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PARTICULATE COLLECTION EFFICIENCY MEASUREMENTS ON AN ESP INSTALLED ON A COAL-FIRED UTILITY BOILER

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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by

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SECTION I
SUMMARY AND CONCLUSIONS

Overall mass and fractional collection efficiency measurements were made on an electrostatic precipitator collecting fly ash resulting from the combustion of a high-sulfur (3.1-5.6% S) coal at the Tennessee Valley Authority's Colbert Steam Plant. The measurements were conducted under the following two sets of electrical conditions: (1) The power supplies were operated under automatic control, which resulted in an average current density of 17×10^{-9} amps/cm^2. (2) The input power to the power supplies was intentionally reduced, which resulted in an average current density of 8×10^{-9} amps/cm^2. Under both sets of electrical conditions, the specific collecting area was maintained at approximately 47 $m^2/(m^3/sec)$, and the average flue gas temperature was 156°C. The maximum value of fly ash resistivity recorded during the test series with a point-plane probe was 2.4×10^{10} ohm-cm. Average overall collection efficiencies of 99.55% and 99.03% were obtained from mass train measurements under automatic control and with the manually reduced power settings, respectively.

Cascade impactor measurements indicated that the mass median particle diameter of the fly ash entering the collector was approximately 40 μm. For the tests conducted under normal current densities, the impactor measurements showed that the collection efficiency of 1.0 μm diameter particles was 97.5%. Under the reduced power settings, the collection efficiency of 1.0 μm diameter particles was 92.0%. The mass median diameter of the particulate mass escaping the precipitator was between 3.0 and 4.0 μm for both the normal and reduced current density test conditions.

A comparison of measured collection efficiencies with those obtained from simulating the precipitator operating conditions with a mathematical model indicated that the theoretical model underpredicted the fine particle collection efficiencies. However, the model predicted the relative effect of the change in electrical operating conditions on overall mass efficiency with reasonable accuracy. The resistivity measurements obtained during the test period indicated that ash resistivity was not limiting the electrical operating conditions of the precipitator. The relatively low values of allowable current density apparently result from sparking due to dust build-ups or to the geometry of the electrode system.

SECTION II
INTRODUCTION

This report presents the information obtained from a performance test conducted by Southern Research Institute on the electrostatic precipitator installed on Unit #4 at the TVA's Colbert Steam Plant. The data in this report were obtained with normal operation of the rapping system. Additional data concerning rapping reentrainment losses were obtained under the sponsorship of the Electric Power Research Institute (EPRI). These data will be available in a future EPRI report. Table 1 gives a description of the tasks performed on each day of the test series. This report presents results from test numbers 2, 3, 6, 7, 9, 10, and 11.

The objectives of the EPA-sponsored portion of the test were (1) to determine the overall particulate collection efficiency of the electrostatic precipitator, and (2) to compare the measured performance of the precipitator with that projected from a mathematical model.

DESCRIPTION OF ELECTROSTATIC PRECIPITATOR

The electrostatic precipitator installed on Unit #4 of the Colbert Station consists of three fields in the direction of gas flow (Figure 1). The precipitator is physically divided into two collectors (A & B). The test program conducted at Colbert was conducted on the "A" side of the #4 precipitator. The total collecting area for the "A" side is 7,374.4 m^2 (79,380 ft^2), with 2,458.13 m^2 (26,460 ft^2) per field. This gives a specific collection area of 34.489 $m^2/(m^3/sec)$(175 $ft^2/1000$ cfm) for the design volume of 213.82 m^3/sec (453,000 ACFM) per collector. Each collector has three double half-wave transformer rectifiers or one per field (see Figure 1). The precipitator has a 27.94 cm (11 in) plate spacing and operates at approximately 149°C (300°F). A drop hammer type of rapping system is employed in which two plates are rapped simultaneously with each hammer. The first field is rapped 10 times/hour, the second field is rapped 6 times/hour, and the third field is rapped 1 time/hour. The emitting electrodes are square twisted wires with an approximate diameter of .419 cm (.165 in) and are 10.0 m (32' 9 3/4") long. There are 12 wires per lane per field for a total of 1512 wires. The discharge electrodes are held in a rigid frame, each frame holds 4 wires (see Figure 2).

SECTION III
MEASUREMENT TECHNIQUES

MASS CONCENTRATION MEASUREMENTS

Mass loading determinations were conducted at the inlet and outlet sampling locations with in-stack filters. Glass fiber thimbles were used at the inlet to collect the particulate mass and preconditioned Gelman 47 mm glass fiber filters were used at the outlet and as back up filters at the inlet. The sampling probes used at the inlet and outlet were heated and contained pitot tubes to monitor the velocities at each sampling location. An isokinetic traverse across the duct was conducted to obtain the mass loading at the precipitator inlet and outlet. The Gelman 47 mm filters were weighed before and after each test in the field on a Cahn electrobalance, whereas the inlet thimbles were weighed in Birmingham before and after the test due to the absence of a suitable balance at the test site.

GAS ANALYSIS MEASUREMENTS

The concentrations of sulfur trioxide, sulfur dioxide, oxygen, carbon dioxide, and the moisture content of the flue gas were determined at the inlet of the precipitator. The sulfur trioxide samples were collected by a condensation method[1] while the sulfur dioxide was collected in a hydrogen peroxide solution, which oxidized the sulfur dioxide to sulfur trioxide. Each of the sampling techniques for the oxides of sulfur produced a sample for analysis that consisted of a dilute sulfuric acid. The concentrations of acid (from which the SOx concentrations may be calculated) were determined by barium perchlorate titration using thorin indicator[2].

The percentage of oxygen and carbon dioxide were determined by the use of Fyrite gas analyzers. The moisture content of the flue gas was determined by pulling a known volume of gas through a preweighed packed drierite column. The drierite column was then weighed and the moisture content calculated from the weight change.

V-I MEASUREMENTS

Primary and secondary voltages and currents were recorded from the transformer control cabinets during each test. At the end of the test period, a voltage divider resistor assembly was attached to the high voltage side of each transformer. The secondary voltages were then calculated from the voltage drop across the measurement resistor and the resistance values from the resistors in the voltage divider assembly. These secondary voltages were used to establish a correction factor for the panel meters. All transformers were checked with the voltage divider assembly, and the secondary voltage readings were corrected accordingly.

OPACITY MEASUREMENTS

A Lear Siegler RM41p portable optical transmissometer was placed in the outlet duct to measure the in-stack plume opacity. The portable transmissometer has an optical path length of two meters and compensation circuitry for determining opacity in terms of the stack exit diameter. All opacity measurements in this report are given in terms of a two meter optical path length.

PARTICLE SIZE MEASUREMENTS

Particle size and concentration measurements were conducted using the following methods: (1) inertial techniques using cascade impactors for determining concentrations and size distributions on a mass basis for particles having diameters between approximately .2 μm and 10.0 μm, (2) electrical mobility analysis for size and concentration measurements on a number basis in the diameter range of 0.015 to 0.3 μm.

Impactor and ultrafine particle sizing data were reduced according to the procedures delineated in the Appendix following this report. Individual impactor calibrations were not yet available when these data were reduced. Andersen Model III Impactors were used at the outlet while SoRI modified Brink Impactors were used to sample at the inlet. Glass fiber impaction substrates and back up filters, which were preconditioned by overnight exposure to the flue gas, were used. Blank runs with the glass fiber substrates were conducted daily. Nominal flow rates were 1.4×10^{-5} m^3/sec (.03 CFM) for the Brink Impactor, and 1.9×10^{-4} m^3/sec (.4 CFM) for the Andersen Impactor.

A system based on the use of particle mobility analysis was used for obtaining essentially real time data on concentration and size distribution on a number basis over the range of particle diameters from 0.015 μm to about 0.3 μm diameters. The data obtained with this system are on a volume concentration by number rather than weight basis. Two types of mobility analyses were considered for use in this test: (1) diffusional methods and (2) electrical mobility methods. Because of its compactness and short measurement time (29.5 kg and 2 minutes) as compared with the diffusional method (136 kg and 2 hours), the electrical mobility method was selected for use on this test (a Thermosystems Model 3030 Electrical Aerosol Analyzer). The electrical mobility method operates by placing a known charge on the particles and precipitating the particles under closely controlled conditions. Size selectivity is obtained by varying the electric field in the precipitator section of the mobility analyzer. Charged particle mobility is monotonically related to particle diameter in the operating regime of the instrument (0.015 to 0.3 μm particle diameter).

None of the instruments used for particle mobility analysis can tolerate raw flue gases as sample streams nor can they cope with the particle concentrations encountered in the flue gas. Thus, particle mobility analyses are based on extractive sampling with a metered sample being diluted with clean dry air, to both condition the sample and reduce the particle concentrations to levels within the operating limits of the instruments. The required dilution typically ranges from 10:1 to 1000:1 depending on the particulate source and the location of the sampling point (i.e., upstream or downstream of the control device). A diagrammatic representation of the system is shown in Figure 3.

ELECTRICAL RESISTIVITY

In situ electrical resistivity measurements were made with a point-to-plane[3] electrostatic collection instrument. The device is inserted into the flue gas environment and allowed to reach near thermal equilibrium with the gas stream. The dust thickness gage is set at zero and the measurement cell positioned for collection. A clean electrode voltage vs. current characteristic is recorded. The current density for collection is selected and a dust layer is precipitated electrostatically. After collection of the dust layer has occurred, a second voltage vs. current characteristic is recorded. This provides one measure of electrical resistivity. The measurement electrode is then lowered to contact the dust layer and the layer thickness determined. The resistance of this known geometrical configuration (right cylinder) is measured. The electrical resistivity is then determined from the measured resistance of the dust layer.

GAS VELOCITY DISTRIBUTION

The gas velocity distribution at the face of the first field of the precipitator was measured during a plant outage using a hot-wire thermal anemometer. The precipitator was washed, prior to conducting the measurement, to remove residual fly ash layers. Measurements were made at 150 points using every third lane and 0.9 m (3 ft) vertical increments with the fans operating at current settings corresponding to full load.

SECTION IV
RESULTS

MASS CONCENTRATION AND GAS ANALYSES

Table 2 presents results obtained from the mass train measurements at the upper inlet test plane and at the outlet "pants leg" sampling locations (see Figure 4). Table 3 gives the average mass collection efficiency of the precipitator calculated from the mass train data. Specific collection areas* for the individual tests were calculated from the volumetric flow measurements at the precipitator inlet.

Table 4 gives a comparison of the mass loadings obtained with the mass trains with those obtained from impactor measurements. The inlet mass train data exhibit considerable scatter, whereas the Brink data are relatively consistent. However, the mass train data should be a better approximation of the true inlet mass loading since they were obtained by means of a 48-point traverse with isokinetic sampling. The inlet Brink data are averages of several runs. Each individual Brink impactor was operated in one port with a two-point traverse per port. Since the velocity profile at the sampling locations did not rapidly vary, near isokinetic sampling was attained in each run. Outlet impactor data were taken with Andersen Model III cascade impactors. Again, the mass train data should be a better approximation of the outlet mass loadings because these data were obtained with 48-point traverses and isokinetic sampling. Outlet impactor data were obtained with 24-point traverses and flowrates isokinetic at the average duct velocities. The coefficient of variation of the velocity distribution at the outlet sampling locations was near 0.2. Thus most of the outlet Andersen sampling was done under conditions which differed from isokinetic by about 20%.

Table 2 also presents calculated inlet mass loadings obtained from the coal ash content (Table 8), the recorded coal feed rate to the boiler

*Specific collection area = ft^2 of collecting area/10^3 ACFM during the test periods, the measured volume flows at the inlet test plane, and the assumptions that (1) 20% of the ash entering the furnace leaves as bottom ash, and (2) 5% of the ash leaving the furnace in the flue gas is removed prior to the precipitator inlet. Significant ash fallout reportedly occurs in hoppers which are upstream from the precipitator. These hoppers were previously associated with a mechanical collector which is no longer present in the system. A comparison of the calculated and measured inlet mass loadings shows that the relatively low measured values of inlet mass loadings obtained for tests 9, 10, and 11 are not consistent with the coal analyses obtained for the same sampling period. One possible explanation of this discrepancy is that the variation in ash content of the coal was such that the samples obtained for analysis were not representative of the fuel burned over the testing periods.

The gas composition data are presented in Table 5. The higher SO_3 concentrations on the afternoon of the 15th and 16th of January are due to inclusions of the probe wash in the total sample. The SO_3 concentrations obtained prior to the three o'clock sample of January 15th are thought to be low as a result of an undetected failure in the heating tape which is used to maintain the probe temperature above the acid dewpoint.

VOLTAGE-CURRENT MEASUREMENTS

The average daily operating voltages and currents during the sampling periods are given in Table 6. Figure 5 shows the secondary voltage and current relationships obtained on the number 3A transformer rectifier with the voltage divider resistor attached. Figures 6 and 7 show the corrected secondary voltage and current relationships for TR's 1A and 2A. All current meters were assumed to function properly since it was reported that all meters had been zeroed and checked during a recent outage.

RESISTIVITY MEASUREMENTS

The resistivity measurements were conducted at the lower inlet sampling location. The data obtained with the *in situ* point-to-plane probe are given in Table 7. The temperatures included in the table are those which were recorded at the sampling location.

COAL AND ASH ANALYSES

A coal sample was obtained during each test from the "B" mill of Unit #4. These samples were analyzed and Table 8 presents the "as received" analysis of the individual samples. The ash content of the samples of the first week were relatively constant but those of the 19th and 20th were somewhat higher than the other data. As was discussed previously, no correlation with the inlet grain loadings to the precipitator can be made with respect to the differences in ash content. Chemical analyses were obtained on two fly ash samples: a proportionate blend of hopper samples and an isokinetic sample collected with a high volume sampler. These data are also reported in Table 8.

OPACITY MEASUREMENTS

No opacity data were obtained during the first week of testing due to instrument failure of the transmissometer. Data obtained on January 19 and 20 were obtained with a portable RM41p transmissometer which was on loan from the EPA. The opacities recorded at the outlet on the 19th and 20th were 26% and 25.5%, respectively. These values are not useful, however, because of the high probability that the retroflecter may be contaminated with dust particles when the instrument is used in ducts with high negative pressure.

PARTICLE SIZE MEASUREMENTS

Table 9 gives stage weights from Andersen blank and real runs using preconditioned glass fiber substrates. A blank impactor was run each test day and is designated with the letter B in Table 9. The runs designated RA are averages of two real impactor runs which were obtained during each test (one impactor traversed each half of the outlet duct). The corrected real average, which is designated as CRA, was obtained by taking the average weight gain per stage of the blank run (less the initial and final filters) and subtracting that average gain from each of the stage weights of the RA runs. The weight gain of the final filter on the CRA runs was obtained by subtracting the weight gain of the blank final filter from the average of the two real runs per test.

Figure 8 presents the average cumulative inlet size distribution obtained with the Brink impactors at the inlet sampling location from January 13, 1976 to January 20, 1976. Outlet cumulative distributions from the Andersen data are given in Figures 9 and 10. Figure 9 presents the average outlet cumulative distribution for normal operation of the precipitator while Figure 10 presents the average outlet cumulative distribution with the precipitator operating at one-half the normal current density. These cumulative data are also presented on log-probability coordinates in Figures 11, 12, and 13. The inlet size distribution data show that about 4% of the particulate mass entering the precipitator consists of particles smaller than 2.0 μm diameter, whereas between 25 and 35% of the particulate mass exiting the collector is smaller than 2.0 μm diameter.

Quality of Measurements

Differential size distributions were computed on a mass basis from the size data obtained with the cascade impactors. These differential distributions have been plotted in Figures 14, 15, and 16. Figures 17 and 18 present the differential size distributions which were computed on a number basis from the concentration data obtained with the cascade impactors and the electrical aerosol analyzer. Ninety percent confidence intervals are also shown for these differential distributions.

A comparison of the differential size distributions obtained with the two measurement techniques (inertial and electrical mobility) indicates whether agreement was obtained in the regions of overlap. This method of presenting the data also indicates the size regions containing the greatest quantities of mass or number concentration. The impactor data presented in Figure 14 show that, at the inlet location, the greatest quantity of mass is contained in the 10 to 100 μm diameter region. Figures 15 and 16 show that the greatest quantity of mass at the outlet occurs at about the 4 μm diameter region for both the normal and one half current density test. Figures 17 and 18 indicate fair agreement between the impactor distribution and those obtained with the electrical aerosol analyzer in the overlap regions. Figures 17 and 18 also show the manner in which the number distributions are skewed toward the smallest particle sizes.

The large error bars on data obtained from the ultrafine particle system are due more to the small number of data points averaged than to the scatter in the data. A relatively small fluctuation in the source concentration can cause the electrical aerosol analyzer to indicate a negative concentration or a concentration not commensurate with other data. In addition, condensation of sulfuric acid in the dilution system for the electrical aerosol analyzer created an interfering aerosol in the ultrafine size range. This led to some erroneous readings in the 0.01 μm to 0.05 μm size range. The data were screened and those results which were felt to be unrealistic or non-representative were discarded. For these reasons there were often few concentrations in any one size band to average.

Figures 19 and 20 present fractional efficiency results obtained during normal and one-half current density operation of the precipitator with the electrical aerosol analyzer and the inertial impactors. The large confidence intervals in the 0.01 μm to 0.03 μm diameter particle size range are due to the lack of a number of valid experimental measurements for these small diameters. Average values are shown for the data which were obtained. These results are compared with theoretical predictions in a subsequent section.

GAS VELOCITY DISTRIBUTION

Figure 21 shows the gas velocity distribution obtained under air load conditions using the procedure described in Section III. The average velocity and the square of the average velocity for all the passages on which measurements were obtained are plotted as a function of vertical position. The average velocity and the average of the velocity squared were obtained by planimetry. The average velocity obtained was 1.74 m/sec, and the standard deviation was 0.955 m/sec, or 55% of the average velocity. This distribution is undesirable because of the large standard deviation and the location of the highest velocities in the region near the bottom of the precipitator. However, at the outlet sampling plane, the flow distribution was changed such that the highest velocities occurred in the upper portion of the duct. The flow distribution plates at the precipitator outlet offer more flow resistance at the bottom than at the top and thus are probably responsible for the change in relative flow pattern.

COMPARISON OF THEORETICAL AND MEASURED RESULTS

A mathematical model of electrostatic precipitation has been developed by Southern Research Institute under another contract for the Environmental Protection Agency[4]. This model has been used to simulate the operating conditions and geometry of the precipitator on which this test series was conducted. Average operating conditions for test numbers 2, 3, 10, and 11 were used in the model to simulate the operating current density allowed by the precipitator power supplies, and the fractional efficiencies predicted by the model are shown in Figure 19. Similarly, the reduced current density conditions for test numbers 6, 7, and 9 were used to produce the theoretical fractional efficiency curve shown in Figure 20. Comparison between measured and theoretically predicted values of overall mass collection efficiency are shown in Table 10.

Figures 19 and 20 indicate that the model underpredicts particle collection efficiencies over the particle diameter range from about 0.05 μm to 5.0 μm. Possible causes for the underprediction are (1) approximations necessary in modelling the electric field produced by the electrode geometry, (2) approximations used in the current version of the model for estimating the effect of particulate space charge, and (3) unmodelled effects such as particle concentration gradients. The probable cause of the lower-than-theoretical efficiencies indicated for the larger particles is the reentrainment of particle agglomerates from the collecting electrodes. Research is currently in progress under EPA and EPRI support which is expected to improve the model's capabilities for predicting fractional efficiencies under field conditions.

Although Table 10 indicates that the theoretically obtained overall mass efficiencies are lower than the measured values, the ratio of the measured to theoretical efficiencies for the two current densities at which the tests were conducted shows that the model predicts the relative effects of the changes in electrical operating conditions with reasonable accuracy.

The voltage-current relationships shown in Figures 5, 6, and 7, and the resistivity measurements reported in Table 7 indicate that the electrical operating conditions at this installation are not limited by dust resistivity. Therefore, the relatively low current densities apparently result from sparking due to the geometry of the electrode system. The nature of the voltage current curve for the inlet set (Figure 6) suggests that a combination of space charge effects and dust accumulation on the electrodes cause the sparking at the relatively low values of current density at which the inlet set operates.

ENERGY COSTS

A typical power consumption of the precipitator TR sets during the normal current density tests was 74 kW, or 0.47 kW/(m^3/sec). If power costs are $0.01/kWh, the energy costs for the TR sets would be about $18.00/day. Since the test program was conducted on one half of the total plate area installed on the Unit 4 boiler, a representative total energy requirement for the total precipitator installation would be 148 kw, or 0.092% of the 160 MW output.

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TABLE 1

DAILY TEST CONDITIONS

Date	Test No.[1]	Operation Of Precipitator
1/12/76	1	Normal
1/13/76	2	Normal
	3	Normal
1/14/76	4	Rappers on for 30 minutes, off for 40 minutes
1/15/76	5	Rappers on for 30 minutes, off for 40 minutes
1/16/76	6	Rappers operating normally, Reduced current density
	7	
1/19/76	8	Rappers on/off, reduced current density
	9	Rappers normal, reduced current density
1/20/76	10	Normal
	11	Normal

[1] All tests run with boiler operating at 160 MW except Test No. 1, during which boiler was operating at 112 MW.

TABLE 2

MASS TRAIN DATA
FROM COLBERT STEAM PLANT

Run Number	2	3	6	7	9	10	11
Date	1/13/76	1/13/76	1/16/76	1/16/76	1/19/76	1/20/76	1/20/76
Avg. Temp. °C	152	156	155	155	158	159	160
Avg. Moisture[3], %	7.3	6.9	7.4	7.1	6.4	5.6	5.2
Volumetric Flow[1]							
Am^3/sec	159.84	149.94	159.14	158.35	153.85	157.71	153.22
ACFM	338,637	317,671	337,157	335,489	325,950	334,129	324,610
SDm^3/sec	97.32	91.90	99.59	97.97	97.09	100.41	97.98
Concentrations							
Inlet:							
gm/SDm^3	7.387	7.648	9.275	8.385	6.545	5.792	3.435
gm/Am^3	4.499	4.689	5.806	5.188	4.131	3.689	2.197
gr/ACF	1.966	2.049	2.537	2.267	1.805	1.612	.960
Outlet:							
gm/SDm^3	.0238	.0151	.0929	.0654	.0739	.0336	.0238
gm/Am^3	.0149	.0094	.0556	.0400	.0458	.0208	.0149
gr/ACF	.0065	.0041	.0243	.0175	.0200	.0091	.0065
% Isokinetic[4] Variation:							
Inlet	103	106	106	107	104	104	103
Outlet	96	96	108	100	101	107	107
Calculated inlet mass loadings[2] gr/ACF	1.81	2.17	1.90	2.41	3.32	3.09	3.32

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[1]Flows calculated from inlet data.

[2]Calculated from coal analyses in Table 8 and assumptions described in text.

[3]Obtained from mass train.

[4]48-point traverse for all runs except run 7 (outlet) and run 9 (inlet and outlet) which consisted of 24 points.

TABLE 3

PRECIPITATOR PERFORMANCE
(MASS TRAIN DATA)

Test Number	2	3	6	7	9	10	11
Date	1/13/76	1/13/76	1/16/76	1/16/76	1/19/76	1/20/76	1/20/76
Efficiency %	99.68	99.80	99.00	99.22	98.87	99.42	99.31
SCA $m^2/(m^3/sec)$	46.10	49.25	46.30	46.69	48.07	46.89	48.27
$Ft^2/1000$ CFM	234	250	235	237	244	238	245
Average Current Density nA/cm^2	17.1	17.1	8.2	8.2	7.9	17.	17.

TABLE 4

COMPARISON OF PARTICULATE CONCENTRATIONS FROM IMPACTORS AND MASS TRAINS

Particulate Concentration, mg/SDm^3

	INLET		OUTLET	
Test No.	Mass Train	Brink Impactor[1]	Mass Train	Andersen Impactor
2	7,387	5,747	23.8	12.9
3	7,648	5,747	15.1	19.0
6	9,275	5,360	92.9	36.7
7	8,385	5,360	65.4	41.6
9	6,545	5,327	73.9	51.6
10	5,792	5,928	33.6	17.8
11	3,435	5,928	23.8	10.9
Average for 2, 3, 10, and 11			24.1	15.2
Average for 6, 7, and 9			77.4	43.3

[1] Impactor Data Obtained From Daily Averages

TABLE 5

DAILY GAS ANALYSIS FOR COLBERT

Date	Time	Temp.°C	$\%CO_2$	$\%O_2$	$\%H_2O$	SO_2ppm	SO_3ppm	Dewpoint[4] °C
1/13	10:00	154	12.0[2]	7.0[3]	8.1	2962 3078	4.6 4.2	127
	4:00	157	12.5[2]	7.0		3436 3540	4.3 6.4	
1/14	10:00	150	11.0[2]	7.0	6.8	3346 3168	5.4 7.2	126
	3:00	154	11.5[2]	6.5		3335	8.3	
1/15	11:00	146	15.0[2]	6.5	8.3	2973	6.1	129
	3:00	152	15.0	4.0		3081	11.9[1]	
1/16	11:00	154	15.0	4.0	7.2	3204	12.1[1]	133
	2:00	155				3198	16.7[1]	

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[1]Probe washed, wash added to condenser wash.

[2]High negative pressure may have caused leak in sampling probe.

[3]Samples for CO_2 and O_2 analyzed sequentially.

[4]Obtained from Figure 6.3 of "An Electrostatic Precipitator Performance Model", by G. B. Nichols and J. P. Gooch. Final report to the Environmental Protection Agency, Contract No. CPA 70-166. (Southern Research Institute, July, 1972).

TABLE 6

AVERAGE ELECTRICAL OPERATING
CONDITIONS DURING SAMPLING PERIODS

Date	TR	Primary		Secondary				Current Density
				Bushing #A		Bushing #B		
		Amps	Volts	Amps	KV	Amps	KV	nA/cm^2
1/12/76	1A	37.5	360	.155	44.8	.145	41.5	12.2
	2A	82.5	377.5	.23	42.5	.21	42.6	18
	3A	97	390	.30	42.2	.295	42.4	24.3
1/13/76	1A	29.7	312.5	.133	41.1	.14	40.1	11.1
	2A	78.2	370.8	.223	42.4	.2	41.8	17.3
	3A	92.5	385.8	.283	42.3	.275	42.6	22.8
1/14/76	1A	32.8	326	.116	41.9	.138	43	10.4
	2A	82	401	.23	47.0	.218	45.8	18.3
	3A	94	401	.30	44.3	.3	44.7	24.5
1/15/76	1A	32.8	331.3	.14	41.8	.148	42.4	11.8
	2A	80	389.2	.222	45.2	.204	44.2	17.4
	3A	93.8	400.1	.297	44.2	.294	45.8	24.1
1/16/76	1A	---	238	.05	31.7	.08	31.1	5.3
	2A	37.4	338	.10	42.9	.094	41.2	7.9
	3A	42.6	350	.14	41.1	.137	41.7	11.3
1/19/76	1A	---	243	.05	32.9	.064	32.3	4.7
	2A	35.4	344	.10	43.5	.092	44.3	7.8
	3A	41.2	350	.14	42	.136	41.5	11.3
1/20/76	1A	31.5	331.3	.14	42.5	.15	42	11.8
	2A	76.5	383.3	.21	44.5	.198	43.7	16.7
	3A	88.8	398.3	.283	44.6	.268	44.6	22.5

TABLE 7

COLBERT RESISTIVITY DATA

Test No.	Temperature °C	Date	Time	Resistivity, Ω-cm
2A	152.7	1/13/76	0900	2.4×10^{10}
2B	153.3	1/13/76	1115	1.9×10^{10}
3	153.8	1/13/76	1530	2.1×10^{10}
4A	147.7	1/14/76	0800	1.7×10^{10}
4B	147.7	1/14/76	1200	1.4×10^{10}
4C	151.6	1/14/76	1430	1.6×10^{10}
5A	152.2	1/15/76	0845	1.5×10^{10}
5B	153.3	1/15/76	1045	1.5×10^{10}
5C	158.3	1/15/76	1300	9.6×10^{9}
6A	158.3	1/16/76	0835	9.8×10^{9}
6B	158.3	1/16/76	1045	1.1×10^{10}
7	157.2	1/16/76	1300	1.2×10^{10}
8A	151.6	1/19/76	0845	1.3×10^{10}
8B	152.2	1/19/76	1100	1.1×10^{10}
9	151.1	1/19/76	1345	1.1×10^{10}
10A	157.7	1/20/76	0845	1.2×10^{10}
10B	157.2	1/20/76	1030	1.1×10^{10}
11	154.4	1/20/76	1300	1.3×10^{10}

TABLE 8

COLBERT COAL ANALYSES
(AS RECEIVED)

Date	1/12/76	1/13/76	1/13/76	1/14/76	1/15/76	1/16/76	1/16/76	1/19/76	1/19/76	1/20/76	1/20/76
Time	16:30	12:10	17:15	12:50		11:30	15:00	10:00	16:30	11:30	15:00
Moisture	2.09	2.02	2.07	1.96	2.04	1.50	1.49	8.72	8.22	1.76	1.74
Volatile Matter	34.91	39.41	38.25	38.64	39.05	38.94	36.72	33.50	33.67	38.27	36.22
Fixed Carbon	42.41	48.11	46.99	47.91	47.91	48.42	47.49	40.85	41.34	45.02	44.42
Ash	20.59	10.46	12.69	11.49	11.00	11.14	14.30	16.93	16.77	14.95	17.62
Sulfur	3.12	3.09	3.90	3.75	3.28	3.28	3.76	3.01	5.59	4.01	4.14
BTU	10,836	12,260	12,098	12,254	12,421	12,861	12,327	10,603	10,687	12,152	11,693

FLY ASH CHEMICAL ANALYSES

	Li_2O	Na_2O	K_2O	MgO	CaO	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	P_2O_5	SO_3	LOI	Total[1]
Proportionate Hopper Sample	0.02	0.55	2.49	0.95	5.64	24.38	18.30	45.08	1.31	0.30	1.86	3.97	100.88
High Volume Sample	0.02	0.54	2.49	0.95	4.73	22.72	18.52	45.69	1.45	0.30	2.77	5.72	100.18

[1]Total based on ignited sample (750°C ignition temperature)

TABLE 9
OUTLET ANDERSEN IMPACTOR RUNS
BLANK (B), REAL AVERAGED (RA), CORRECTED REAL AVERAGED (CRA)

Test #	2			3		6			7		9			10			11	
Date	1/13/76	1/13/76		1/13/76		1/16/76	1/16/76		1/16/76		1/19/76	1/19/76		1/20/76	1/20/76		1/20/76	
Type of Run	B	RA	CRA	RA	CRA	B	RA	CRA	RA	CRA	B	RA	CRA	B	RA	CRA	RA	CRA
Run Time Minutes	120	120		120		120	80		90		84	84		120	120		120	
Weight Gains (mg)																		
S0	1.21																	
S1	0.54	1.86	1.40	4.44	3.98	0.50	4.51	3.92	4.30	3.71	0.29	4.75	4.47	0.57	3.32	2.78	2.37	1.83
S2	0.46	1.32	0.86	2.92	2.46	0.45	2.51	1.92	3.31	2.72	0.16	2.83	2.55	0.14	2.24	1.70	1.49	0.95
S3	0.52	2.59	2.13	2.85	2.39	0.61	3.18	2.59	4.70	4.11	0.37	4.19	3.91	0.76	2.47	1.93	2.32	1.78
S4	0.37	1.78	1.32	2.18	1.72	0.44	3.03	2.44	4.10	3.51	0.31	3.91	3.63	0.55	2.74	2.20	1.65	1.11
S5	0.46	1.85	1.39	1.96	1.50	0.45	3.61	3.02	4.50	3.91	0.38	4.32	4.04	0.68	2.66	2.12	1.74	1.20
S6	0.37	1.83	1.37	2.82	2.36	0.69	5.43	4.84	5.69	5.10	0.25	6.14	5.86	0.34	3.31	2.77	2.13	1.59
S7	0.47	1.90	1.44	1.95	1.49	0.92	2.99	2.40	3.15	2.56	0.24	4.16	3.88	0.72	2.25	1.71	1.31	0.77
S8	0.45	1.02	0.56	0.93	0.47	0.62	1.39	0.80	1.34	0.75	0.21	1.88	1.60	0.55	0.94	0.40	0.99	0.45
SF	1.03	1.31	0.28	1.31	0.28	0.44	1.40	0.96	2.00	1.56	0.19	1.31	1.12	0.82	0.87	0.05	1.09	0.27
$\bar{x}$	0.46 (No SO and SF)					0.59 (No SF)					0.28 (No SF)			0.54 (No SF)				
σ	0.06 (No SO and SF)					0.16 (No SF)					0.08 (No SF)			0.21 (No SF)				

Table 10
Comparison of Computed and Measured
Mass Collection Efficiency

Average Specific Collecting Area $m^2/(m^3/sec)$	Test Numbers	Collection Efficiency: Theoretical From Model	Collection Efficiency: Measured From Mass Train	Ratio of Measured to Theoretical Efficiency
47.6	2,3,10,& 11	99.32	99.55	1.0023
47.0	6, 7,& 9	98.66	99.03	1.0034

