Appendix 1

Unit 2 Baseline Electrostatic Precipitator Performance

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LIST OF ABBREVIATIONS

ABS	Absolute
acfm	Actual Cubic Feet per Minute
ASTM	American Society for Testing and Materials
Amps	Amperes
Avg	Average
$BaCl_2$	Barium Chloride
C-Factor	Pitot Tube Calibrations
CCT-4	Clean Coal Technology Round 4
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CONSOL R&D	CONSOL Inc., Research & Development
D_{16}	Particle Diameter (μm) at 16% Level
D_{50}	Particle Diameter (μm) at 50% Level
D_{84}	Particle Diameter (μm) at 84% Level
°F	Degrees Farenheit
Delta H	Dry Test Meter Orifice Calibration
dM/d log dp	Change in Mass Loading/Change in the Log of the Particle Diameter
dscf	Dry Standard Cubic Feet
dscfm	Dry Standard Cubic Feet per Minute
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
F-Factor	Fuel Factor Relating Gas Volume to Coal Quality
FPS	Foot per Second
ft	Foot
ft^3	Cubic foot

LIST OF ABBREVIATIONS (Continued)

gr	Grains
gr/dscf	Grains per Dry Standard Cubic Foot
GMD	Geometric Mean Diameter
GSD	Geometric Standard Deviation
H_2O	Water
Hg	Mercury
hr	Hour
%ISO	Percent Isokinetic Sampling Rate
KV	Kilovolts, Direct Current
lb/lb-Mole	Pound per Pound-Mole
lb/hr	Pound per Hour
lb/MM Btu	Pound per Million Btu Heat Input
"Hg	Inches Mercury
MACS	Miniature Acid Condensation System
μm	Micrometers
min	Minutes
MM Btu	Million British Thermal Units
MMD	Mass Median Diameter
MWe	Station Rating, Megawatts-Electric
N_2	Nitrogen
O_2	Oxygen
0% O_2	Emissions Corrected Oxygen Free Basis
PM	Particulate Matter
PM_{10}	Particulate Matter Smaller than 10 Micrometers in Diameter
ppmv	Parts per Million, Volumetric
PRSD	Percent Relative Standard Deviation
PSD	Particle Size Distribution
QA/QC	Quality Assurance/Quality Control
"S" Pitot	Stausscheibe or Reverse Type Pitot Tube
SQ FT	Square Foot
SDEV	Standard Deviation
SO_2	Sulfur Dioxide
SO_3	Sulfuric Acid Mist
SOx	Total of SO_2 and SO_3
Std Ft^3	Standard Cubic Foot
Temp	Temperature
TC	Thermocouple
V-I Curves	Voltage-to-Power Ratio
Vol	Volume
wt	Weight
Y-Factor	Dry Test Meter Volume Calibration

EPA METHODS

Method 1	Sample Point Selection
Method 2	Determination of Volumetric Gas Flow
Method 3	Determination of Gas Composition (ORSAT)
Method 4	Determination of Flue Gas Moisture
Method 5	Determination of Particulate Matter (Out-of-Stack Filter Method)
Method 6	Determination of SO_2 Emissions
Method 17	Determination of Particulate Matter (In-Stack Filter Method)

EQUIPMENT

The Milliken Station consists of two 160 MWe coal-fired steam electric generating units. The existing ESP system on each unit consisted of two ESPs, one above the other. The lower ESP was the original unit which was constructed between 1955 and 1958. The upper ESP was added in the early 1970s. When the upper ESP was retrofitted, the gas flow path was modified to flow into the upper ESP first, then double back to flow in series through the second (original) ESP. The ESP design information is presented as follows:

MILLIKEN BASELINE ESP DESIGN INFORMATION

	Lower ESP	Upper ESP
Date Built	1955-58	1971-74
SCA	150	242
Chambers	4	4
Fields	2	2
Plate Spacing, inches	8 3/4	9
Plate Height, ft	20	30
Field Depth, ft	18	18
Gas Velocity, fps	5.71	3.42
Gas Flow, acfm	477,400	477,400

ABSTRACT

ESP performance parameters were measured at the NYSEG Milliken Unit #2 during the week of April 17, 1994. Measurements made at the ESP inlet and outlet included particulate, SO_2/SO_3 concentrations, and particle size distributions. A comparison of the stack emissions using two different sampling methodologies was conducted. Fly ash resistivity was measured at the ESP inlet location and daily as-fired coal samples were obtained.

ESP particulate removal efficiency ranged from 99.50% to 99.76% (Method 5 data) and from 99.69% to 99.87% using the Method 17 data. ESP inlet SO_3 concentrations averaged 4 ppm (duct conditions). The ESP inlet particle size distributions showed a mass mean particle diameter of 10.5 μm while the outlet showed a mass mean diameter of 3.1 μm. Approximately 87% of the ESP outlet particulate emissions consisted of particles smaller than 10 μm.

All of the sampling data were obtained using EPA reference methods or EPA- endorsed methodology. All of the sampling data, sampling methods, and coal analyses are contained in this report. A similar test program for Unit #1 is scheduled for later this year.

INTRODUCTION

Unit #2 ESP performance evaluation was conducted as part of the CONSOL CCT-4 work responsibility. This test program involved the simultaneous sampling at both the ESP inlet and ESP outlet for a number of species including particulate matter, SO_3, fly ash resistivity, and particle size. The sampling was conducted during the week of April 17, 1994. SO_2/SO_3 measurements were conducted on April 17. Total particulate matter (PM) and particle size distributions (PSD) were measured on April 18-20. Corresponding as-fired coal samples were taken for each test period.

The ESP performance data will be used in the evaluation of an ESP predictive model. Because of this application, additional particulate emission measurements were conducted at the ESP outlet to compare the PM emissions obtained using both an in-stack (Method 17) and out-of-stack filter (Method 5).

All of the sampling was coordinated with the control room operators to assure that the testing was conducted under full load and normal operating conditions. A similar test program for Unit #1 is scheduled for later this year.

SAMPLING LOCATIONS

ESP Inlet - The ESP inlet sampling location is shown in Figure 1. Sampling was conducted in the two inlet ducts located immediately upstream of the ESP. These ducts are fitted with a total of twenty, 6" sampling ports. A sampling scheme using every odd sampling port was used for the PM sampling. Three sample points were located for each port. This plan resulted in a total of 30 sampling points. PM sampling was conducted for 4 min at each point which resulted in a total sampling time of 120 min.

Particle size sampling was conducted at the mid-point in four different ports (two ports in each duct). These ports were selected based on the velocity profile obtained from the PM sampling data.

SO_3 sampling and resistivity measurements were conducted at a number of uniformly spaced sampling ports to provide representative measurements for this location.

ESP Outlet - The ESP outlet samples were obtained at the existing stack sampling location. A schematic of this location is shown in Figure 1. The flue gas from Unit #2 discharges through a 16 ft diameter stack. The existing stack sampling location is equipped with four, 4" sampling port spaced 90° apart. PM sampling was conducted at three points in each of the four sampling ports for a total of 12 individual points. Each point was sampled for a total of 10 min which resulted in a total sampling time of 120 min.

Particle size sampling was conducted through one port using the individual points that most closely matched the average stack gas velocity.

SO_3 sampling was conducted at a single point located approximately 1/3 the way into the stack.

As-Fired Coal Samples - Coal samples were taken from the individual gravimetric feeders located above the coal mills. This sample was obtained using a custom-designed sampling scoop which was constructed to sweep a complete cross-section of free-falling coal as the coal was discharged from the feed belt. These samples were coordinated with the emission measurements. Sample size and increments were taken in accordance with ASTM procedures. At the completion of the test program, the gross coal sample was riffled down to fit into a 5 gallon bucket. These samples were then transported back to the R&D lab for final sample preparation and subsequent analysis.

EXPERIMENTAL

The emission sampling was conducted using EPA reference techniques, if applicable. In cases where no suitable reference method applied, sampling was conducted using EPA endorsed methodologies or other published, well-documented procedures. A summary of the sampling procedures used in this test program is provided below.

Selection of Sampling Points - The sampling points at both locations were selected as described in EPA Method 1. The ESP inlet location failed to meet the optimum location criteria but this was the only location possible. Additional sampling points were used at the inlet to help offset any potential location biases. The stack location does conform to the EPA criteria which specifies a 12 point sampling grid for circular ducts.

Volumetric Flow Rate - Individual point velocities and duct volumetric flow rates were determined in conjunction with the PM sampling using the procedure outlined in EPA Method 2. The particulate sampling probes were equipped with calibrated type "S" pitot assemblies complete with thermocouples.

Gas Composition (O_2, CO_2, and N_2) - Flue gas compositions at both locations were determined using a Teledyne Model Max 5 combustion gas analyzer. This instrument uses an electrochemical sensor to determine oxygen and calculates the CO_2 concentration based on fuel chemistry. Nitrogen is determined by difference. The O_2 and CO_2 concentration determined by this instrument were confirmed by ORSAT analysis on selected gas bag samples. The dry molecular weight of the flue gas samples were calculated from these data using the calculations outlined in EPA Method 3.

Flue Gas Moisture Content - Flue gas moisture was determined by measuring the condensate found in the impinger assemblies for each of the PM samples. This procedure is outlined in both EPA Method 4 and Method 5.

Particulate Matter Concentrations - PM sampling was conducted at the ESP inlet and outlet as outline in EPA Method 17. This method specifies the use of an in-stack filter which is located at the front end of the sampling probe. Particulate matter is defined as

any material that is collected on the filter at the duct temperature and pressure. The ESP inlet had a nominal average temperature of ~260 °F and an absolute pressure of ~28.5" Hg. Ceramic filters were used at this location. The stack also showed a nominal average temperature of ~260 °F. The absolute stack pressure was very close to the ambient barometric pressure (~29.6" Hg). A flat-pack filter assembly fitted with a glass fiber filter mat was used at this location.

A series of Method 5 PM measurements were also conducted at the stack location. The Method 5 procedure uses an out-of-stack filter connect to a heated, glass-lined sampling probe. The probe and filter temperature is maintained at 248 °F ±25 °F. Particulate matter is defined as any material that is collected on the sampling media at this temperature. A schematic contrasting the two particulate trains is shown in Figure 2.

SO_2 Emissions - SO_2 emissions were measured by replacing the water solution in the PM sampling impingers with a 3% hydrogen peroxide solution. After sampling, the impinger contents were analyzed for SO_2 as described in EPA Method 6. This technique is a $BaCl_2$ titration to a thorin end point. Additional SO_2 emissions were obtained with the acid condensation sampling trains using a similar recovery and analytical procedure.

Particle Size Sampling ESP Inlet - Particle size sampling was conducted at the ESP inlet using an Andersen 5-stage cyclone sampler. This sampler is designed to operate in-situ and provides aerodynamic particle size data. All sampling was conducted as outlined in the instruction manual and also following published procedures prepared by Southern Research Institute for the California Air Resource Board.

Particle Size Sampling ESP Outlet - Particle size sampling was conducted at the ESP outlet using an Andersen 7-stage impactor sampler. This sampler is designed to operate in-situ and provides aerodynamic particle size data. The sampling was conducted as outlined in the instruction manual and also following published procedures prepared by Southern Research Institute for the California Air Resource Board. The impactor was fitted with a right-angle flow adapter which eliminated the need for the goose-neck inlet nozzle. The right-angle flow adapter produces a more valid size distribution.

SO_3 Measurements - SO_3 (sulfuric acid mist) and SO_2 emissions were sampled using a CONSOL R&D modified EPA "Miniature Acid Condensation System" (MACS). In this sampling train (Figure 3), the flue gas is pulled through a heated quartz probe (500 °F) fitted with a quartz wool filter plug into a condenser packed with glass wool. The condenser temperature is maintained at ~140 °F which allows for the selective condensation of SO_3 (as sulfuric acid mist). The gas then exits the condenser and is pulled through hydrogen peroxide-filled impingers which oxidize the SO_2 to sulfate. After sampling, the quartz plug, sampling probe, condenser, and impingers are separately recovered and analyzed for sulfate using the $BaCl_2$ titration discussed in EPA Method 6.

Ash Resistivity Measurements - Resistivity measurements were made using a point-to-plane fly ash resistivity probe and were conducted by R&D Combustion personnel. With this probe, the voltage drop across an ash layer is determined by taking the difference

between the "clean plate" and "dirty plate" V-I curves and using the corresponding measured current. Measurements were also calculated using the "spark method". These methods are documented in the instructions supplied with the sampling probe.

RESULTS AND DISCUSSION

As-Fired Coal Analysis

Coal samples were obtained for every test day and were taken to coincide with the daily sampling activities. The analyses of these samples are shown in Table 1. These data show a highly consistent coal product for the four test days. The samples showed an average ash content of 7.10% with a percent relative standard deviation (PRSD) of less than 2%. The average sulfur content was 1.79% with a PRSD of 3%. These data reflect a constant coal supply for the test duration and make day-to-day data comparisons more meaningful.

Particulate Sampling Results and ESP Operating Efficiency

The individual particulate sampling data for each test run are shown in Table 2 and are summarized as follows.

