specification 2 - Performance Specification and Specification Test Procedures for Monitors of SO₂ and NO_x from Stationary Sources," were followed when possible. A Dynasciences Air Pollution Monitor with a NO_x sensor was used. The instrument is designed to give results within ± 5 ppm of the actual concentration.

The continuous monitoring sampling train consisted of a heated probe, filter, condensing coil and flask, and pump. After the exhaust gases passed through the pump they were pushed through an SO₂ scrubbing solution and a filter before they reached the NO_x sensor. Approximately 1 cubic foot per hour of stack gas was sampled.

The system was calibrated in the morning and again checked at the end of the day to insure there was no instrument drift. The 347 ppm NO in nitrogen calibration gas was certified by the manufacturer and hence no Method 7 check was run. The calibration gas was placed into the system before the pump which pushed the gas through scrubbing solution and filter into the NO_x monitor.

The Dynascience unit was connected to a continuous strip chart recorder and the data was continuously recorded. A listing of the reading for every 10 minutes is given in Appendix F. The value at the time corresponding to the Method 7 grab flask was used in the various tables.

The negative pressure in the stack caused difficulties in obtaining a representative sample the first day of sampling. Fresh air was being drawn into the stack

and causing a dilution to occur. This problem was eliminated by sealing the port area around the probe, drawing off a larger volume of the stack gas, and directing a portion of this gas to the instrument or sampling system.

Cooler weather on October 3 and 4 caused morning problems with NO_x sensor. The accuracy of the sensor is very dependent on the temperature of its electrolyte. On October 10, 11, and 12 a heating tape was wrapped around the monitor to keep the sensor warm. No early morning problems were encountered with calibration or sampling after the heating tape was used.

Voltage drop at the platform during the first three days of sampling may have resulted in incorrect results. The voltage problem was corrected for the completion of the test by providing a separate power line for the electronic instruments involving the NO_x monitor and temperature measurement devices.

Zero gas was used initially for the zero setting of the Dynasciences monitor. However, zeroing the monitor with the zero gas resulted in inconsistent readings. When ambient air was used, no problems were encountered. Therefore, ambient air was used as a zero gas for the last six days of the sampling program.

5. Lignite samples were taken every half hour. These samples were composited and at the end of the sampling day were quartered down into a single sample for that day. There was no sampling location at the inlet to the boilers, so the samples were taken before the lignite was deposited in storage silos. It was estimated that there was a 3-hour

time lag from the time the lignite went into the silos until it was fired into the boilers. Sampling of the lignite began as soon as MRC personnel reached the job site each morning and ended 3 hours before the NO_x sampling was completed.

ANALYTICAL PROCEDURES

Analytical procedures used generally followed the methods outlined in the Federal Register. Some exceptions are discussed below.

The NO_x grab samples were analyzed by the phenoldisulfonic acid method in the December 23, 1971 Federal Register, Vol. 36, Number 247. The following are exceptions to the method. The samples were evaporated in 250 ml beakers, not evaporating dishes as described in the proposed Method 7 changes. The samples collected on October 10, 11, and 12, 1974 were diluted to 100 ml and a 50 ml aliquot was used to perform the analysis. These samples were evaporated on the steam bath with cover glasses on the beakers to prevent contamination of the samples. The absorbance of each sample was measured at 410 nm using the blank solution as zero. The observances of the calibration standards were also measured at this wavelength.

The percent moisture, volatile, ash, and heat of combustion were determined on the daily composites of lignite coal. The samples were ground to pass a 60 mesh sieve and all analyses were performed on the ground sample. After grinding the composite sample, ASTM D271-70 was followed for moisture, ash, volatile, BTU, carbon, hydrogen, nitrogen, and sulfur determinations.

Specifically, the volatiles were measured by the Meker burner method; the BTU values were obtained with the Parr Bomb Calorimeter; the nitrogen determined by the Kjeldahl-Gunning method; and the carbon and hydrogen were analyzed with a Hewlett Packard Model 185 Carbon and Hydrogen Analyzer. All results are reported on an "as determined" basis, except the BTU values which were obtained from the oven dried sample.

For the calorific value, the sample was oven dried at 100-110°C so that reproducible results were obtained. The ground sample had a high moisture content which caused the BTU value to vary when duplicate ground samples were run. After the samples were dried the BTU values were in agreement described by the Parr Bomb method.

The Orsat analysis of Method 3 was performed in accordance with the methods outlined in the Federal Register with two exceptions. Only two consecutive samples were analyzed if the results varied no more than 0.5 percent by volume of each component being analyzed. The carbon monoxide analysis was only performed once per sample if none was detected in the first sample.