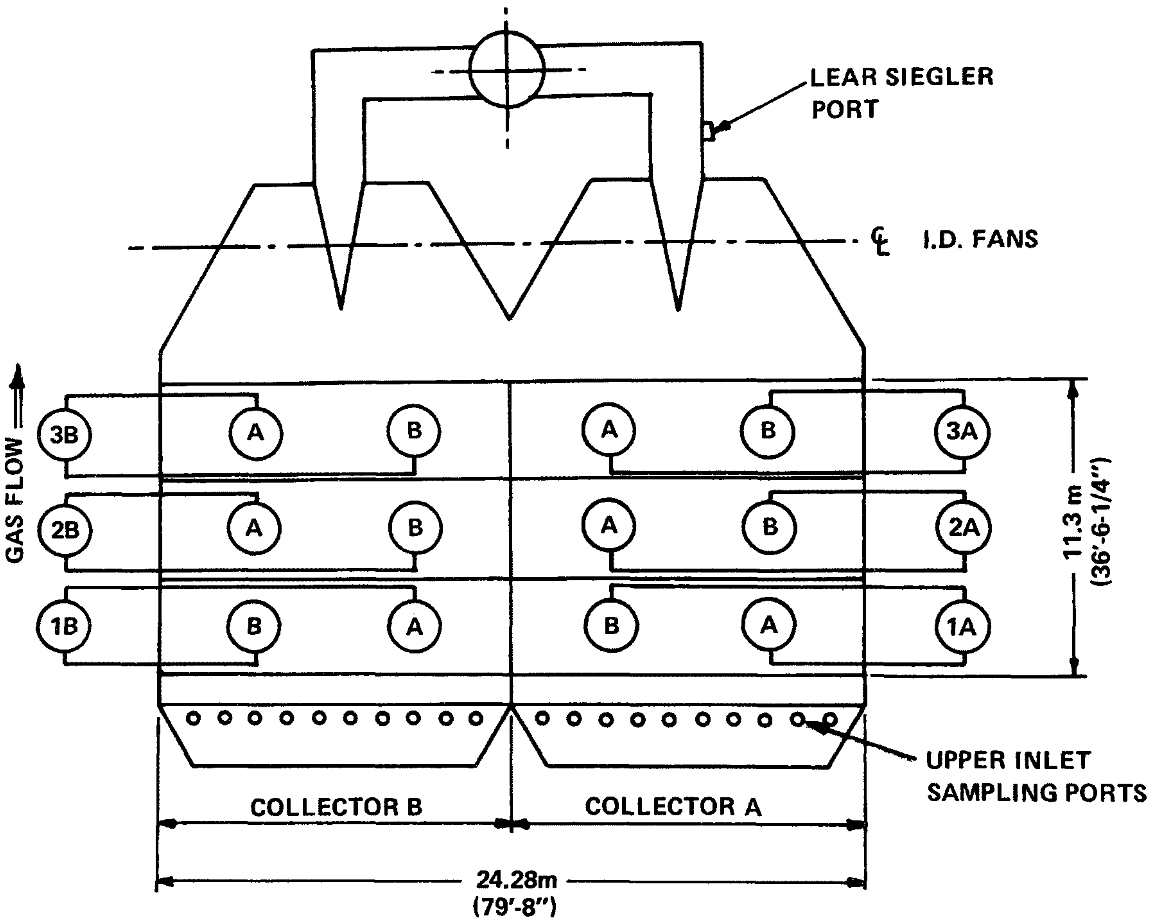


Figure 1. Precipitator Layout

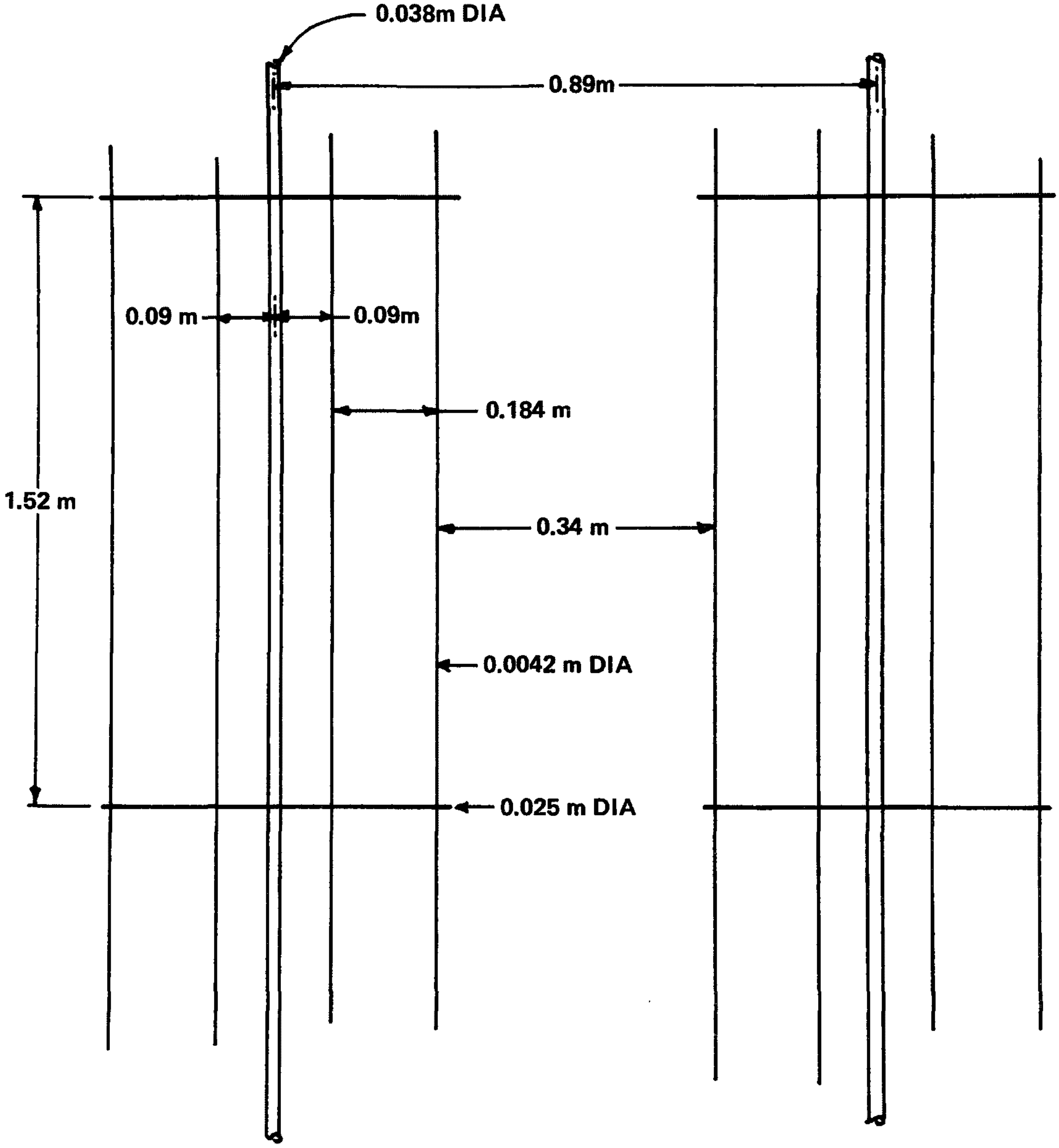


Figure 2. Discharge Electrode and Frame Geometry

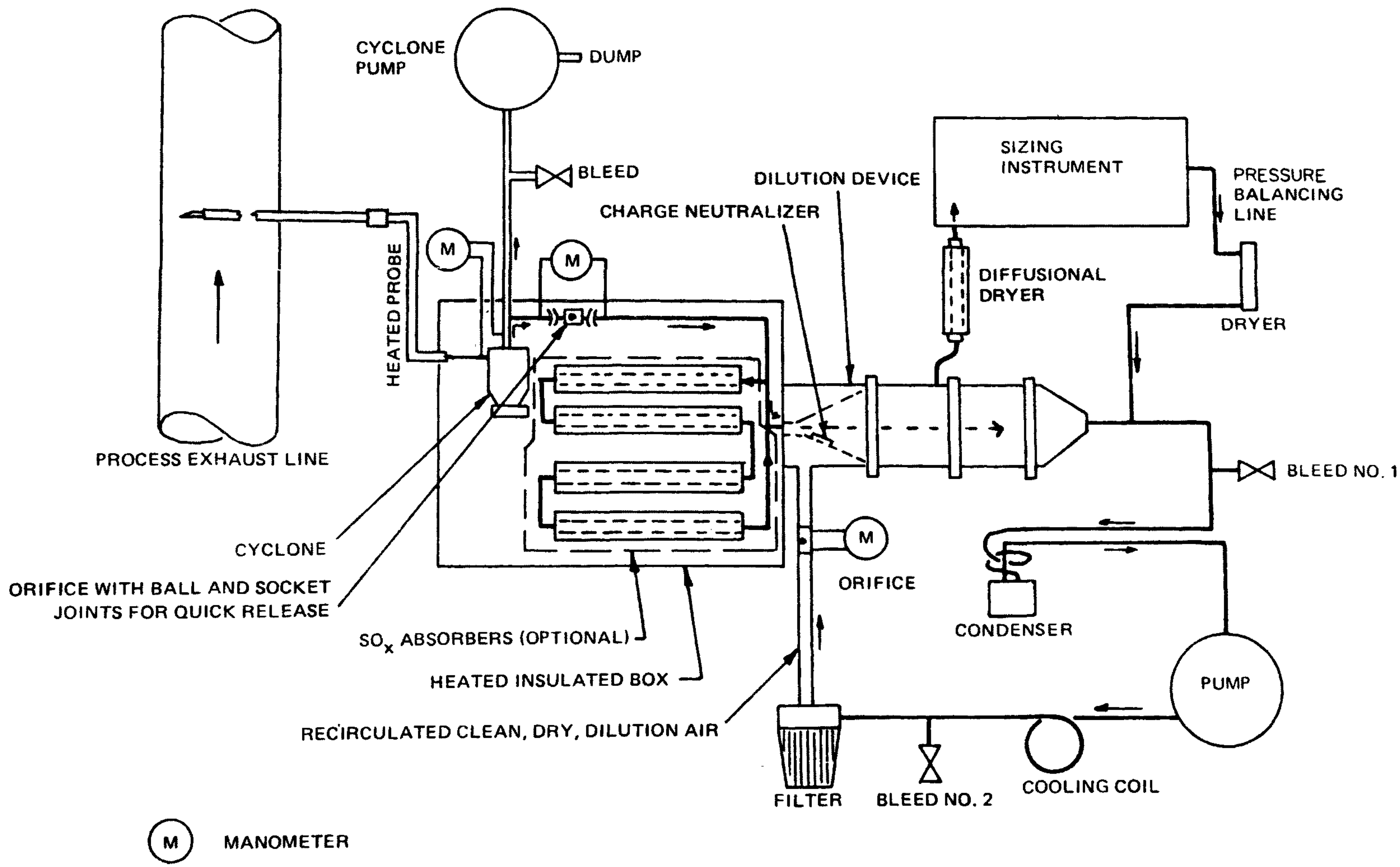


Figure 3. Sample Extraction-Dilution System

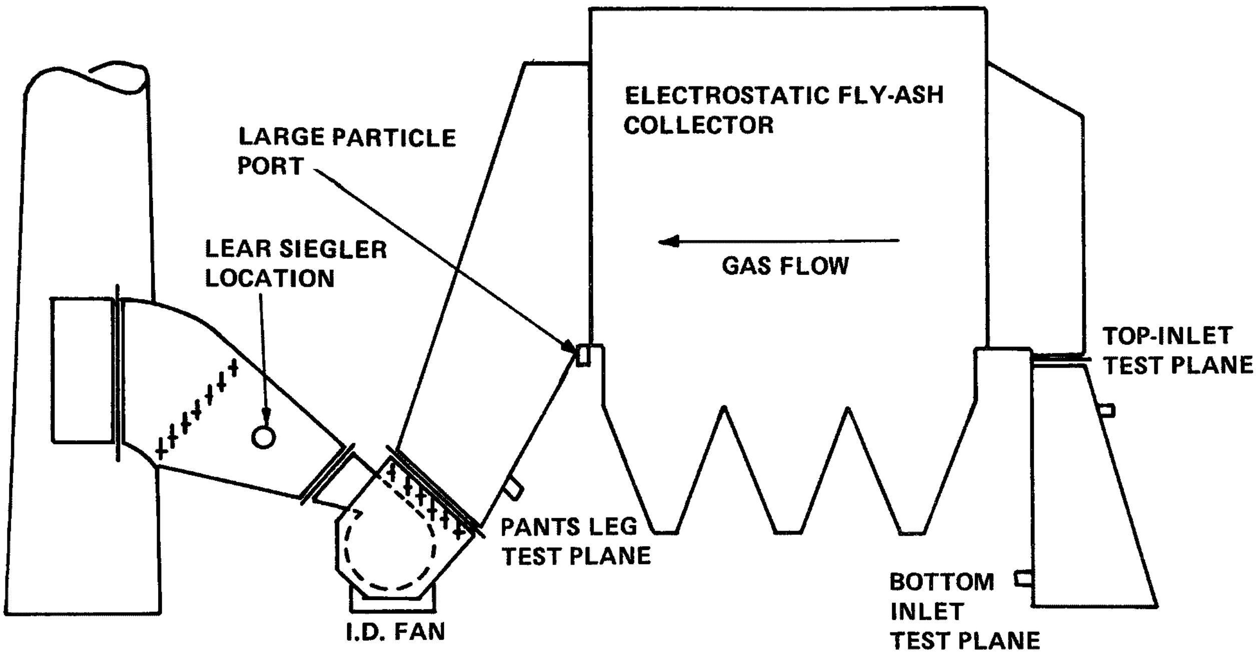


Figure 4. Sampling Locations

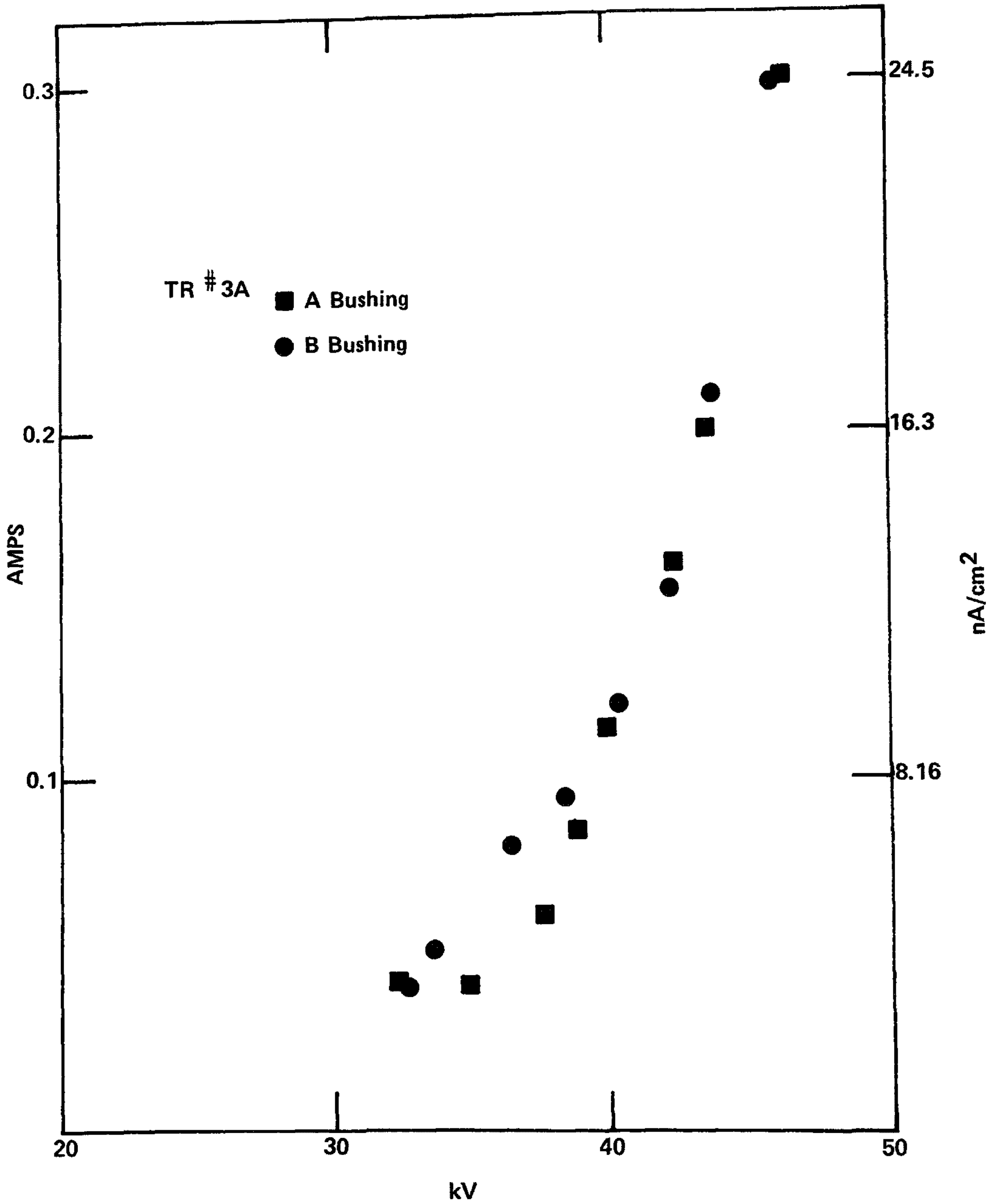


Figure 5. Voltage vs. Current for Transformer Rectifier #3A, January 21, 1976

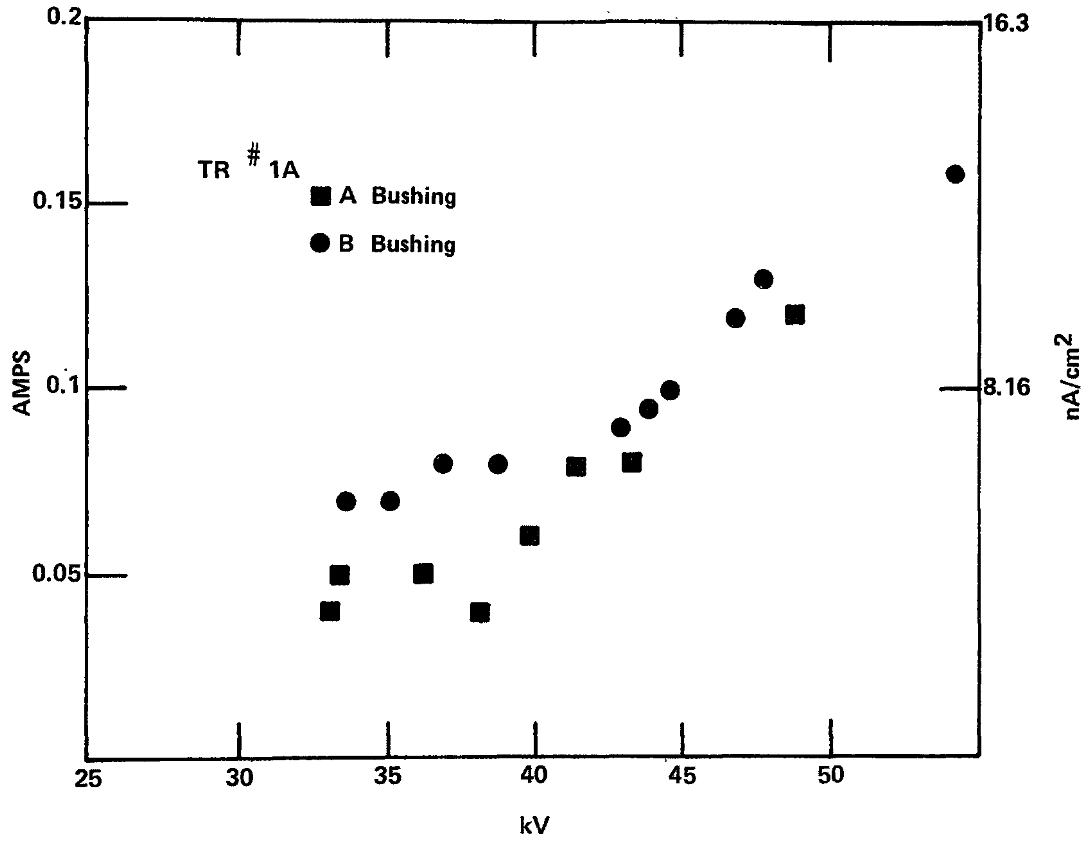


Figure 6. Voltage vs. Current for Transformer Rectifier #1A, January 21, 1976

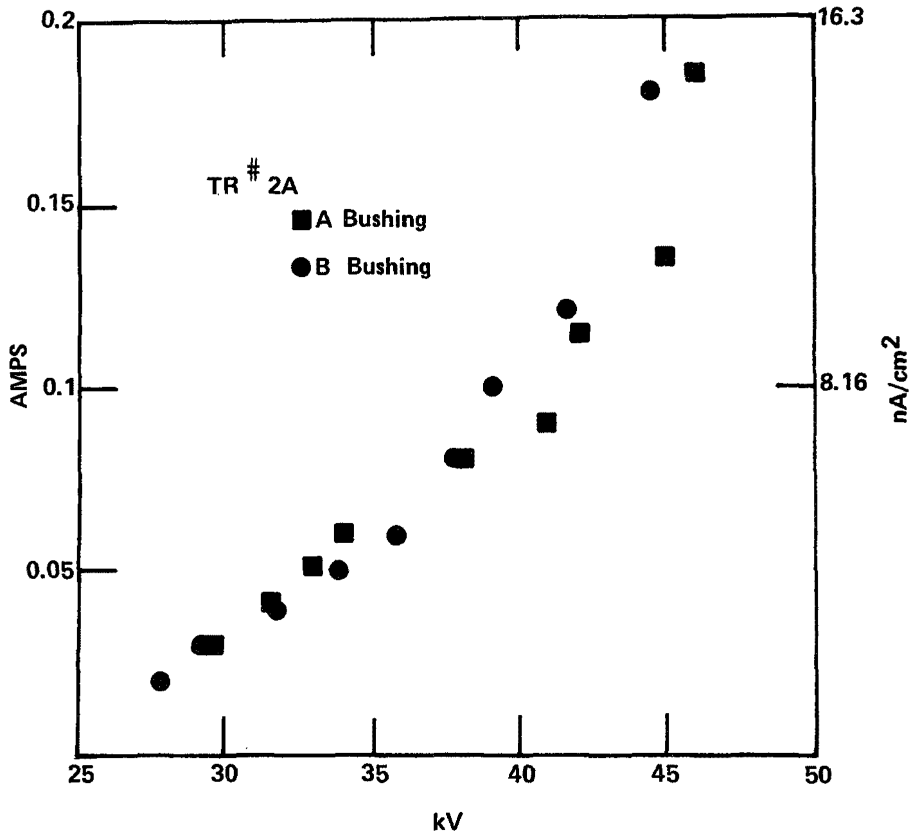


Figure 7. Voltage vs. Current for Transformer Rectifier #2A, January 21, 1976

COLBERT STEAM PLANT
INLET IMPACTOR DATA
ASSUMED PARTICLE DENSITY = 2.40 gm/cm³

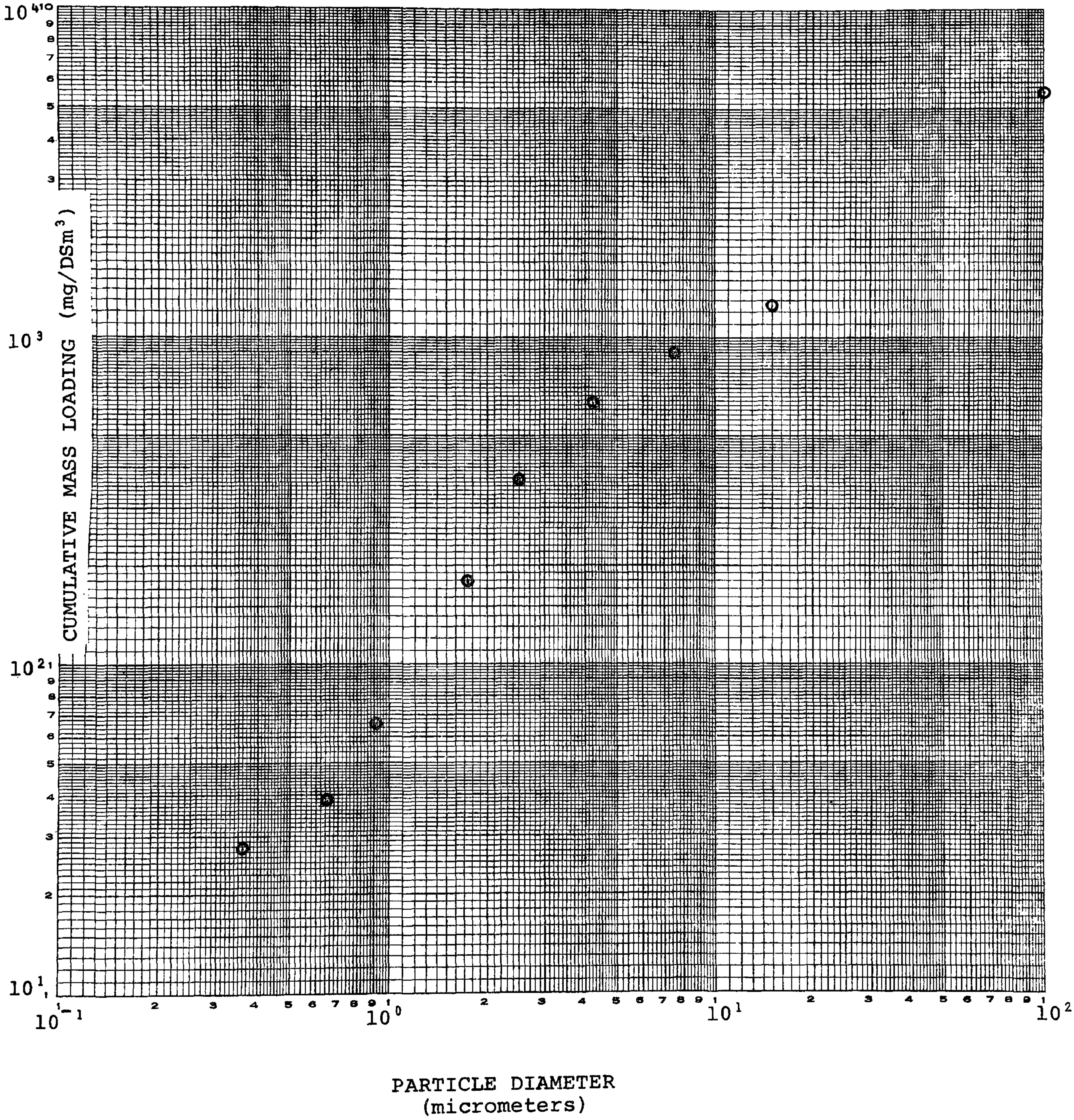


Figure 8. Inlet Particle Size vs. Cumulative Mass Loading for January 13, 1976 to January 20, 1976

COLBERT STEAM PLANT
OUTLET IMPACTOR DATA
ASSUMED PARTICLE DENSITY = 2.40 gm/cm³

Test 2, 3, 10, 11

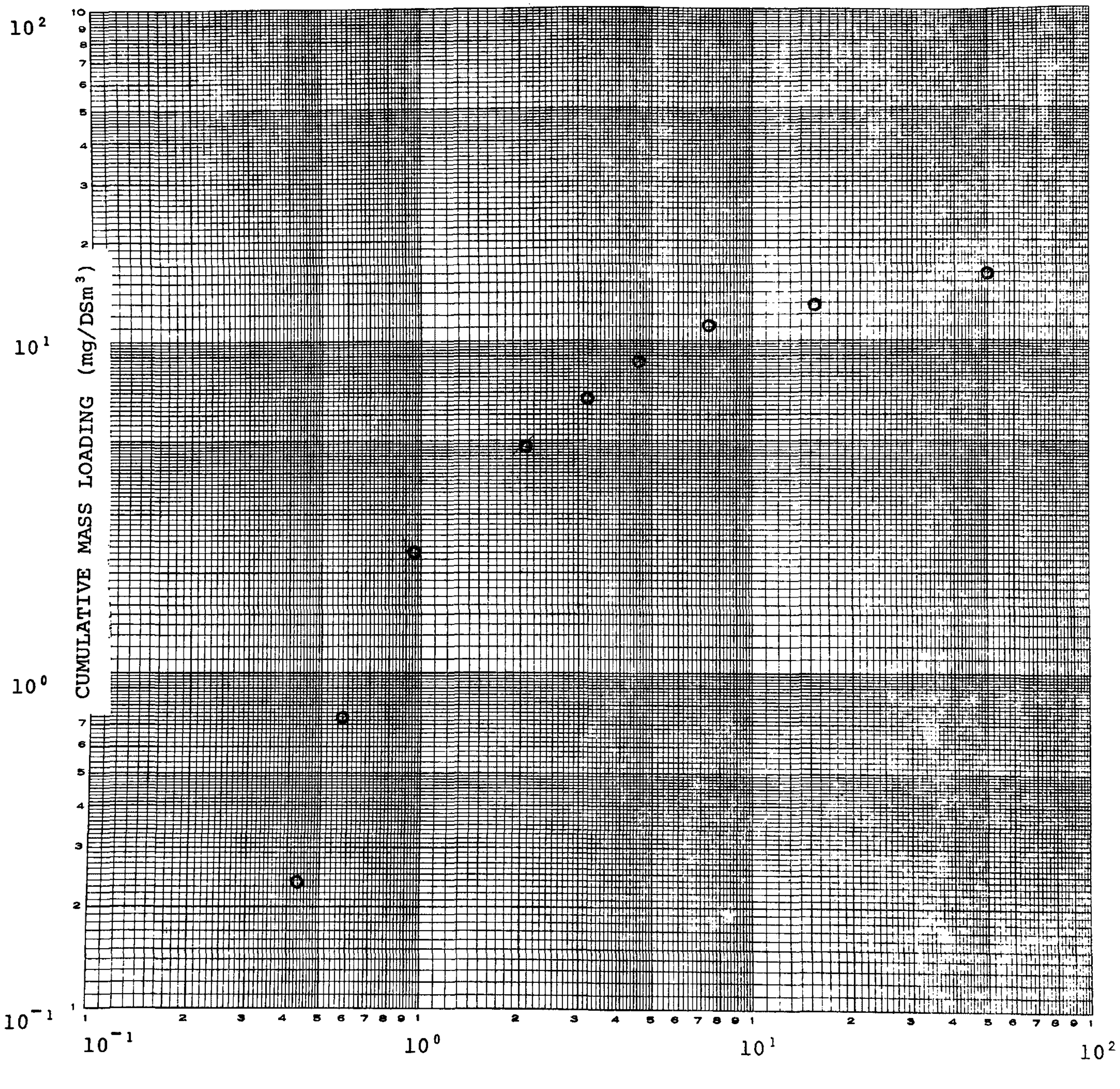


Figure 9. Outlet Particle Size vs. Cumulative Mass Loading for Tests 2, 3, 10, and 11

COLBERT STEAM PLANT
OUTLET IMPACTOR DATA
ASSUMED PARTICLE DENSITY = 2.40 gm/cm³

TEST 6, 7, 9

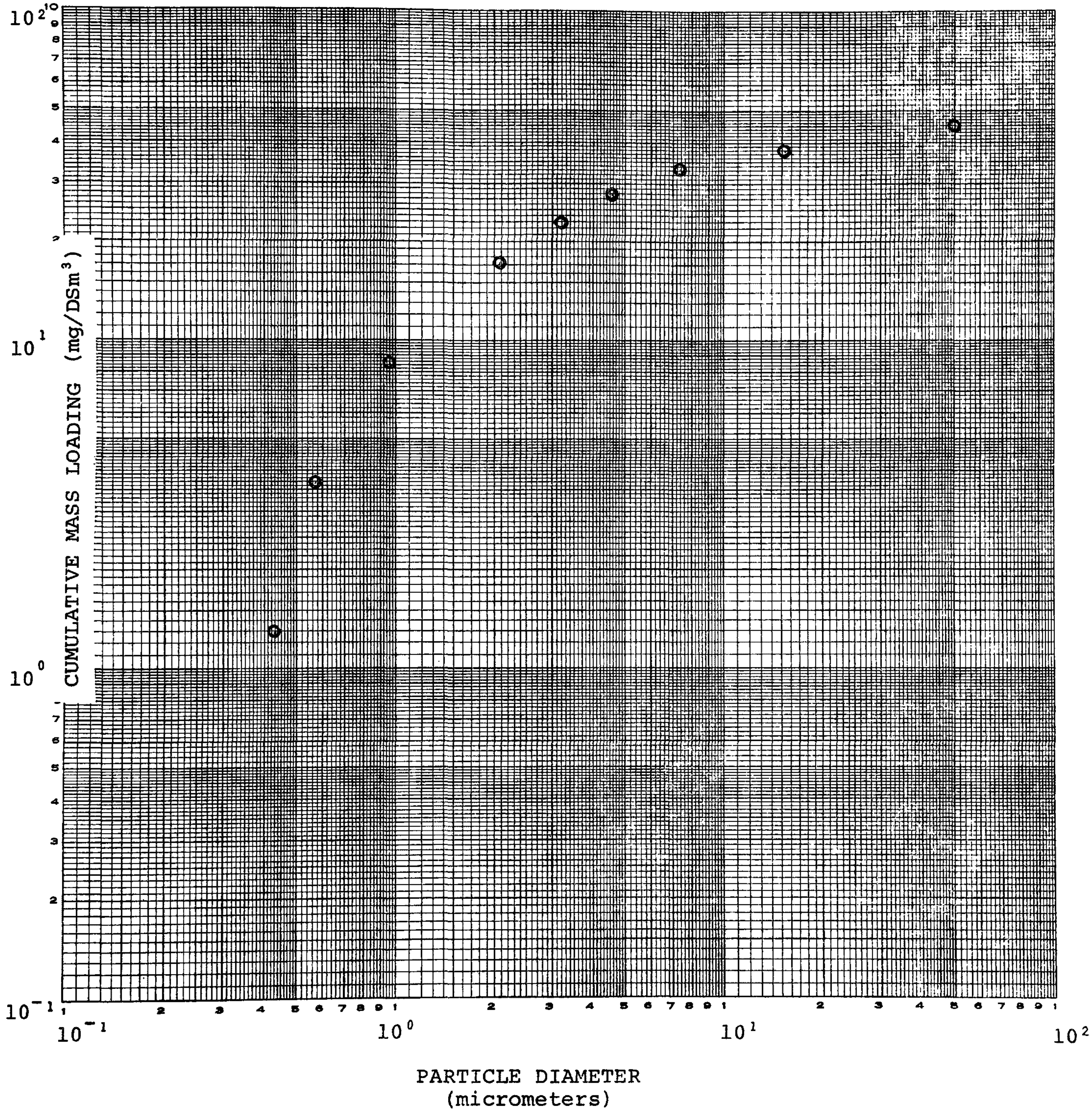


Figure 10. Outlet Particle Size vs. Cumulative Mass Loading for Test 6, 7, and 9

Colbert Steam Plant, January 13-20, 1976 Grand Average
Inlet Impactor Data
Assumed Particle Density = 2.40 gm/cm³
Cumulative Percent Distribution