ESP Inlet and Outlet Particulate Summary

	Test #1	Test #2	Test #3	Avg	PRSD
Date	4/18/94	4/19/94	4/20/94		
Inlet, lb/hr	9059	6363	7841	7754	17%
Stack, lb/hr (Method 5 Values)	36.6	15.6	39.4	30.5	43%
ESP Efficiency	99.60	99.75	99.50	99.62	0.13%
Stack, lb/hr (Method 17 Values)	12.0	13.8	24.0	16.6	39%
ESP Efficiency	99.87	99.78	99.69	99.78	0.09%

These data show 17% variability in the inlet dust loading value. This variability may be attributed to the soot blowing schedule. The Unit #2 soot-blowers operate as required and are triggered by pressure differentials. There was no attempt made during this program to coordinate the sampling and soot-blowing schedules. The ESP outlet (stack) emissions measured with the EPA Method 5 train ranged from 15.6 lb/hr to 39.4 lb/hr. Particulate removal efficiencies ranged from 99.50% to 99.75% and averaged 99.62%. The stack emissions measured with the Method 17 train were lower than those measured

with the Method 5 train. These emissions ranged from 12.0 lb/hr to 24.0 lb/hr. The ESP collection efficiencies using these values ranged from 99.69% to 99.87%

The primary reason for the differences between these two methods is the temperature at which the particulate matter is collected. The Method 17 in-stack filter was operated at the stack temperature of ~260 °F while the Method 5 filter was maintained at a temperature of ~248 °F. The lower operating temperature of the Method 5 filter results in the additional condensation of some particles or aerosols. The 248 °F to 265 °F temperature window is in the range of the SO_3 acid dew point for this facility. Sulfuric acid mist is known to affect particulate measurements. Future testing should be conducted while maintaining a higher filter temperature (320 °F), as outlined in U.S. EPA Method 5B; "The Determination of Nonsulfuric Acid Particulate Matter from Stationary Sources".

ESP Inlet Fly Ash Analysis

A summary of the analysis collected on the ESP inlet Method 17 catch is shown in Table 1. The unburnt carbon-in-the-ash values for the three test were 3.43%, 4.85%, and 3.84% for an average of 4.04%.

Particle Size Distributions and PM_{10} Emissions

A complete tabulation of the particle size data for both the ESP inlet and outlet are presented in Tables 3 through 6. A graphical presentation of these data showing both the cumulative and differential particle size distributions is shown in Appendix A. The particle size data are summarized as follows:

Summary of Particle Size Sampling Data

ESP Inlet Data:	Test 1	Test 2	Test 3	Average
Mass Median Diameter, μm	13.5	9.6	11.0	10.5
Geometric Standard Deviation, μm	2.5	2.1	2.3	2.2
$\%PM_{10}$	50%	52%	46%	47%

ESP Outlet Data:	Test 1	Test 2	Test 3	Average
Mass Median Diameter, μm	3.0	2.8	4.0	3.1
Geometric Standard Deviation, μm	3.0	2.5	2.7	2.9
$\%PM_{10}$	86%	91%	82%	87%

The mass median diameter is defined as the mid point of the cumulative particle size distribution. The geometric standard deviation is given by the following equation:

$$GSD = D_{84}/D_{50} = D_{50}/D_{16} = \text{square root of } D_{84}/D_{16}$$

By knowing the MMD and the GSD, the complete particle size distribution can be reconstructed providing a log-normal relationship holds true.

PM_{10} refers to the particles that are smaller than 10 μm on an aerodynamic basis. PM_{10} emissions are becoming more important in a number of states and the particle size samplers can provide this type of data.

The data presented in the table above are typical of emission data for coal-fired PC boilers. The average particle size entering the control device is ~10.5 μm while the particles exiting the ESP show an average particle size of ~3 μm. These data show that approximately 90% of the stack emissions are classified as PM_{10}.

Particulate Removal by Particle Size

The particle size distribution data, in conjunction with the PM measurements can be used to calculate the ESP particulate removal as a function of particle size. These data are summarized in the following table and are shown graphically in Figure 4.

ESP Particulate Removal by Particle Size

Size Interval	ESP Inlet gr/dscf	ESP Outlet gr/dscf	Particulate Removal Efficiency
< 1 μm	0.0511	0.0023	95.50%
1 μm to 2 μm	0.0443	0.0012	97.29%
2 μm to 5 μm	0.5222	0.0029	99.44%
5 μm to 10 μm	0.7010	0.0028	99.60%
> 10 μm	1.2600	0.0023	99.82%
Net Particulate	2.5275	0.0115	99.55%

As expected, the ESP shows the greatest collection efficiency for the larger particles and the minimum collection efficiency for the smaller particles. The high net operating efficiency of the ESP is a result of the high fraction of large particles (>5 μm) entering the device.

ESP Inlet and Outlet SO_2 and SO_3 Measurements

A series of SOx measurements were obtained at both the ESP inlet and outlet. SO_2 concentrations were measured with the PM testing at each location which shows the results over three successive days. These data are shown in Table 2 and are summarized below.

ESP Inlet and Outlet SO_2 Emissions

	4/18/94			4/19/24			4/20/94		
	Inlet	Outlet (M-5)	Outlet (M-17)	Inlet	Outlet (M-5)	Outlet (M-17)	Inlet	Outlet (M-5)	Outlet (M-17)
ppmv, (duct)	1049	1008	1033	1082	1026	1055	1098	1046	1041
ppmv, (0% O_2)	1578	1634	1661	1638	1663	1723	1662	1707	1727
lb/hr	3646	3681	3450	3522	3520	3598	3561	3777	3524
lb/MM Btu	2.45	2.55	2.59	2.54	2.59	2.68	2.58	2.66	2.69

These data show an excellent comparison between the ESP inlet and outlet measurements and also excellent repeatability between the two separate outlet measurements. The average ESP inlet SO_2 measurements are 1626 ppmv (0% O_2 basis), 3576 lb/hr, and 2.52 lb/MM Btu. The average ESP outlet SO_2 measurements, using both measurement techniques, are 1685 ppmv (0% O_2 basis), 3591 lb/hr, and 2.63 lb/MM Btu.

The SO_3 sampling was conducted on April 17, 1994. Four samples were obtained from each sampling location. The SO_3 sampling technique also provides an SO_2 value. These data are shown in Tables 7 and 8 and are summarized as follows:

ESP Inlet and Outlet and SO_3 Measurements

	ESP Inlet		ESP Outlet	
	Value	SDEV	Value	SDEV
No. of Samples	4	---	4	---
Stack Temp, °F	271	5	268	0
Stack O_2, %	7.2	0.4	8.0	0.1
Gas Phase SO_3, ppmv (duct)	3.9	0.6	3.2	0.6
Gas Phase SO_3, ppmv (0% O_2)	5.9	0.9	5.1	0.9
% SO_3 on Particulate Plug	16	4	14	9
SO_2, ppmv (duct)	1009	21	957	10
SO_2, ppmv (0% O_2)	1539	18	1544	20
% SO_3 in total SOx	0.46	0.08	0.38	0.08

These data show very consistent ESP inlet and outlet gas phase SO_3 levels. The inlet showed an average value of 3.9 ppmv (duct conditions) with a standard deviation of 0.6 ppmv. This calculates to a PRSD of 16%. The average outlet concentration was 3.2 ppmv with a standard deviation of 0.6 ppmv. The outlet values showed a PRSD of 19%. There is no statistical difference between the inlet and outlet SO_3 values. However, a closer look at the run-by-run data suggest that a small amount of the SO_3 is being absorbed on the fly ash material as the flue gas passes through the ESP.

Fly Ash Resistivity Measurements

Fly ash resistivity measurements were conducted at the ESP inlet location by R&D Combustion personnel. The field sampling sheets are included in Appendix B. A summary of the ash resistivity results is presented in the following table.

Ash Resistivity Summary

	Date	Duct/Port	Temp, °F	Resistivity, ohms
Run #1	4/17/94	A/8	283	6.51×10^{10}
Run #2	4/18/94	A/2	251	4.09×10^{10}
Run #3	4/18/94	A/2	252	7.67×10^{10}
Run #4	4/18/94	A/5	269	4.49×10^{10}
Run #5	4/18/94	B/2	272	3.09×10^{12}
Run #6	4/18/94	B/5	272	8.90×10^{10}
Run #7	4/18/94	B/9	230	5.69×10^{10}

(Ports are in increasing order from left to right)

QA/QC PROCEDURES

The sampling and associated QA/QC procedures were followed as prescribed in the sampling methods. Pretest calibrations were performed on the major sampling equipment, and included the pitot tubes, sampling nozzles, dry test meters, meter orifices, barometer, and temperature readouts. The analytical balance used for the gravimetric filter analyses is checked out twice a year. The accuracy of this balance was checked daily with class "S" standard weights. The calibration data are on file at CONSOL R&D, Pittsburgh, PA.

The sampling team was in daily communication with the Unit #2 operators to assure that the unit was operating at the required test conditions. Most of the sampling data was reduced in the field to assure data quality and accuracy.

Table 1

Milliken Unit #2 Coal Analysis
Analyses Reported on a Dry Basis

Date	4/17/94	4/18/94	4/19/94	4/20/94	Average	SDEV	PRSD
% Carbon	78.43	77.89	77.86	77.85	78.01	0.28	0.4%
% Hydrogen	5.26	5.25	5.25	5.24	5.25	0.01	0.2%
% Nitrogen	1.52	1.55	1.53	1.43	1.51	0.05	3.5%
% Sulfur	1.75	1.74	1.84	1.83	1.79	0.05	2.9%
% Oxygen	6.12	6.42	6.41	6.44	6.35	0.15	2.4%
% Ash	6.92	7.15	7.11	7.21	7.10	0.12	1.8%
% Volatile Matter	37.34	37.35	37.49	37.27	37.36	0.09	0.2%
Btu/lb	13961	13934	13955	13949	13950	12	0.1%
F-Factor	9852	9799	9785	9783	9805	32	0.3%

Representative Samples Collected from Coal Feeders Throughout Test Duration

ESP Inlet Flyash Collected From Method 17 Filter

Date	4/18/94	4/19/94	4/20/94	Average	SDEV	PRSD
% Carbon	3.43	4.85	3.84	4.04	0.73	18.0%
% Hydrogen	0.03	0.03	0.03	0.03	0.00	0.0%
% Nitrogen	0.03	0.03	0.03	0.03	0.00	0.0%
% Sulfur	0.34	0.34	0.37	0.35	0.02	4.6%

Table 2

MILLIKEN UNIT #2 PERFORMANCE TESTING

Location			ESP IN	STACK	STACK	ESP IN	STACK	STACK	ESP IN	STACK	STACK
Date			4-18-94	4-18-94	4-18-94	4-19-94	4-19-94	4-19-94	4-20-94	4-20-94	4-20-94
Start Time			1100	1105	1456	0930	0933	1332	0913	0925	1356
Stop Time			1330	1325	1728	1145	1152	1548	1130	1200	1620
Sample Type			M-17	M-5	M-17	M-17	M-5	M-17	M-17	M-5	M-17
SAMPLING DATA:											
Y factor of dry gas meter	–		0.983	0.978	0.978	0.983	0.978	0.978	0.983	0.978	0.978
Gas Volume	–	Cubic Feet	66.27	37.75	37.70	64.30	46.00	44.84	62.42	44.71	43.81
Delta H of dry gas meter	–	" H_2O	1.07	0.32	0.32	1.00	0.50	0.48	0.93	0.49	0.44
Meter Temperature	–	°F	113.0	52.0	63.4	126.0	68.6	62.6	111.8	44.3	47.8
C Factor of pitot tube	–		0.763	0.827	0.796	0.763	0.827	0.796	0.763	0.827	0.796
Nozzle Diameter	–	inches	0.246	0.178	0.178	0.246	0.193	0.193	0.246	0.193	0.193
A n (area of nozzle)	–	Square Feet	0.00033	0.00017	0.00017	0.00033	0.00020	0.00020	0.00033	0.00020	0.00020
Area of Stack	–	Square Feet	238	201	201	238	201	201	238	201	201
H_2O Weight	–	Grams	83.9	48.6	49.5	93.2	59.4	61.4	74.8	57.8	58.7
Sample Time	–	minutes	120	120	120	120	120	120	120	120	120
Barometric Pressure	–	" Hg	29.60	29.60	29.58	29.28	29.28	29.38	29.60	29.60	29.59
Static Pressure	–	" H_2O	-14.00	-0.40	-0.58	-13.40	-0.54	0.66	-14.30	-0.40	-0.40
% Oxygen	–		7.0	8.0	7.9	7.1	8.0	8.1	7.1	8.1	8.3
% Carbon Dioxide	–		12.5	11.5	11.6	12.4	11.5	11.4	12.4	11.4	11.2
% N_2 + CO	–		80.5	80.5	80.5	80.5	80.5	80.5	80.5	80.5	80.5
Stack Temp (Dry Bulb)	–	°F	264	263	267	266	268	266	258	256	259
"S" sample (avg vel pressure)	–	" H_2O	0.420	0.523	0.478	0.380	0.480	0.501	0.361	0.506	0.483
Dust Wt.	–	Grams	11.1573	0.0258	0.0095	7.8492	0.0144	0.0127	9.7628	0.0357	0.0226
CALCULATED DATA:											
DSCF SAMPLED	–		59.52	37.68	36.79	55.85	44.01	43.54	56.16	45.33	44.09
ABS ST PRES	–	" Hg	28.57	29.57	29.54	28.29	29.24	29.43	28.55	29.57	29.56
ABS ST TEMP	–	Degrees R	724	723	727	726	728	726	718	716	719
H_2O – % by Vol	–	Measured	6.23	5.73	5.96	7.29	6.91	6.23	5.90	5.67	5.90
Water Volume	–	Std. Ft^3	3.95	2.29	2.33	4.39	3.27	2.89	3.52	2.72	2.76
Dry Molecular Weight	–	lb/lb-Mole	30.28	30.16	30.17	30.27	30.16	30.15	30.27	30.15	30.12
Wet Molecular Weight	–	lb/lb-Mole	29.52	29.46	29.45	29.37	29.32	29.39	29.54	29.46	29.41
% EXCESS AIR	–		49.1	60.4	59.2	50.2	60.4	61.6	50.2	61.6	64.1
Dry Mole Frac.	–		0.938	0.943	0.940	0.927	0.931	0.938	0.941	0.943	0.941
Wet Mole Frac.	–		0.062	0.057	0.060	0.073	0.069	0.062	0.059	0.057	0.059
GAS FLOW DATA:											
GAS VELOCITY	–	FPS	39.17	46.58	43.01	37.58	45.14	44.13	36.16	45.59	43.01
ACFM	–		559342	561781	518807	536653	544425	532256	516367	549930	518766
DSCFM	–		365269	382251	349806	342196	359210	357024	340931	378091	354172
Excess Air Free DSCFM	–		242930	235935	217583	225948	221713	218656	225112	231558	213520
PARTICULATE LOADING:											
Grains/DSCF	–		2.892	0.011	0.004	2.169	0.005	0.005	2.682	0.012	0.008
lb/hr	–		9059	34.63	11.95	6363	15.55	13.78	7841	39.40	24.02
lb/MM Btu	–		6.09	0.02	0.01	4.59	0.01	0.01	5.68	0.03	0.02
ESP Collection Efficiency				99.62%	99.87%		99.76%	99.78%		99.50%	99.69%
% ISOKINETIC	–		98.02	95.66	102.06	98.18	101.14	100.67	99.09	98.96	102.76
SO2 CALCULATIONS:											
lb/DSCF	–		1.66E-04	1.60E-04	1.64E-04	1.72E-04	1.63E-04	1.68E-04	1.74E-04	1.66E-04	1.66E-04
lb/hr	–		3646	3681	3450	3522	3520	3598	3561	3777	3525
PPMV @ DUCT CONDITIONS	–		1049	1008	1033	1082	1026	1055	1098	1046	1041
PPMV @ 0% OXYGEN	–		1578	1634	1661	1638	1663	1723	1662	1707	1727
lb/MM,Btu (O_2 Based)	–		2.45	2.55	2.59	2.54	2.59	2.68	2.58	2.66	2.69
COAL ANALYSIS:											
% Carbon			77.89	77.89	77.89	77.86	77.86	77.86	77.85	77.85	77.85
% Hydrogen			5.25	5.25	5.25	5.25	5.25	5.25	5.24	5.24	5.24
% Nitrogen			1.55	1.55	1.55	1.53	1.53	1.53	1.43	1.43	1.43
% Sulfur			1.74	1.74	1.74	1.84	1.84	1.84	1.83	1.83	1.83
% Oxygen			6.42	6.42	6.42	6.41	6.41	6.41	6.44	6.44	6.44
% Ash			7.15	7.15	7.15	7.11	7.11	7.11	7.21	7.21	7.21
% Volatile Matter			37.35	37.35	37.35	37.49	37.49	37.49	37.27	37.27	37.27
Btu/lb			13934	13934	13934	13955	13955	13955	13949	13949	13949
CARBON CONVERSION			99.90%	99.90%	99.90%	99.90%	99.90%	99.90%	99.90%	99.90%	99.90%
CALCULATED FEED, lb/hr (dry)			106687	102716	94815	99187	96561	95139	98833	100766	92735
F-Factor			9799	9799	9799	9785	9785	9785	9783	9783	9783
Moisture			7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%
F-Factor Firning Rate, lb/hr-dry			106753	103679	95615	99281	97421	96077	98976	101810	93875
F-Factor Firning Rate, lb/hr-wet			114789	111483	102812	106754	104753	103309	106426	109473	100945
ASH ANALYSIS:											
% Ash			96.03			94.61			95.59		
% Carbon			3.43			4.85			3.84		
% Sulfur			0.34			0.34			0.37		
Calculated MWe Rating			157	152	140	146	143	141	145	149	138

Table 3

NYSEG MILLIKEN STATION ESP INLET & OUTLET PARTICLE SIZE DATA
SOUTHERN RESEARCH FIVE STAGE CYCLONE SAMPLING SUMMARY

PLANT – Milliken Station DATE – April 18, 1994
LOCATION – ESP INLET TIME – 1440–1550

TABULAR PRESENTATION OF CYCLONE DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
1	7.4	4.6097	73.63	26.37	2.13E+00	1.88E+00	27.1	6465.1
2	3.4	1.2460	19.90	6.47	5.76E–01	1.72E+00	5.0	1747.5
3	2.4	0.2671	4.27	2.20	1.23E–01	7.83E–01	2.8	374.7
4	1.1	0.0631	1.01	1.20	2.92E–02	8.50E–02	1.6	88.5
5	0.63	0.0305	0.49	0.71	1.41E–02	5.99E–02	0.8	42.7
Filter	0.31	0.0445	0.71	----	2.05E–02	6.82E–02	0.44	62.4
TOTALS		6.2609	100.00		2.8924			8781

ACFM = 0.830 D–50 = 13.5μm
% ISO = 89.5 SIGMA = 2.5μm
% H2O = 6.5 % < 10μm= 50%

ANDERSEN SEVEN STAGE IMPACTOR SAMPLING SUMMARY

PLANT – Milliken Station DATE – April 18, 1994
LOCATION – Stack TIME – 1615–1800

TABULAR PRESENTATION OF IMPACTOR DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
PRE	9.5	0.0058	13.48	86.52	1.54E–03	1.50E–03	30.83	5.062
1	5.9	0.0068	15.82	70.70	1.80E–03	8.64E–03	7.47	5.943
2	3.7	0.0071	16.60	54.10	1.89E–03	9.60E–03	4.68	6.236
3	2.3	0.0060	14.06	40.04	1.60E–03	7.94E–03	2.96	5.282
4	1.4	0.0027	6.25	33.79	7.13E–04	3.41E–03	1.84	2.348
5	0.9	0.0047	10.94	22.85	1.25E–03	5.46E–03	1.11	4.108
6	0.58	0.0027	6.25	16.60	7.13E–04	4.16E–03	0.70	2.348
7	0.31	0.0035	8.20	8.40	9.36E–04	3.48E–03	0.42	3.081
Filter	0.16	0.0036	8.40	----	9.58E–04	3.18E–03	0.22	3.155
TOTALS		0.0430	100.00		0.0114			37.6

ACFM = 0.864 D–50 = 3.0μm
% H2O = 5.4 SIGMA = 3.0μm
% ISO = 92.4 % < 10μm= 86%

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Table 4

NYSEG MILLIKEN STATION ESP INLET & OUTLET PARTICLE SIZE DATA
SOUTHERN RESEARCH FIVE STAGE CYCLONE SAMPLING SUMMARY

PLANT – Milliken Station DATE – April 19, 1994
LOCATION – ESP INLET TIME – 1238–1408

TABULAR PRESENTATION OF CYCLONE DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
1	7.5	4.2888	64.01	35.99	1.39E+00	1.24E+00	27.5	4089.1
2	3.5	1.8429	27.50	8.49	5.97E–01	1.80E+00	5.2	1757.0
3	2.4	0.3826	5.71	2.78	1.24E–01	7.83E–01	2.9	364.8
4	1.1	0.0871	1.30	1.48	2.82E–02	8.34E–02	1.7	83.0
5	0.66	0.0567	0.85	0.64	1.83E–02	7.89E–02	0.9	54.0
Filter	0.33	0.0427	0.64	----	1.38E–02	4.59E–02	0.47	40.7
TOTALS		6.7007	100.00		2.1690			6389

ACFM = 0.790 D–50 = 9.6μm
% ISO = 95.2 SIGMA = 2.1μm
% H2O = 6.7 % < 10μm= 52%

ANDERSEN SEVEN STAGE IMPACTOR SAMPLING SUMMARY

PLANT – Milliken Station DATE – April 19, 1994
LOCATION – Stack TIME – 1115–1335

TABULAR PRESENTATION OF IMPACTOR DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
PRE	9.5	0.0040	8.27	91.73	9.07E–04	8.88E–04	30.86	2.939
1	5.9	0.0088	17.99	73.74	1.97E–03	9.45E–03	7.49	6.388
2	3.7	0.0070	14.39	59.35	1.58E–03	7.99E–03	4.69	5.111
3	2.3	0.0082	16.73	42.63	1.83E–03	9.07E–03	2.96	5.941
4	1.5	0.0052	10.61	32.01	1.16E–03	5.56E–03	1.85	3.769
5	0.9	0.0043	8.81	23.20	9.66E–04	4.23E–03	1.12	3.130
6	0.58	0.0041	8.45	14.75	9.27E–04	5.39E–03	0.70	3.002
7	0.31	0.0030	6.12	8.63	6.70E–04	2.50E–03	0.42	2.172
Filter	0.16	0.0042	8.63	----	9.46E–04	3.14E–03	0.22	3.066
TOTALS		0.0489	100.00		0.0110			35.5

ACFM = 0.862 D–50 = 2.8μm
% H2O = 5.5 SIGMA = 2.5μm
% ISO = 92.6 % < 10μm= 91%

Table 5

NYSEG MILLIKEN STATION ESP INLET & OUTLET PARTICLE SIZE DATA
SOUTHERN RESEARCH FIVE STAGE CYCLONE SAMPLING SUMMARY

PLANT – Milliken Station
LOCATION – ESP INLET
DATE – April 20, 1994
TIME – 1225–1405

TABULAR PRESENTATION OF CYCLONE DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
1	7.5	6.2722	67.01	32.99	1.80E+00	1.60E+00	27.4	5217.6
2	3.5	2.2460	24.00	8.99	6.44E−01	1.94E+00	5.1	1868.4
3	2.4	0.5346	5.71	3.28	1.53E−01	9.60E−01	2.9	444.7
4	1.1	0.1329	1.42	1.86	3.81E−02	1.13E−01	1.6	110.6
5	0.65	0.0885	0.95	0.91	2.54E−02	1.10E−01	0.9	73.6
Filter	0.33	0.0854	0.91	----	2.45E−02	8.13E−02	0.46	71.1
TOTALS		9.3596	100.00		2.6820			7786

ACFM = 0.792
% ISO = 98.2
% H2O = 6.3
D−50 = 11.0μm
SIGMA = 2.3μm
% < 10μm = 46%

ANDERSEN SEVEN STAGE IMPACTOR SAMPLING SUMMARY

PLANT – Milliken Station
LOCATION – Stack
DATE – April 20, 1994
TIME – 1100–1300

TABULAR PRESENTATION OF IMPACTOR DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
PRE	9.5	0.0095	17.46	82.54	2.10E−03	2.06E−03	30.85	6.146
1	5.9	0.0118	21.70	60.85	2.61E−03	1.25E−02	7.49	7.639
2	3.7	0.0086	15.84	45.01	1.91E−03	9.65E−03	4.69	5.576
3	2.3	0.0072	13.22	31.80	1.59E−03	7.86E−03	2.96	4.654
4	1.5	0.0044	7.98	23.82	9.60E−04	4.59E−03	1.85	2.810
5	0.9	0.0039	7.11	16.71	8.55E−04	3.77E−03	1.12	2.502
6	0.58	0.0029	5.36	11.35	6.45E−04	3.73E−03	0.71	1.888
7	0.31	0.0031	5.74	5.61	6.90E−04	2.58E−03	0.42	2.020
Filter	0.16	0.0031	5.61	----	6.75E−04	2.24E−03	0.22	1.976
TOTALS		0.0545	100.00		0.0120			35.2

ACFM = 0.857
% H2O = 5.8
% ISO = 104.1
D−50 = 4.0μm
SIGMA = 2.7μm
% < 10μm = 82%

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Table 6

NYSEG MILLIKEN STATION ESP INLET & OUTLET PARTICLE SIZE DATA
SOUTHERN RESEARCH FIVE STAGE CYCLONE SAMPLING SUMMARY

PLANT – Milliken Station DATE – Three Test Average
LOCATION – ESP INLET TIME –

TABULAR PRESENTATION OF CYCLONE DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
1	7.5	6.1188	67.96	32.04	1.75E+00	1.56E+00	27.4	5090.1
2	3.5	2.1517	23.90	8.14	6.17E−01	1.86E+00	5.1	1790.0
3	2.4	0.4777	5.31	2.83	1.37E−01	8.58E−01	2.9	397.4
4	1.1	0.1142	1.27	1.56	3.27E−02	9.71E−02	1.6	95.0
5	0.65	0.0709	0.79	0.77	2.03E−02	8.79E−02	0.9	59.0
Filter	0.33	0.0697	0.77	----	2.00E−02	6.63E−02	0.46	58.0
TOTALS		9.0031	100.00		2.5799			7489

ACFM = 0.792 D−50 = 10.5μm
% ISO = 98.2 SIGMA = 2.2μm
% H2O = 6.3 % < 10μm= 47%

ANDERSEN SEVEN STAGE IMPACTOR SAMPLING SUMMARY

PLANT – Milliken Station DATE – Three Test Average
LOCATION – Stack TIME –

TABULAR PRESENTATION OF IMPACTOR DATA

STAGE	D_{50}	MASS	MASS %	CUM %	GR/DSCF	dM/dLOG dp	GMD	LBS/HR
PRE	9.5	0.0067	12.86	87.14	1.48E−03	1.45E−03	30.85	4.326
1	5.9	0.0096	18.43	68.71	2.12E−03	1.02E−02	7.49	6.198
2	3.7	0.0080	15.36	53.36	1.76E−03	8.94E−03	4.69	5.165
3	2.3	0.0078	14.97	38.39	1.72E−03	8.51E−03	2.96	5.036
4	1.5	0.0042	8.06	30.33	9.26E−04	4.43E−03	1.85	2.712
5	0.9	0.0047	9.02	21.31	1.04E−03	4.57E−03	1.12	3.034
6	0.58	0.0036	6.91	14.40	7.94E−04	4.59E−03	0.71	2.324
7	0.31	0.0035	6.72	7.68	7.72E−04	2.89E−03	0.42	2.260
Filter	0.16	0.0040	7.68	----	8.82E−04	2.93E−03	0.22	2.583
TOTALS		0.0521	100.00		0.0115			34