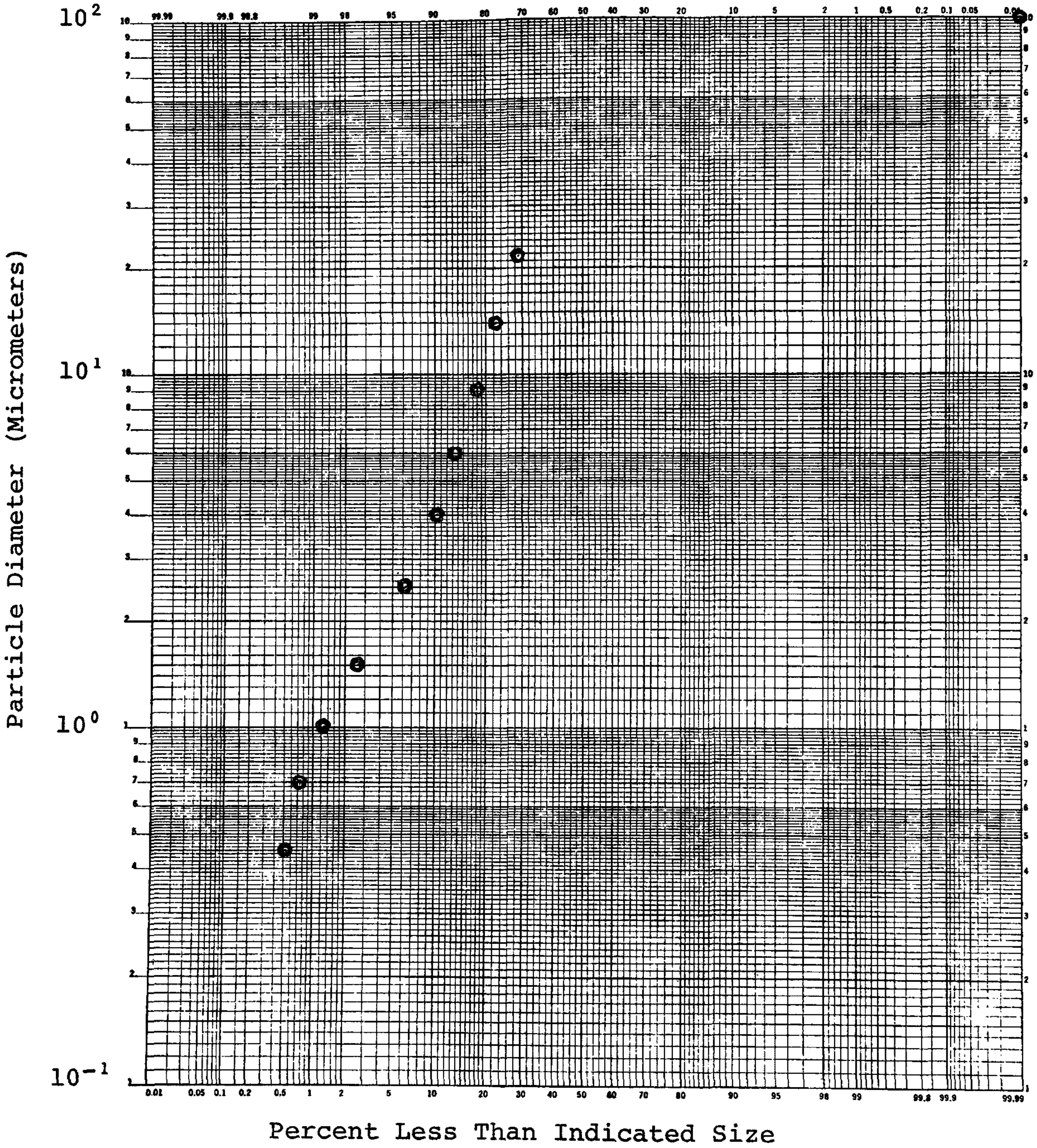


Figure 11. Inlet Size Distributions on Log-probability Coordinates, January 13, 1976 - January 20, 1976

Colbert Steam Plant, January 1976 Tests #2, 3, 10, 11
Outlet Impactor Data
Assumed Particle Density = 2.40 gm/cm^3
Cumulative Percent Distribution

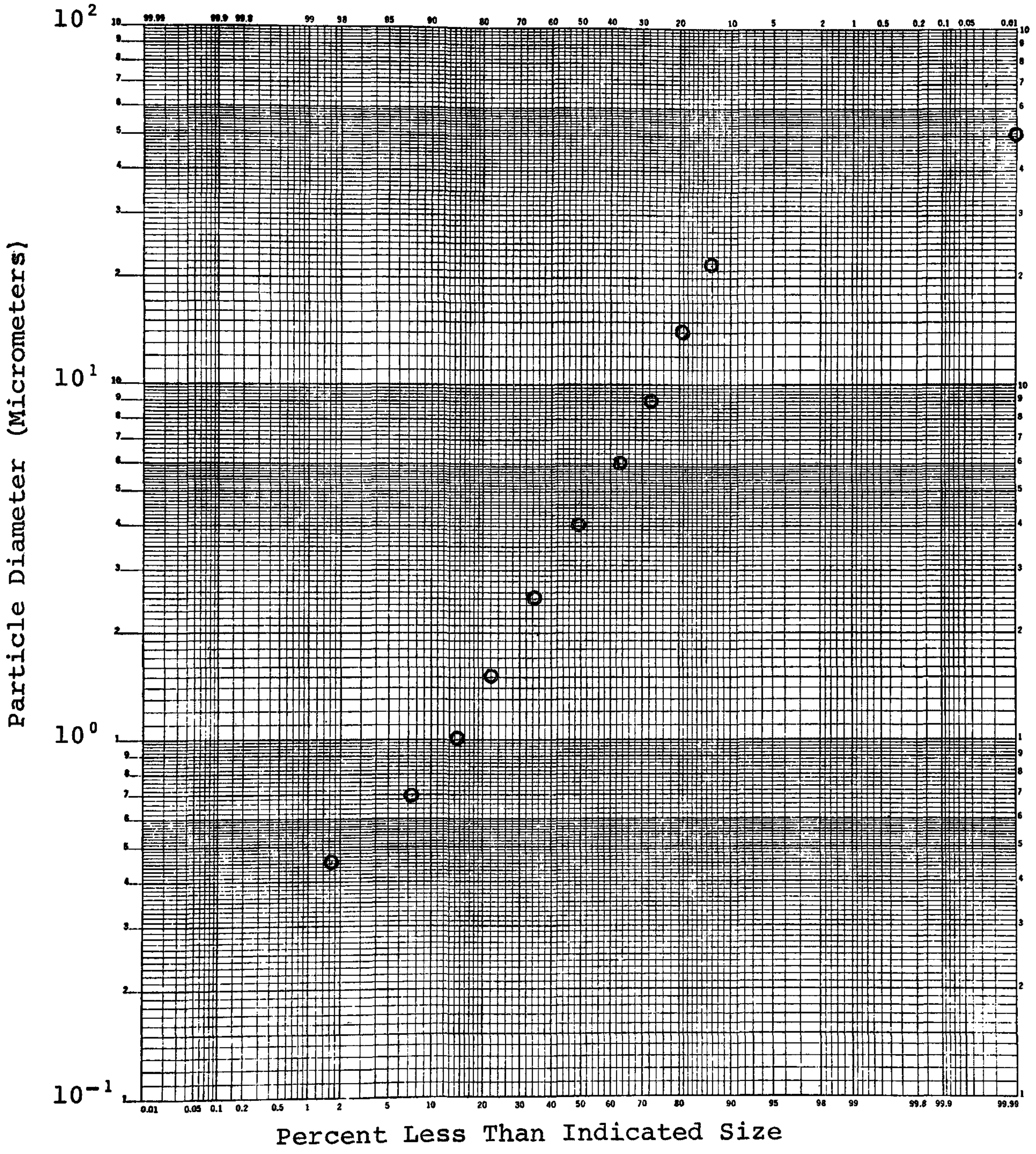


Figure 12. Outlet Size Distributions on Log-probability Coordinates, Test 2, 3, 10, and 11

Colbert Steam Plant, January 1976 Tests #6, 7, 9
Outlet Impactor Data
Assumed Particle Density = 2.40 gm/cm^3
Cumulative Percent Distribution

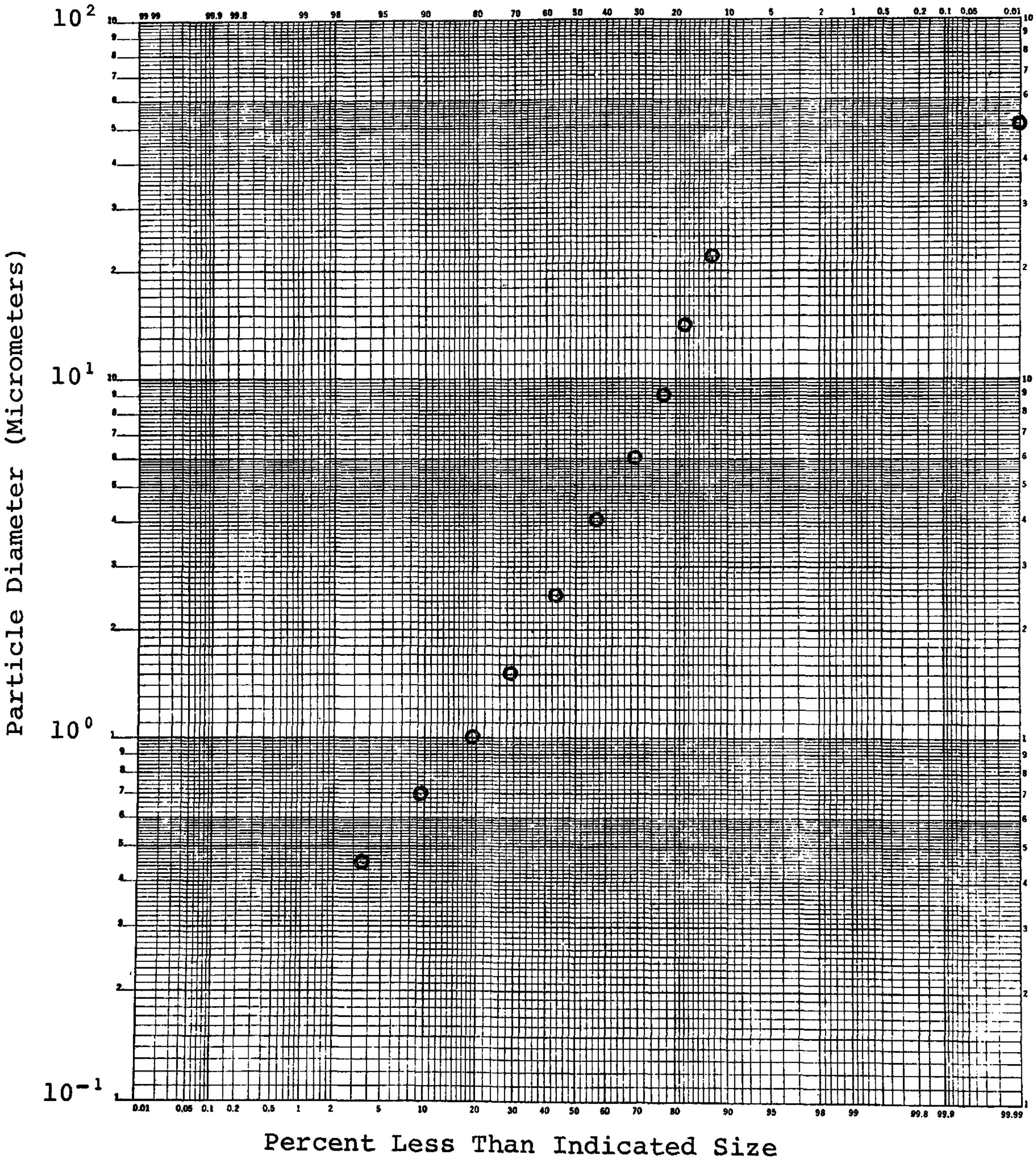


Figure 13. Outlet Size Distributions on Log-probability Coordinates, Test 6, 7, and 9

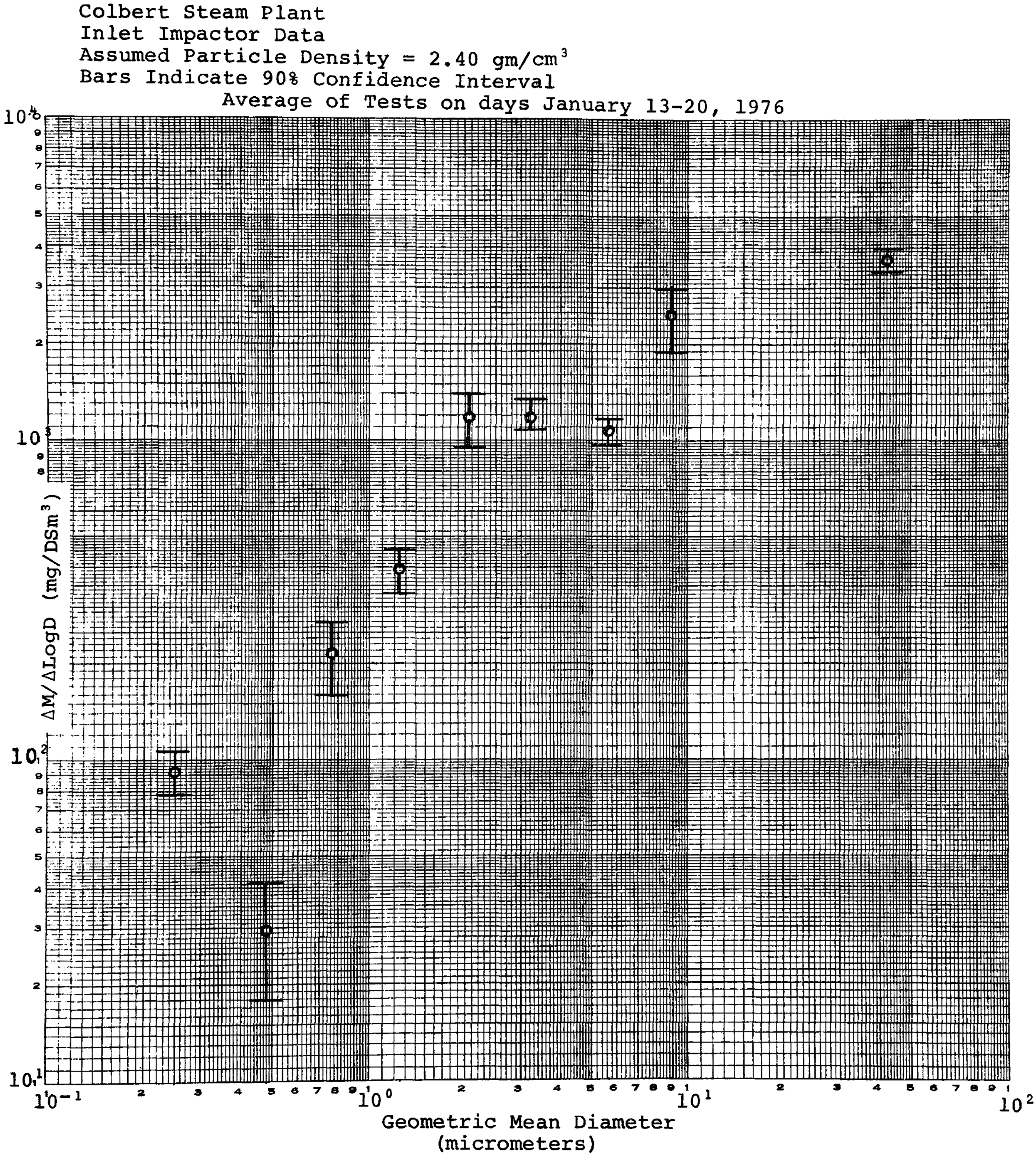


Figure 14. Inlet Differential Mass Distributions
January 13, 1976 - January 20, 1976

Colbert Steam Plant
Outlet Impactor Data
Assumed Particle Density = 2.40 gm/cm³
Bars Indicate 90% Confidence Interval

Test (2, 3, 10, 11)

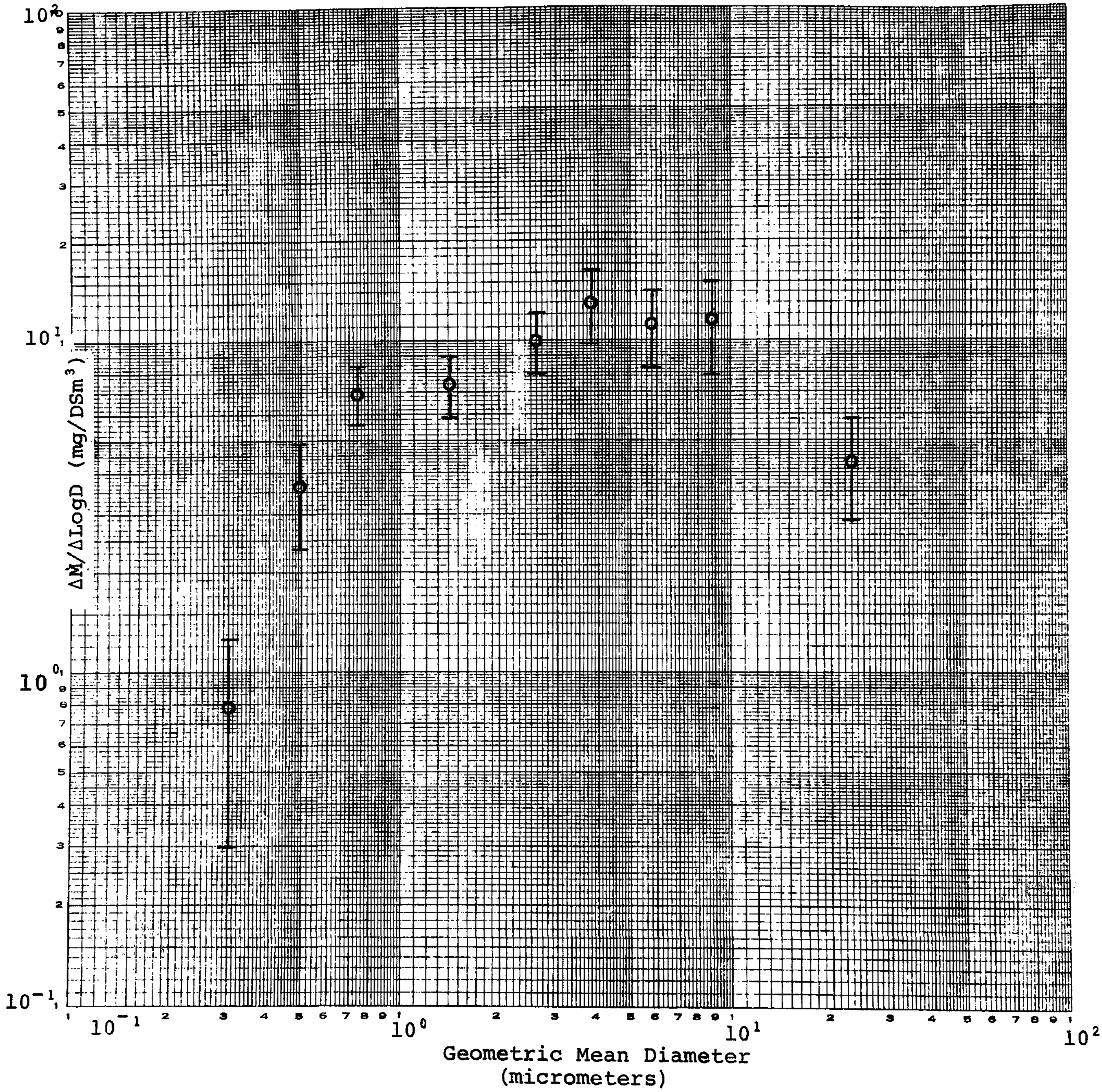


Figure 15. Outlet Differential Mass Distributions, Test 2, 3, 10, and 11

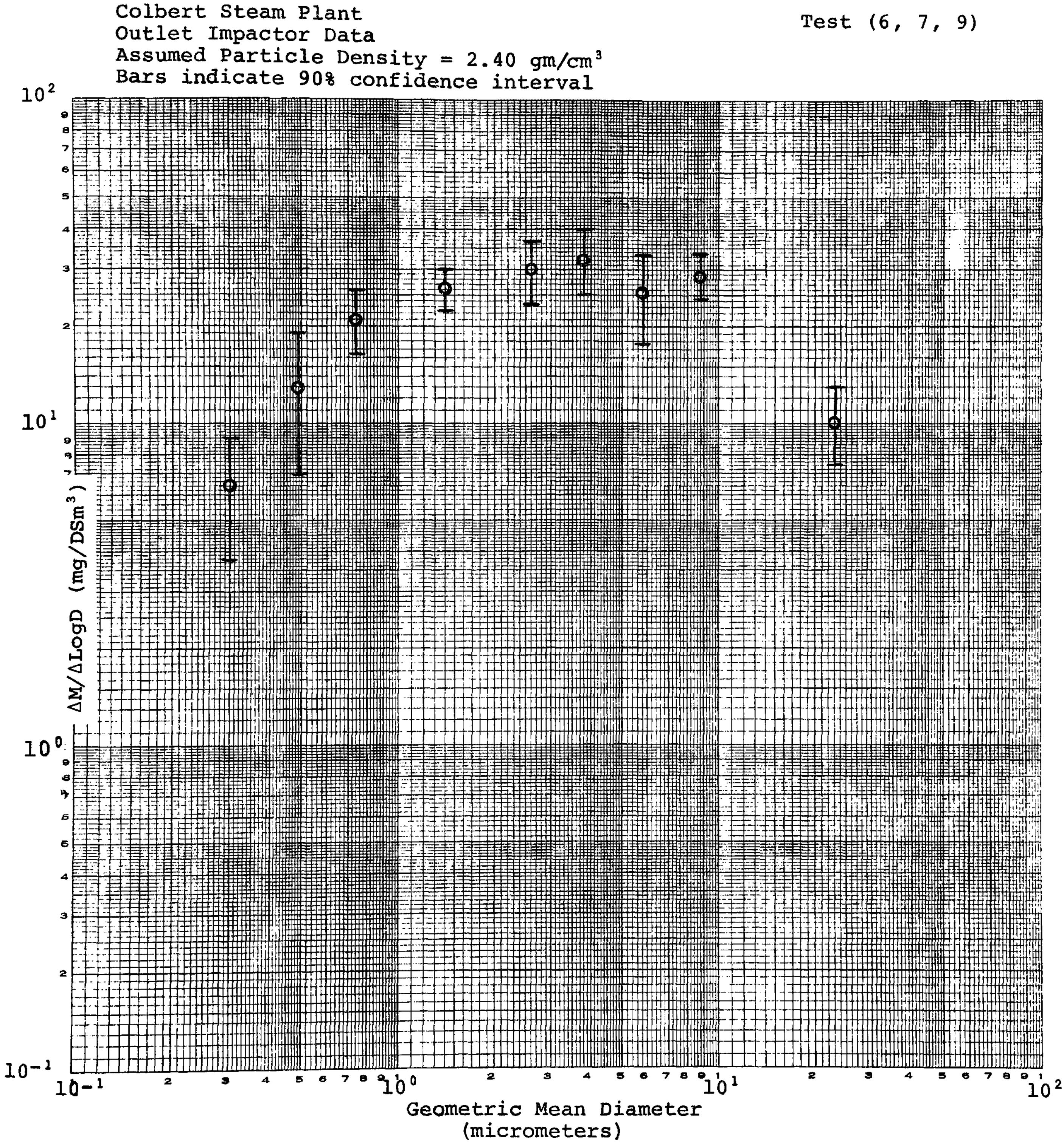


Figure 16. Outlet Differential Mass Distributions, Test 6, 7, and 9

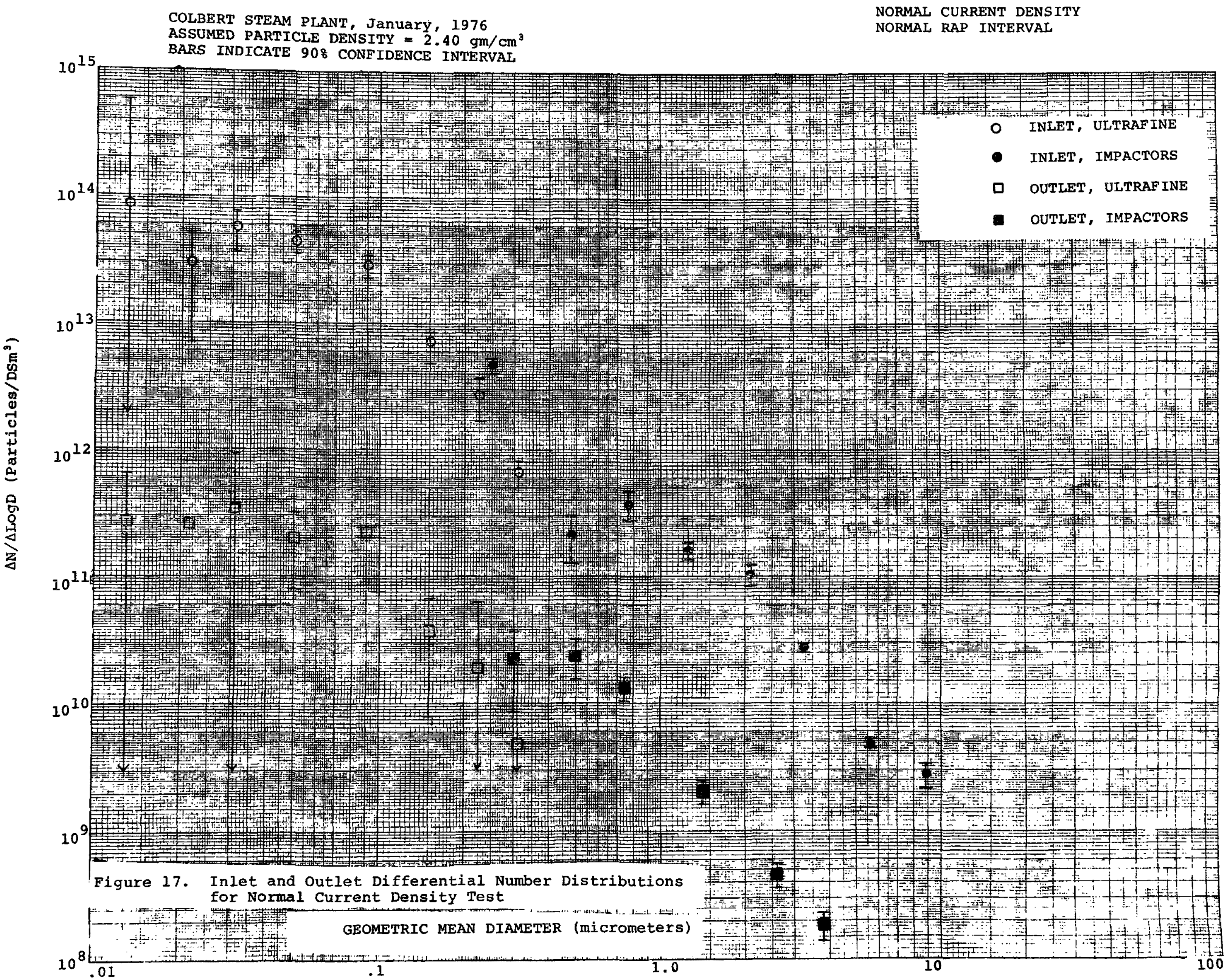


Figure 17. Inlet and Outlet Differential Number Distributions for Normal Current Density Test

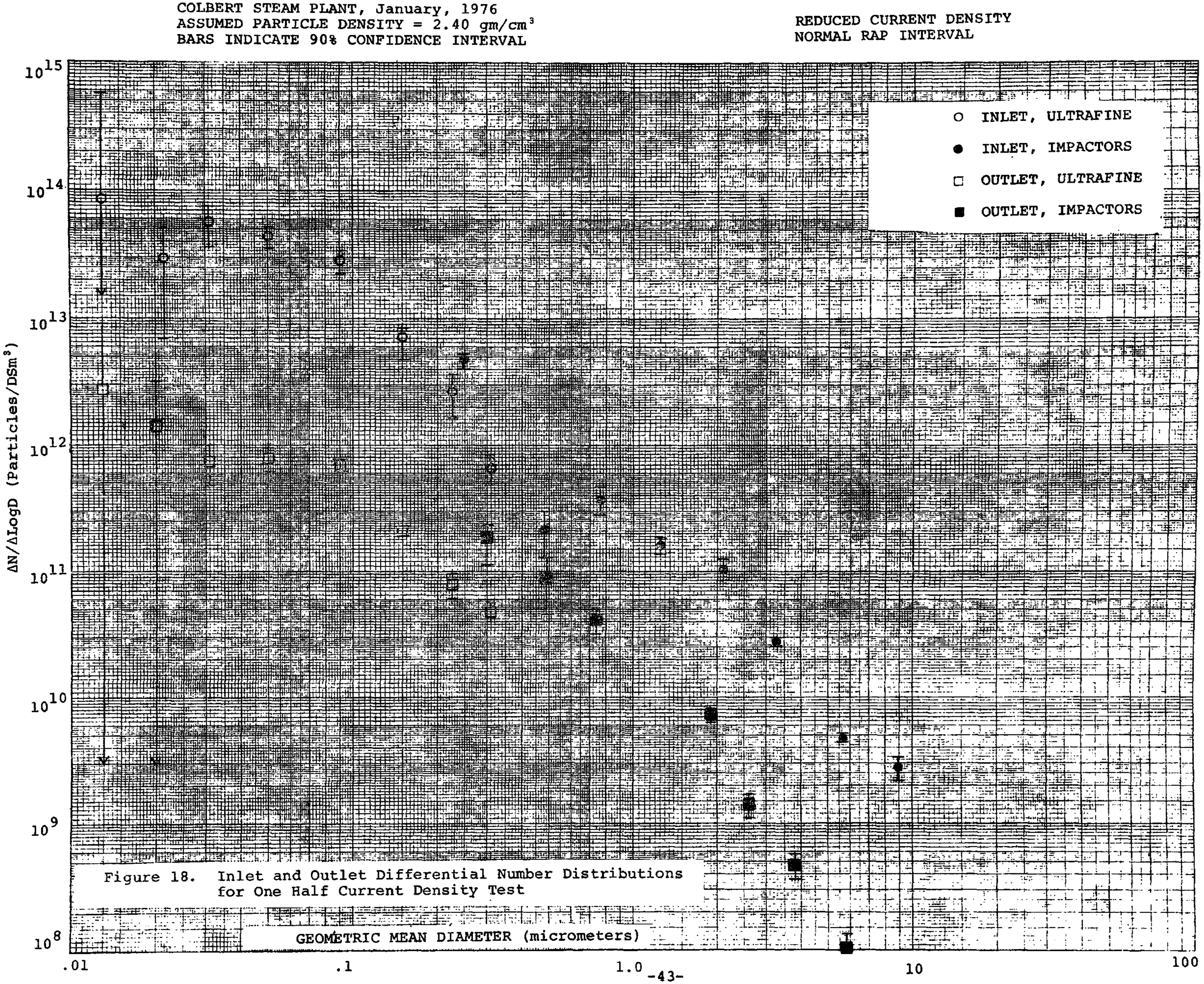


Figure 18. Inlet and Outlet Differential Number Distributions for One Half Current Density Test

Colbert Steam Plant, January 1976
Tests (2, 3, 10, 11)
Assume Particle Density = 2.40 gm/cm³
Bars Indicate 90% Confidence Interval