ACFM = 0.857 D−50 = 3.1μm
% H2O = 5.8 SIGMA = 2.9μm
% ISO = 104.1 % < 10μm= 87%

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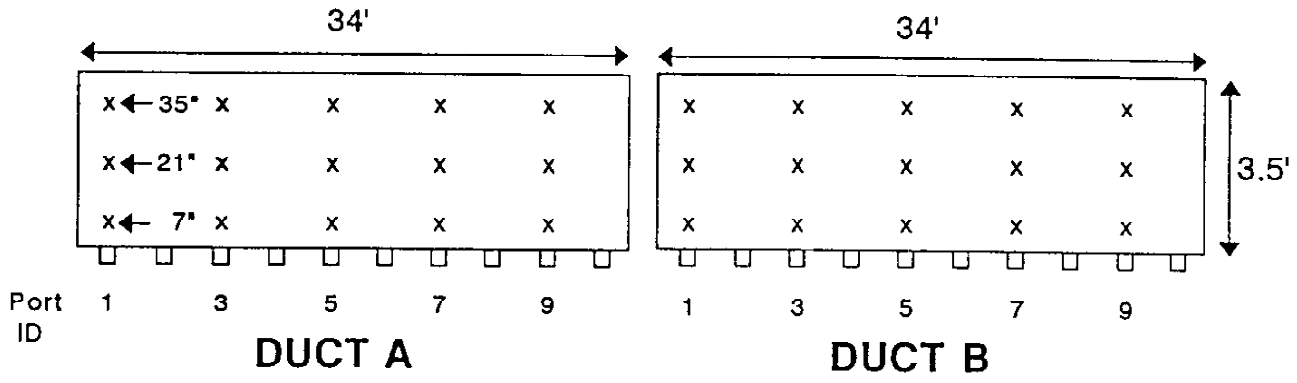
Table 7
Milliken Unit #2 SO_3 Sampling – Inlet Data

TEST	#1	#2	#3	#4	Average	SDEV	PRSD
Plant Load, MWe	146	142	143	147	145	2	1.4%
DATE	4/17/94	4/17/94	4/17/94	4/17/94			
START TIME	1015	1210	1355	1535			
END TIME	1125	1320	1505	1645			
LOCATION	INLET–A		INLET–B				
METER VARIABLES							
SAMPLE TIME [Minutes]	60	60	60	60			
BAROMETRIC PRESSURE [" Hg]	29.30	29.34	29.33	29.34			
SAMPLE VOLUME [ft ^{3}]	4.82	6.00	6.06	6.18			
METER TEMPERATURE [° F]	106.0	106.0	107.0	109.0			
ORIFICE PRESSURE [" H_2O]	0.02	0.02	0.02	0.02			
Y FACTOR	0.983	0.983	0.983	0.983			
DSCF SAMPLED	4.327	5.393	5.436	5.526			
CONDENSER TEMP [° F]	132	132	144	140			
CC/MIN @ COND	2289	2854	2934	2963			
DUCT OXYGEN [%]	7.40	7.20	6.70	7.50	7.2	0.4	4.9%
DUCT TEMP DURING TEST [° F]	275	276	266	268	271	5	1.8%
SO_2							
SO_2 in IMPINGERS							
lb/DSCF	1.67E–04	1.68E–04	1.71E–04	1.62E–04			
PPMV, As Sampled	1009	1013	1033	981			
PPMV, @ 0% Oxygen	1562	1545	1520	1530	1539	18	1.2%
PPMV, @ Duct Conditions	1009	1013	1033	981	1009	21	2.1%
SO_3							
SO_3 in FILTER PLUG							
lb/DSCF	1.03E–07	2.06E–07	1.23E–07	2.02E–07			
PPMV, As Sampled	0.5	1.0	0.6	1.0			
PPMV, @ 0% Oxygen	0.8	1.5	0.9	1.5	1.2	0.4	34.5%
PPMV, @ Duct Conditions	0.5	1.0	0.6	1.0	0.8	0.3	33.5%
SO_3 in PROBE							
lb/DSCF	2.06E–07	1.24E–07	2.05E–07	2.02E–07			
PPMV, As Sampled	1.0	0.6	1.0	1.0			
PPMV, @ 0% Oxygen	1.5	0.9	1.5	1.5	1.4	0.3	21.9%
PPMV, @ Duct Conditions	1.0	0.6	1.0	1.0	0.9	0.2	21.7%
SO_3 in CONDENSER							
lb/DSCF	4.63E–07	5.99E–07	6.56E–07	7.46E–07			
PPMV, As Sampled	2.2	2.9	3.2	3.6			
PPMV, @ 0% Oxygen	3.5	4.4	4.7	5.6	4.5	0.9	19.4%
PPMV, @ Duct Conditions	2.2	2.9	3.2	3.6	3.0	0.6	19.1%
GAS PHASE SO_3 [lb/DSCF]	6.69E–07	7.23E–07	8.60E–07	9.47E–07			
GAS PHASE SO_3 [Duct PPM]	3.2	3.5	4.2	4.6	3.9	0.6	15.8%
GAS PHASE SO_3, 0% OXYGEN	5.0	5.3	6.1	7.1	5.9	0.9	16.0%
TOTAL PHASE SO_3 [lb/DSCF]	7.72E–07	9.29E–07	9.83E–07	1.15E–06			
TOTAL PHASE SO_3 [Duct PPM]	3.7	4.5	4.8	5.6	4.6	0.7	16.1%
TOTAL SO_3, 0% OXYGEN	5.8	6.9	7.0	8.7	7.1	1.2	16.8%
% SO_3 in SOLIDS [filter plug/total]	13.3	22.2	12.5	17.5	16.4	4.4	27.1%
% SO_3 in TOTAL SO_x	*0.37*	*0.44*	*0.46*	*0.56*	0.46	0.08	17.4%

Table 8
Milliken Unit #2 SO_3 Sampling -- Outlet Data

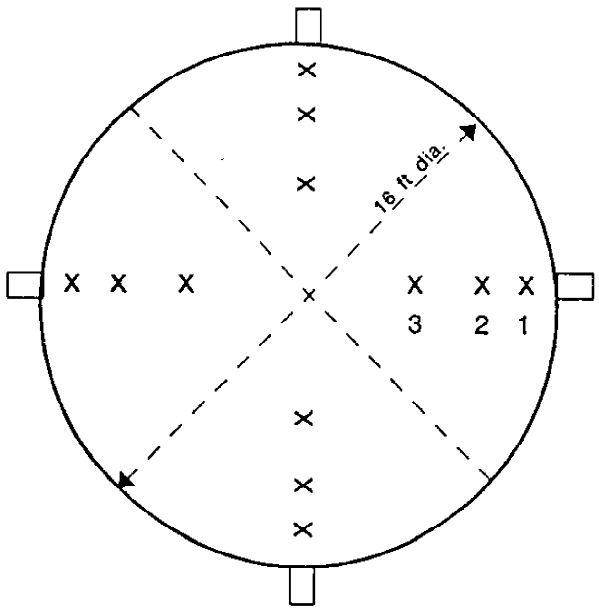
TEST	#1	#2	#3	#4	Average	SDEV	PRSD
Plant Load, MWe	146	142	143	147	145	2	1.4%
DATE	4/17/94	4/17/94	4/17/94	4/17/94			
START TIME	1020	1221	1403	1542			
END TIME	1120	1321	1503	1642			
LOCATION	STACK		STACK				
METER VARIABLES							
SAMPLE TIME [Minutes]	60	60	60	60			
BAROMETRIC PRESSURE ["Hg]	29.30	29.34	29.33	29.34			
SAMPLE VOLUME [ft^3]	5.17	5.44	5.59	5.64			
METER TEMPERATURE [°F]	48.3	52.4	55.4	55.1			
ORIFICE PRESSURE ["H_2O]	0.02	0.02	0.02	0.02			
Y FACTOR	0.989	0.989	0.989	0.989			
DSCF SAMPLED	5.199	5.435	5.550	5.605			
CONDENSER TEMP [°F]	130	130	130	135			
CC/MIN @ COND	2742	2866	2927	2981			
DUCT OXYGEN [%]	7.90	8.00	8.10	7.80	8.0	0.1	1.6%
DUCT TEMP DURING TEST [°F]	268	268	268	267	268	0	0.2%
SO_2							
SO_2 in IMPINGERS							
lb/DSCF	1.58E-04	1.61E-04	1.57E-04	1.58E-04			
PPMV, As Sampled	956	970	946	956			
PPMV, @ 0% Oxygen	1536	1571	1544	1525	1544	20	1.3%
PPMV, @ Duct Conditions	956	970	946	956	957	10	1.0%
SO_3							
SO_3 in FILTER PLUG							
lb/DSCF	4.28E-08	4.10E-08	2.01E-07	1.59E-07			
PPMV, As Sampled	0.2	0.2	1.0	0.8			
PPMV, @ 0% Oxygen	0.3	0.3	1.6	1.2	0.9	0.6	73.5%
PPMV, @ Duct Conditions	0.2	0.2	1.0	0.8	0.5	0.4	73.1%
SO_3 in PROBE							
lb/DSCF	1.50E-07	2.46E-07	3.21E-07	3.97E-07			
PPMV, As Sampled	0.7	1.2	1.6	1.9			
PPMV, @ 0% Oxygen	1.2	1.9	2.5	3.1	2.2	0.8	37.5%
PPMV, @ Duct Conditions	0.7	1.2	1.6	1.9	1.3	0.5	37.8%
SO_3 in CONDENSER							
lb/DSCF	3.85E-07	4.30E-07	2.61E-07	4.17E-07			
PPMV, As Sampled	1.9	2.1	1.3	2.0			
PPMV, @ 0% Oxygen	3.0	3.4	2.1	3.2	2.9	0.6	20.1%
PPMV, @ Duct Conditions	1.9	2.1	1.3	2.0	1.8	0.4	20.6%
GAS PHASE SO_3 [lb/DSCF]	5.35E-07	6.76E-07	5.82E-07	8.15E-07			
GAS PHASE SO_3, [Duct PPM]	2.6	3.3	2.8	3.9	3.2	0.6	18.8%
GAS PHASE SO_3, 0% OXYGEN	4.2	5.3	4.6	6.3	5.1	0.9	18.1%
TOTAL PHASE SO_3 [lb/DSCF]	5.78E-07	7.17E-07	7.82E-07	9.73E-07			
TOTAL PHASE SO_3 [Duct PPM]	2.8	3.5	3.8	4.7	3.7	0.8	21.4%
TOTAL SO_3, 0% OXYGEN	4.5	5.6	6.2	7.5	5.9	1.2	21.0%
% SO_3 in SOLIDS [filter plug/total]	7.4	5.7	25.6	16.3	13.8	9.1	66.4%
% SO_3 in TOTAL SO_x	*0.29*	*0.36*	*0.40*	*0.49*	0.38	0.08	21.6%

ESP Inlet Sampling Ducts



Total Ports Sampled - 10
Total Points Sampled - 30
Cross-Sectional Ares - 238 sq ft

ESP Outlet (Stack) Sampling Ducts

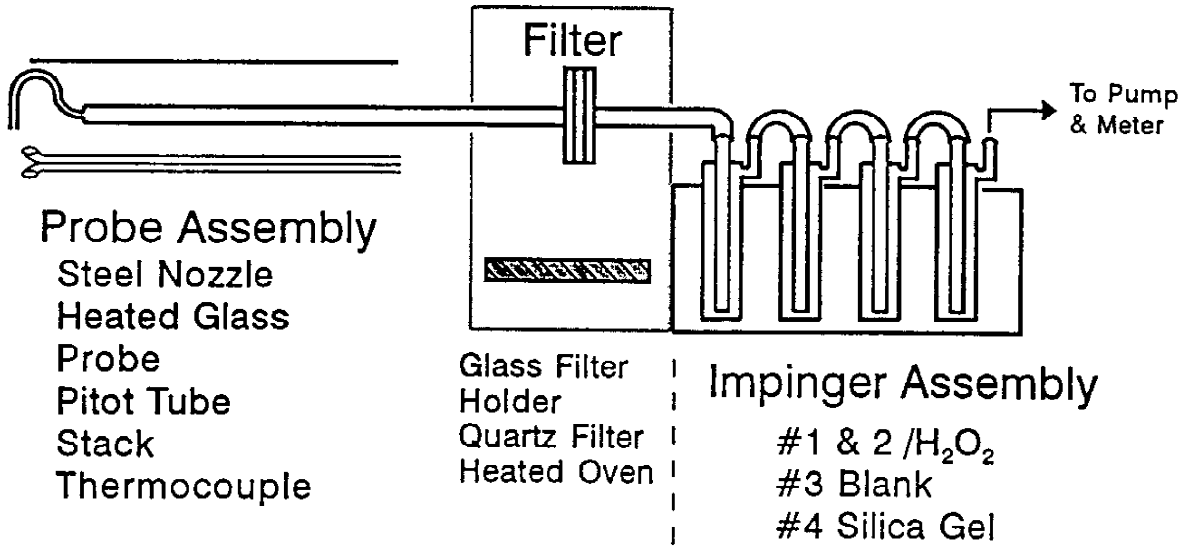


Point Distances From Wall		
Point 1	8.5	inches
Point 2	28.0	inches
Point 3	56.75	inches

Stack Diameter - 16 ft
Total Ports Sampled - 4
Total Points Sampled - 12
Cross-Sectional Area - 201 sq ft

Figure 1 - Milliken Unit #2 ESP Sampling Locations

EPA Method 5 Particulate Sampling Train
(Out-of-Stack Filter Technique)



EPA Method 17 Particulate Sampling Train
(In-Stack Filter Technique)