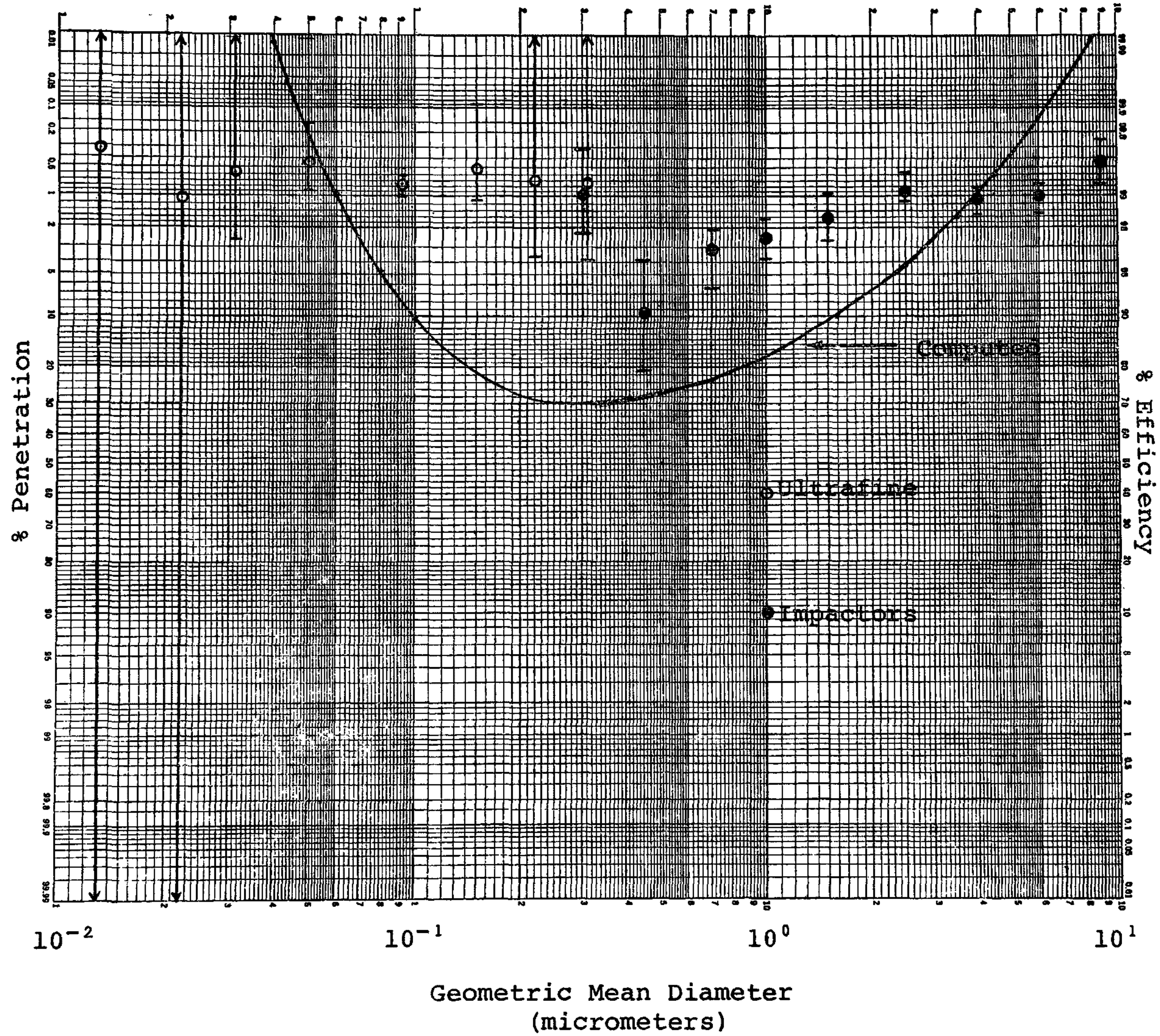


Figure 19. Measured and Theoretically Calculated Fractional Efficiency for Normal Current Density Test

Colbert Steam Plant, January 1976
Tests (6, 7, 9)
Assume Particle Density = 2.40 gm/cm^3
Bars Indiate 90% Confidence Interval

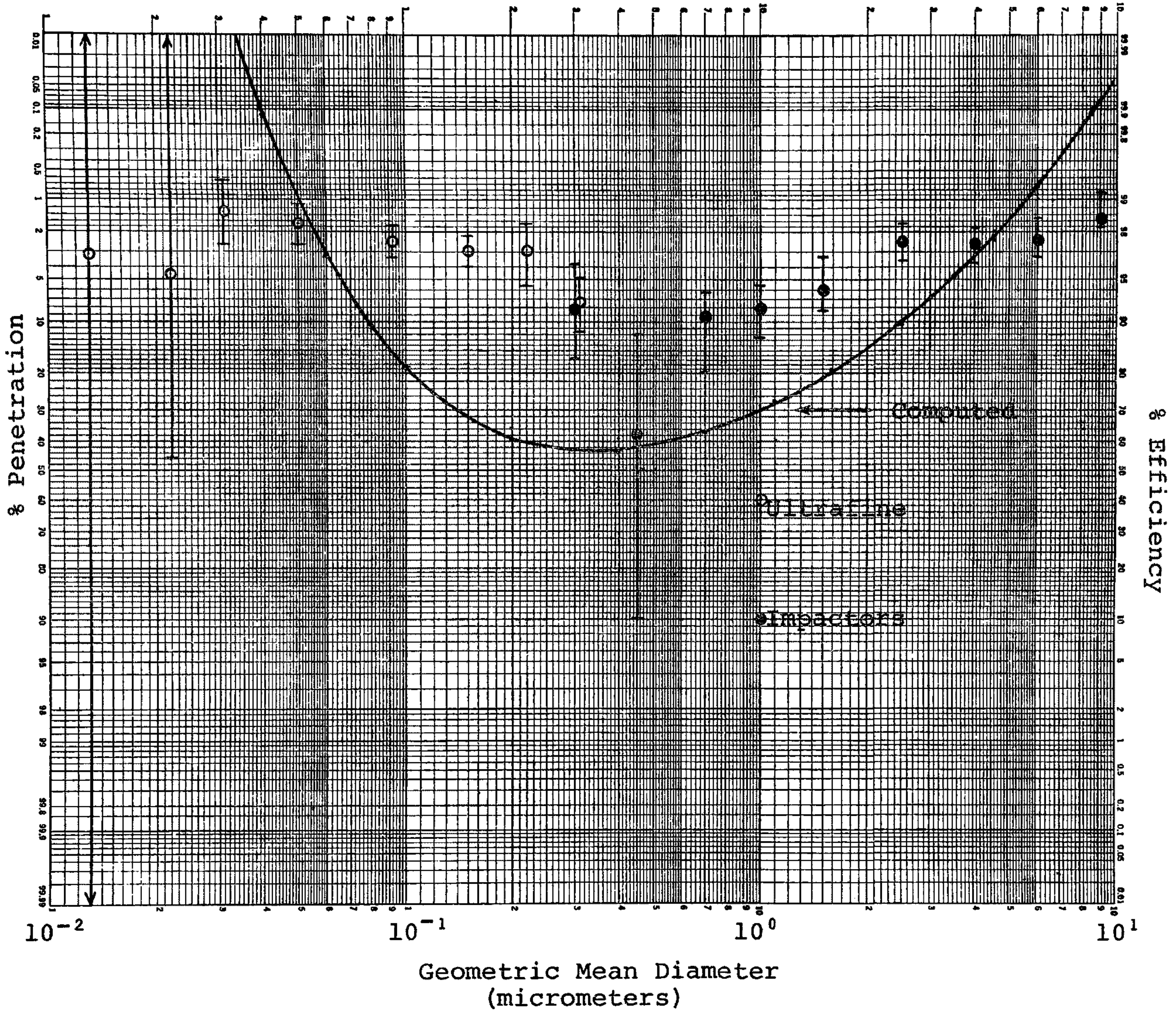


Figure 20. Measured and Theoretically Calculated Fractional Efficiency for One Half Current Density Test

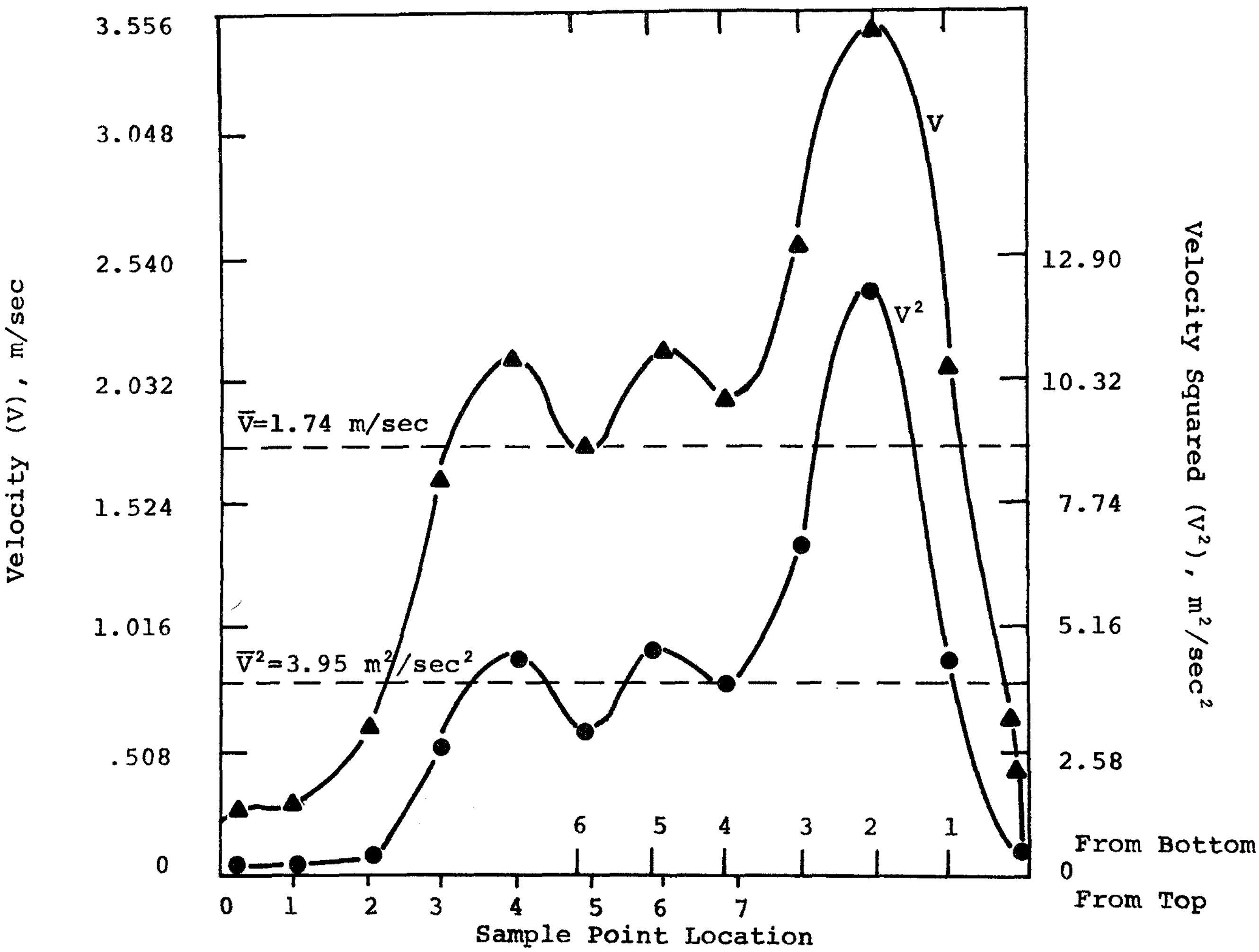


Figure 21. Gas Velocity Distribution

APPENDIX A

SAMPLE DATA REDUCTION CALCULATIONS FOR IMPACTOR AND ELECTRICAL MOBILITY (ULTRAFINE) SIZING DATA

In this appendix we include information on how individual impactor stage weights and run data are used to obtain the cumulative mass distribution, ΔN/ΔLogD, ΔN/ΔLogD, and fractional efficiency information cited in this report. Next the data reduction scheme used for obtaining ultrafine particle size distribution data is explained. In a third section the ultrafine particle size distribution data recorded for this test are included. Finally, the computer printouts for each impactor run are given. In this test ultrafine particle sizing data were obtained by electrical mobility analysis.

The organization of the section describing the ultrafine data reduction has been revised since the last report under this contract (EPA-600/2-76-141). Although the basic data reduction scheme has not been changed, data are now taken with a strip chart recorder and not recorded by hand. In addition, a specially designed heated box which contains the sample dilution system was first used on this field test.

At the end of the section explaining how the impactor data reduction is accomplished, we show the relationship between the Stokes' or Physical particle diameter (density = 2.40 gm/cm^3) and aerodynamic diameter (density = 1.00 gm/cm^3). In order to compare measurements made on other control devices it is useful to normalize the particle density to unity and use the aerodynamic particle diameter. The graph on page 70 facilitates this comparison. We recognize that some of the data reduction procedures are not statistically rigorous. Work is currently underway to improve data reduction techniques. These improved techniques will be used in future work.

SAMPLE CALCULATION FOR DATA REDUCTION OF IMPACTOR SIZE MEASUREMENTS

After an impactor run, it is necessary to obtain a particle size distribution from the mass loading on each stage. The conditions at which the impactor was run determine stage D_{50} cut points. These are calculated by an iterative solution of the following two equations:

(E1) $$D_{50} = 1.43 \times 10^4 \left[\frac{\mu D_C{}^3 P_S\ X(I)}{\rho_p Q_I P_o C 472.0}\right]^{1/2}$$

(E2) $$C = 1 + \frac{2L}{D_{50} \times 10^{-4}}\left[1.23 + 0.41\ \mathrm{Exp}\left[(-0.44 D_{50}/L) \times 10^{-4}\right]\right]$$

where D_{50} = the stage cut point (μm),
μ = gas viscosity (poise),
D_c = stage jet diameter (cm),
P_s = local pressure at stage jet (atm),
ρ_p = particle density (gm/cm^3),
Q_I = impactor flow rate (cfm),
P_o = ambient pressure at impactor inlet (atm),
C = Cunningham Correction factor,
L = gas mean free path (cm), and
$X(I)$ = number of holes per stage.

The easiest way to calculate these cut points is to write a computer program. Otherwise, it is a tedious process. The size parameter reported is either aerodynamic equivalent diameter, that is, diameter based on the settling velocity of unit density particles, or approximate physical diameter, based on a measurement of the true particle density. In either case, the particles are assumed to be spherical.

Certain of the values in equations E1 and E2 are calculated separately. A brief discussion of each of these calculations follows.

To find the viscosity of the flue gas, μ, the viscosity of the pure gas components of the flue gas must first be found. Viscosity is a function of temperature, and the temperature difference in different flue gases can be quite significant. The following equations (derived from curves fitted to viscosity data from the Handbook of Chemistry and Physics, Chemical Rubber Company Publisher, 54 Edition, 1973-1974, pp. F52-55), are used to find the viscosities of $CO_2(\mu_1)$, $CO(\mu_2)$, $N_2(\mu_3)$, $O_2(\mu_4)$ and $H_2O(\mu_5)$.

(E3) $\mu_1 = 138.494 + 0.499T - 0.267 \times 10^{-3}T^2 + 0.972 \times 10^{-7}T^3$

(E4) $\mu_2 = 165.763 + 0.442T - 0.213 \times 10^{-3}T^2$

(E5) $\mu_3 = 167.086 + 0.417T - 0.139 \times 10^{-3}T^2$

(E6) $\mu_4 = 190.187 + 0.558T - 0.336 \times 10^{-3}T^2 + 0.139 \times 10^{-6}T^3$

(E7) $\mu_5 = 87.800 + 0.374T + 0.238 \times 10^{-4}T^2$

where T is the temperature of the flue gas in degrees Celsius. The units of μ are 10^{-6} g/cm-sec. Next, these values of μ_1 through μ_5 are used in a general viscosity equation for a mixture of any number of components (See "A Viscosity Equation for Gas Mixtures" by C. R. Wilke, Journal of Chemical Physics, Volume 8, Number 4, April 1950, page 517) used to find the viscosity of the flue gas:

(E8) $$\mu = \sum_{i=1}^{n} \frac{\mu_i}{\left[1 + \frac{1}{X_i} \sum_{\substack{j=1 \\ j \neq i}}^{j=n} X_j \phi_{ij}\right]}$$

where ϕ_{ij} is given by the equation:

(E9) $$\phi_{ij} = \frac{\left[1 + (\mu_i/\mu_j)^{\frac{1}{2}} (M_j/M_i)^{\frac{1}{4}}\right]^2}{(4/\sqrt{2}) \left[1 + (M_i/M_j)\right]^{\frac{1}{2}}} ,$$

and

M = molecular weight of a component in the mixture,

X = mole fraction of a component in the mixture,

μ = viscosity, g/cm-sec; μ_1, μ_2, etc. refer to the pure components at the temperature and pressure of the mixture, μ is the viscosity of the mixture, and

ϕ = dimensionless constant defined above.

To find the pressure PS_i (in atmospheres) at each impactor stage i, the following equation is used:

$$PS_i = POA - (PI_i)(DP) \qquad \text{(E10)}$$

where POA is the gas pressure at the impactor inlet in atmospheres, PI_i is the fraction of impactor pressure drop at each stage i, and DP is the pressure drop across the impactor in atmospheres.

To find the gas mean free path L_i (in centimeters) for each impactor stage i, the following equation is used:

$$L_i = \frac{2\mu}{1.01325 \times 10^6 \; PS_i} \times \sqrt{\frac{8.3117 \times 10^7 \; T_k}{3 \; MM}} \qquad \text{(E11)}$$

where μ is the gas viscosity,

PS_i is the pressure at each impactor stage i,

T_k is the gas temperature at the impactor stage in degrees Kelvin, and

MM is the average molecular weight of the flue gas.

Procedures for presenting the particle size distribution in graphical and tabular form are outlined below. A sample computer printout is shown on page 65 which includes reduced data from a hypothetical test. It is assumed for this sample calculation that an Andersen Stack Sampler was used to collect the particulate.

Information obtained from the data log sheets for each test is printed at the top of the sheet. The maximum particle diameter is measured by examining the particles collected on the first stage (or first cyclone) through an optical microscope. Gas analysis samples are taken at the same time the impactor is run. The mass loading is calculated from the total mass of the partic-culate collected by the impactor and listed in four different units after the heading CALC. MASS LOADING. The units are defined as:

GR/ACF - grains per actual cubic foot of gas at stack conditions of temperature, pressure, and water content.

GR/DSCF - grains per dry standard cubic foot of gas at engineering standard conditions of the gas. Engineering standard conditions are defined as 0% water content, 70°F, and 29.92 inches of Hg.

MG/ACM - milligrams per actual cubic meter of gas at stack conditions of temperature, pressure, and water content.

MG/DSCM - milligrams per dry standard cubic meter of gas at engineering standard conditions of the gas. Engineering standard conditions are defined as 0% water content, 21°C and 760 mm of Hg (Torr).

Below these data the information pertinent to each stage is summarized in columnar form in order of decreasing particle size from left to right. Thus S1 is the first stage, S8 is the last stage, and FILTER is the back-up filter. If a cyclone was used, then to the left of S1 a column labelled CYC will appear and information relevant to the cyclone will be listed in this column. Beneath each impactor stage number is listed the corresponding stage index members, which also serve as identification for the stages. Directly beneath these listings is the stage cut point calculated from Equations E1 and E2 for the actual test conditions. It is labelled D_{50} and is given in micrometer units. The stage weights are likewise listed for the respective stages, labelled MASS and are in milligram units.

The mass loadings per unit volume of gas sampled indicated by the stage weights are labelled MG/DSCM/STAGE and are written in milligrams per dry standard cubic meter. The /STAGE indicates that it is not a cumulative. It is calculated for a particular stage j by the formula

$$\text{MG/DSCM/STAGE}_j = \frac{\text{MASS}_j}{\text{SAMPLING DURATION (minutes)}}$$

$$\times \frac{\text{35.314667 cubic feet/cubic meter}}{\text{FLOWRATE (ACFM)}} \times \frac{\text{Absolute Stack Temperature}}{\text{Absolute Standard Temperature}}$$

$$\times \frac{\text{Absolute Standard Pressure}}{\text{Absolute Stack Pressure}} \times \frac{1}{(\text{1-Fraction of } H_2O)}$$

where absolute means the temperature and pressure are in absolute units-degrees Rankin or degrees Kelvin for temperature, and atmospheres, inches or millimeters of mercury for pressure.

For S1,

$$\text{MG/DSCM/STAGE}_1 = \frac{.72\ \text{mg}}{20\ \text{min.}} \times \frac{\text{35.314667 cubic feet/cubic meter}}{\text{0.500 ACFM}}$$

$$\times \frac{(400 + 460)^0\text{R}}{(70 + 460)^0\text{R}} \times \frac{29.92\ \text{in. Hg}}{26.50\ \text{in. Hg}} \times \frac{1}{(1.0 - 0.01)} = 4.71\ \text{mg/DSCM}$$

The subscripts indicate stage index numbers.

The percent of the mass of particles with diameters smaller than the corresponding D_{50} is called the CUMULATIVE PERCENT OF MASS SMALLER THAN D50. It is the cumulative mass at stage j divided by the toal mass collected on all the stages, and converted to a percentage:

$$\text{CUM }\%_j = \frac{\sum_{i=j+1}^{9} \text{MASS}_i}{\text{Total Mass}} \times 100$$

For example, for S6, the cumulative percent is given by

$$\text{CUM }\%_6 = \frac{\text{MASS}_7 + \text{MASS}_8 + \text{MASS}_9}{\text{Total Mass}} \times 100$$

$$= \frac{1.25\ \text{mg} + 0.04\ \text{mg} + 0.39\ \text{mg}}{5.24\ \text{mg}} \times 100 = 32.06\%$$

For S8, the mass of the particulate collected on the filter is used,

$$\text{CUM }\%_8 = \frac{\text{MASS}_9}{\text{Total Mass}} \times 100$$

$$= \frac{0.39 \text{ mg}}{5.24 \text{ mg}} \times 100$$

$$= 7.44\%$$

Note that the apparent error in the least significant figures of the calculated percentages is due to using masses from the computer printout which have been rounded off to two decimal places before printing.

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in milligrams per actual cubic meter (CUM. (MG/ACM) SMALLER THAN D50) for a particular stage j is given by the formula

$$\text{CUM. (MG/ACM)}_j = \frac{\sum_{i=j+1}^{9} \text{MASS}_i}{\text{SAMPLING DURATION (min)}} \times \frac{35.314667 \text{ cubic feet/cubic meter}}{\text{FLOWRATE (ACFM)}}$$

From the information at the top of the computer print-out sheet, the flowrate is 0.500 actual cubic feet per minute (ACFM) and the sampling duration is 20.00 minutes. Therefore, for S4,

$$\text{CUM. (MG/ACM)}_4 = \frac{\text{MASS}_5 + \text{MASS}_6 + \text{MASS}_7 + \text{MASS}_8 + \text{MASS}_9}{20 \text{ minutes}}$$

$$\times \frac{35.314667 \text{ cubic feet/cubic meter}}{0.500 \text{ ACFM}} = 12.3 \text{ mg/ACM}$$

For S8, the mass of the particulate collected on the filter is again used,

$$\text{CUM. (MG/ACM)}_8 = \frac{\text{MASS}_9}{20 \text{ minutes}} \times \frac{35.314667 \text{ cubic feet/cubic meter}}{0.500 \text{ ACFM}}$$

$$= \frac{0.39 \text{ mg}}{20 \text{ minutes}} \times \frac{35.314667 \text{ cubic feet/cubic meter}}{0.500 \text{ ACFM}}$$

$$= 1.38 \text{ mg/ACM}$$

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in grains per actual cubic foot (CUM. (GR/ACF) SMALLER THAN D50) for a particular stage j is given by the formula

$$\text{CUM.(GR/ACF)}_j = \frac{\text{CUM.(MG/ACM)}_j}{2.2883519 \frac{\text{grams/cubic meter}}{\text{grains/cubic foot}} \times 1000 \text{ mg/gram}}$$

For S7,

$$\text{CUM.(GR/ACF)}_7 = \frac{1.52 \text{ mg/ACM}}{2.2883519 \frac{\text{grams/cubic meter}}{\text{grains/cubic foot}} \times 1000 \text{ mg/gram}}$$

$$= 6.64 \times 10^{-4} \text{ grains/ACF}$$

The cumulative mass loading of particles smaller in diameter than the corresponding D_{50} in grains per dry standard cubic foot (CUM. (GR/DSCF) SMALLER THAN D50) is calculated to show what the above cumulative would be for one cubic foot of dry gas at 70°F and at a pressure of 29.92 inches of mercury. For a particular stage j,

$$\text{CUM.(GR/DSCF)}_j = \text{CUM.(GR/ACF)}_j$$

$$\times \frac{\text{Absolute Stack Temperature}}{\text{Absolute Standard Temperature}} \times \frac{\text{Absolute Standard Pressure}}{\text{Absolute Stack Pressure}}$$

$$\times \frac{1}{(1\text{-Fraction of } H_2O)}$$

where absolute means the temperature and pressure are in absolute units-degrees Rankin or degrees Kelvin for temperature, and atmospheres, inches or millimeters of mercury for pressure.

For S1,

$$\text{CUM.(GR/DSCF)}_1 = 6.96 \times 10^{-3} \text{ gr/ACF}$$

$$\times \frac{(400 + 460)\,^0\text{R}}{(70 + 460)\,^0\text{R}} \times \frac{29.92 \text{ in. Hg}}{26.50 \text{ in. Hg}} \times \frac{1}{(1.00-0.01)} = 1.29 \times 10^{-2} \text{ gr/DSCF}$$

The particle size distribution may be presented on a differential basis which is the slope of the cumulative curve. If we define the terms:

ΔM_j = MG/DSCM/STAGE$_j$ and

$(\Delta \log D)_j = \log_{10}(D50_{j-1}) - \log_{10}(D50_j)$ then

$$\left(\frac{\Delta M}{\Delta \log D}\right)_j = \frac{MG/DSCM/STAGE_j}{\log_{10}(D50_{j-1}) - \log_{10}(D50_j)}$$

Because the computer printer does not contain Greek letters, the computer print-out sheet reads DM/DLOG D instead of ΔM/ΔLOG D. For S6,

$$\left(\frac{\Delta M}{\Delta LOGD}\right)_6 = \frac{9.35 \text{ mg/DSCM}}{\log_{10}(2.22) - \log_{10}(1.29)} = 39.7 \text{ mg/DSCM}$$

Note that ΔM/ΔLOGD has the dimensions of the numerator since the denominator is dimensionless. In the calculation for S1, a maximum particle diameter is used. For this example, MAX. PARTICLE DIAMETER = 100.0 microns.

$$\left(\frac{\Delta M}{\Delta LOGD}\right)_1 = \frac{4.71 \text{ mg/DSCM}}{\log_{10}(100) - \log_{10}(10.74)} = 4.86 \text{ mg/DSCM}$$

For the filter stage, the D50 is arbitrarily chosen to be one-half of the D_{50} for stage eight (S8). For this example, it is chosen to be 0.33 micrometers/2 = 0.165 micrometers. Thus,

$$\left(\frac{\Delta M}{\Delta LOGD}\right)_9 = \frac{2.55 \text{ mg/DSCM}}{\log_{10}(0.33) - \log_{10}(0.165)} = 8.47 \text{ mg/DSCM}$$

The geometric mean diameter in micrometers (GEO. MEAN DIA. (MICROMETERS)) for a particular stage j is given by the formula

$$\text{GEO. MEAN DIA.}_j = \sqrt{D50_j \times D50_{j-1}}$$

For S8,

$$\text{GEO. MEAN DIA.}_8 = \sqrt{0.33 \times 0.69} \text{ micrometers}$$
$$= 0.477 \text{ micrometers}$$

As in the ΔLOGD calculation, we again use the maximum particle diameter for the stage one calculation and one-half the D_{50} for stage eight for the filter stage calculation.

For S1,

$$\text{GEO. MEAN DIA.}_1 = \sqrt{10.74 \times 100.0} \text{ micrometers} = 32.8 \text{ micrometers}$$

For the filter,

$$\text{GEO. MEAN DIA.}_9 = \sqrt{0.165 \times 0.33} \text{ micrometers} = 0.23 \text{ micrometers}$$

A differential number distribution can also be derived. Since ΔM_j = MG/DSCM/STAGE$_j$ is the mass per unit volume for stage j then we can define ΔN_j as ΔN_j = NUMBER OF PARTICLES/DSCM/STAGE$_j$ or the number of particles per unit volume for stage j. Now ΔM_j and ΔN_j are related by the equation $\Delta M_j = \Delta N_j \times m_p$, where m_p is the average mass of the particles collected on one stage. Dividing both sides of the equation by $m_p \times \Delta\text{LOGD}$ yields

$$\frac{(\Delta M/\Delta \text{LOGD})_j}{m_p} = \left(\frac{\Delta N}{\Delta \text{LOG D}}\right)_j \quad .$$

Now $m_p = \rho_p V_p$ where ρ_p is the assumed particle density and V_p is the average volume of one particle on one stage. To obtain m_p in milligram units when ρ_p is in grams per cubic centimeter and V_p is in cubic micrometers, certain conversion factors must be used. The complete formula, using the correct conversion factors and the expression $(4/3)\ (\pi)\ (d/2)^3$ for V_p where d is the geometric mean diameter in micrometers, is:

$$m_p = \rho_p \left(\frac{10^3 \text{ mg}}{1 \text{ gm}}\right) \left(\frac{4\pi}{3}\right)\left(\frac{d}{2}\right)^3 \left(\frac{10^{-12} \text{ cm}^3}{1 \text{ cubic micrometer}}\right) = 5.23599 \times 10^{-10}\ \rho_p d^3.$$

Therefore,

$$\left(\frac{\Delta N}{\Delta \text{LOGD}}\right)_j = \frac{(\Delta M/\Delta \text{LOGD})_j}{5.23599 \times 10^{-10}\ \rho_p d^3}$$

where $\Delta M/\Delta LOGD$ is in units of mg/DSCM, ρ_p is in gm/cc, d is in microns, and $\Delta N/\Delta LOGD$ is in number of particles/DSCM.

For S3,

$$\left(\frac{\Delta N}{\Delta LOGD}\right)_3 = \frac{17.9 \text{ mg/DSCM}}{(5.23599 \times 10^{-10}) \times (1.35 \text{ gm/cc}) \times (7.96 \text{ microns})^3}$$

$$= 5.02 \times 10^7 \text{ particles/DSCM.}$$

For the filter stage

$$\left(\frac{\Delta N}{\Delta LOGD}\right)_9 = \frac{8.47 \text{ mg/DSCM}}{(5.23599 \times 10^{-10}) \times (1.35 \text{ gm/cc}) \times (0.231 \text{ microns})^3}$$

$$= 9.72 \times 10^{11} \text{ particles/DSCM}$$

The test data are usually classified according to sampling location (outlet or inlet), sampling time (day, week, etc.) and combustion chamber or pollution control device conditions (high or low sulfur coal for coal plants, normal or below normal fuel consumption, normal or below normal current density for electrostatic precipitators, etc.). When classified, all of the data taken in a single classification are usually averaged and plotted on appropriate graph paper. For example, the $\Delta M/\Delta LOGD$ at a given geometric mean diameter or within a small range of geometric mean diameters might be averaged over all the tests performed in a day and plotted as ordinate and abscissa, respectively on log-log graph paper.

Error bars indicating standard deviation or confidence limits are normally included on the graph. A Hewlett-Packard HP-25 calculator program is included which will calculate the average ($\overline{X}$), the standard deviation(S), the relative standard deviation ($S/\overline{X}$), a 90% or 95% confidence interval (CI), the lower confidence limit ($\overline{X}$ - CI or LCL), and the upper confidence limit ($\overline{X}$ + CI or UCL). Also included is some hypothetical data typical of Brink impactor samples giving the $\Delta M/\Delta LOGD$ and geometric mean diameter values for one day. The average and other programmed calculations have been listed underneath the data in this table and on page 66 a graph of the average $\Delta M/\Delta LOGD$ values with 90% confidence limits versus the average of the geometric mean diameters is plotted on log-log graph paper. A smooth line was drawn through the ΔM/ΔLOGD data points and the upper and lower standard deviations. These curves are used to calculate the fractional efficiency.

On page 68 is a ΔM/ΔLOGD plot of hypothetical data from an Andersen impactor, which is normally used by SRI at the outlets of emission control devices while the Brink impactor is typically used at the inlets of those devices. It was assumed that the Andersen ΔM/ΔLOGD plot represented values obtained the same day as that of the Brink. Thus it was valid to find the efficiency of the control device by comparing the two plots. A set of particle sizes was chosen which would be used in deriving an average cumulative mass loading and the efficiency of the control device from the ΔM/ΔLOGD plots. The maximum and minimum particle sizes are chosen for which ΔM/ΔLOGD values are available in both the inlet and outlet ΔM/ΔLOGD distributions. These particle sizes are listed under the heading Geometric Mean Diameter on page 64.