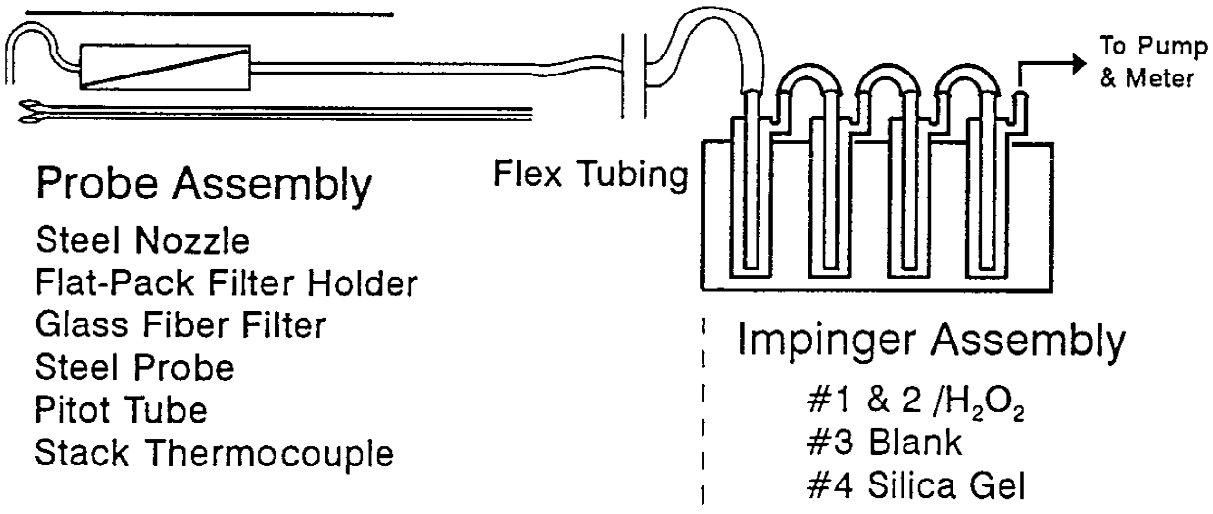


Figure 2 - Schematics of Particulate Sampling Trains

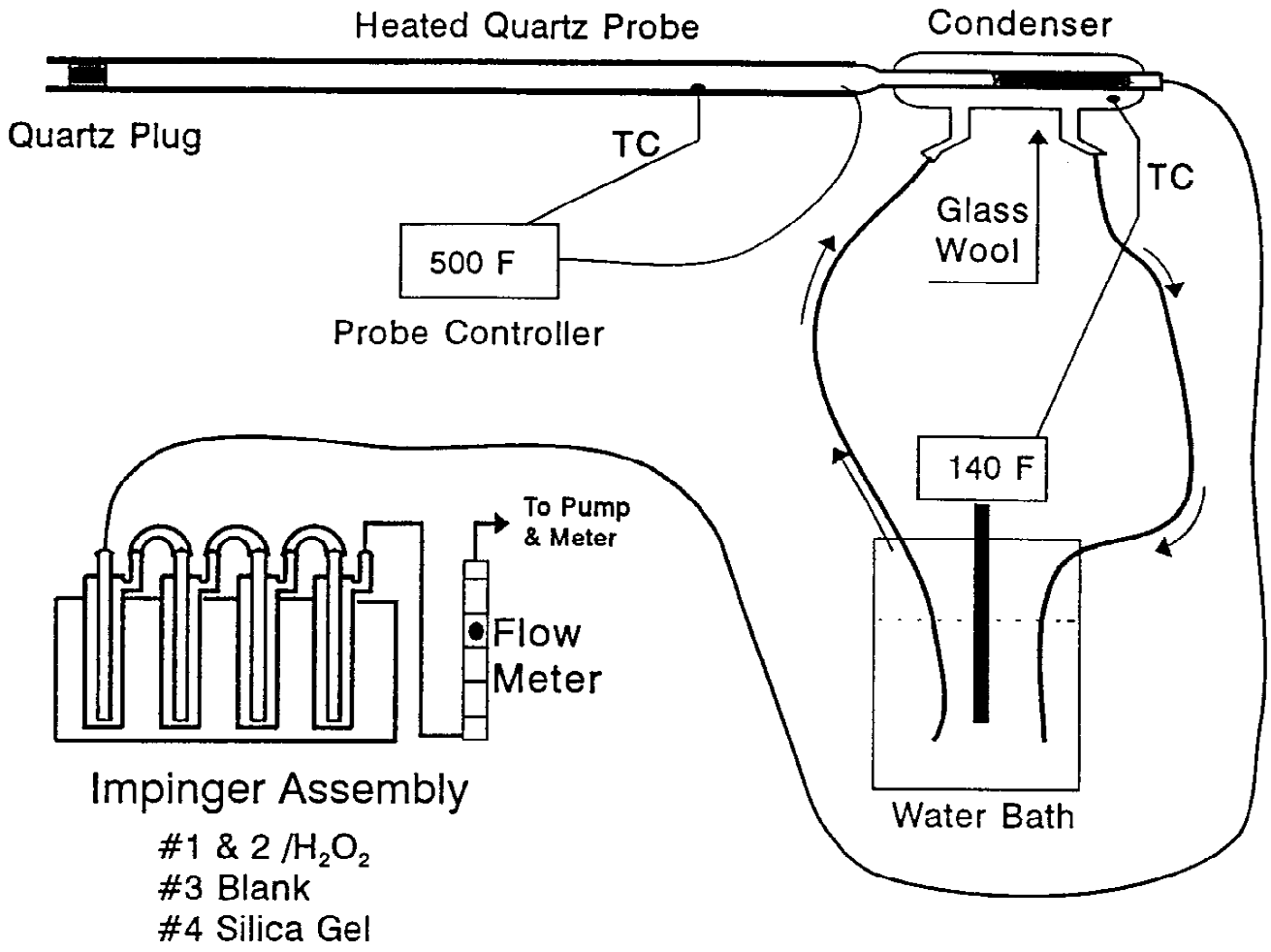


Figure 3 - CONSOL R&D SO_3 Sampling Train

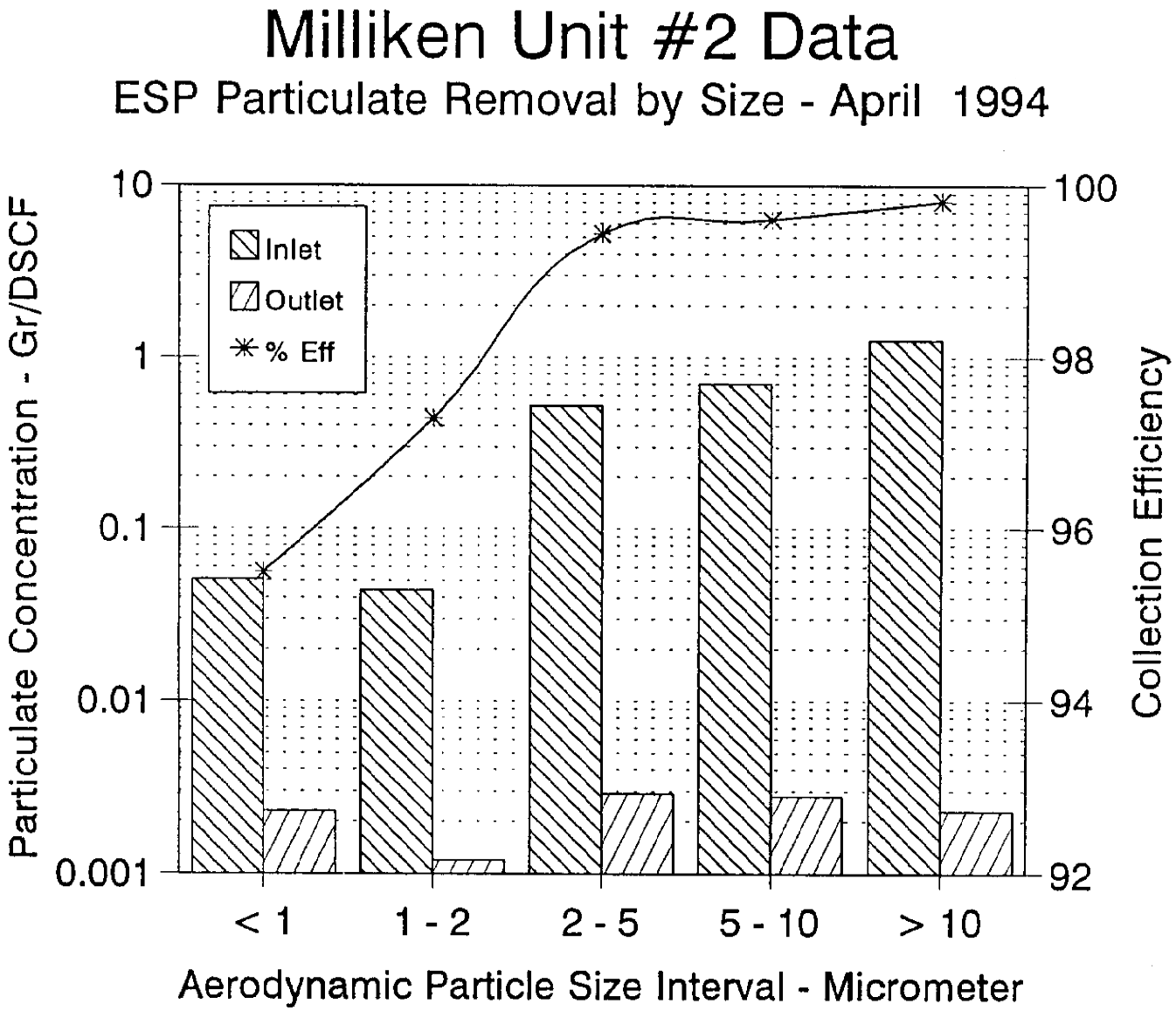


Figure 4 - ESP Particulate Removal by Particle Size

APPENDIX A

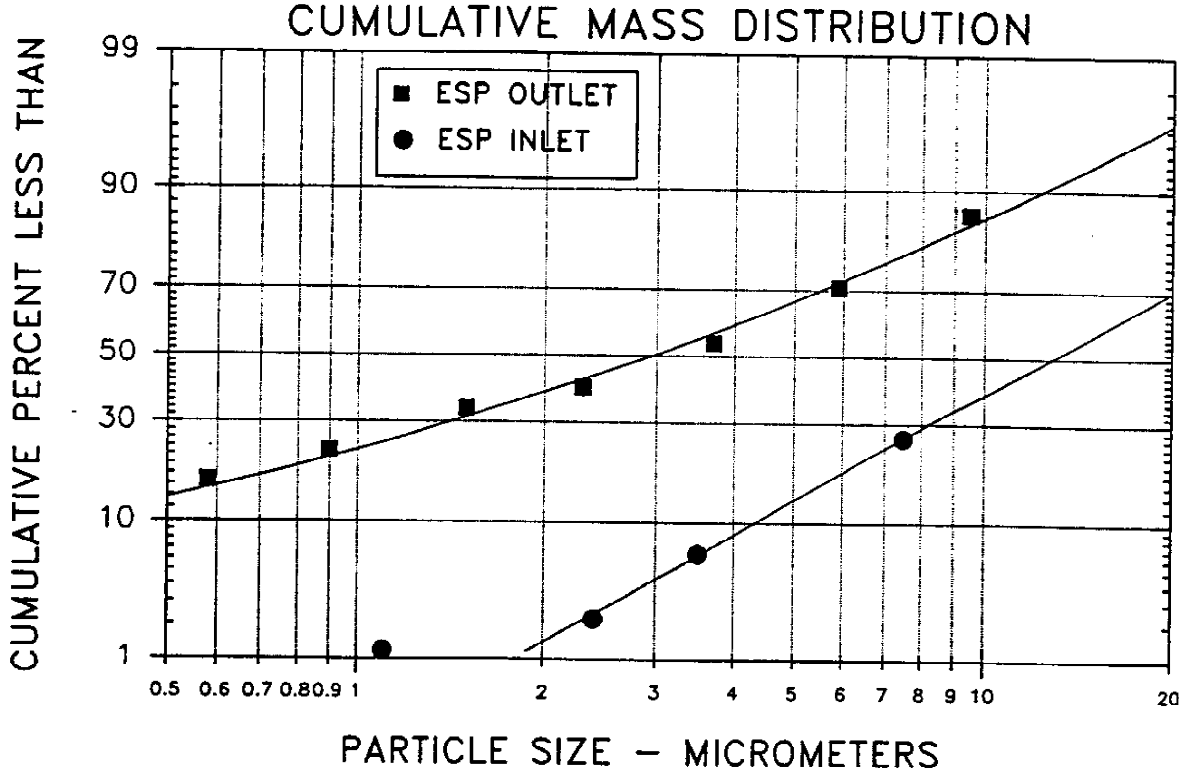
Cumulative and Differential Particle Size Graphs

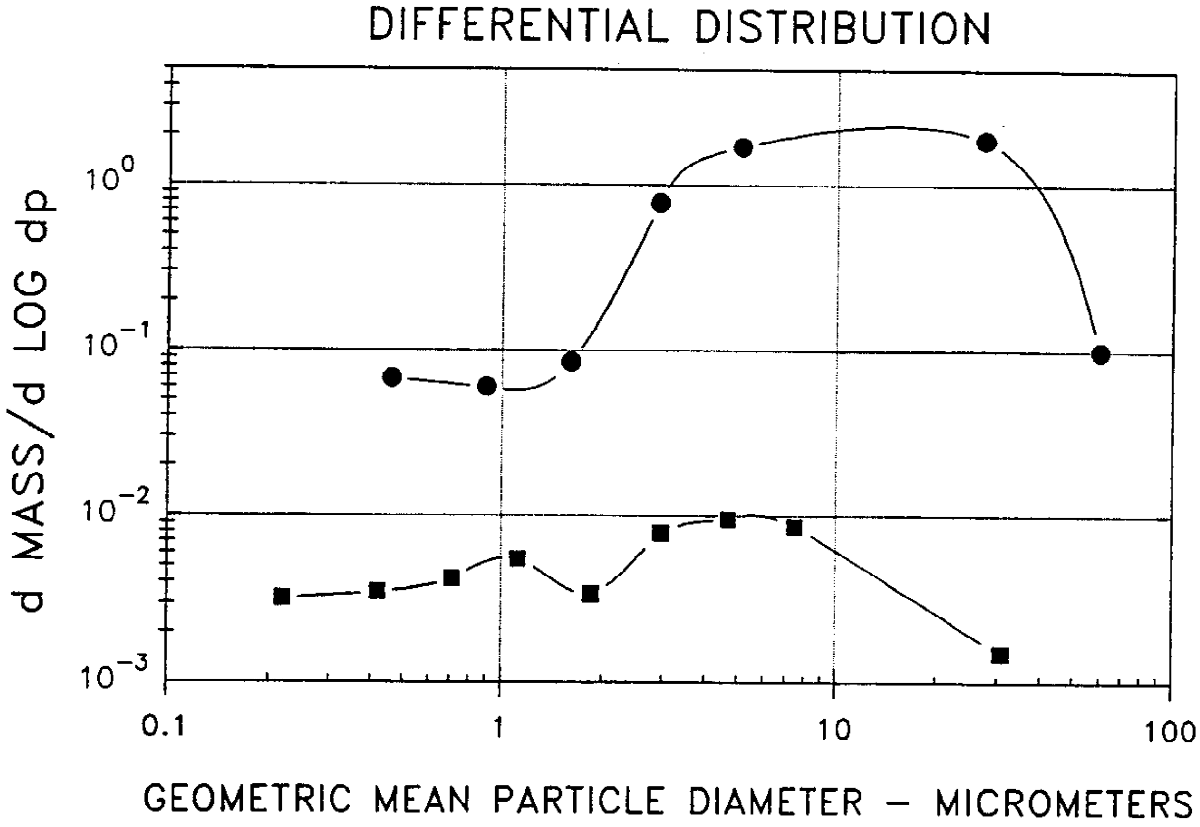
4/18/94 Inlet / Outlet Data
4/19/94 Inlet / Outlet Data
4/20/94 Inlet / Outlet Data

Average Inlet Data
Average Outlet Data

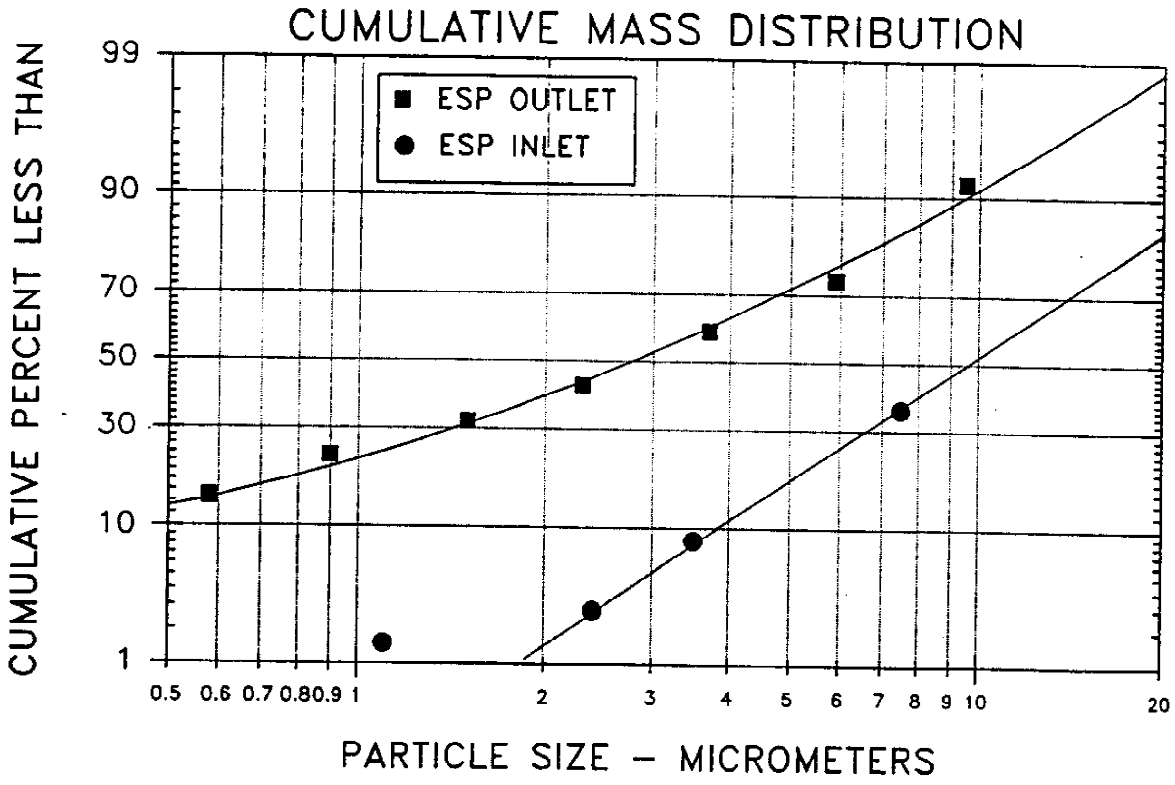
Average Inlet / Outlet Data

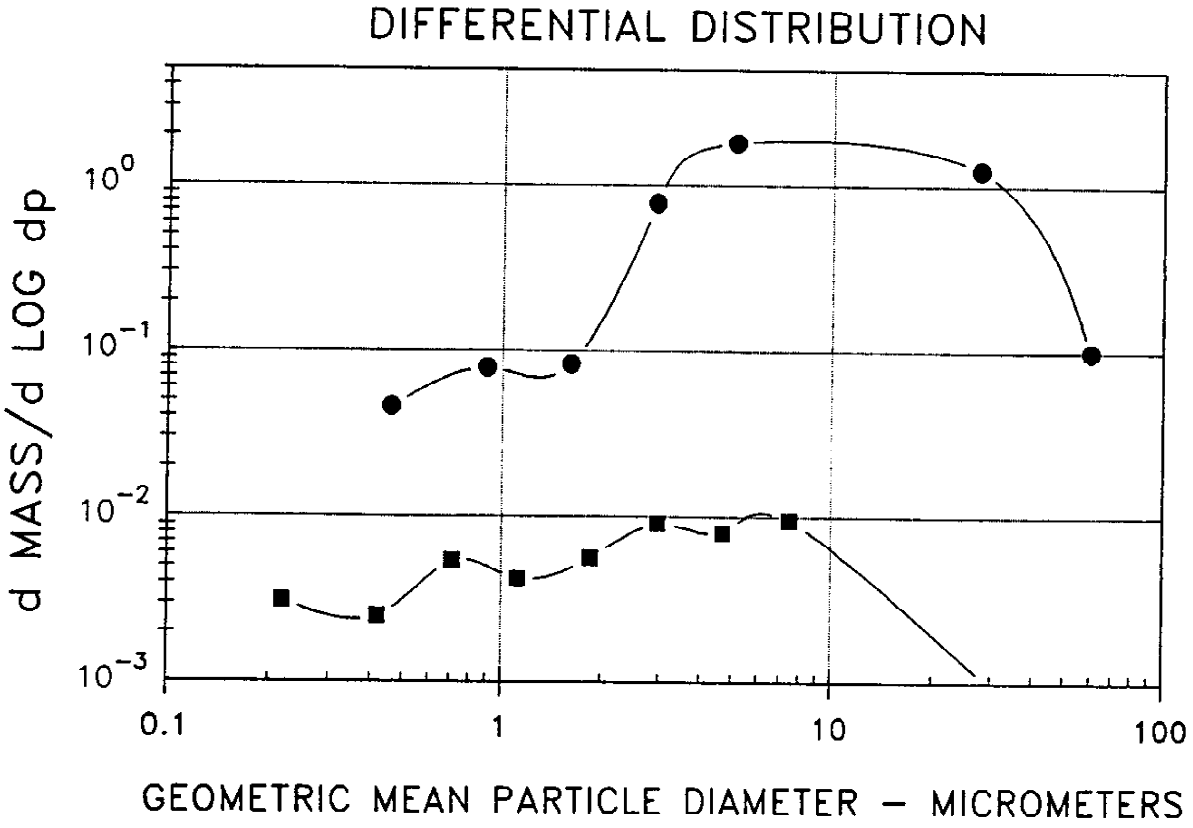
PARTICLE SIZE DISTRIBUTIONS – APRIL 18, 1994



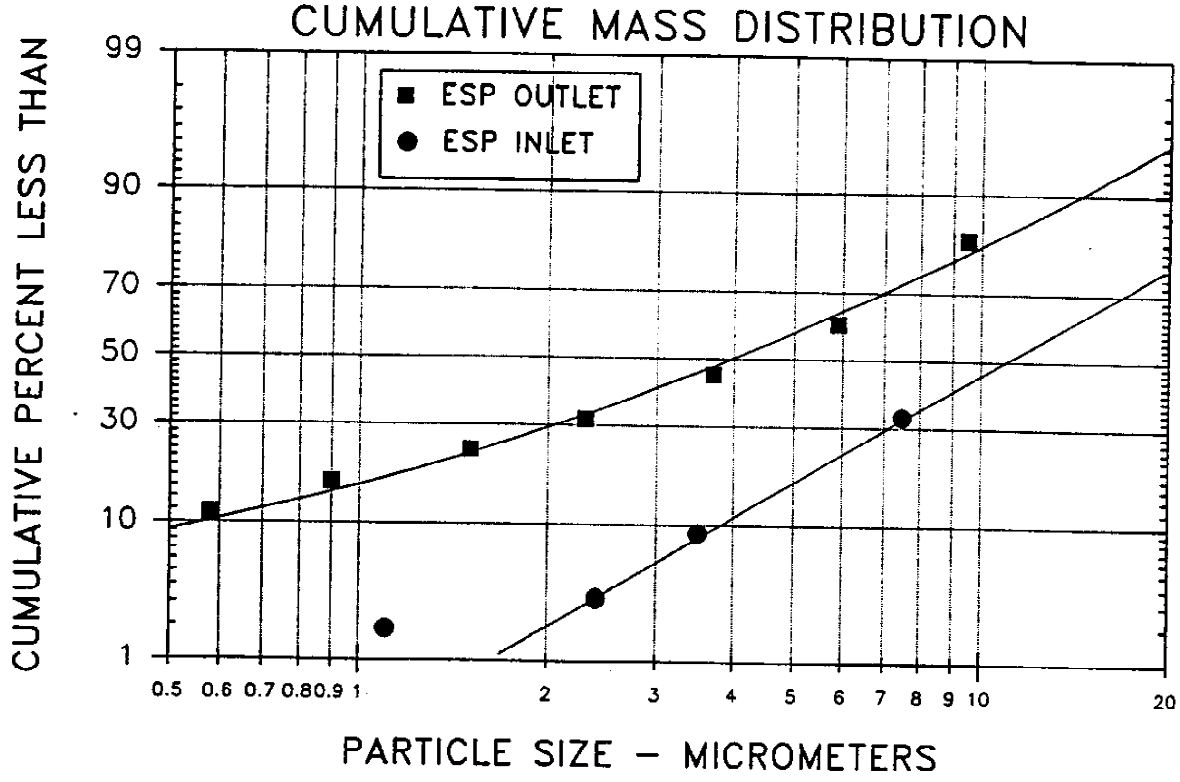


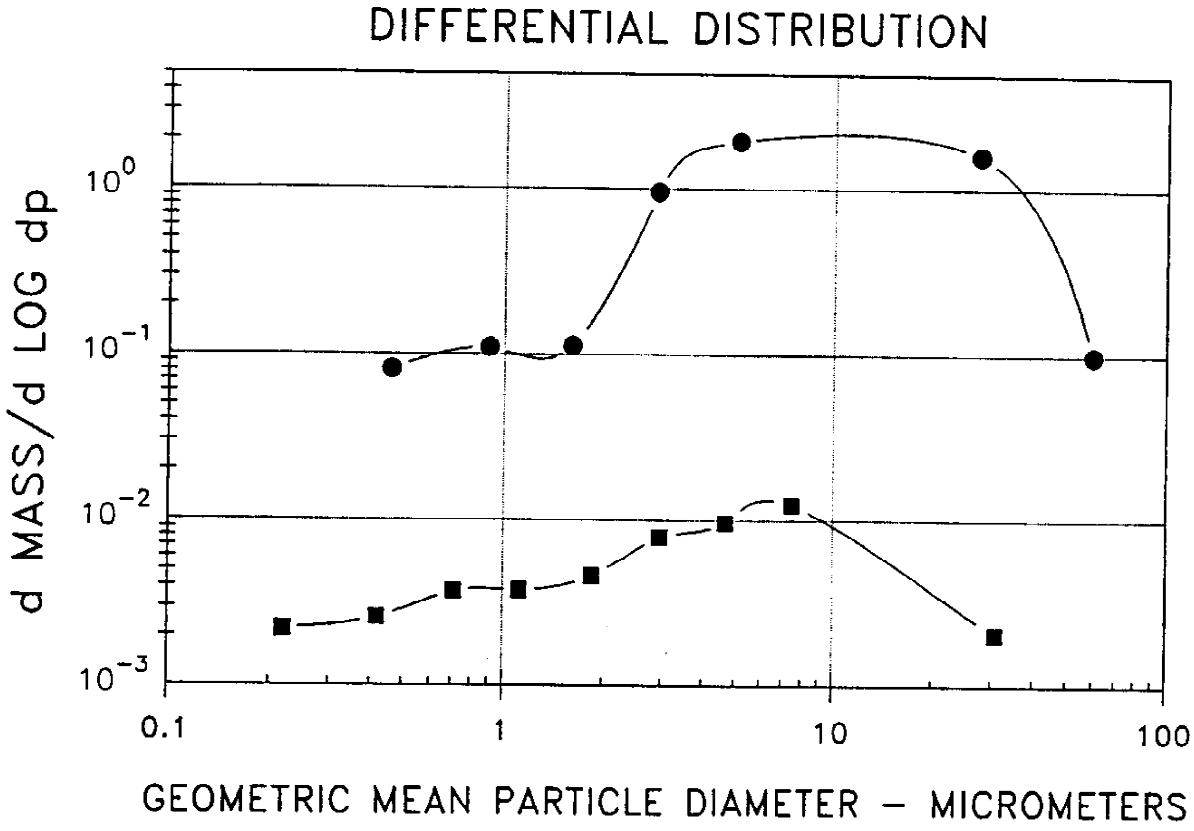
PARTICLE SIZE DISTRIBUTIONS – APRIL 19, 1994