Notice that by beginning the set with the particle size 0.500 micrometers, the data from the filter stages is not utilized. The reason the filter stage data is not included is that during the operation of a cascade impactor there is frequently a certain amount of particle bounce and reentrainment into the gas stream, and subsequent deposition on a lower stage. These particles are larger than most of the particles collected on the stage and thus in the lower stages, their mass can be a significant percentage of the total mass for that stage. The errors tend to be more significant for the fine particle end of the distribution and most significant of all for the filter. In addition, many filter media contain components which react chemically with constituents of flue gases (SO_2, for example). This gaseous reaction with the filter substrate can result in a change in the weight of the substrate even though the substrate was pre-conditioned. Again, substrate weight changes would usually be much more serious for the lower stages and back-up filter, whose particulate mass loadings are generally small. Also, the filter has a larger surface area than the substrates and is more thoroughly permeated by the gas going through it.

The filter stage weight, then, is likely to contain a larger error and may not be an accurate record of the concentration of small particles in the gas stream sampled. For this reason, the derived $\Delta M/\Delta LOGD$ value for the filter stage weights is often ignored especially if it exhibits any unusual characteristics. For more information on particle bounce and reentrainment see Particulate Sizing Techniques for Control Device Evaluation by Cushing, Lacey, McCain, and Smith, Final Report of EPA Contract No. 68-02-0273, to be published. For more information on substrate weight changes due to reactions with the components in a gas stream see Particulate Sizing Techniques for Control Device Evaluation by Cushing, Lacey, McCain, and Smith, August, 1975, Publication Number EPA-650/2-74-102a.

The percent penetration for a particular size particle is found by dividing the $\Delta M/\Delta LOGD$ for the outlet at that size by the $\Delta M/\Delta LOGD$ for the inlet at that same size, and multiplying the quotient by 100. The same is done using the upper curve (in which the 90% confidence interval is added) for the outlet and the lower curve (in which the 90% confidence interval is subtracted) for the inlet and <u>vice versa</u> from the $\Delta M/\Delta LOGD$ plots to obtain a set of penetration values which may be roughly interpreted as "upper and lower 90% confidence limits for the percent penetration". The collection efficiency of the emission control device is 100% minus the percent penetration. The collection efficiency corresponding to various particle sizes is plotted on log-log probability graph paper on page 69.

Although cumulative mass loading data for each impactor test is presented in tabular form on the computer print-out sheet, a more accurate average cumulative mass loading is found by integrating the average ΔM/ΔLOGD curve. The equation below yields ΔM_i corresponding to a particular size interval (Geometric Mean Diameter) d_i to d_{i+1} from the values of ΔM/ΔLOGD at those particle sizes. These values are taken from the ΔM/ΔLOGD plots on pages 66 and 68 and listed opposite the corresponding geometric mean diameters and identification numbers i on the table on page 64.

$$\Delta M_i = \frac{(\Delta M/\Delta LOGD)_i + (\Delta M/\Delta LOGD)_{i-1}}{2} \times \log_{10}\left(\frac{d_i}{d_{i-1}}\right)$$

Next the ΔM_i's are progressively summed to obtain the cumulative mass loading. Upper and lower 90% confidence limits are found by similar integrations of the upper and lower 90% confidence limits of the ΔM/ΔLOGD plots. A table listing ΔM/ΔLOGD, percent penetration, and cumulative mass loading values and their corresponding standard deviations for each size d_i is found on page 64. There is no value of the cumulative for d_1 because there is no valid $(\Delta M/\Delta LOGD)_0$ value due to particle bounce, etc. Thus the cumulative mass loadings plotted are cumulatives for particles larger than the D_{50} of the last impactor stage. Plots of cumulative mass loading for the inlet and percent efficiency of the emissions control device are found on pages 67 and 69.

HP-25 Program Form

Title Mean, Standard Deviation, 90/95% Confidence Interval Page 1 of 2

Switch to PRGM mode, press [f] [PRGM], then key in the program.

DISPLAY LINE	DISPLAY CODE	KEY ENTRY	X	Y	Z	T	COMMENTS
00							
01	14 21	f $\bar{x}$					
02	23 04	STO 4					
03	74	R/S					
04	14 22	fs					
05	23 05	STO 5					
06	74	R/S					
07	24 04	RCL 4					
08	71	÷					
09	74	R/S					
10	24 05	RCL 5					
11	24 03	RCL 3					
12	14 02	f $\sqrt{x}$					
13	71	÷					
14	24 03	RCL 3					
15	01	1					
16	41	−					
17	24 02	RCL 2					
18	14 03	f y^x					
19	24 01	RCL 1					
20	61	X					
21	24 00	RCL 0					
22	51	+					
23	61	X					
24	23 05	STO 5					
25	74	R/S					
26	24 04	RCL 4					
27	24 05	RCL 5					
28	41	−					
29	74	R/S					
30	24 04	RCL 4					
31	24 05	RCL 5					
32	51	+					
33	74	R/S					
34	00	0					
35	23 03	STO 3					
36	23 04	STO 4					
37	23 05	STO 5					
38	23 06	STO 6					
39	23 07	STO 7					
40	13 00	GTO 00					
41							
42							
43							
44							
45							
46							
47							
48							
49							

REGISTERS	
R_0	
R_1	
R_2	
R_3	n
R_4	$\bar{x}$
R_5	~~s1~~ C.I.
R_6	Σx^2
R_7	Σx

HP-25 Program Form

Title: Mean, Standard Deviation, 90/95% Confidence Interval — Page 2 of 2

Programmer: Joseph D. McCain

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS				OUTPUT DATA/UNITS
1	Initialize		f PRGM	f REG			
2a	For 90% C.I.	1.645	STO 0				
		2.60481	STO 1				
		1.18553	CHS	STO 2			
2b	For 95% C.I.	1.96	STO 0				
		5.5495	STO 1				
		1.34635	CHS	STO 2			
3	Enter values x_i						
	for i = 1, N:	x_i	Σ+				i
	if error in x_i:		fLASTx	f Σ-			
4a	Calculate mean		R/S				$\bar{x}$
b	Cal. standard deviation		R/S				s
c	Cal. relative std. deviation		R/S				$s/\bar{x}$
d	Cal. confidence interval		R/S				C.I.
e	Cal. lower confidence limit		R/S				LCL
f	Cal. upper confidence limit		R/S				UCL
5	To determine effect of omitting a point, x_m, from data set:	x_m	fΣ-	GTO 00			
	and go to step 4.						
6	To abandon calculation during step 4:		GTO 34	R/S			
	and go to step 3.						
7	For new data set after step 4f (UCL):		R/S				

and go to step 3.

Hypothetical Data - Brink Impactor

Test		CYC	S0	S1	S2	S3	S4	S5	S6	SF
1	ΔM/ΔLOGD*	3770	2630	1010	1190	1060	503	279	75.1	92.8
2	ΔM/ΔLOGD	3960	1500	866	991	1410	398	300	28.3	77.7
3	ΔM/ΔLOGD	3540	1720	1080	1080	913	452	163	41.5	104
4	ΔM/ΔLOGD	3410	2680	1130	1200	907	347	236	41.9	111
5	ΔM/ΔLOGD	3260	2910	1180	1310	1560	321	165	21.5	99.4
6	ΔM/ΔLOGD	3830	3050	1160	1380	1180	326	142	40.5	68.0
	ΔM/ΔLOGD Average	3630	2420	1070	1190	1170	391	214	41.5	92.2
	Standard Deviation	269	646	118	143	267	74.0	66.8	18.5	16.4
	Relative Std. Dev.	0.074	0.267	0.110	0.120	0.228	0.189	0.312	0.445	0.178
90% Confidence Interval		223	536	97.5	119	222	61.4	55.4	15.3	13.6
Lower Confidence Limit		3410	1880	973	1070	950	330	159	26.2	78.6
Upper Condidence Limit		3850	2950	1170	1310	1390	453	270	56.8	106
1	Geo. Mean Dia.	43.0	9.25	5.86	3.40	2.18	1.31	0.804	0.506	0.270
2	Geo. Mean Dia.	43.0	9.26	5.87	3.40	2.18	1.31	0.806	0.504	0.260
3	Geo. Mean Dia.	42.2	8.92	5.65	3.28	2.10	1.27	0.770	0.480	0.250
4	Geo. Mean Dia.	42.1	8.87	5.62	3.25	2.08	1.25	0.766	0.476	0.246
5	Geo. Mean Dia.	41.0	8.42	5.33	3.09	1.97	1.19	0.726	0.451	0.233
6	Geo. Mean Dia.	41.0	8.41	5.33	3.09	1.97	1.19	0.725	0.451	0.233
	Geo. Mean Dia. Average	42.1	8.86	5.61	3.25	2.08	1.25	0.766	0.478	0.249

*NOTE: ΔM/ΔLOGD in units of mg/DSCM.
Geometric Mean Diameter in units of micrometers.

Hypothetical Data

i	Geometric Mean Diameter (Micrometers)		Outlet ΔM/ΔLOGD (mg/DSCM)	Inlet ΔM/ΔLOGD (mg/DSCM)	Percent Penetration %	Inlet Cumulative Mass Loading (mg/DSCM)
1	0.500	$\bar{X}$	2.95	41.8	7.06	
		UCL	5.27	57.0	19.3	
		LCL	0.635	27.3	1.11	
2	0.800	$\bar{X}$	6.40	225	2.84	27.2
		UCL	8.70	281	5.12	34.5
		LCL	4.05	170	1.44	20.1
3	1.28	$\bar{X}$	7.40	410	1.80	92.0
		UCL	10.2	498	2.99	114
		LCL	4.99	341	1.00	72.3
4	2.05	$\bar{X}$	9.30	1140	0.82	250
		UCL	13.0	1390	1.40	307
		LCL	6.00	930	0.43	202
5	3.28	$\bar{X}$	13.2	1190	1.11	488
		UCL	19.0	1310	1.78	582
		LCL	7.20	1070	0.55	406
6	5.24	$\bar{X}$	12.8	1050	1.22	717
		UCL	18.8	1150	1.96	833
		LCL	6.90	960	0.60	613
7	8.39	$\bar{X}$	10.7	2280	0.47	1057
		UCL	15.3	2790	0.88	1235
		LCL	5.80	1730	0.21	888
8	13.4	$\bar{X}$	7.60	3290	0.23	1625
		UCL	10.6	3800	0.39	1908
		LCL	4.00	2700	0.11	1340
9	21.5	$\bar{X}$	4.50	3800	0.12	2349
		UCL	6.00	4180	0.17	2722
		LCL	2.55	3430	0.061	1966

HYPOTHETICAL ANDERSEN

IMPACTOR FLOWRATE = 0.500 ACFM   IMPACTOR TEMPERATURE = 400.0 F = 204.4 C   SAMPLING DURATION = 20.00 MIN

IMPACTOR PRESSURE DROP = 1.5 IN. OF HG   STACK TEMPERATURE = 400.0 F = 204.4 C

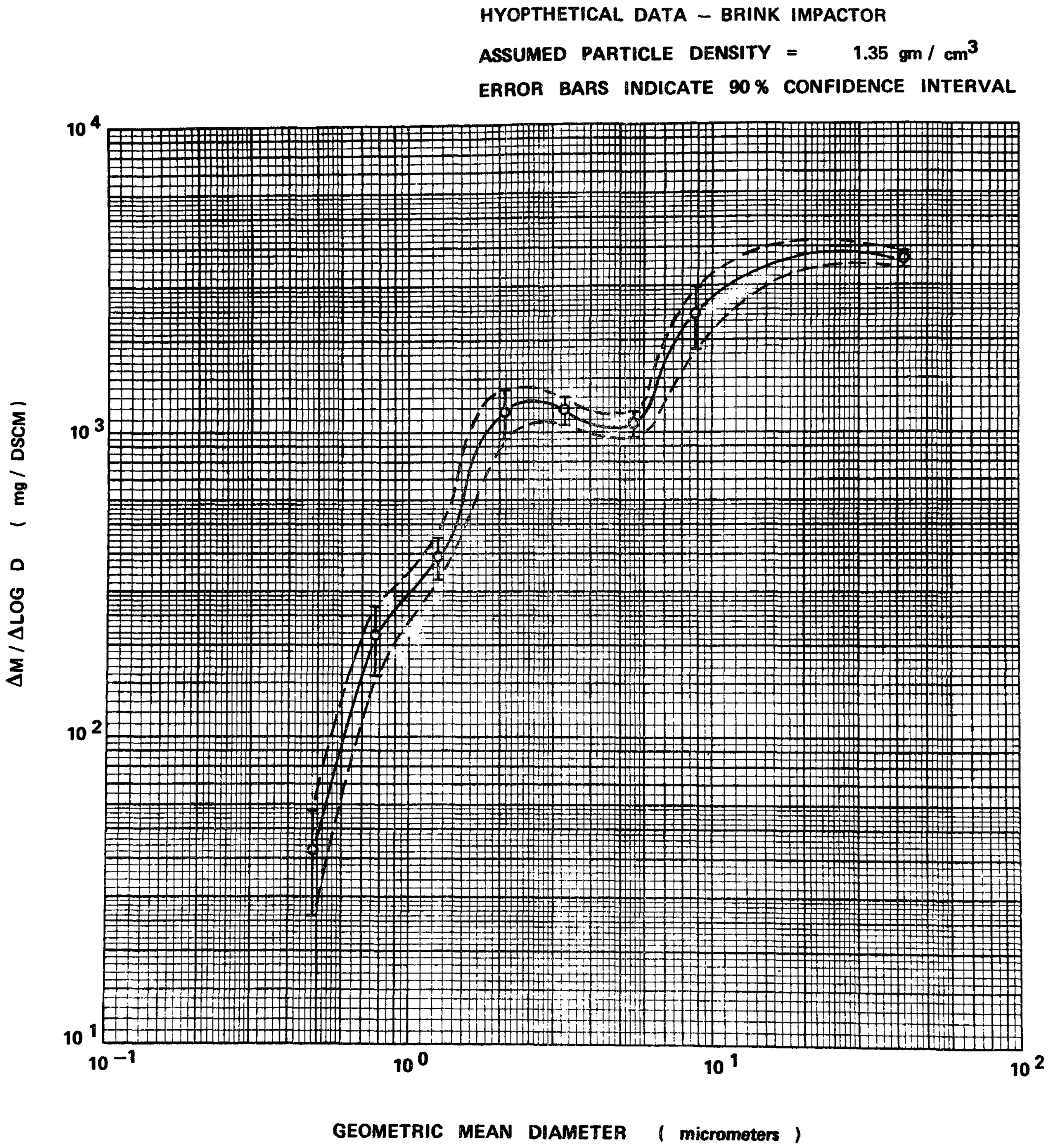
ASSUMED PARTICLE DENSITY = 1.35 GM/CU.CM.   STACK PRESSURE = 26.50 IN. OF HG   MAX. PARTICLE DIAMETER = 100.0 MICROMETERS

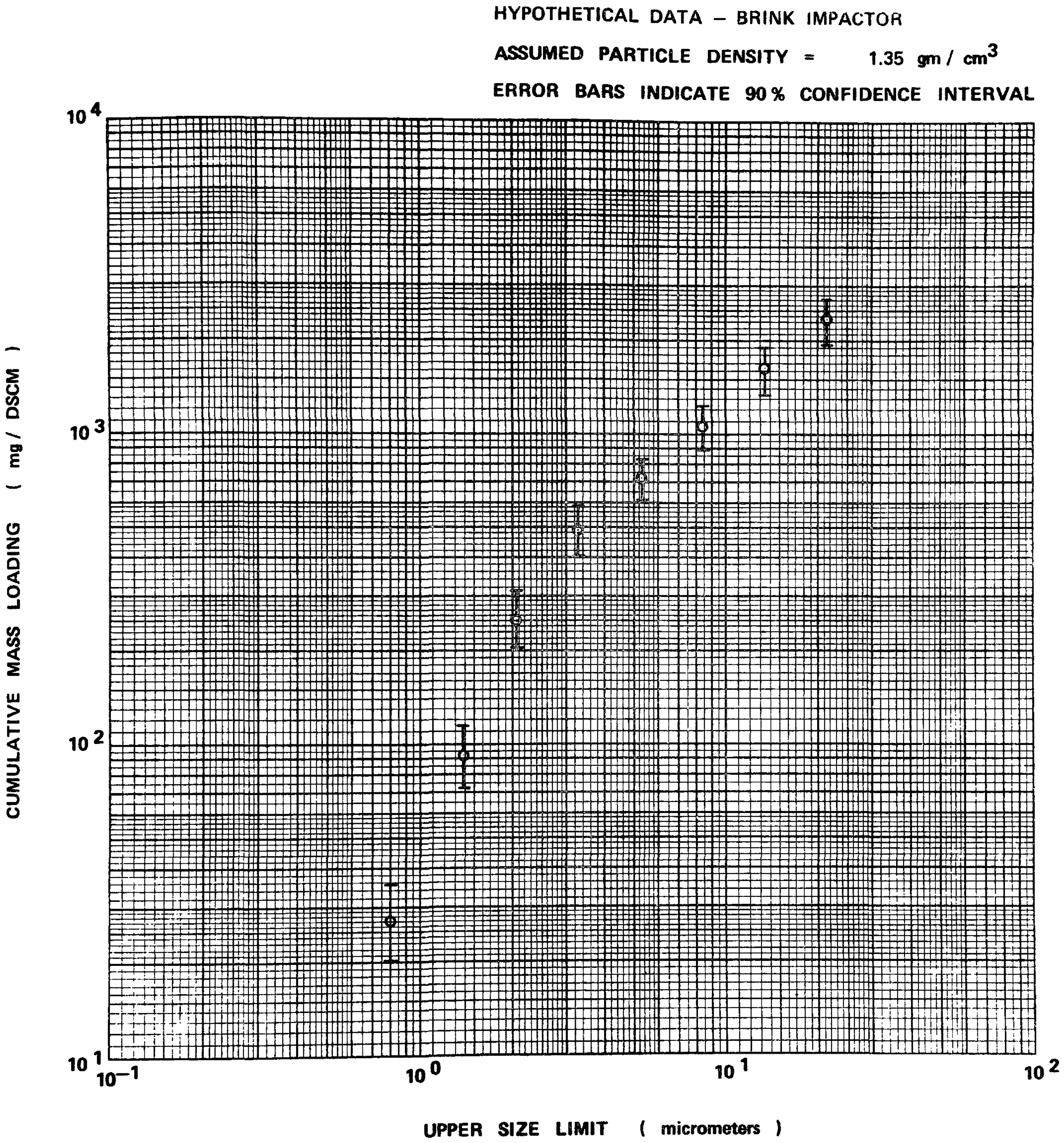
GAS COMPOSITION (PERCENT)   CO2 = 0.95   CO = 0.00   N2 = 76.53   O2 = 20.53   H2O = 1.00

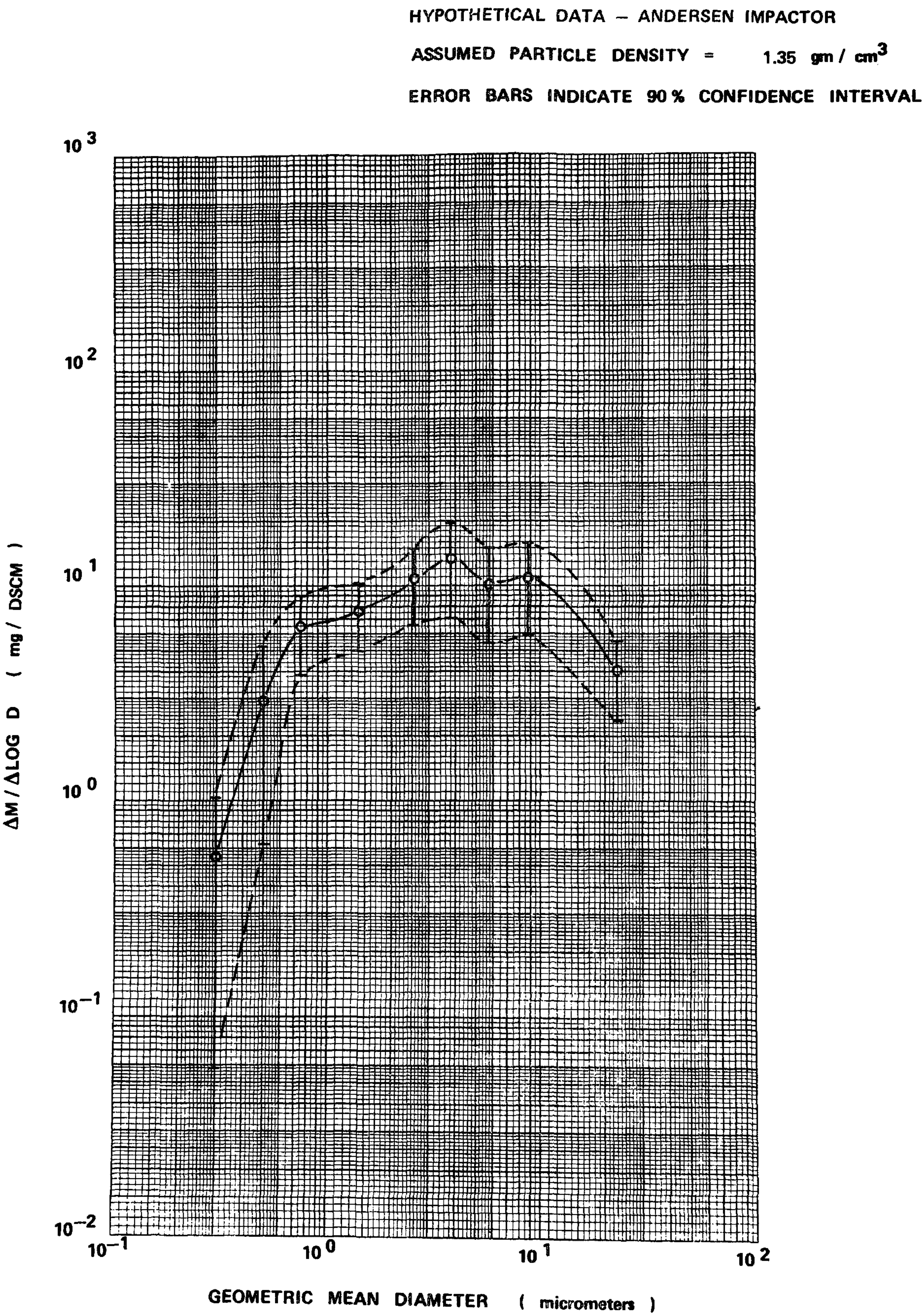
CALC. MASS LOADING = 8.0711E-03 GR/ACF   1.4948E-02 GR/DSCF   1.8470E+01 MG/ACM   3.4207E+01 MG/DSCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.74	9.95	6.36	4.19	2.22	1.29	0.69	0.33	
MASS (MILLIGRAMS)	0.72	0.40	0.53	0.09	0.38	1.43	1.25	0.04	0.39
MG/DSCM/STAGE	4.71E+00	2.62E+00	3.47E+00	5.89E-01	2.49E+00	9.35E+00	8.18E+00	2.62E-01	2.55E+00
CUM. PERCENT OF MASS SMALLER THAN D50	86.24	78.59	68.46	66.74	59.47	32.13	8.23	7.46	
CUM. (MG/ACM) SMALLER THAN D50	1.59E+01	1.45E+01	1.26E+01	1.23E+01	1.10E+01	5.93E+00	1.52E+00	1.38E+00	
CUM. (GR/ACF) SMALLER THAN D50	6.96E-03	6.34E-03	5.53E-03	5.39E-03	4.80E-03	2.59E-03	6.64E-04	6.02E-04	
CUM. (GR/DSCF) SMALLER THAN D50	1.29E-02	1.17E-02	1.02E-02	9.98E-03	8.89E-03	4.80E-03	1.23E-03	1.12E-03	
GEO. MEAN DIA. (MICROMETERS)	3.28E+01	1.03E+01	7.96E+00	5.17E+00	3.05E+00	1.69E+00	9.43E-01	4.74E-01	2.31E-01
DM/DLOGD (MG/DSCM)	4.86E+00	7.94E+01	1.79E+01	3.25E+00	8.99E+00	3.99E+01	2.98E+01	8.09E-01	8.47E+00
DN/DLOGD (NO. PARTICLES/DSCM)	1.95E+05	1.02E+08	5.01E+07	3.33E+07	4.48E+08	1.16E+10	5.03E+10	1.08E+10	9.74E+11

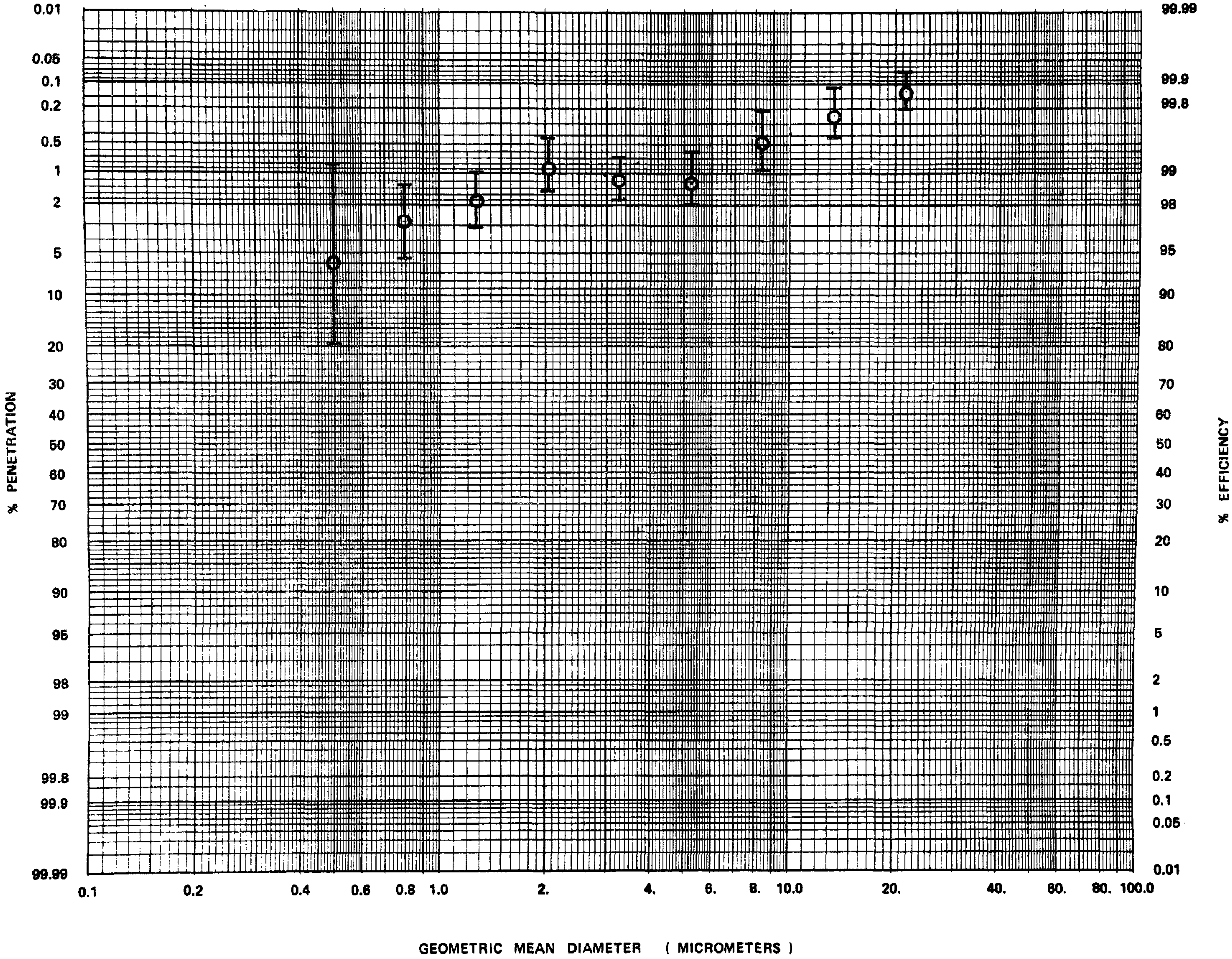
NORMAL OR STANDARD CONDITIONS ARE 21 DEG C AND 760MM HG


HYOPTHETICAL DATA – BRINK IMPACTOR
ASSUMED PARTICLE DENSITY = 1.35 gm / cm3
ERROR BARS INDICATE 90 % CONFIDENCE INTERVAL
10 4
10 3
10 2
10 1
ΔM / ΔLOG D (mg / DSCM)
10 −1
10 0
10 1
10 2
GEOMETRIC MEAN DIAMETER (micrometers)

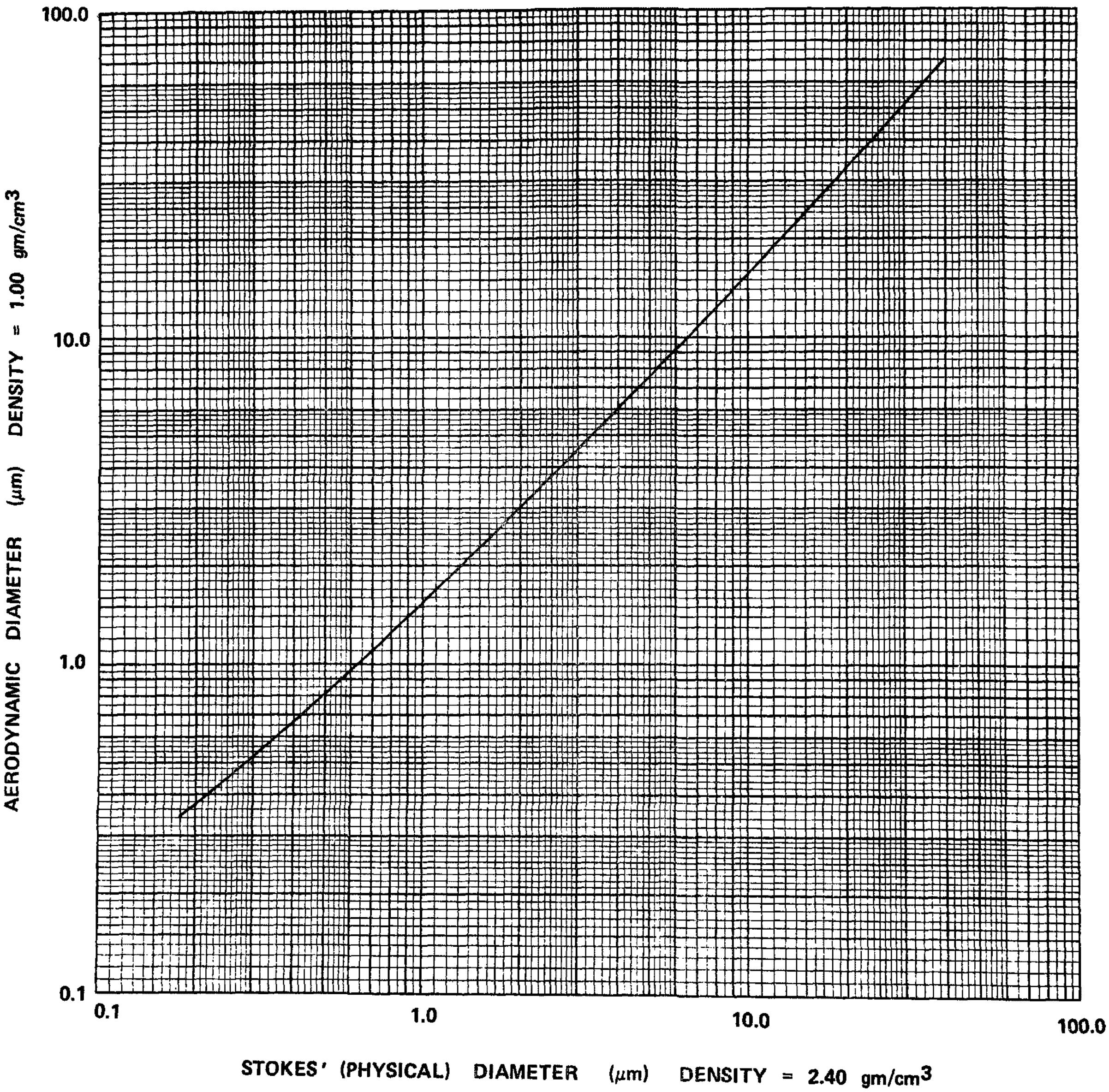

HYPOTHETICAL DATA – BRINK IMPACTOR
ASSUMED PARTICLE DENSITY = 1.35 gm / cm3
ERROR BARS INDICATE 90 % CONFIDENCE INTERVAL
CUMULATIVE MASS LOADING (mg / DSCM)
10 4
10 3
10 2
10 1
10−1
10 0
10 1
10 2
UPPER SIZE LIMIT (micrometers)


HYPOTHETICAL DATA – ANDERSEN IMPACTOR
ASSUMED PARTICLE DENSITY = 1.35 gm / cm3
ERROR BARS INDICATE 90 % CONFIDENCE INTERVAL
10 3
10 2
10 1
10 0
10−1
10−2
ΔM / ΔLOG D (mg / DSCM)
10−1
10 0
10 1
10 2
GEOMETRIC MEAN DIAMETER (micrometers)

NOTE
ERROR BARS DERIVED FROM 90% CONFIDENCE INTERVALS INDICATED ON INLET AND OUTLET ΔM/ΔLOG D CURVES



Relationship between Stokes' or Physical diameter (Density = 2.40 gm/cm^3) and Aerodynamic Diameter (Density = 1.00 gm/cm^3).