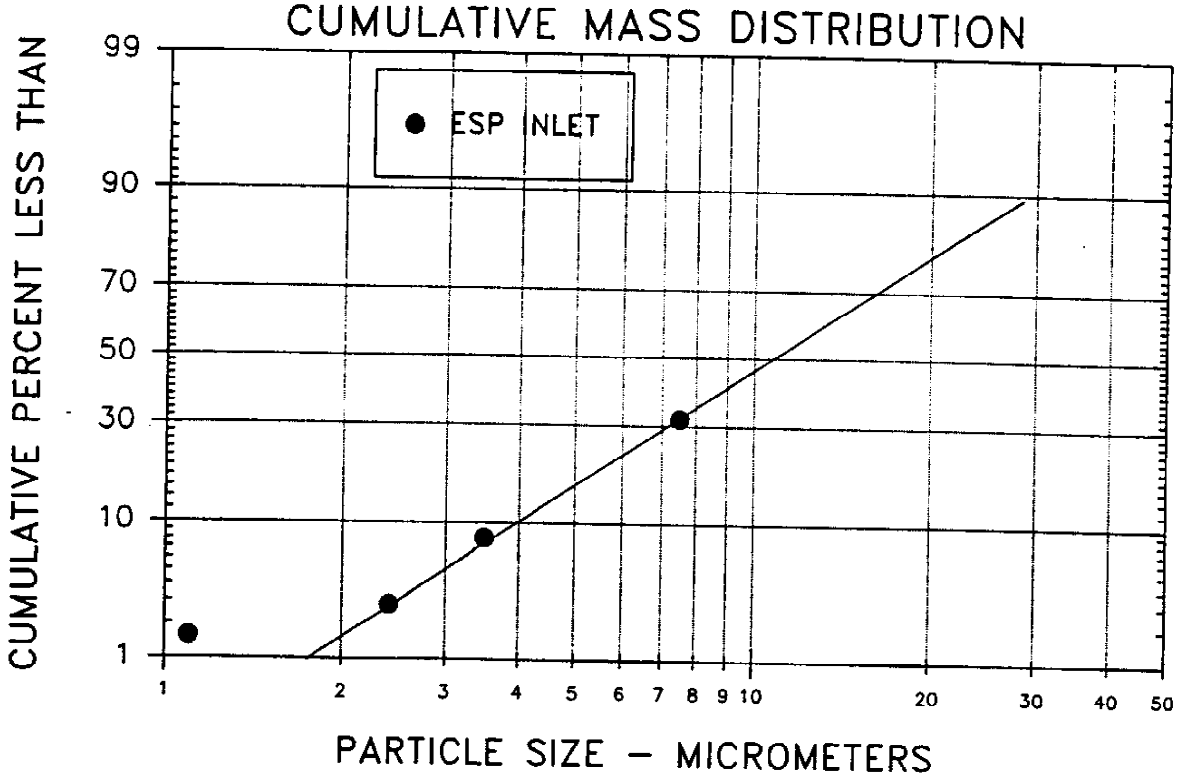


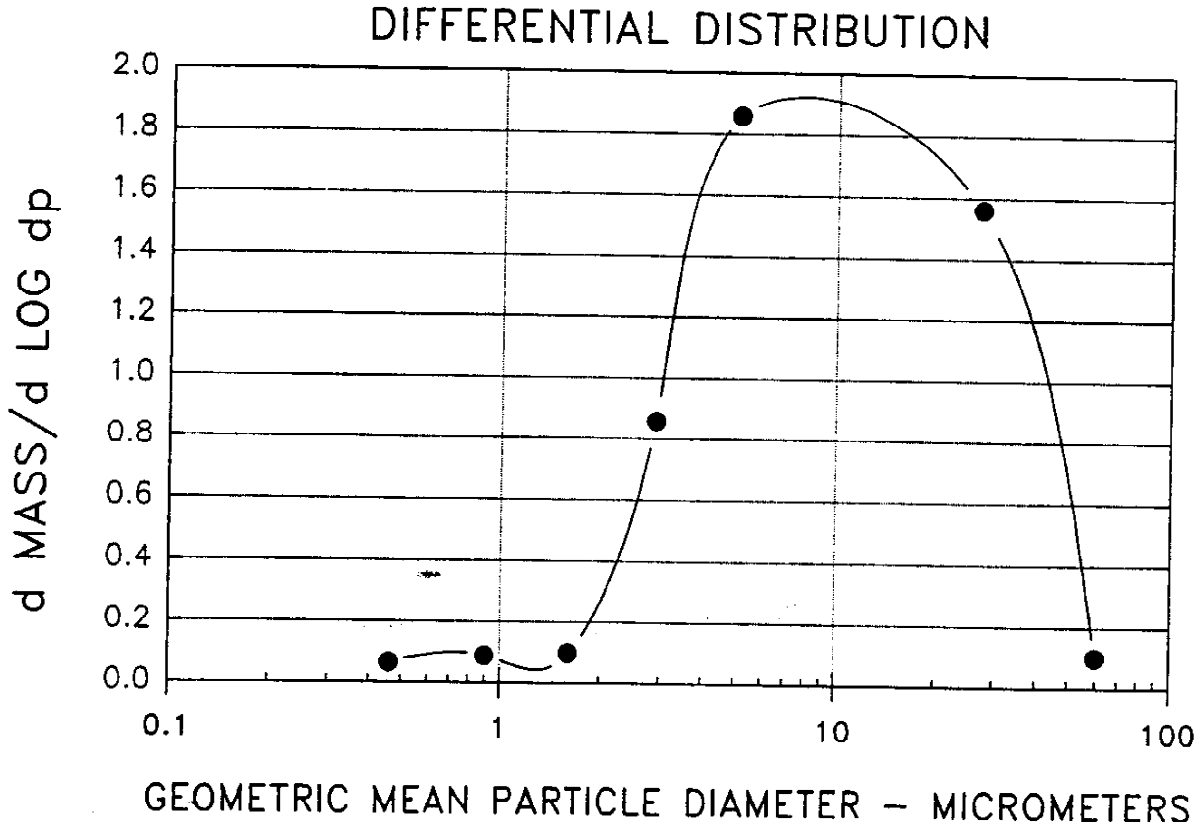
PARTICLE SIZE DISTRIBUTIONS – APRIL 20, 1994



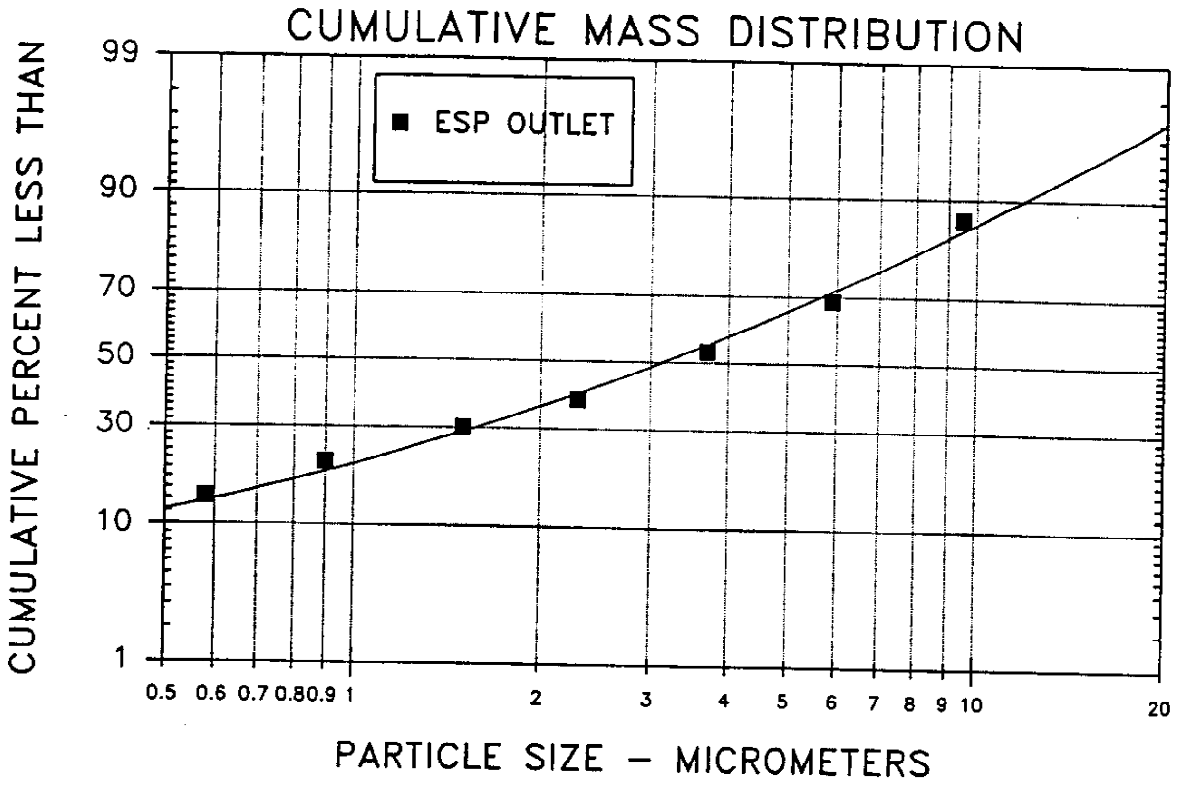


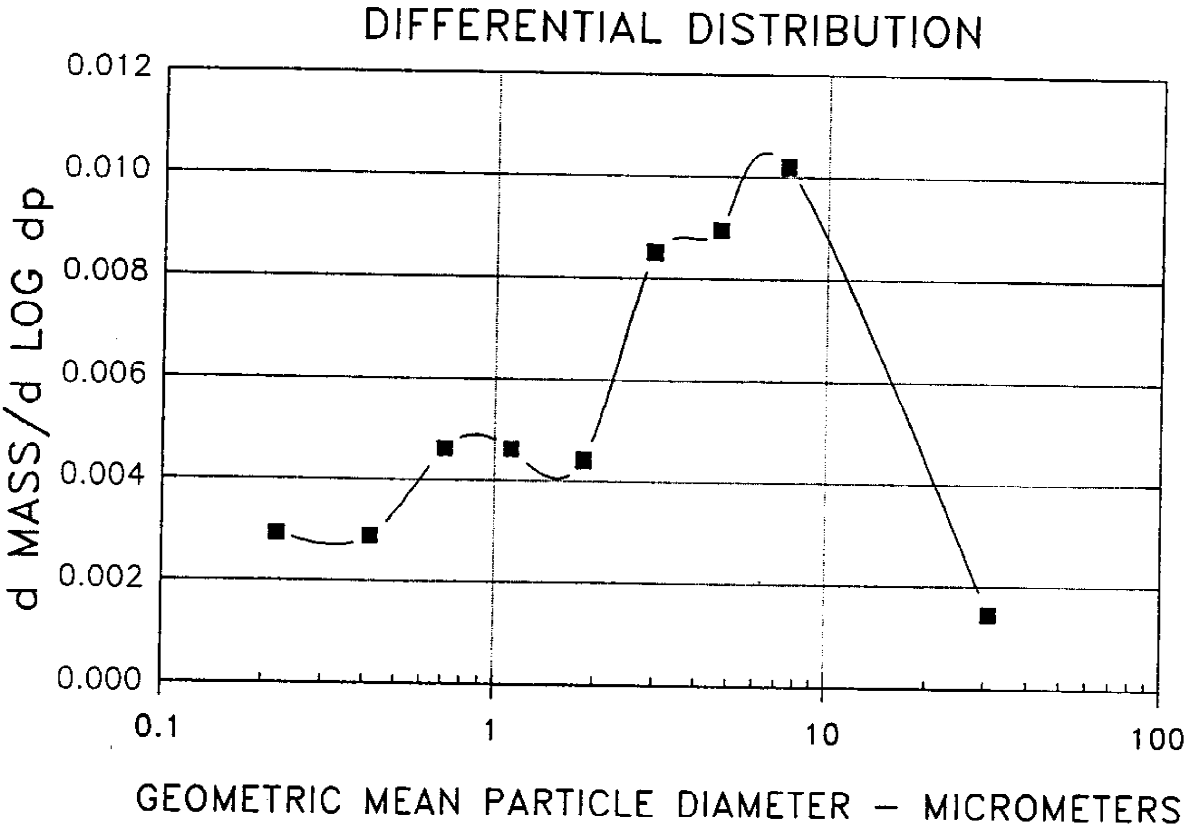
ESP INLET SIZE DISTRIBUTIONS -3 TEST AVERAGE