SAMPLE CALCULATION FOR DATA REDUCTION OF ULTRAFINE PARTICLE SIZE MEASUREMENTS

INSTRUMENTATION

A Thermo-Systems Inc. Model 3030 Electrical Aerosol Size Analyzer (EAA) with a 0.0032 μm to 0.360 μm range at the operating conditions used ($N_Ot = 7 \times 10^6$ at 4.0×10^{-9} amperes ionizer current and 50 volts ionizer voltage) was used to determine concentration vs size information in the ultrafine size range.

PROCEDURES

Once the equipment has been set up as shown schematically in Figure 1, the flows were adjusted through the sample orifice and the dilution air orifice, to obtain the desired dilution factor. The EAA was placed in a manual scan mode and the current readings for each channel were recorded with a strip chart recorder. Manual control allowed run times of from two to five minutes in each of the nine channels. This allows one to average out rapid source fluctuations. At the beginning of each day the internal calibration points and flows through the EAA were checked, as described in the instrument manual. These were also periodically rechecked throughout the day. The optional SO_x absorbers shown in Figure 1 were not used in this test.

The theory of operation and basic equations for the EAA have been given by Liu et al[1] and calibration of the Model 3030 EAA has been done by Liu and Pui[2] which revises the previous calibration. Table 1 shows these revised calibration constants in a data reduction format. The calibration by Liu suggested the use of a calibration matrix; however typical source fluctuations in industrial processes generally negate any potential advantage of such refinements. Table 1 is essentially self-explanatory. The heading "D_p,μm" (column 3) is the particle diameter in microns. A value of 0.0100 means that the center rod voltage is such that all particles of 0.0100 μm diameter and smaller are collected in the analyzer tube while larger particles penetrate to the current collecting filter where an electrometer measures the total current carried by the unprecipitated particles. This current represents the charges on all particles larger than 0.0100 μm. This measured current is the basic output of the Model 3030.

The fourth column (D_{pi},μm) is the geometric mean diameter of the particles represented by the current difference of two successive steps (Channel No.'s). For example, the difference in current for the 0.0100 μm cut-off and the current for the 0.0178 μm cut-off is the total current collected from particles between these sizes, or rather for a mean diameter of 0.0133 μm. The current differences are entered in column 8 headed "ΔI,pA" (picoAmps).

The fifth column gives the revised calibration factor (based on the calibration by Liu and Pui[2]) for each of the eight size bands. These factors are in units of particles per cm^3 per picoAmpere. Multiplying this size specific current sensitivity, ΔN/ΔI, (column 5) by the current difference, ΔI, (column 8) gives the total number of particles, ΔN, (column 9) in units of particles per cm^3, within this size band (column 4) for the diluted aerosol. To correct for dilution and find in-stack concentrations, multiply column 9 by the dilution factor (DF) and enter the result, ΔN_s, in column 10. Columns 6 and 12 are used for $\Delta N_s/\Delta \mathrm{Log}D$ information calculated from the number distribution in column 10. Column 11 is used for cumulative concentrations, corrected for dilution to engineering standard (normal) conditions by a dilution factor (i.e. column 10). Engineering standard or normal conditions are defined as 21°C and 760mm Hg pressure.

The basic data from the EAA is cumulative current for each of nine channels (column 7). One must then take the differences of the current readings for successive channels (column 8) in order to find ΔN, etc. These ΔI values are multiplied by a series of constants ($\Delta N/\Delta I_i$, DF_j) to arrive at ΔN_s (concentration in stack corrected to dry, standard conditions). While a single scan should be made at a constant dilution, different scans may be made at different dilutions. To simplify the arithmetic for each test condition, we form the product $\alpha_i = \Delta I_{i,j} \times DF_j$ and average all such inlet (outlet) products for the same size band. This average is used in Table 2 to calculate ΔN_s, cumulative concentration, and $\Delta N_s/\Delta LogD$ for each size band. When Table 2 is used the data reduction is as follows:

SUMMARY OF THE CALCULATION FORMAT

STEP 1

A. Calculate the average instrument reading (I) for each channel as obtained from the strip chart recording of channel current vs. time.

B. Calculate all dilution factors (DF_j).

STEP 2

Calculate current differences ($\Delta I_{i,j}$) from adjacent channels and average the α_i products ($\alpha_i = \Delta I_{i,j} \times DF_j$) for the same size band for all scans taken for the same test conditions. Calculate 90% confidence intervals for each $\bar{\alpha}_i$. Note: the i subscript denotes size and the j subscript denotes dilution setting.

STEP 3

Using $\bar{\alpha}_i$ and Table 2 calculate "number concentration" (ΔN_s), "average cumulative concentration of all particles having diameter greater than the indicated size" ($\Sigma\Delta N_s$), and "$\Delta N_s/\Delta LogD$" for each size band for each test condition.

STEP 4

Plot "Cumulative Concentration vs. Size" for each test condition.

STEP 5

Plot $\Delta N_s/\Delta LogD$ (with upper and lower 90% confidence limits) vs. size for each test condition.

STEP 6

Calculate and plot efficiency vs. size with upper and lower 90% confidence limits.

SAMPLE CALCULATION FOLLOWING THE CALCULATION FORMAT

STEP 1

A. Calculate the average instrument reading (I) for each channel as obtained from the strip chart recording of channel current vs. time. Each complete size scan (Table 1) consists of nine instrument readings (I, column 7 of Table 1). These instrument readings are the average current outputs as taken from the strip chart recordings, for each of the nine channels. Run times were manually controlled and varied from two to ten minutes per channel as the instrument operator sequentially stepped through channels 3, 4, 5, ..., 11. Table four gives the instrument readings used as data for the sample calculation (10 scans, 90 average current readings).

B. Calculate all dilution factors (DF_j; corrected to engineering standard (normal) conditions: 70°F (21°C) and 29.92 inches of mercury pressure (760 mmHg)). The flow through a calibrated orifice is given by:

$$Q = k \sqrt{\frac{T \times \Delta P}{P}}$$

where Q is the actual flow through the orifice

T is the orifice temperature

P is the pressure at the high pressure side of the orifice

ΔP is the pressure drop across the orifice

and k is a constant of proportionality for a limited range of ΔP values.

The flow rate, Q_N, corrected to engineering standard, or normal conditions of temperature, T_N, and pressure, P_N is given by:

$$Q_N = \left(\frac{P}{P_N}\right) \left(\frac{T_N}{T}\right) Q$$

The constant of proportionality, k, is found from the calibration data thusly:

$$k = Q_c \sqrt{\frac{P_c}{T_c \times \Delta P_c}}$$

Where the subscript c refers to calibration conditions of flow, pressure, pressure drop, and temperature.

By collecting constants one can tabulate a single constant (C_N) for each orifice so that:

$$Q_N = C_N \sqrt{\frac{P \times \Delta P}{T}}$$

where

$$C_N = \left(\frac{T_N}{P_N}\right) \quad Q_c \sqrt{\frac{P_c}{T_c \times \Delta P_c}}$$

For example:

If for the .029 orifice, an actual flow rate (Q_c) of 1.526 liters per minute were measured for a pressure drop (ΔP_c) of 10 inches H_2O at temperature (T_c) 537°R and pressure (P_c) 29.40 inches mercury, C_N is given by:

$$C_N \text{ (for .029 orifice)} = \left(\frac{530°R}{29.92"Hg}\right) \text{ (1.526 lpm) } \sqrt{\frac{29.40"Hg}{(537°R)\ (10"H_2O)}}$$

$$= \text{ 2.00 (for Q in lpm)}$$

By definition the dilution factor (DF) is the ratio of the total flow ($Q_D + Q_S$) divided by the sample flow (Q_S) thus:

$$DF = \frac{Q_D}{Q_S} + 1$$

or

$$DF = \frac{C_{N,D} \sqrt{\frac{(P_D)\ (\Delta P_D)}{T_D}}}{C_{N,S} \sqrt{\frac{(P_S)\ (\Delta P_S)}{T_S}}} + 1$$

where the subscripts D and S denote dilution air orifice and sample air orifice respectively.

The diagram in Figure 2 will help illustrate how the pressures P_D and P_S are determined.

P_D then is:

$$P_D = P_{AMB} + \Delta P_7 + \Delta P_D$$

and P_S is:

$$P_S = P_{AMB} + \Delta P_{DU} - \Delta P_{CY}$$

where

P_{AMB} = ambient absolute pressure

ΔP_7 = differential pressure between the internal diluter pressure and ambient (negative when the diluter is negative to ambient)

ΔP_D = pressure drop across the dilution air orifice

ΔP_{DU} = differential pressure, duct to ambient (negative when duct is negative to ambient)

ΔP_{CY} = pressure drop across the cyclone

The calculation of DF is done using a programmable calculator (HP-25) and the following format is used to collectively restate the data values for direct input to the calculator each time a different DF is calculated.

ΔP_S	T_{DI}	P_A
ΔP_D	T_{DU}	C_S
ΔP_7	P_S	DF =

Note: ΔP_S, ΔP_D, and ΔP_7 are in inches H_2O, T_{DI}, and T_{DU} are in °R ($T_{DU} = T_S$), P_S and P_A are in inches Hg, $C_S = C_{N,S}$ and is for Q in lpm ($C_{N,D}$ = 590 is programmed in the calculator).

Typical data may be recorded as follows (for Q in SLPM):

Inlet, Friday (13 May, 1976), Dilution air orifice $\dddot{DA}$

26.34	329	45	-25.0	48
P_A	T_{DU}	T_{DI}	ΔP_{DU}	T_A

TIME	OR	CAL
3:15 pm	$.0\ddot{2}9$	✓
(6.7, 3.2, -30)	.5	

where

P_A = ambient pressure (P_{AMB}) in "Hg

T_{DU} = temperature of the flue gas (Note: $T_S = T_{DU}$) in °F

T_{DI} = temperature of the dilution air orifice (T_D) in °F

ΔP_{DU} = differential pressure, duct to ambient (negative when duct is negative to ambient)

T_A = ambient temperature in °F

TIME = time at which these variables were recorded

OR = sample air orifice identification number

CAL = reminder to check the calibration adjustments on all instruments

The following format is also used in conjunction with the data logging stamp:

$$(\Delta P_S, \Delta P_D, \Delta P_7) \quad \Delta P_{CY}$$

where all pressure drops are in "H_2O.

From calibration tables for our orifices, Table 3, we have:

$$.0\ddot{2}9 \text{ orifice; } C_{N,S} = 2.00$$

and

dilution air orifice, $\dddot{DA}$; $C_{N,D}$ = 590 (in program) thus:

ΔP_S	6.7	T_{DI}	505	P_A	26.34
ΔP_D	3.2	T_{DU}	789	C_S	2.00
ΔP_7	-30	P_S	24.5	DF = 255	

or

$$DF = \frac{590 \sqrt{\dfrac{(24.4\ ''Hg)\ (3.2\ ''H_2O)}{(505°R)}}}{2.00 \sqrt{\dfrac{(24.5\ ''Hg)\ (6.7\ ''H_2O)}{(789°R)}}} + 1 = 255$$

for

$$P_D = 26.34''Hg + \left(\frac{-30''H_2O + 3.2''H_2O}{13.6\ ''H_2O/''Hg}\right) = 24.4''Hg$$

$$P_S = 26.34''Hg + \left(\frac{-25.0''H_2O - .5''H_2O}{13.6\ ''H_2O/''Hg}\right) = 24.5''Hg$$

While a single scan should be made at a constant dilution ratio, this is not always practical. When different dilution ratios are used, one can obtain a corrected instrument reading that gives what the instrument reading would have been if the dilution factor had remained constant. This allows the calculation of the α_i products as described in Step 2 for use with Table 2. This corrected instrument reading is given by:

$$I' = I\ (DF'/DF)$$

For example, if during a scan at DF = 255, the parameters shifted and the recalculated dilution was 280, for a true channel current of 0.749 picoAmps, the corrected reading would be 0.749 picoAmps x 255/280 = 0.682 picoAmps.

STEP 2

Calculate current differences ($\Delta I_{i,j}$) from adjacent channels and average the α_i products for the same size band for all scans taken at the same test condition. Calculate 90% confidence intervals for each $\overline{\alpha_i}$:

The α_i product is given by the following:

$$\alpha_i = \Delta I_{i,j} \times DF_j$$

where i denotes the size band and j denotes the dilution value.

SAMPLE CALCULATION (FOR ILLUSTRATION ONLY)

Find $\bar{\alpha}_i$ for the ten scans given in Table 4 made at two different dilutions.

For channels 3-4 we have:

Scan #1: $\alpha_{3-4,1}$ = (.135) (255) pA

#2: $\alpha_{3-4,1}$ = (.124) (255) pA

#3: $\alpha_{3-4,1}$ = (.132) (255) pA

.
.
.

#9: $\alpha_{3-4,2}$ = (.290) (113) pA

#10: $\alpha_{3-4,2}$ = (.296) (113) pA

thus $\bar{\alpha}_{3-4}$ = 33.179 pA; n = 10 and CI = .579.

In a similar manner we can find $\bar{\alpha}_{4-5}$, $\bar{\alpha}_{5-6}$, ..., $\bar{\alpha}_{10-11}$.

A Hewlett-Packard HP-25 calculator program (included in the discussion of the impactor data reduction) has been written to calculate the error estimates given on graphs of the data points. Given a set of data, this program calculates the average ($\bar{X}$), the standard deviation (S), the relative standard deviation (S/$\bar{X}$), a 90% or 95% confidence interval (CI), the lower confidence limit ($\bar{X}$-CI or LCL), and the upper confidence limit ($\bar{X}$+CI or UCL).

Thus the mean, with upper and lower 90% confidence limits for $\bar{\alpha}_{3-4}$ is given by:

$$\bar{\alpha}_{3-4} = (33.179 \pm 0.579) \text{ pA}$$

or

$$\bar{\alpha}_{3-4} = (33.2 \pm 0.6) \text{ pA}$$

STEP 3

Using $\bar{\alpha}_i$ and Table 2 calculate "number concentration" (ΔN_S), "average cumulative concentration ..." ($\Sigma \Delta N_S$), and "$\Delta N_S/\Delta \text{LogD}$" for each size band for each test condition.

Table 5 shows these calculations for the sample data of Table 4. Column 7 is $\bar{\alpha}$ as shown in Step 2. Column 8 is the product of columns 7 and 5. Column 9 is the summation of 8 for all sizes "equal to or greater than the indicated size". Column 10 is column 5 times column 7 divided by column 6.

STEP 4

Plot cumulative concentration vs. size for each test condition. For the sample data set of Table 4 this would be the concentrations in Table 5 column 9 plotted against the sizes in column 4. No error bars are used.

STEP 5

Plot $\Delta N_S/\Delta \text{LogD}$ with upper and lower 90% confidence limits for each test condition.

For the sample data set of Table 4 this would be the concentrations in Table 5, column 10 plotted against the sizes in column 4. The upper error bar is the value plus the 90% confidence interval. The lower error bar is the value minus the 90% confidence interval. For $\bar{\alpha}_{3-4}$ in Table 4 we would have $\bar{\alpha}_{3-4} = 33.2 \pm 0.6$ thus:

$$\Delta N_S/\Delta \text{LogD} = \frac{33.2 \times 4.76 \times 10^5}{.250} \pm \frac{0.6 \times 4.76 \times 10^5}{.250}$$

$$= (63.2 \pm 1.1) \times 10^6$$

STEP 6

Calculate and plot efficiency vs. size with upper and lower 90% confidence limits:

The efficiency of the control device is given by the following:

$$\text{Eff} = \left(1 - \frac{\text{Outlet } \Delta N_S/\Delta \text{LogD}}{\text{Inlet } \Delta N_S/\Delta \text{LogD}}\right) \times 100\%$$

Sample Calculation:

If, for 0.0133 μm particles, the inlet $\Delta N_S/\Delta \text{LogD} = (63.2 \pm 1.1) \times 10^6$ and outlet $\Delta N_S/\Delta \text{LogD} = (8.85 \pm .23) \times 10^5$, then:

$$\text{Eff} = \left(1 - \frac{8.85 \times 10^5}{63.2 \times 10^6}\right) \times 100 = 98.6\%$$

the upper limit (UL_E) and lower limit (LL_E) are given by:

$$UL_E = \left(1 - \frac{\text{Outlet} - \text{CI}}{\text{Inlet} + \text{CI}}\right) \times 100\%$$

$$= \left(1 - \frac{8.62 \times 10^5}{64.3 \times 10^6}\right) \times 100\%$$

$$= 98.7\%$$

$$LL_E = \left(1 - \frac{\text{Outlet} + \text{CI}}{\text{Inlet} - \text{CI}}\right) \times 100\%$$

$$= \left(1 - \frac{9.08 \times 10^5}{62.1 \times 10^6}\right) \times 100\%$$

$$= 98.5\%$$

Efficiencies with upper and lower limits are calculated for each of the eight sizes in column 4 from the $\Delta N_S/\Delta \text{LogD}$ values in column 10 for each test condition.

The following data were taken with the ultrafine sampling system described previously. These data were taken during January 1976 on an electrostatic precipitator collecting fly ash resulting from the combustion of a high-sulfur (3.1 - 5.6%S) coal at the Tennessee Valley Authority's Colbert Steam Plant.

REFERENCES

1. Liu, B. Y. H., Whitby, K. T. and Pui, D. Y. H., "A Portable Electric Aerosol Analyzer for Size Distribution Measurement of Submicron Aerosols", presented at the 66th Annual Meeting of the Air Pollution Control Association, Paper No. 73-283 (June 1973).

2. Liu, B. Y. H., and Pui, D. Y. H., "On the Performance of the Electrical Aerosol Analyzer," J. Aerosol Science, 6, pp. 249-64, (1975).

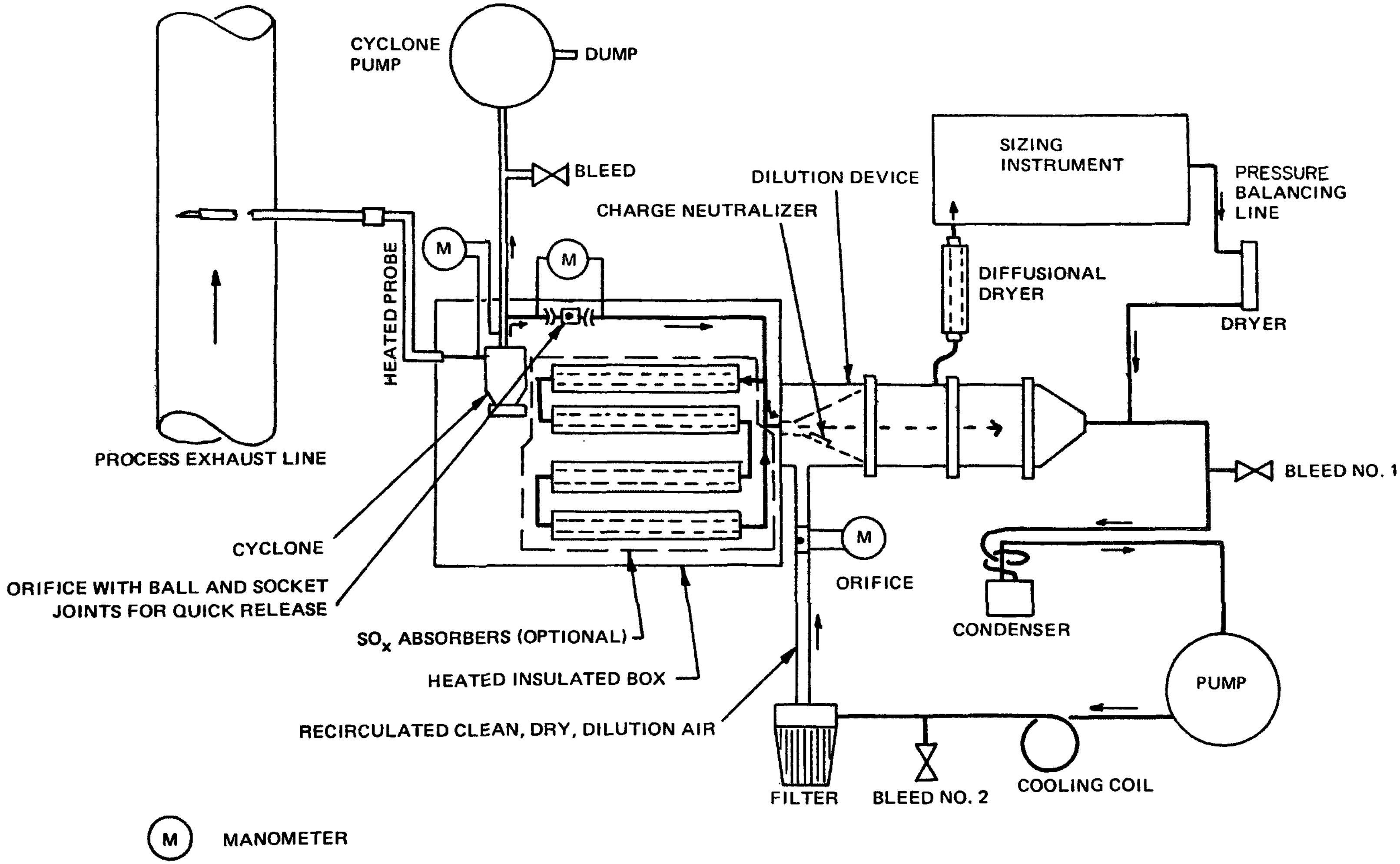


Figure 1. Sample Extraction-Dilution System

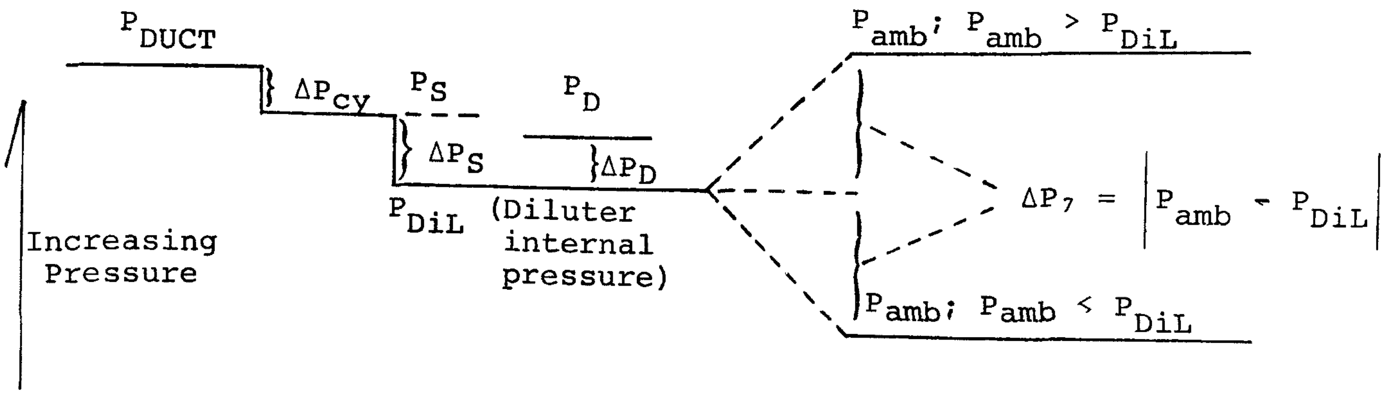


Figure 2. Diagrammatic representation of pressure drops in the ultrafine particle sizing system.

Table 1

EAA (Model 3030) Data Reduction Form
Concentration, Cumulative Concentration, and $\Delta N_s/\Delta \text{LogD}$ from Scan No. _____
for DF = ____

1	2	3	4	5	6	7	8	9	10	11	12
Channel No.	Collector Voltage	D_p, μm	D_{pi}, μm	$\Delta N/\Delta I$	$\Delta \log D_p$	I,pA	ΔI,pA	ΔN	ΔN_s	ΣN_s	$\Delta N_s/\Delta \log D$
3	196	0.0100									
			0.0133	4.76×10^5	0.250						
4	593	0.0178									
			0.0215	2.33×10^5	0.165						
5	1220	0.026									
			0.0306	1.47×10^5	0.141						
6	2183	0.036									
			0.0502	8.33×10^4	0.289						
7	3515	0.070									
			0.0917	4.26×10^4	0.234						
8	5387	0.120									
			0.149	2.47×10^4	0.188						
9	7152	0.185									
			0.219	1.56×10^4	0.148						
10	8642	0.260									
			0.306	1.10×10^4	0.141						
11	9647	0.360									

Table 2

EAA (Model 3030) Data Reduction Form
Concentration, Cumulative Concentration, and $\Delta N_s/\Delta \text{LogD}$
From Average $\bar{\alpha}$ for Condition ________

1 Channel No.	2 Collector Voltage	3 D_p, µm	4 D_{pi}, µm	5 ΔN/ΔI	6 $\Delta \log D_p$	7 $\bar{\alpha}$	8 ΔN_s	9 $\Sigma \Delta N_s$	10 $\Delta N_s/\Delta \log D$
3	196	0.0100							
			0.0133	4.76×10^{5}	0.250	____	____	____	________
4	593	0.0178							
			0.0215	2.33×10^{5}	0.165	____	____	____	________
5	1220	0.026							
			0.0306	1.47×10^{5}	0.141	____	____	____	________
6	2183	0.036							
			0.0502	8.33×10^{4}	0.289	____	____	____	________
7	3515	0.070							
			0.0917	4.26×10^{4}	0.234	____	____	____	________
8	5387	0.120							
			0.149	2.47×10^{4}	0.188	____	____	____	________
9	7152	0.185							
			0.219	1.56×10^{4}	0.148	____	____	____	________
10	8642	0.260							
			0.306	1.10×10^{4}	0.141	____	____	____	________
11	9647	0.360							

Table 3

ORIFICE CONSTANTS (C_N)

#	2 Dot Set	3 Dot Set
.120	45	52
.082	14	16
.059	5.9	5.9
.042	3.7	3.3
.029	2.0	1.5
.021K	.96	.78
.021L	.82	—
.014K	.37	.45
.014L	.48	—
DA		590

Table 4[1]

EAA Current Readings (I, in picoamps and Dilution Factors)
for this Sample Calculation: Hypothetical Inlet Data

SCAN	Time	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8	CH 9	CH 10	CH 11	Dilution Factor[2]
	Friday 12/4/75										
1	1:30p	2.869	2.734	2.519	2.227	1.362	.682[3]	.242[3]	.102[3]	.020[3]	255
2	1:32	2.835	2.711	2.495	2.205	1.344	.669	.220	.075	-.010	255
3	1:34	2.841	2.709	2.500	2.200	1.340	.655	.218	.081	.001	255
4	1:36	2.859	2.722	2.522	2.235	1.368	.676	.226	.096	.010	255
5	1:38	2.866	2.740	2.530	2.251	1.381	.714	.279	.137	.052	255
6	1:40	2.866	2.736	2.531	2.238	1.378	.698	.255	.115	.033	255
7	1:45	6.477	6.188	5.716	5.056	3.111	1.575	.565	.243	.053	113
8	1:47	6.580	6.288	5.818	5.153	3.233	1.613	.510	.195	.010	113
9	1:49	6.377	6.087	5.620	4.960	3.021	1.526	.537	.227	.032	113
10	1:51	6.390	6.094	5.614	4.956	3.006	1.467	.492	.187	.005	113

1. .029 Orifice; ΔP_{DUCT} = 25.5 "Hg, ΔP_{cy} = 0.5 "H_2O

2. For Runs 1 - 6, ΔP_s = 6.7 "H_2O T_{DI} = 505°R P_A = 26.34 "Hg
ΔP_D = 3.2 "H_2O T_{DU} = 789°R C_S = 2.00
ΔP_7 = -30 "H_2O P_S = 24.5 "Hg
For Runs 7 - 10, ΔP_s = 9.7 "H_2O T_{DI} = 505°R P_A = 26.34 "Hg
ΔP_D = 3.2 "H_2O T_{DU} = 789°R C_S = 3.70
ΔP_7 = - 41 "H_2O P_S = 24.5 "Hg

3. Corrected Instrument Reading

Table 5

EAA (Model 3030) Data Reduction Form
Concentration, Cumulative Concentration, and $\Delta N_S/\Delta LogD$
From Average ΔI for Condition Inlet
(Sample Calculation)

1	2	3	4	5	6	7	8	9	10
Channel No.	Collector Voltage	D_p, μm	D_{pi}, μm	$\Delta N/\Delta I$	$\Delta \log D_p$	$\bar{\alpha}$	ΔN_s	$\Sigma \Delta N_s$	$\Delta N_s/\Delta LogD$
							$\times 10^6$	$\times 10^6$	$\times 10^6$
3	196	0.0100							
			0.0133	4.76×10^5	0.250	33.2±.6	15.8±.3	68.4	63.2±1.1
4	593	0.0178							
			0.0215	2.33×10^5	0.165	53.3±.7	12.4±.2	52.6	75.3±1.0
5	1220	0.026							
			0.0306	1.47×10^5	0.141	74.3±.8	10.9±.1	40.2	77.5±.8
6	2183	0.036							
			0.0502	8.33×10^4	0.289	219.8±.8	18.3±.1	29.3	63.4±.2
7	3515	0.070							
			0.0917	4.26×10^4	0.234	174±2	7.41±.09	11.0	31.7±.4
8	5387	0.120							
			0.149	2.47×10^4	0.188	114±2	2.82±.05	3.61	15.0±.3
9	7152	0.185							
			0.219	1.56×10^4	0.148	35.4±.6	.552±.009	.785	3.73±.06
10	8642	0.260							
			0.306	1.10×10^4	0.141	21.2±.3	.233±.003	.233	1.65±.02
11	9647	0.360							

Table 6

Ultrafine Particle System: Data Log

DATE	TIME	TEST NO.	SCAN NO.	TEST CONDITION, CURRENT DENSITY: NORMAL	REDUCED
		INLET			
1/12/76	6:02 - 6:42	1	1		
	6:42 - 7:50		2		
1/13/76	8:42 - 9:27	2	3		
	9:30 - 10:15		4		
	10:15 - 11:13		5		
	12:10 - 12:37	3	6		
	1:00 - 3:10		7		
	3:15 - 3:53		8		
	4:00 - 4:50		9		
	4:50 - 5:10		10		
		OUTLET			
1/15/76	9:32 - 9:58	6	33		•
	9:59 - 10:22		34		•
	10:22 - 10:52		35		•
	11:53 - 12:14	7	36		•
	1:21 - 1:42		37		•
	1:43 - 2:00		38		•
	2:05 - 2:26		39		•
1/19/76	3:32 - 3:54	9	47		•
	4:05 - 4:34		48		•
	4:38 - 5:08		49		•
1/20/76	9:32 - 10:05	10	50	•	
	10:05 - 10:40		51	•	
	10:48 - 11:12		52	•	
	3:17 - 3:42	11	53	•	

NOTE: Scans 11→32 and 40→46 involve different test conditions connected with the EPRI portion of the test.

Table 7

Ultrafine Particle System: Instrument Current Readings (I) And Dilution Factors (DF)

Scan No.	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8	CH 9	CH 10	CH 11	Dilution Factor
					INLET					
1	.800[2]	.825[2]	.825	.800	.500	.193	.117*	.051*	.035*	814
2	.365*	.297*	.271*	.255*	.195	.088	.071	.024	.016	1240
3	1.382[2]*	1.411*	1.360	1.290	.880	.238	.078	.052	.033	333
4	.656[2]	.660	.650	.550	.320	.143	.056	.028	.016	624
5	.520[2]	.500[2]	.520	.460	.290	.133	.052	.023	.003	689
6	.230	.228	.222	.200	.112	.052	.019	.006	.004	1500
7	4.015[2]*	4.188*	3.775	3.000	1.800	.600	.235	.106	.056	134
8	3.400[2]*	3.274[2]*	3.350*	2.700	1.625	.615	.217*	.085*	.044*	136
9	3.610[2]	3.650[2]	3.650	3.150	1.850	.708	.265	.128	.063	135
10	5.200[2]	5.210	5.180	4.450	2.750	1.020	.356	.171	.097	135
				OUTLET - REDUCED CURRENT DENSITY						
33	.250[2]	.250[2]	.230[2]	.230	.175	.069	.025	-.201[2]	-.030[2]	47.0
34	3.750[2]	.365[2]	.300	.290	.200	.085	.020	.002	-.022	30.0
35	20.750[1,2]	2.410[1,2]	.315[2]	.250	.185	.074	.011	-.013	-.039	30.0
36	21.150[1,2]	3.350[1,2]	.405[2]	.230	.167	.063	.022	-.006	-.021	35.2
37	.084[2]	.090	.089	.085	.061	.017	.006	-.006[2]	-.003[2]	106
38	.121[2]*	.135*	.121*	.107*	.086	.028	.006	.001	-.008	77.6
39	38.000[1,2]	11.100[1,2]	.855[1,2]	.280[1]	.195[1]	.095[1]	.048[1]	.024[1]	+.009[1]	27.2
47	.238	.220	.213	.198	.128	.049	.015	-.005	-.335[2]	46.2
48	.145	.120	.119	.107	.075	.026	.008	-.002	-.011	74.7
49	.118[2]	.119	.092	.085	.041	.016	.005	-.003	-.042[2]	123

Table 7 (Continued)

Scan No.	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8	CH 9	CH 10	CH 11	Dilution Factor
OUTLET - NORMAL CURRENT DENSITY										
50	.030	.030	.027[2]	.028	.014	-.001	-.004	-2.475[2]	-.006	82.8
51	.011[2]	.012[2]	.012	.009	.005	-.004	-.005	-.005	-.005	140
52	.044	.040	.032[2]	.036	.021	-.006	-.010	-.012	-.012	44.1
53	.065	.060	.055	.050	.042	.017	.005	-.005	-.009	46.5

[1] Indicates that this data was taken in the X10 mode. Readings shown have been corrected to true.

[2] Indicates data elements that have been rejected.

* Indicates corrected instrument reading: I' = I (DF'/DF), see Table 8 for uncorrected values.

Table 8

Ultrafine Particle System: Instrument Current Readings (I) Corrected For Small Shifts In Dilution (I')

$$I' = I\ (DF'/DF)$$

		TRUE:		CORRECTED:	
Scan No.	Channel No.	Current I	Dilution DF	Current I'	Dilution DF'
1	9	0.115	798	0.117	814
	10	0.050	798	0.051	814
	11	0.034	798	0.035	814
2	3	0.950	686	Rejected	1240
	3	0.350	1190	0.365	1240
	4	0.285	1190	0.297	1240
	5	0.260	1190	0.271	1240
	6	0.245	1190	0.255	1240
3	3	1.440	347	1.382	333
	4	1.470	347	1.411	333
7	3	4.075	136	4.015	134
	4	4.250	136	4.188	134
8	3	3.375	135	3.400	136
	4	3.250	135	3.274	136
	5	3.325	135	3.350	136
	9	0.215	135	0.217	136
	10	0.084	135	0.085	136
	11	0.044	135	0.044	136
38	3	0.120	76.7	0.121	77.6
	4	0.133	76.7	0.135	77.6
	5	0.120	76.7	0.121	77.6
	6	0.106	76.7	0.107	77.6

Table 9

Ultrafine Particle Sizing System Data

Dilution Factor Parameters, Colbert Steam Plant EPA Test, January 1976

Scan No.	Time	Parameters ΔP_S ("H_2O)	ΔP_D ("H_2O)	ΔP_7 ("H_2O)	T_{Di} (°R)	T_{DU} (°R)	P_S ("H_g)	P_A ("H_g)	C_S	D_F
					1/12/76					
1	6:02 - 6:31	4.0	2.5	-15.0	518	960	28.87	29.68	.78	814
1	6:32 - 7:02	4.0	2.4	-14.0	518	960	28.87	29.68	.78	798
2	7:03 - 7:05	5.9	2.6	-12.4	518	960	28.87	29.68	.78	686
2	7:06 - 7:22	1.8	2.4	-12.5	518	960	28.87	29.68	.78	1190
2	7:23 - 7:50	1.7	2.4	-12.5	518	980	28.87	29.68	.78	1240
					1/13/76					
3	8:42 - 8:48	6.0	2.9	-21.2	525	855	28.70	29.50	1.5	347
3	8:49 - 9:27	6.5	2.9	-21.0	525	855	28.70	29.50	1.5	333
4	9:28 - 10:14	2.0	3.1	-16.5	525	855	28.70	29.50	1.5	624
5	10:15 - 11:13	4.0	3.1	-17.5	525	855	28.70	29.50	.96	689
6	12:10 - 12:37	5.6	3.1	-20.5	525	855	28.70	29.50	.37	1500
7	1:50 - 2:09	6.0	2.9	-22.2	530	800	28.70	29.50	3.7	136
7	2:10 - 2:51	6.0	2.9	-22.2	531	780	28.70	29.50	3.7	134
7, 8	2:52 - 3:23	5.9	3.0	-23.0	532	760	28.70	29.50	3.7	135
8	3:24 - 3:53	5.8	3.0	-22.9	532	760	28.70	29.50	3.7	136
9, 10	4:04 - 5:12	2.6	3.0	-23.1	530	840	28.70	29.50	5.9	135

Table 9 (Continued)

Scan No.	Time	ΔP_S ("H_2O)	ΔP_D ("H_2O)	ΔP_7 ("H_2O)	T_{DI} (°R)	T_{DU} (°R)	P_S ("H_g)	P_A ("H_g)	C_S	D_F
		Parameters								
					1/16/76					
33	9:32 - 9:58	3.3	3.3	-31.2	523	840	28.28	29.48	16	47.0
34, 35	9:59 - 10:52	8.3	3.3	-42.1	510	840	28.28	29.48	16	30.0
36	11:53 - 12:14	5.5	3.3	-38.0	519	780	28.28	29.48	16	35.2
37	1:15 - 1:42	4.9	3.3	-27.2	513	860	28.28	29.48	5.9	106
38	1:43 - 1:52	9.3	3.3	-32.6	514	860	28.28	29.48	5.9	76.7
38	1:52 - 2:00	9.3	3.3	-32.6	514	880	28.28	29.48	5.9	77.6
39	2:05 - 2:26	9.6	3.3	-42.1	511	800	28.28	29.48	16	27.2
					1/19/76					
47	3:32 - 3:54	3.3	3.4	-53.0	528	840	28.67	29.97	16	46.2
48	4:05 - 4:34	9.1	3.4	-44.8	523	810	28.67	29.97	5.9	74.7
49	4:38 - 5:08	3.4	3.3	-36.7	526	840	28.67	29.97	5.9	123
					1/20/76					
50	9:32 - 10:05	8.2	3.4	-35.3	519	870	28.70	30.00	5.9	82.8
51	10:05 - 10:40	2.7	3.3	-28.5	522	840	28.70	30.00	5.9	140
52	10:48 - 11:12	3.7	3.4	-50.3	522	840	28.70	30.00	16	44.1
53	3:17 - 3:42	3.3	3.4	-53.0	522	840	28.70	30.00	16	46.5

INLET IMPACTOR DATA

COLI-1 1-12-76 1809 N.A.

IMPACTOR FLOWRATE = 0.030 ACFM IMPACTOR TEMPERATURE = 310.0 F = 154.4 C SAMPLING DURATION = 13.00 MIN

IMPACTOR PRESSURE DROP = 2.0 IN. OF HG STACK TEMPERATURE = 310.0 F = 154.4 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 29.67 IN. OF HG MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 3.3215E+00 GR/ACF 5.2222E+00 GR/DNCF 7.6008E+03 MG/ACM 1.1950E+04 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11.07	7.85	4.46	2.64	1.83	0.96	0.69	0.38	
MASS (MILLIGRAMS)	72.12	3.21	2.95	2.11	1.63	1.41	0.27	0.10	0.14
MG/DNCM/STAGE	1.03E+04	4.57E+02	4.20E+02	3.00E+02	2.32E+02	2.01E+02	3.84E+01	1.42E+01	1.99E+01
CUM. PERCENT OF MASS SMALLER THAN D50	14.09	10.26	6.75	4.23	2.29	0.61	0.29	0.17	
CUM. (MG/ACM) SMALLER THAN D50	1.07E+03	7.80E+02	5.13E+02	3.22E+02	1.74E+02	4.66E+01	2.21E+01	1.31E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.68E+03	1.23E+03	8.06E+02	5.06E+02	2.74E+02	7.32E+01	3.48E+01	2.05E+01	
CUM. (GR/ACF) SMALLER THAN D50	4.68E-01	3.41E-01	2.24E-01	1.41E-01	7.61E-02	2.03E-02	9.66E-03	5.71E-03	
CUM. (GR/DNCF) SMALLER THAN D50	7.36E-01	5.36E-01	3.52E-01	2.21E-01	1.20E-01	3.20E-02	1.52E-02	8.97E-03	
GEO. MEAN DIA. (MICROMETERS)	4.31E+01	9.32E+00	5.91E+00	3.43E+00	2.19E+00	1.33E+00	8.15E-01	5.15E-01	2.72E-01
DM/DLOGD (MG/DNCM)	8.69E+03	3.06E+03	1.71E+03	1.32E+03	1.46E+03	7.23E+02	2.63E+02	5.63E+01	6.62E+01
DN/DLOGD (NO. PARTICLES/DNCM)	8.62E+07	3.01E+09	6.58E+09	2.60E+10	1.10E+11	2.46E+11	3.87E+11	3.29E+11	2.62E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-2 1-12-76 1825 N.A.

IMPACTOR FLOWRATE = 0.030 ACFM   IMPACTOR TEMPERATURE = 310.0 F = 154.4 C   SAMPLING DURATION = 13.00 MIN

IMPACTOR PRESSURE DROP = 2.0 IN. OF HG   STACK TEMPERATURE = 310.0 F = 154.4 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.67 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 3.3516E+00 GR/ACF   5.2695E+00 GR/DNCF   7.6696E+03 MG/ACM   1.2058E+04 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11.07	7.85	4.46	2.64	1.83	0.96	0.69	0.38	
MASS (MILLIGRAMS)	65.95	3.58	5.09	5.91	1.96	1.21	0.61	0.15	0.24
MG/DNCM/STAGE	9.39E+03	5.10E+02	7.25E+02	8.41E+02	2.79E+02	1.72E+02	8.68E+01	2.14E+01	3.42E+01
CUM. PERCENT OF MASS SMALLER THAN D50	22.14	17.92	11.91	4.93	2.61	1.19	0.47	0.29	
CUM. (MG/ACM) SMALLER THAN D50	1.70E+03	1.37E+03	9.13E+02	3.78E+02	2.00E+02	9.09E+01	3.57E+01	2.21E+01	
CUM. (MG/DNCM) SMALLER THAN D50	2.67E+03	2.16E+03	1.44E+03	5.94E+02	3.15E+02	1.43E+02	5.61E+01	3.48E+01	
CUM. (GR/ACF) SMALLER THAN D50	7.42E-01	6.00E-01	3.99E-01	1.65E-01	8.76E-02	3.97E-02	1.56E-02	9.66E-03	
CUM. (GR/DNCF) SMALLER THAN D50	1.17E+00	9.44E-01	6.27E-01	2.60E-01	1.38E-01	6.25E-02	2.45E-02	1.52E-02	
GEO. MEAN DIA. (MICROMETERS)	4.31E+01	9.32E+00	5.91E+00	3.43E+00	2.19E+00	1.33E+00	8.15E-01	5.15E-01	2.72E-01
DM/DLOGD (MG/DNCM)	7.95E+03	3.41E+03	2.95E+03	3.69E+03	1.75E+03	6.20E+02	5.94E+02	8.45E+01	1.14E+02
DN/DLOGD (NO. PARTICLES/DNCM)	7.89E+07	3.35E+09	1.13E+10	7.29E+10	1.32E+11	2.11E+11	8.74E+11	4.93E+11	4.49E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-3 1-13-76 1320 6UAI

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 320,0 F = 160,0 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 1,6 IN, OF HG   STACK TEMPERATURE = 320,0 F = 160,0 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,37 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 2,2438E+00 GR/ACF   3,6102E+00 GR/DNCF   5,1347E+03 MG/ACM   8,2614E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,94	7,75	4,40	2,60	1,80	0,95	0,68	0,38	
MASS (MILLIGRAMS)	54,90	4,01	1,68	3,11	1,95	1,13	0,44	0,15	0,24
MG/DNCM/STAGE	6,71E+03	4,90E+02	2,05E+02	3,80E+02	2,38E+02	1,38E+02	5,38E+01	1,83E+01	2,93E+01
CUM, PERCENT OF MASS SMALLER THAN D50	18,80	12,87	10,39	5,79	2,90	1,23	0,58	0,36	
CUM, (MG/ACM) SMALLER THAN D50	9,66E+02	6,61E+02	5,33E+02	2,97E+02	1,49E+02	6,33E+01	2,99E+01	1,85E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,55E+03	1,06E+03	8,58E+02	4,78E+02	2,40E+02	1,02E+02	4,81E+01	2,97E+01	
CUM, (GR/ACF) SMALLER THAN D50	4,22E-01	2,89E-01	2,33E-01	1,30E-01	6,52E-02	2,77E-02	1,31E-02	8,08E-03	
CUM, (GR/DNCF) SMALLER THAN D50	6,79E-01	4,65E-01	3,75E-01	2,09E-01	1,05E-01	4,45E-02	2,10E-02	1,30E-02	
GEO, MEAN DIA, (MICROMETERS)	4,29E+01	9,21E+00	5,84E+00	3,38E+00	2,17E+00	1,31E+00	8,02E-01	5,08E-01	2,69E-01
DM/DLOGD (MG/DNCM)	5,66E+03	3,27E+03	8,35E+02	1,66E+03	1,50E+03	4,96E+02	3,67E+02	7,33E+01	9,74E+01
DN/DLOGD (NO, PARTICLES/DNCM)	5,71E+07	3,33E+09	3,33E+09	3,41E+10	1,17E+11	1,76E+11	5,66E+11	4,44E+11	3,96E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-4 1-13-76 1450 4UAI

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 330,0 F = 165,6 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,0 IN, OF HG   STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,50 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,7908E+00 GR/ACF   2,9054E+00 GR/DNCF   4,0980E+03 MG/ACM   6,6486E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,00	7,79	4,42	2,61	1,81	0,95	0,68	0,38	
MASS (MILLIGRAMS)	39,38	6,12	2,90	2,16	1,63	1,18	0,30	0,10	0,19
MG/DNCM/STAGE	4,85E+03	7,54E+02	3,57E+02	2,66E+02	2,01E+02	1,45E+02	3,70E+01	1,23E+01	2,34E+01
CUM, PERCENT OF MASS SMALLER THAN D50	27,03	15,68	10,31	6,31	3,29	1,10	0,54	0,36	
CUM, (MG/ACM) SMALLER THAN D50	1,11E+03	6,43E+02	4,22E+02	2,58E+02	1,35E+02	4,50E+01	2,22E+01	1,46E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,80E+03	1,04E+03	6,85E+02	4,19E+02	2,18E+02	7,30E+01	3,61E+01	2,37E+01	
CUM, (GR/ACF) SMALLER THAN D50	4,84E-01	2,81E-01	1,85E-01	1,13E-01	5,88E-02	1,97E-02	9,71E-03	6,40E-03	
CUM, (GR/DNCF) SMALLER THAN D50	7,85E-01	4,56E-01	3,00E-01	1,83E-01	9,54E-02	3,19E-02	1,58E-02	1,04E-02	
GEO, MEAN DIA, (MICROMETERS)	4,30E+01	9,26E+00	5,87E+00	3,40E+00	2,18E+00	1,31E+00	8,05E-01	5,06E-01	2,67E-01
DM/DLOGD (MG/DNCM)	4,10E+03	5,04E+03	1,45E+03	1,16E+03	1,26E+03	5,22E+02	2,51E+02	4,82E+01	7,78E+01
DN/DLOGD (NO, PARTICLES/DNCM)	4,11E+07	5,05E+09	5,72E+09	2,36E+10	9,74E+10	1,83E+11	3,84E+11	2,96E+11	3,26E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-5 1-13-76 1715 2UAI

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 330,0 F = 165,6 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,0 IN, OF HG   STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,50 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,9876E+00 GR/ACF   3,2247E+00 GR/DNCF   4,5484E+03 MG/ACM   7,3793E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,00	7,79	4,42	2,61	1,81	0,95	0,68	0,38	
MASS (MILLIGRAMS)	49,15	2,37	1,97	2,83	1,16	1,45	0,43	0,30	0,23
MG/DNCM/STAGE	6,06E+03	2,92E+02	2,43E+02	3,49E+02	1,43E+02	1,79E+02	5,30E+01	3,70E+01	2,83E+01
CUM, PERCENT OF MASS SMALLER THAN D50	17,94	13,98	10,69	5,97	4,03	1,61	0,89	0,39	
CUM, (MG/ACM) SMALLER THAN D50	8,16E+02	6,36E+02	4,86E+02	2,71E+02	1,83E+02	7,31E+01	4,05E+01	1,77E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,32E+03	1,03E+03	7,89E+02	4,40E+02	2,97E+02	1,19E+02	6,57E+01	2,87E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,57E-01	2,78E-01	2,13E-01	1,19E-01	8,01E-02	3,20E-02	1,77E-02	7,73E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,78E-01	4,51E-01	3,45E-01	1,92E-01	1,30E-01	5,19E-02	2,87E-02	1,25E-02	
GEO, MEAN DIA, (MICROMETERS)	4,30E+01	9,26E+00	5,87E+00	3,40E+00	2,18E+00	1,31E+00	8,05E-01	5,06E-01	2,67E-01
DM/DLOGD (MG/DNCM)	5,11E+03	1,95E+03	9,87E+02	1,53E+03	8,97E+02	6,41E+02	3,60E+02	1,45E+02	9,41E+01
DN/DLOGD (NO, PARTICLES/DNCM)	5,13E+07	1,96E+09	3,89E+09	3,09E+10	6,93E+10	2,25E+11	5,50E+11	8,87E+11	3,95E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-6 1-13-76 12UAI

IMPACTOR FLOWRATE = 0,031 ACFM IMPACTOR TEMPERATURE = 330,0 F = 165,6 C SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,0 IN, OF HG STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,50 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 6,2692E-01 GR/ACF 1,0171E+00 GR/DNCF 1,4346E+03 MG/ACM 2,3275E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,00	7,79	4,42	2,61	1,81	0,95	0,68	0,38	
MASS (MILLIGRAMS)	12,70	1,76	0,91	1,16	1,06	0,73	0,22	0,10	0,25
MG/DNCM/STAGE	1,56E+03	2,17E+02	1,12E+02	1,43E+02	1,31E+02	8,99E+01	2,71E+01	1,23E+01	3,08E+01
CUM, PERCENT OF MASS SMALLER THAN D50	32,77	23,46	18,64	12,50	6,89	3,02	1,86	1,33	
CUM, (MG/ACM) SMALLER THAN D50	4,70E+02	3,37E+02	2,67E+02	1,79E+02	9,88E+01	4,34E+01	2,67E+01	1,91E+01	
CUM, (MG/DNCM) SMALLER THAN D50	7,63E+02	5,46E+02	4,34E+02	2,91E+02	1,60E+02	7,03E+01	4,32E+01	3,09E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,05E-01	1,47E-01	1,17E-01	7,84E-02	4,32E-02	1,89E-02	1,16E-02	8,33E-03	
CUM, (GR/DNCF) SMALLER THAN D50	3,33E-01	2,39E-01	1,90E-01	1,27E-01	7,00E-02	3,07E-02	1,89E-02	1,35E-02	
GEO, MEAN DIA, (MICROMETERS)	4,30E+01	9,26E+00	5,87E+00	3,40E+00	2,18E+00	1,31E+00	8,05E-01	5,06E-01	2,67E-01
DM/DLOGD (MG/DNCM)	1,32E+03	1,45E+03	4,56E+02	6,25E+02	8,19E+02	3,23E+02	1,84E+02	4,82E+01	1,02E+02
DN/DLOGD (NO, PARTICLES/DNCM)	1,32E+07	1,45E+09	1,79E+09	1,27E+10	6,34E+10	1,13E+11	2,82E+11	2,96E+11	4,29E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-7 1-13-76 1822 10UAI

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 330,0 F = 165,6 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,0 IN, OF HG   STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,50 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,1168E+00 GR/ACF   1,8119E+00 GR/DNCF   2,5556E+03 MG/ACM   4,1462E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,00	7,79	4,42	2,61	1,81	0,95	0,68	0,38	
MASS (MILLIGRAMS)	25,24	1,78	2,25	1,77	1,04	1,20	0,28	0,07	0,02
MG/DNCM/STAGE	3,11E+03	2,19E+02	2,77E+02	2,18E+02	1,28E+02	1,48E+02	3,45E+01	8,63E+00	2,46E+00
CUM, PERCENT OF MASS SMALLER THAN D50	25,00	19,71	13,02	7,76	4,67	1,10	0,27	0,06	
CUM, (MG/ACM) SMALLER THAN D50	6,39E+02	5,04E+02	3,33E+02	1,98E+02	1,19E+02	2,82E+01	6,96E+00	1,65E+00	
CUM, (MG/DNCM) SMALLER THAN D50	1,04E+03	8,17E+02	5,40E+02	3,22E+02	1,94E+02	4,58E+01	1,13E+01	2,67E+00	
CUM, (GR/ACF) SMALLER THAN D50	2,79E-01	2,20E-01	1,45E-01	8,67E-02	5,22E-02	1,23E-02	3,04E-03	7,20E-04	
CUM, (GR/DNCF) SMALLER THAN D50	4,53E-01	3,57E-01	2,36E-01	1,41E-01	8,46E-02	2,00E-02	4,94E-03	1,17E-03	
GEO, MEAN DIA, (MICROMETERS)	4,30E+01	9,26E+00	5,87E+00	3,40E+00	2,18E+00	1,31E+00	8,05E-01	5,06E-01	2,67E-01
DM/DLOGD (MG/DNCM)	2,63E+03	1,46E+03	1,13E+03	9,54E+02	8,04E+02	5,31E+02	2,35E+02	3,38E+01	8,19E+00
DN/DLOGD (NO, PARTICLES/DNCM)	2,63E+07	1,47E+09	4,44E+09	1,93E+10	6,22E+10	1,86E+11	3,58E+11	2,07E+11	3,43E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-8 1-14-76 1250 12UAI S6,S5, HAD MINUS MASSES

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 300,0 F = 148,9 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,00 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 2,6418E-01 GR/ACF   4,0544E-01 GR/DNCF   6,0452E+02 MG/ACM   9,2779E+02 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,84	7,68	4,36	2,58	1,79	0,94	0,67	0,37	
MASS (MILLIGRAMS)	0,00	1,68	2,11	1,40	0,00	2,44	0,00	0,00	0,33
MG/DNCM/STAGE	0,00E-01	1,96E+02	2,46E+02	1,63E+02	0,00E-01	2,84E+02	0,00E-01	0,00E-01	3,85E+01
CUM, PERCENT OF MASS SMALLER THAN D50	100,00	78,90	52,39	34,80	34,80	4,15	4,15	4,15	
CUM, (MG/ACM) SMALLER THAN D50	6,05E+02	4,77E+02	3,17E+02	2,10E+02	2,10E+02	2,51E+01	2,51E+01	2,51E+01	
CUM, (MG/DNCM) SMALLER THAN D50	9,28E+02	7,32E+02	4,86E+02	3,23E+02	3,23E+02	3,85E+01	3,85E+01	3,85E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,64E-01	2,08E-01	1,38E-01	9,19E-02	9,19E-02	1,10E-02	1,10E-02	1,10E-02	
CUM, (GR/DNCF) SMALLER THAN D50	4,05E-01	3,20E-01	2,12E-01	1,41E-01	1,41E-01	1,68E-02	1,68E-02	1,68E-02	
GEO, MEAN DIA, (MICROMETERS)	4,27E+01	9,12E+00	5,79E+00	3,36E+00	2,15E+00	1,30E+00	7,97E-01	5,00E-01	2,63E-01
DM/DLOGD (MG/DNCM)	0,00E-01	1,31E+03	1,00E+03	7,15E+02	0,00E-01	1,02E+03	0,00E-01	0,00E-01	1,28E+02
DN/DLOGD (NO, PARTICLES/DNCM)	0,00E-01	1,37E+09	4,11E+09	1,51E+10	0,00E-01	3,71E+11	0,00E-01	0,00E-01	5,62E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-9 1-14-76 1430 10UAI S6,S4,HAD MINUS MASSES

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 330,0 F = 165,6 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,00 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,8954E+00 GR/ACF   3,0238E+00 GR/DNCF   4,3372E+03 MG/ACM   6,9195E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,00	7,79	4,42	2,61	1,81	0,95	0,68	0,37	
MASS (MILLIGRAMS)	48,22	1,91	2,29	2,21	2,26	0,00	0,07	0,00	0,15
MG/DNCM/STAGE	5,84E+03	2,31E+02	2,77E+02	2,68E+02	2,74E+02	0,00E-01	8,48E+00	0,00E-01	1,82E+01
CUM, PERCENT OF MASS SMALLER THAN D50	15,57	12,23	8,22	4,35	0,39	0,39	0,27	0,27	
CUM, (MG/ACM) SMALLER THAN D50	6,75E+02	5,30E+02	3,56E+02	1,89E+02	1,69E+01	1,69E+01	1,16E+01	1,16E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,08E+03	8,46E+02	5,69E+02	3,01E+02	2,70E+01	2,70E+01	1,85E+01	1,85E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,95E-01	2,32E-01	1,56E-01	8,24E-02	7,40E-03	7,40E-03	5,07E-03	5,07E-03	
CUM, (GR/DNCF) SMALLER THAN D50	4,71E-01	3,70E-01	2,48E-01	1,31E-01	1,18E-02	1,18E-02	8,09E-03	8,09E-03	
GEO, MEAN DIA, (MICROMETERS)	4,30E+01	9,26E+00	5,87E+00	3,40E+00	2,18E+00	1,31E+00	8,06E-01	5,04E-01	2,64E-01
DM/DLOGD (MG/DNCM)	4,93E+03	1,55E+03	1,13E+03	1,17E+03	1,72E+03	0,00E-01	5,76E+01	0,00E-01	6,04E+01
DN/DLOGD (NO, PARTICLES/DNCM)	4,94E+07	1,55E+09	4,44E+09	2,37E+10	1,33E+11	0,00E-01	8,77E+10	0,00E-01	2,61E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-10 1-14-76 1520 1UAI

IMPACTOR FLOWRATE = 0.031 ACFM   IMPACTOR TEMPERATURE = 340.0 F = 171.1 C   SAMPLING DURATION = 15.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 340.0 F = 171.1 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 30.00 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 3.9892E-01 GR/ACF   6.4449E-01 GR/DNCF   9.1286E+02 MG/ACM   1.4748E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11.05	7.83	4.44	2.63	1.82	0.96	0.68	0.37	
MASS (MILLIGRAMS)	8.21	0.75	0.86	0.48	0.84	0.58	0.16	0.00	0.14
MG/DNCM/STAGE	1.01E+03	9.20E+01	1.06E+02	5.89E+01	1.03E+02	7.12E+01	1.96E+01	0.00E-01	1.72E+01
CUM. PERCENT OF MASS SMALLER THAN D50	31.70	25.46	18.31	14.31	7.33	2.50	1.17	1.17	
CUM. (MG/ACM) SMALLER THAN D50	2.89E+02	2.32E+02	1.67E+02	1.31E+02	6.69E+01	2.28E+01	1.07E+01	1.07E+01	
CUM. (MG/DNCM) SMALLER THAN D50	4.68E+02	3.76E+02	2.70E+02	2.11E+02	1.08E+02	3.69E+01	1.73E+01	1.73E+01	
CUM. (GR/ACF) SMALLER THAN D50	1.26E-01	1.02E-01	7.30E-02	5.71E-02	2.92E-02	9.98E-03	4.67E-03	4.67E-03	
CUM. (GR/DNCF) SMALLER THAN D50	2.04E-01	1.64E-01	1.18E-01	9.23E-02	4.72E-02	1.61E-02	7.54E-03	7.54E-03	
GEO. MEAN DIA. (MICROMETERS)	4.31E+01	9.30E+00	5.90E+00	3.42E+00	2.19E+00	1.32E+00	8.08E-01	5.05E-01	2.64E-01
DM/DLOGD (MG/DNCM)	8.52E+02	6.15E+02	4.29E+02	2.58E+02	6.47E+02	2.55E+02	1.33E+02	0.00E-01	5.71E+01
DN/DLOGD (NO. PARTICLES/DNCM)	8.48E+06	6.08E+08	1.66E+09	5.14E+09	4.93E+10	8.84E+10	2.01E+11	0.00E-01	2.46E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-11 1-14-76 1545 3UAI

IMPACTOR FLOWRATE = 0.031 ACFM IMPACTOR TEMPERATURE = 340.0 F = 171.1 C SAMPLING DURATION = 15.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG STACK TEMPERATURE = 340.0 F = 171.1 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 30.00 IN. OF HG MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 3.1057E+00 GR/ACF 5.0175E+00 GR/DNCF 7.1070E+03 MG/ACM 1.1482E+04 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11.05	7.83	4.44	2.63	1.82	0.96	0.68	0.37	
MASS (MILLIGRAMS)	76.79	3.82	2.48	4.43	3.39	0.28	1.02	1.16	0.21
MG/DNCM/STAGE	9.42E+03	4.69E+02	3.04E+02	5.44E+02	4.16E+02	3.44E+01	1.25E+02	1.42E+02	2.58E+01
CUM. PERCENT OF MASS SMALLER THAN D50	17.95	13.86	11.21	6.48	2.86	2.56	1.47	0.23	
CUM. (MG/ACM) SMALLER THAN D50	1.28E+03	9.85E+02	7.97E+02	4.61E+02	2.03E+02	1.82E+02	1.04E+02	1.63E+01	
CUM. (MG/DNCM) SMALLER THAN D50	2.06E+03	1.59E+03	1.29E+03	7.44E+02	3.28E+02	2.94E+02	1.69E+02	2.63E+01	
CUM. (GR/ACF) SMALLER THAN D50	5.57E-01	4.31E-01	3.48E-01	2.01E-01	8.88E-02	7.95E-02	4.56E-02	7.12E-03	
CUM. (GR/DNCF) SMALLER THAN D50	9.00E-01	6.96E-01	5.63E-01	3.25E-01	1.43E-01	1.28E-01	7.37E-02	1.15E-02	
GEO. MEAN DIA. (MICROMETERS)	4.31E+01	9.30E+00	5.90E+00	3.42E+00	2.19E+00	1.32E+00	8.08E-01	5.05E-01	2.64E-01
DM/DLOGD (MG/DNCM)	7.97E+03	3.13E+03	1.24E+03	2.38E+03	2.61E+03	1.23E+02	8.49E+02	5.45E+02	8.56E+01
DN/DLOGD (NO. PARTICLES/DNCM)	7.93E+07	3.10E+09	4.80E+09	4.75E+10	1.99E+11	4.27E+10	1.28E+12	3.37E+12	3.69E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-12 1-14 76 1600 SUAI