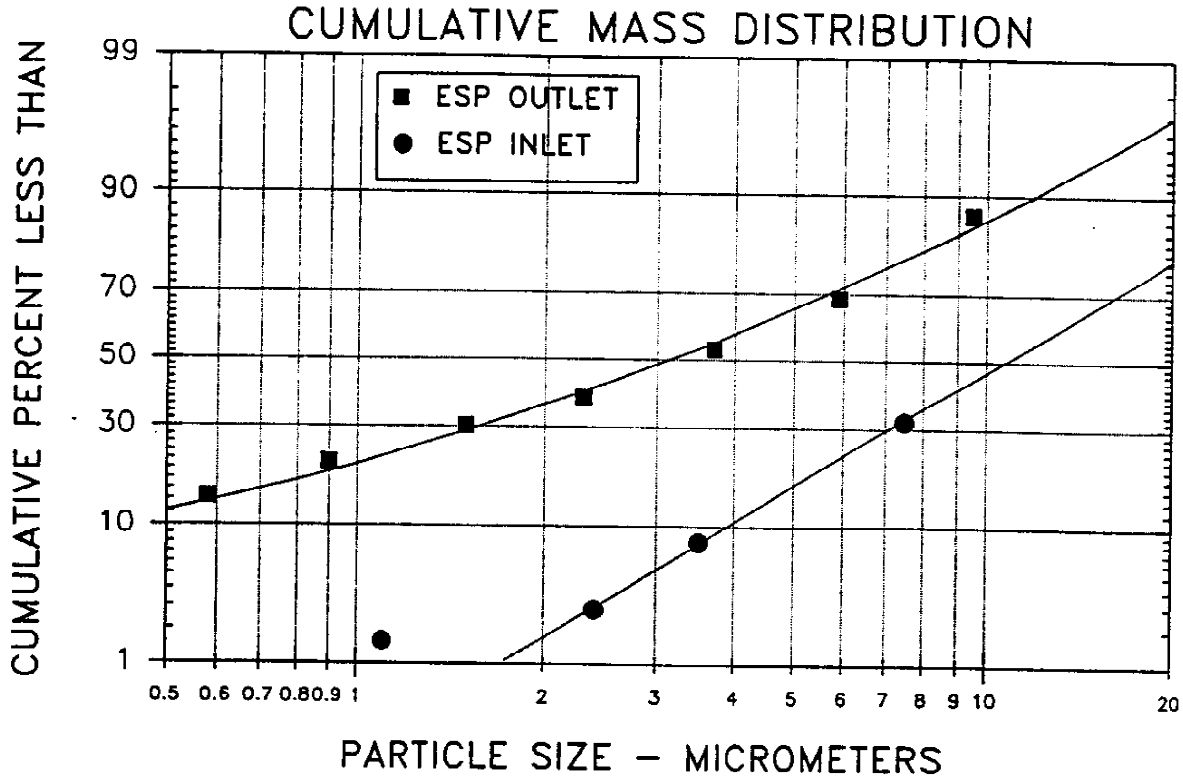


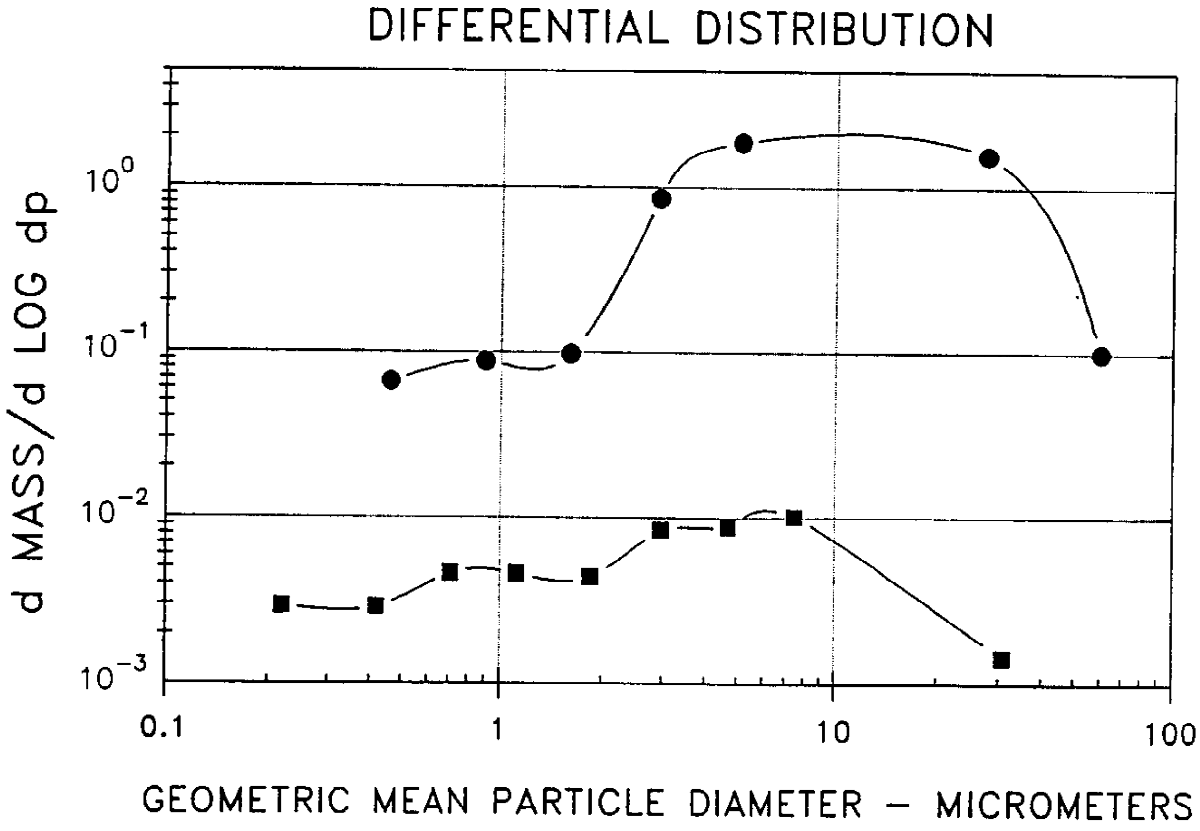
ESP OUTLET SIZE DISTRIBUTIONS –3 TEST AVERAGE





PARTICLE SIZE DISTRIBUTIONS –3 TEST AVERAGE





APPENDIX B

Ash Resistivity Field Data

Duct A / Port 8
Duct A / Port 2
Duct A / Port 2
Duct A / Port 5
Duct B / Port 2
Duct B / Port 5
Duct B / Port 9

TYPICAL POINT PLANE PROBE DATA

LOCATION ESP inlet LAYER THICKNESS 2.28 mm

TIME _____ DATE 4-17-94 TEST NO. 1 Duct A Port H (8)

CONDITIONS _____ NOTE: Hot side $P = 6.51 \times 10^{10}$

STARTING READING 10.16 10.26 10.19 10.20 142 mW to 147 mW

ENDING READING 7.92

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°F)	GAS TEMP (°F)
0	10.08	2.00	282	281
30	10.02	1.62	284	284
60	10.03	1.14	285	285
90	10.02	0.99	282	281
120	10.01	0.79	282	283

V-I DATA		
KV	CLEAN	DIRTY
1	4.79	5.57
2	5.42	6.72
3	5.87	7.56
4	6.32	8.30
5	6.65	8.98
6	7.06	9.51
7	7.42	10.11
8	7.67	10.41
9	8.03	10.91
10	~~8.80~~	11.22
11	~~8.85~~	11.55
12	8.82	11.97
13	9.01	12.22
14	9.17	~~12.55~~
15	9.42	12.89
2 ~~16~~	10.39	14.01
3 ~~17~~	11.91	14.96
4 ~~18~~	13.16	16.33
5 ~~19~~	13.76	17.34
20		
21		
22		
23		
24		
25		

2.97

GAS TEMP (C) 283

SPARK DATA		
V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

652

LOCATION _____ LAYER THICKNESS 1.42mm

TIME _____ DATE 4-17-94 TEST NO. 2 Duct A Port B (3)

CONDITIONS _____ NOTE: P = 4.08 x 10^10

STARTING READING 7.82 7.83 7.83 7.83

ENDING READING 6.41

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°C)	GAS TEMP (°F)
0	14.20	200	122 251F	
30	14.22	1.81	122	
60	14.23	1.81	122	

V-I DATA

KV	CLEAN	DIRTY
1	6.93	7.35
2	7.28	8.29
3	7.90	9.01
4	8.41	9.76
5	8.97	10.38
6	9.42	10.98
7	9.95	11.47
8	10.23	12.11
9	10.79	12.62
10	11.12	13.05
11	11.40	13.51
12	11.89	13.80
13	11.94	14.18
14	12.41	14.68
15	12.53	14.99
16	13.98	16.44
17	14.01	16.67
18	17.95	20.39
19	18.96	21.58
20		
21		
22		
23		
24		
25		

1.16

2 3 4 5

GAS TEMP (C) 122

SPARK DATA

V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

LOCATION ESP Inlet LAYER THICKNESS 2.71 cm

TIME _____ DATE _____ TEST NO. 1 Aduct Port B(2

CONDITIONS _____ NOTE: Cool side

STARTING READING 8.09 805 803-806 142 MW Res. 7.67×10^{10}

ENDING READING 5,35 Voltage & Amperage Reads Drifting

SAMPLE COLLECTION

TIME min.	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°C)	GAS TEMP (°F)
[redacted]0	14.19	2.0	122	
30	14.19	1.95	122	
60	14.19	1.69	122	
90	14.19	1.38	122	
120	14.19	1.08	123	

Adjusted Voltage To Read →

V-I DATA			
KV	CLEAN	DIRTY	
1	6.00	[redacted]	725
2	7.06	[redacted]	887
3	7.69	[redacted]	10.03
4	8.17	10.95	
5	8.73	11.83	
6	9.30	12.62	
7	9.81	13.25	
8	10.25	13.78	
9	10.51	14.42	
10	11.05	15.21	4.16
11	11.50	15.55	
12	11.97	16.01	
13	12.21	16.42	
14	12.45	16.73	
15	12.69	16.93	
16	14.31	18.21	
17	16.45	20.95	
18	18.08	→ spark	
19	18.83		
20			
21			
22			
23			
24			
25			

2
3
4
6

GAS TEMP (C) _____

SPARK DATA		
V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

LOCATION ESP inlet LAYER THICKNESS 2.17

TIME _____ DATE 4-18-94 TEST NO. 1 A Duct Port E(

CONDITIONS _____ NOTE: ρ = 4.49 x 10^10

STARTING READING 846 848 842 (845) 140mw

ENDING READING 6.28

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°C)	GAS TEMP (°F)
0	15.25	2.50	126	
20	15.13	2.30	130 269	
40	15.14	1.92	132	
60	15.16	1.58	132	

V-I DATA		
KV	CLEAN	DIRTY
1	6.28	6.60
2	7.06	7.84
3	7.64	8.62
4	8.19	9.58
5	8.92	10.20
6	9.44	10.92
7	9.90	11.48
8	10.25	11.93
9	10.70	12.55
10	11.22	13.17
11	11.58	13.60
12	11.82	14.08
13	12.19	14.45
14	12.57	14.86
15	12.79	15.29
16	14.18	16.88
17	16.15	19.12
18	18.13	21.10
19	19.32	22.43
20		
21		
22		
23		
24		
25		

1.95

2
3
4
5

GAS TEMP (C) _____

SPARK DATA		
V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

LOCATION ESP inlet LAYER THICKNESS 1.88

TIME _____ DATE 4-18-94 TEST NO. 1 Duct B Port B

CONDITIONS _____ NOTE: Hot Side.

STARTING READING 10.26 10.24 1023 (10.24) 140mw P = 3.085x10^10

ENDING READING 8.36 Sample

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (F)	GAS TEMP (°F)
0	10.91	2.50	275	274
20	10.91	2.35	271	272
40	10.92	2.09	271	270
60	10.93	1.86	270	270

V-I DATA		
KV	CLEAN	DIRTY
1	4.33	4.72
2	5.10	5.42
3	5.47	6.16
4	5.97	6.70
5	6.33	7.12
6	6.76	7.53
7	7.09	7.98
8	7.42	8.26
9	7.67	8.73
10	7.93	9.09
11	8.17	9.50
12	8.47	9.85
13	8.65	10.13
14	8.83	10.23
15	8.92	10.47
16	10.21	11.58
17	11.53	13.37
18	12.86	14.70
19	13.52	14.91
20		
21		
22		
23		
24		
25		

7.93
9.09
1.16
9.50

2
3
4
5

GAS TEMP (C) _____

SPARK DATA		
V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

new Probe

LOCATION ESP Inlet LAYER THICKNESS 0.95

TIME _____ DATE 4-18-94 TEST NO. 1 Duct B Port E (3)

CONDITIONS _____ NOTE: 140mm

STARTING READING 9.78 9.76 9.84 (9.79) $P = 8.895 \times 10^{10}$

ENDING READING 8.84

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°F)	GAS TEMP (°F)
0	10.94	2.50	271	269
20	10.93	241	269	269
40	10.95	200	270	270
60	10.93	169	271	275

V-I DATA		
KV	CLEAN	DIRTY
1	4.80	7.77
2	4.93	5.78
3	5.14	6.46
4	5.64	7.05
5	6.27	7.43
6	6.58	7.99
7	6.98	8.39
8	7.23	8.77
9	7.57	9.24
10	7.82	9.51
11	8.17	9.84
12	8.38	10.21
13	8.56	10.52
14	8.81	10.72
15	9.02	11.07
16	10.00	12.00
17	11.47	13.98
18	12.70	15.21
19	13.65	16.33
20		
21		
22		
23		
24		
25		

(1.69)

GAS TEMP (C) _____

SPARK DATA		
V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____

TYPICAL POINT PLANE PROBE DATA

old Probe

LOCATION _____ LAYER THICKNESS 0.80

TIME _____ DATE 4-18-94 TEST NO. 1 Duct B - Port I

CONDITIONS Hot! NOTE: 140mm

STARTING READING 7.98 7.96 7.97 (7.97) P = 5.688 x 10^10

ENDING READING 7.17

SAMPLE COLLECTION

TIME	VOLTAGE (KV)	CURRENT (AMPS)	PROBE TEMP (°C)	GAS TEMP (°F)
0	15.28	2.50	109	
20	15.11	2.41	108	
40	14.99	2.28	109	
60	14.97	1.98	110	

V-I DATA

KV	CLEAN	DIRTY
1	6.97	Call
2	7.45	7.08
3	8.08	7.97
4	8.57	8.74
5	9.12	9.37
6	9.58	10.05
7	10.01	10.49
8	10.46	11.04
9	10.63	11.48
10	11.04	11.95
11	11.26	12.38
12	11.60	12.82
13	11.93	13.30
14	12.45	13.70
15	12.71	13.96
16	14.14	15.40
17	16.33	17.92
18	18.60	19.89
19	18.83	21.28
20		
21		
22		
23		
24		
25		

0.91

2 3 4 5

GAS TEMP (C) _____

SPARK DATA

V	I	E
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		
2800		
2900		
3000		

GAS TEMP (C) _____