IMPACTOR FLOWRATE = 0,031 ACFM   IMPACTOR TEMPERATURE = 345,0 F = 173,9 C   SAMPLING DURATION = 15,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 345,0 F = 173,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,00 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 8,1609E-01 GR/ACF   1,3267E+00 GR/DNCF   1,8675E+03 MG/ACM   3,0360E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	11,08	7,85	4,45	2,63	1,82	0,96	0,68	0,37	
MASS (MILLIGRAMS)	19,96	1,11	1,06	0,80	0,83	0,44	0,19	0,06	0,14
MG/DNCM/STAGE	2,46E+03	1,37E+02	1,31E+02	9,88E+01	1,02E+02	5,43E+01	2,35E+01	7,41E+00	1,73E+01
CUM, PERCENT OF MASS SMALLER THAN D50	18,83	14,32	10,01	6,76	3,38	1,59	0,82	0,57	
CUM, (MG/ACM) SMALLER THAN D50	3,52E+02	2,67E+02	1,87E+02	1,26E+02	6,31E+01	2,97E+01	1,53E+01	1,07E+01	
CUM, (MG/DNCM) SMALLER THAN D50	5,72E+02	4,35E+02	3,04E+02	2,05E+02	1,03E+02	4,83E+01	2,48E+01	1,74E+01	
CUM, (GR/ACF) SMALLER THAN D50	1,54E-01	1,17E-01	8,17E-02	5,51E-02	2,76E-02	1,30E-02	6,68E-03	4,69E-03	
CUM, (GR/DNCF) SMALLER THAN D50	2,50E-01	1,90E-01	1,33E-01	8,96E-02	4,48E-02	2,11E-02	1,09E-02	7,62E-03	
GEO, MEAN DIA, (MICROMETERS)	4,31E+01	9,32E+00	5,91E+00	3,42E+00	2,19E+00	1,32E+00	8,10E-01	5,05E-01	2,64E-01
DM/DLOGD (MG/DNCM)	2,09E+03	9,15E+02	5,32E+02	4,32E+02	6,43E+02	1,95E+02	1,59E+02	2,83E+01	5,74E+01
DN/DLOGD (NO, PARTICLES/DNCM)	2,07E+07	8,99E+08	2,05E+09	8,57E+09	4,87E+10	6,70E+10	2,38E+11	1,74E+11	2,47E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-13 1-15-76 1135 8UAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 315.0 F = 157.2 C   SAMPLING DURATION = 15.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 315.0 F = 157.2 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.91 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.9432E+00 GR/ACF   3.0504E+00 GR/DNCF   4.4468E+03 MG/ACM   6.9804E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.58	7.50	4.26	2.51	1.74	0.92	0.65	0.36	
MASS (MILLIGRAMS)	52.28	2.39	2.52	2.20	1.29	1.15	0.21	0.08	0.21
MG/DNCM/STAGE	5.85E+03	2.68E+02	2.82E+02	2.46E+02	1.44E+02	1.29E+02	2.35E+01	8.96E+00	2.35E+01
CUM. PERCENT OF MASS SMALLER THAN D50	16.13	12.29	8.25	4.72	2.65	0.81	0.47	0.34	
CUM. (MG/ACM) SMALLER THAN D50	7.17E+02	5.47E+02	3.67E+02	2.10E+02	1.18E+02	3.59E+01	2.09E+01	1.52E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.13E+03	8.58E+02	5.76E+02	3.30E+02	1.85E+02	5.63E+01	3.28E+01	2.39E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.13E-01	2.39E-01	1.60E-01	9.18E-02	5.15E-02	1.57E-02	9.14E-03	6.64E-03	
CUM. (GR/DNCF) SMALLER THAN D50	4.92E-01	3.75E-01	2.52E-01	1.44E-01	8.09E-02	2.46E-02	1.43E-02	1.04E-02	
GEO. MEAN DIA. (MICROMETERS)	4.22E+01	8.91E+00	5.65E+00	3.27E+00	2.09E+00	1.26E+00	7.73E-01	4.83E-01	2.53E-01
DM/DLOGD (MG/DNCM)	4.88E+03	1.79E+03	1.15E+03	1.08E+03	9.06E+02	4.62E+02	1.59E+02	3.42E+01	7.81E+01
DN/DLOGD (NO. PARTICLES/DNCM)	5.18E+07	2.01E+09	5.07E+09	2.45E+10	7.87E+10	1.82E+11	2.74E+11	2.42E+11	3.86E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-14 1-15-76 1155 4UAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 310.0 F = 154.4 C   SAMPLING DURATION = 8.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 310.0 F = 154.4 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.91 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.0154E+00 GR/ACF   1.5836E+00 GR/DNCF   2.3235E+03 MG/ACM   3.6239E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.56	7.48	4.25	2.51	1.74	0.91	0.65	0.36	
MASS (MILLIGRAMS)	12.44	1.32	1.09	1.13	0.41	0.56	0.04	0.30	0.08
MG/DNCM/STAGE	2.60E+03	2.75E+02	2.27E+02	2.36E+02	8.55E+01	1.17E+02	8.35E+00	6.26E+01	1.67E+01
CUM. PERCENT OF MASS SMALLER THAN D50	28.39	20.79	14.51	8.01	5.65	2.42	2.19	0.47	
CUM. (MG/ACM) SMALLER THAN D50	6.60E+02	4.83E+02	3.37E+02	1.86E+02	1.31E+02	5.63E+01	5.09E+01	1.08E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.03E+03	7.53E+02	5.26E+02	2.90E+02	2.05E+02	8.78E+01	7.95E+01	1.69E+01	
CUM. (GR/ACF) SMALLER THAN D50	2.88E-01	2.11E-01	1.47E-01	8.13E-02	5.73E-02	2.46E-02	2.23E-02	4.73E-03	
CUM. (GR/DNCF) SMALLER THAN D50	4.50E-01	3.29E-01	2.30E-01	1.27E-01	8.94E-02	3.84E-02	3.47E-02	7.37E-03	
GEO. MEAN DIA. (MICROMETERS)	4.21E+01	8.88E+00	5.63E+00	3.26E+00	2.09E+00	1.26E+00	7.72E-01	4.82E-01	2.52E-01
DM/DLOGD (MG/DNCM)	2.16E+03	1.84E+03	9.25E+02	1.03E+03	5.37E+02	4.19E+02	5.66E+01	2.39E+02	5.54E+01
DN/DLOGD (NO. PARTICLES/DNCM)	2.30E+07	2.09E+09	4.11E+09	2.36E+10	4.69E+10	1.66E+11	9.79E+10	1.70E+12	2.75E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-15 1-15-75 1212 6LUAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 310.0 F = 154.4 C   SAMPLING DURATION = 8.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 310.0 F = 154.4 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.91 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 3.4355E+00 GR/ACF   5.3580E+00 GR/DNCF   7.8615E+03 MG/ACM   1.2261E+04 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.56	7.46	4.25	2.51	1.74	0.91	0.65	0.36	
MASS (MILLIGRAMS)	50.95	1.34	1.44	2.38	1.23	0.83	0.28	0.07	0.25
MG/DNCM/STAGE	1.06E+04	2.80E+02	3.00E+02	4.97E+02	2.57E+02	1.73E+02	5.84E+01	1.46E+01	5.22E+01
CUM. PERCENT OF MASS SMALLER THAN D50	13.31	11.03	8.58	4.53	2.44	1.03	0.55	0.43	
CUM. (MG/ACM) SMALLER THAN D50	1.05E+03	8.67E+02	6.75E+02	3.56E+02	1.92E+02	8.07E+01	4.32E+01	3.38E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.63E+03	1.35E+03	1.05E+03	5.56E+02	2.99E+02	1.26E+02	6.74E+01	5.28E+01	
CUM. (GR/ACF) SMALLER THAN D50	4.57E-01	3.79E-01	2.95E-01	1.56E-01	8.38E-02	3.52E-02	1.89E-02	1.48E-02	
CUM. (GR/DNCF) SMALLER THAN D50	7.13E-01	5.91E-01	4.60E-01	2.43E-01	1.31E-01	5.50E-02	2.94E-02	2.31E-02	
GEO. MEAN DIA. (MICROMETERS)	4.21E+01	8.88E+00	5.63E+00	3.26E+00	2.09E+00	1.26E+00	7.72E-01	4.82E-01	2.52E-01
DM/DLOGD (MG/DNCM)	8.84E+03	1.87E+03	1.22E+03	2.17E+03	1.61E+03	6.21E+02	3.96E+02	5.59E+01	1.73E+02
DN/DLOGD (NO. PARTICLES/DNCM)	9.43E+07	2.12E+09	5.44E+09	4.97E+10	1.41E+11	2.47E+11	6.85E+11	3.97E+11	8.58E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-16 1-15-76 1458 10UAI S5 HAD A MINUS MASS

IMPACTOR FLOWRATE = 0,033 ACFM IMPACTOR TEMPERATURE = 325,0 F = 162,8 C SAMPLING DURATION = 8,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 325,0 F = 162,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,91 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 5,9333E-01 GR/ACF 9,4341E-01 GR/DNCF 1,3577E+03 MG/ACM 2,1588E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,63	7,53	4,28	2,53	1,75	0,92	0,65	0,36	
MASS (MILLIGRAMS)	5,25	1,05	1,37	1,00	0,56	0,74	0,00	0,05	0,13
MG/DNCM/STAGE	1,12E+03	2,23E+02	2,91E+02	2,13E+02	1,19E+02	1,57E+02	0,00E-01	1,06E+01	2,77E+01
CUM, PERCENT OF MASS SMALLER THAN D50	48,28	37,94	24,44	14,59	9,07	1,78	1,78	1,29	
CUM, (MG/ACM) SMALLER THAN D50	6,56E+02	5,15E+02	3,32E+02	1,98E+02	1,23E+02	2,41E+01	2,41E+01	1,75E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,04E+03	8,19E+02	5,28E+02	3,15E+02	1,96E+02	3,84E+01	3,84E+01	2,78E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,86E-01	2,25E-01	1,45E-01	8,65E-02	5,38E-02	1,06E-02	1,06E-02	7,63E-03	
CUM, (GR/DNCF) SMALLER THAN D50	4,55E-01	3,58E-01	2,31E-01	1,38E-01	8,56E-02	1,68E-02	1,68E-02	1,21E-02	
GEO, MEAN DIA, (MICROMETERS)	4,23E+01	8,95E+00	5,67E+00	3,29E+00	2,10E+00	1,27E+00	7,76E-01	4,84E-01	2,53E-01
DM/DLOGD (MG/DNCM)	9,32E+02	1,49E+03	1,19E+03	9,30E+02	7,47E+02	5,64E+02	0,00E-01	4,05E+01	9,19E+01
DN/DLOGD (NO, PARTICLES/DNCM)	9,82E+06	1,66E+09	5,16E+09	2,09E+10	6,40E+10	2,20E+11	0,00E-01	2,85E+11	4,52E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-17 1-15-76 1506 JUAI

IMPACTOR FLOWRATE = 0,033 ACFM   IMPACTOR TEMPERATURE = 325,0 F = 162,8 C   SAMPLING DURATION = 8,30 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 325,0 F = 162,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,91 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 9,6798E-01 GR/ACF   1,5391E+00 GR/DNCF   2,2151E+03 MG/ACM   3,5220E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,63	7,53	4,28	2,53	1,75	0,92	0,65	0,36	
MASS (MILLIGRAMS)	12,43	1,20	1,09	0,92	0,76	0,52	0,07	0,05	0,14
MG/DNCM/STAGE	2,55E+03	2,46E+02	2,23E+02	1,89E+02	1,56E+02	1,07E+02	1,44E+01	1,03E+01	2,87E+01
CUM, PERCENT OF MASS SMALLER THAN D50	27,65	20,67	14,32	8,97	4,55	1,52	1,11	0,82	
CUM, (MG/ACM) SMALLER THAN D50	6,13E+02	4,58E+02	3,17E+02	1,99E+02	1,01E+02	3,36E+01	2,46E+01	1,82E+01	
CUM, (MG/DNCM) SMALLER THAN D50	9,74E+02	7,28E+02	5,04E+02	3,16E+02	1,60E+02	5,35E+01	3,91E+01	2,89E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,68E-01	2,00E-01	1,39E-01	8,68E-02	4,40E-02	1,47E-02	1,08E-02	7,94E-03	
CUM, (GR/DNCF) SMALLER THAN D50	4,26E-01	3,18E-01	2,20E-01	1,38E-01	7,00E-02	2,34E-02	1,71E-02	1,26E-02	
GEO, MEAN DIA, (MICROMETERS)	4,23E+01	8,95E+00	5,67E+00	3,29E+00	2,10E+00	1,27E+00	7,76E-01	4,84E-01	2,53E-01
DM/DLOGD (MG/DNCM)	2,13E+03	1,64E+03	9,09E+02	8,25E+02	9,77E+02	3,82E+02	9,71E+01	3,91E+01	9,53E+01
DN/DLOGD (NO, PARTICLES/DNCM)	2,24E+07	1,82E+09	3,96E+09	1,85E+10	8,37E+10	1,49E+11	1,65E+11	2,74E+11	4,69E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-18 1-15-76 1445 BUAI

IMPACTOR FLOWRATE = 0,033 ACFM IMPACTOR TEMPERATURE = 325,0 F = 162,8 C SAMPLING DURATION = 8,50 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 325,0 F = 162,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,91 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,1031E+00 GR/ACF 1,7540E+00 GR/DNCF 2,5243E+03 MG/ACM 4,0137E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,63	7,53	4,28	2,53	1,75	0,92	0,65	0,36	
MASS (MILLIGRAMS)	15,71	1,26	1,34	0,48	0,56	0,37	0,08	0,05	0,20
MG/DNCM/STAGE	3,14E+03	2,52E+02	2,68E+02	9,61E+01	1,12E+02	7,41E+01	1,60E+01	1,00E+01	4,00E+01
CUM, PERCENT OF MASS SMALLER THAN D50	21,65	15,37	8,68	6,29	3,50	1,65	1,25	1,00	
CUM, (MG/ACM) SMALLER THAN D50	5,47E+02	3,88E+02	2,19E+02	1,59E+02	8,83E+01	4,17E+01	3,16E+01	2,53E+01	
CUM, (MG/DNCM) SMALLER THAN D50	8,69E+02	6,17E+02	3,49E+02	2,52E+02	1,40E+02	6,63E+01	5,02E+01	4,02E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,39E-01	1,70E-01	9,58E-02	6,94E-02	3,86E-02	1,82E-02	1,38E-02	1,11E-02	
CUM, (GR/DNCF) SMALLER THAN D50	3,80E-01	2,70E-01	1,52E-01	1,10E-01	6,13E-02	2,90E-02	2,20E-02	1,76E-02	
GEO, MEAN DIA, (MICROMETERS)	4,23E+01	8,95E+00	5,67E+00	3,29E+00	2,10E+00	1,27E+00	7,76E-01	4,84E-01	2,53E-01
DM/DLOGD (MG/DNCM)	2,62E+03	1,68E+03	1,09E+03	4,20E+02	7,03E+02	2,65E+02	1,08E+02	3,81E+01	1,33E+02
DN/DLOGD (NO, PARTICLES/DNCM)	2,77E+07	1,87E+09	4,75E+09	9,43E+09	6,02E+10	1,04E+11	1,85E+11	2,68E+11	6,54E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-20 1-16-76 0943 11UAI

IMPACTOR FLOWRATE = 0.033 ACFM IMPACTOR TEMPERATURE = 320.0 F = 160.0 C SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG STACK TEMPERATURE = 320.0 F = 160.0 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 29.45 IN. OF HG MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 1.5549E+00 GR/ACF 2.4950E+00 GR/DNCF 3.5582E+03 MG/ACM 5.7094E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.61	7.51	4.26	2.52	1.74	0.92	0.65	0.36	
MASS (MILLIGRAMS)	24.98	2.80	1.61	1.64	1.25	0.59	0.10	0.07	0.21
MG/DNCM/STAGE	4.29E+03	4.81E+02	2.76E+02	2.82E+02	2.15E+02	1.01E+02	1.72E+01	1.20E+01	3.61E+01
CUM. PERCENT OF MASS SMALLER THAN D50	24.88	16.46	11.61	6.68	2.92	1.15	0.85	0.64	
CUM. (MG/ACM) SMALLER THAN D50	8.85E+02	5.86E+02	4.13E+02	2.38E+02	1.04E+02	4.08E+01	3.01E+01	2.27E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.42E+03	9.40E+02	6.63E+02	3.81E+02	1.67E+02	6.55E+01	4.84E+01	3.63E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.87E-01	2.56E-01	1.81E-01	1.04E-01	4.54E-02	1.78E-02	1.32E-02	9.90E-03	
CUM. (GR/DNCF) SMALLER THAN D50	6.21E-01	4.11E-01	2.90E-01	1.67E-01	7.29E-02	2.86E-02	2.11E-02	1.59E-02	
GEO. MEAN DIA. (MICROMETERS)	4.22E+01	8.93E+00	5.66E+00	3.28E+00	2.10E+00	1.26E+00	7.73E-01	4.81E-01	2.51E-01
DM/DLOGD (MG/DNCM)	3.58E+03	3.21E+03	1.12E+03	1.23E+03	1.34E+03	3.63E+02	1.16E+02	4.56E+01	1.20E+02
DN/DLOGD (NO. PARTICLES/DNCM)	3.78E+07	3.59E+09	4.93E+09	2.79E+10	1.16E+11	1.43E+11	2.00E+11	3.26E+11	6.01E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-21 1-16-76 0952 7UAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 320.0 F = 160.0 C   SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 320.0 F = 160.0 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.45 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.7504E+00 GR/ACF   2.8087E+00 GR/DNCF   4.0055E+03 MG/ACM   6.4272E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.61	7.51	4.26	2.52	1.74	0.92	0.65	0.36	
MASS (MILLIGRAMS)	29.69	2.09	1.90	1.61	0.71	0.69	0.53	0.04	0.17
MG/DNCM/STAGE	5.10E+03	3.59E+02	3.26E+02	2.76E+02	1.22E+02	1.18E+02	9.10E+01	6.87E+00	2.92E+01
CUM. PERCENT OF MASS SMALLER THAN D50	20.68	15.10	10.02	5.72	3.83	1.98	0.57	0.46	
CUM. (MG/ACM) SMALLER THAN D50	8.28E+02	6.05E+02	4.02E+02	2.29E+02	1.53E+02	7.94E+01	2.27E+01	1.84E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.33E+03	9.70E+02	6.44E+02	3.68E+02	2.46E+02	1.27E+02	3.64E+01	2.95E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.62E-01	2.64E-01	1.75E-01	1.00E-01	6.70E-02	3.47E-02	9.91E-03	8.04E-03	
CUM. (GR/DNCF) SMALLER THAN D50	5.81E-01	4.24E-01	2.82E-01	1.61E-01	1.07E-01	5.57E-02	1.59E-02	1.29E-02	
GEO. MEAN DIA. (MICROMETERS)	4.22E+01	8.93E+00	5.66E+00	3.28E+00	2.10E+00	1.26E+00	7.73E-01	4.81E-01	2.51E-01
DM/DLOGD (MG/DNCM)	4.25E+03	2.39E+03	1.33E+03	1.21E+03	7.64E+02	4.24E+02	6.15E+02	2.61E+01	9.70E+01
DN/DLOGD (NO. PARTICLES/DNCM)	4.50E+07	2.68E+09	5.82E+09	2.73E+10	6.61E+10	1.67E+11	1.06E+12	1.86E+11	4.87E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-22 1-16-76 1008 9UAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 320.0 F = 160.0 C   SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 320.0 F = 160.0 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.45 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 6.6780E-01 GR/ACF   1.0715E+00 GR/DNCF   1.5282E+03 MG/ACM   2.4520E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.61	7.51	4.26	2.52	1.74	0.92	0.65	0.36	
MASS (MILLIGRAMS)	9.96	1.33	0.82	1.04	0.44	0.35	0.11	0.06	0.17
MG/DNCM/STAGE	1.71E+03	2.28E+02	1.41E+02	1.79E+02	7.56E+01	6.01E+01	1.89E+01	1.03E+01	2.92E+01
CUM. PERCENT OF MASS SMALLER THAN D50	30.26	20.94	15.20	7.92	4.84	2.39	1.62	1.20	
CUM. (MG/ACM) SMALLER THAN D50	4.62E+02	3.20E+02	2.32E+02	1.21E+02	7.39E+01	3.65E+01	2.47E+01	1.83E+01	
CUM. (MG/DNCM) SMALLER THAN D50	7.42E+02	5.14E+02	3.73E+02	1.94E+02	1.19E+02	5.85E+01	3.96E+01	2.93E+01	
CUM. (GR/ACF) SMALLER THAN D50	2.02E-01	1.40E-01	1.02E-01	5.29E-02	3.23E-02	1.59E-02	1.08E-02	7.98E-03	
CUM. (GR/DNCF) SMALLER THAN D50	3.24E-01	2.24E-01	1.63E-01	8.48E-02	5.18E-02	2.56E-02	1.73E-02	1.28E-02	
GEO. MEAN DIA. (MICROMETERS)	4.22E+01	8.93E+00	5.66E+00	3.28E+00	2.10E+00	1.26E+00	7.73E-01	4.81E-01	2.51E-01
DM/DLOGD (MG/DNCM)	1.43E+03	1.52E+03	5.73E+02	7.81E+02	4.73E+02	2.15E+02	1.28E+02	3.91E+01	9.70E+01
DN/DLOGD (NO. PARTICLES/DNCM)	1.51E+07	1.71E+09	2.51E+09	1.77E+10	4.09E+10	8.48E+10	2.20E+11	2.79E+11	4.87E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-23 1-16-76 1413 3UAI

IMPACTOR FLOWRATE = 0.033 ACFM   IMPACTOR TEMPERATURE = 330.0 F = 165.6 C   SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 330.0 F = 165.6 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.44 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 2.4682E+00 GR/ACF   4.0127E+00 GR/DNCF   5.6482E+03 MG/ACM   9.1823E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.66	7.55	4.28	2.53	1.75	0.92	0.65	0.36	
MASS (MILLIGRAMS)	42.46	3.75	2.34	2.26	1.02	0.55	0.18	0.04	0.18
MG/DNCM/STAGE	7.39E+03	6.52E+02	4.07E+02	3.93E+02	1.77E+02	9.57E+01	3.13E+01	6.96E+00	3.13E+01
CUM. PERCENT OF MASS SMALLER THAN D50	19.56	12.45	8.02	3.74	1.80	0.76	0.42	0.35	
CUM. (MG/ACM) SMALLER THAN D50	1.10E+03	7.03E+02	4.53E+02	2.11E+02	1.02E+02	4.31E+01	2.38E+01	1.95E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.80E+03	1.14E+03	7.36E+02	3.43E+02	1.66E+02	7.00E+01	3.87E+01	3.18E+01	
CUM. (GR/ACF) SMALLER THAN D50	4.83E-01	3.07E-01	1.98E-01	9.23E-02	4.46E-02	1.88E-02	1.04E-02	8.54E-03	
CUM. (GR/DNCF) SMALLER THAN D50	7.85E-01	5.00E-01	3.22E-01	1.50E-01	7.24E-02	3.06E-02	1.69E-02	1.39E-02	
GEO. MEAN DIA. (MICROMETERS)	4.23E+01	8.97E+00	5.69E+00	3.29E+00	2.10E+00	1.27E+00	7.76E-01	4.82E-01	2.52E-01
DM/DLOGD (MG/DNCM)	6.17E+03	4.35E+03	1.65E+03	1.72E+03	1.11E+03	3.42E+02	2.11E+02	2.63E+01	1.04E+02
DN/DLOGD (NO. PARTICLES/DNCM)	6.48E+07	4.80E+09	7.17E+09	3.84E+10	9.49E+10	1.33E+11	3.60E+11	1.87E+11	5.20E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-24 1-16-76 1425 1UAI

IMPACTOR FLOWRATE = 0,033 ACFM   IMPACTOR TEMPERATURE = 330,0 F = 165,6 C   SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 330,0 F = 165,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,44 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 8,7591E-01 GR/ACF   1,4240E+00 GR/DNCF   2,0044E+03 MG/ACM   3,2585E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,66	7,55	4,28	2,53	1,75	0,92	0,65	0,36	
MASS (MILLIGRAMS)	12,45	1,74	1,52	1,07	0,64	0,78	0,19	0,13	0,21
MG/DNCM/STAGE	2,17E+03	3,03E+02	2,64E+02	1,86E+02	1,11E+02	1,36E+02	3,31E+01	2,26E+01	3,65E+01
CUM, PERCENT OF MASS SMALLER THAN D50	33,53	24,24	16,13	10,42	7,00	2,83	1,82	1,13	
CUM, (MG/ACM) SMALLER THAN D50	6,72E+02	4,86E+02	3,23E+02	2,09E+02	1,40E+02	5,68E+01	3,65E+01	2,26E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,09E+03	7,90E+02	5,26E+02	3,39E+02	2,28E+02	9,24E+01	5,93E+01	3,67E+01	
CUM, (GR/ACF) SMALLER THAN D50	2,94E-01	2,12E-01	1,41E-01	9,12E-02	6,13E-02	2,48E-02	1,59E-02	9,86E-03	
CUM, (GR/DNCF) SMALLER THAN D50	4,78E-01	3,45E-01	2,30E-01	1,48E-01	9,97E-02	4,04E-02	2,59E-02	1,60E-02	
GEO, MEAN DIA, (MICROMETERS)	4,23E+01	8,97E+00	5,69E+00	3,29E+00	2,10E+00	1,27E+00	7,76E-01	4,82E-01	2,52E-01
DM/DLOGD (MG/DNCM)	1,81E+03	2,02E+03	1,07E+03	8,14E+02	6,97E+02	4,85E+02	2,23E+02	8,56E+01	1,21E+02
DN/DLOGD (NO, PARTICLES/DNCM)	1,90E+07	2,23E+09	4,65E+09	1,82E+10	5,95E+10	1,89E+11	3,80E+11	6,07E+11	6,07E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-25 1-16-76 1400 SUAI

IMPACTOR FLOWRATE = 0.037 ACFM　IMPACTOR TEMPERATURE = 330.0 F = 165.6 C　SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG　STACK TEMPERATURE = 330.0 F = 165.6 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.　STACK PRESSURE = 29.44 IN. OF HG　MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)　CO2 = 12.88　CO = 0.00　N2 = 73.60　O2 = 5.52　H2O = 8.00

CALC. MASS LOADING = 1.3993E+00 GR/ACF　2.2749E+00 GR/DNCF　3.2022E+03 MG/ACM　5.2058E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.07	7.12	4.04	2.38	1.65	0.86	0.61	0.33	
MASS (MILLIGRAMS)	25.40	2.49	1.60	2.10	1.09	0.46	0.12	0.05	0.24
MG/DNCM/STAGE	3.94E+03	3.86E+02	2.48E+02	3.26E+02	1.69E+02	7.14E+01	1.86E+01	7.76E+00	3.72E+01
CUM. PERCENT OF MASS SMALLER THAN D50	24.30	16.88	12.11	5.85	2.60	1.23	0.87	0.72	
CUM. (MG/ACM) SMALLER THAN D50	7.78E+02	5.40E+02	3.88E+02	1.87E+02	8.32E+01	3.93E+01	2.78E+01	2.31E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.26E+03	8.78E+02	6.30E+02	3.04E+02	1.35E+02	6.39E+01	4.53E+01	3.75E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.40E-01	2.36E-01	1.69E-01	8.18E-02	3.64E-02	1.72E-02	1.22E-02	1.01E-02	
CUM. (GR/DNCF) SMALLER THAN D50	5.53E-01	3.84E-01	2.75E-01	1.33E-01	5.91E-02	2.79E-02	1.98E-02	1.64E-02	
GEO. MEAN DIA. (MICROMETERS)	4.11E+01	8.47E+00	5.36E+00	3.10E+00	1.98E+00	1.19E+00	7.27E-01	4.49E-01	2.33E-01
DM/DLOGD (MG/DNCM)	3.22E+03	2.57E+03	1.01E+03	1.42E+03	1.06E+03	2.54E+02	1.25E+02	2.89E+01	1.24E+02
DN/DLOGD (NO. PARTICLES/DNCM)	3.69E+07	3.37E+09	5.20E+09	3.79E+10	1.08E+11	1.19E+11	2.59E+11	2.54E+11	7.75E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-26 1-19-76 1113 12UAI CYCLONE CATCH WAS DESTROYED

IMPACTOR FLOWRATE = 0.037 ACFM IMPACTOR TEMPERATURE = 310.0 F = 154.4 C SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG STACK TEMPERATURE = 310.0 F = 154.4 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 30.06 IN. OF HG MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 2.7111E-01 GR/ACF 4.2072E-01 GR/DNCF 6.2039E+02 MG/ACM 9.6275E+02 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9.97	7.06	4.00	2.36	1.64	0.86	0.61	0.33	
MASS (MILLIGRAMS)	0.00	1.92	1.45	1.27	1.26	0.24	0.16	0.02	0.18
MG/DNCM/STAGE	0.00E-01	2.84E+02	2.15E+02	1.88E+02	1.87E+02	3.55E+01	2.37E+01	2.96E+00	2.67E+01
CUM. PERCENT OF MASS SMALLER THAN D50	100.00	70.47	48.16	28.62	9.24	5.54	3.08	2.77	
CUM. (MG/ACM) SMALLER THAN D50	6.20E+02	4.37E+02	2.99E+02	1.78E+02	5.73E+01	3.44E+01	1.91E+01	1.72E+01	
CUM. (MG/DNCM) SMALLER THAN D50	9.63E+02	6.78E+02	4.64E+02	2.76E+02	8.89E+01	5.34E+01	2.97E+01	2.67E+01	
CUM. (GR/ACF) SMALLER THAN D50	2.71E-01	1.91E-01	1.31E-01	7.76E-02	2.50E-02	1.50E-02	8.36E-03	7.52E-03	
CUM. (GR/DNCF) SMALLER THAN D50	4.21E-01	2.96E-01	2.03E-01	1.20E-01	3.89E-02	2.33E-02	1.30E-02	1.17E-02	
GEO. MEAN DIA. (MICROMETERS)	4.09E+01	8.39E+00	5.32E+00	3.08E+00	1.97E+00	1.19E+00	7.24E-01	4.50E-01	2.35E-01
DM/DLOGD (MG/DNCM)	0.00E-01	1.90E+03	8.73E+02	8.22E+02	1.17E+03	1.27E+02	1.60E+02	1.12E+01	8.86E+01
DN/DLOGD (NO. PARTICLES/DNCM)	0.00E-01	2.56E+09	4.62E+09	2.25E+10	1.22E+11	6.07E+10	3.35E+11	9.77E+10	5.45E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-27 1-19-76 1102 10UAI S6 HAD A MINUS MASS

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 310,0 F = 154,4 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 310,0 F = 154,4 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 30,06 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,9291E+00 GR/ACF 2,9936E+00 GR/DNCF 4,4143E+03 MG/ACM 6,8503E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9,97	7,06	4,00	2,36	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	35,83	3,74	1,95	1,75	1,78	0,83	0,14	0,00	0,23
MG/DNCM/STAGE	5,31E+03	5,54E+02	2,89E+02	2,59E+02	2,64E+02	1,23E+02	2,07E+01	0,00E-01	3,41E+01
CUM, PERCENT OF MASS SMALLER THAN D50	22,53	14,45	10,23	6,45	2,60	0,80	0,50	0,50	
CUM, (MG/ACM) SMALLER THAN D50	9,95E+02	6,38E+02	4,52E+02	2,85E+02	1,15E+02	3,55E+01	2,22E+01	2,22E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,54E+03	9,90E+02	7,01E+02	4,42E+02	1,78E+02	5,51E+01	3,44E+01	3,44E+01	
CUM, (GR/ACF) SMALLER THAN D50	4,35E-01	2,79E-01	1,97E-01	1,24E-01	5,01E-02	1,55E-02	9,69E-03	9,69E-03	
CUM, (GR/DNCF) SMALLER THAN D50	6,75E-01	4,33E-01	3,06E-01	1,93E-01	7,78E-02	2,41E-02	1,50E-02	1,50E-02	
GEO, MEAN DIA, (MICROMETERS)	4,09E+01	8,39E+00	5,32E+00	3,08E+00	1,97E+00	1,19E+00	7,24E-01	4,50E-01	2,35E-01
DM/DLOGD (MG/DNCM)	4,33E+03	3,69E+03	1,17E+03	1,13E+03	1,65E+03	4,39E+02	1,40E+02	0,00E-01	1,13E+02
DN/DLOGD (NO, PARTICLES/DNCM)	5,02E+07	4,98E+09	6,22E+09	3,09E+10	1,73E+11	2,10E+11	2,93E+11	0,00E-01	6,97E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-28 1,19176 1050 8UAI

IMPACTOR FLOWRATE = 0,037 ACFM   IMPACTOR TEMPERATURE = 310,0 F = 154,4 C   SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 310,0 F = 154,4 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,06 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,7981E+00 GR/ACF   2,7903E+00 GR/DNCF   4,1146E+03 MG/ACM   6,3853E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9,97	7,06	4,00	2,36	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	33,79	1,95	2,15	2,08	2,03	0,66	0,16	0,05	0,24
MG/DNCM/STAGE	5,00E+03	2,89E+02	3,18E+02	3,08E+02	3,01E+02	9,78E+01	2,37E+01	7,41E+00	3,55E+01
CUM, PERCENT OF MASS SMALLER THAN D50	21,62	17,10	12,11	7,29	2,58	1,05	0,68	0,56	
CUM, (MG/ACM) SMALLER THAN D50	8,90E+02	7,04E+02	4,98E+02	3,00E+02	1,06E+02	4,32E+01	2,79E+01	2,31E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,38E+03	1,09E+03	7,73E+02	4,65E+02	1,65E+02	6,70E+01	4,33E+01	3,59E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,89E-01	3,07E-01	2,18E-01	1,31E-01	4,64E-02	1,89E-02	1,22E-02	1,01E-02	
CUM, (GR/DNCF) SMALLER THAN D50	6,03E-01	4,77E-01	3,38E-01	2,03E-01	7,20E-02	2,93E-02	1,89E-02	1,57E-02	
GEO, MEAN DIA, (MICROMETERS)	4,09E+01	8,39E+00	5,32E+00	3,08E+00	1,97E+00	1,19E+00	7,24E-01	4,50E-01	2,35E-01
DM/DLOGD (MG/DNCM)	4,08E+03	1,93E+03	1,29E+03	1,35E+03	1,88E+03	3,49E+02	1,60E+02	2,80E+01	1,18E+02
DN/DLOGD (NO, PARTICLES/DNCM)	4,74E+07	2,60E+09	6,86E+09	3,68E+10	1,97E+11	1,67E+11	3,35E+11	2,44E+11	7,27E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-29 1-19176 1553 2UAI

IMPACTOR FLOWRATE = 0.037 ACFM   IMPACTOR TEMPERATURE = 325.0 F = 162.8 C   SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 325.0 F = 162.8 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.98 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 9.0968E-01 GR/ACF   1.4430E+00 GR/DNCF   2.0817E+03 MG/ACM   3.3022E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.04	7.11	4.03	2.38	1.65	0.86	0.61	0.33	
MASS (MILLIGRAMS)	12.69	3.15	1.64	1.84	1.24	0.93	0.12	0.04	0.16
MG/DNCM/STAGE	1.92E+03	4.77E+02	2.48E+02	2.79E+02	1.88E+02	1.41E+02	1.82E+01	6.06E+00	2.42E+01
CUM. PERCENT OF MASS SMALLER THAN D50	41.82	27.38	19.86	11.42	5.74	1.47	0.92	0.74	
CUM. (MG/ACM) SMALLER THAN D50	8.71E+02	5.70E+02	4.13E+02	2.38E+02	1.19E+02	3.06E+01	1.92E+01	1.54E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.38E+03	9.04E+02	6.56E+02	3.77E+02	1.89E+02	4.86E+01	3.04E+01	2.44E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.80E-01	2.49E-01	1.81E-01	1.04E-01	5.22E-02	1.34E-02	8.39E-03	6.72E-03	
CUM. (GR/DNCF) SMALLER THAN D50	6.03E-01	3.95E-01	2.87E-01	1.65E-01	8.28E-02	2.12E-02	1.33E-02	1.07E-02	
GEO. MEAN DIA. (MICROMETERS)	4.11E+01	8.45E+00	5.35E+00	3.10E+00	1.98E+00	1.19E+00	7.27E-01	4.51E-01	2.35E-01
DM/DLOGD (MG/DNCM)	1.57E+03	3.18E+03	1.01E+03	1.22E+03	1.17E+03	5.02E+02	1.22E+02	2.28E+01	8.05E+01
DN/DLOGD (NO. PARTICLES/DNCM)	1.80E+07	4.19E+09	5.23E+09	3.26E+10	1.20E+11	2.36E+11	2.52E+11	1.97E+11	4.94E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-30 1-19-76 1530 6UAI

IMPACTOR FLOWRATE = 0.037 ACFM   IMPACTOR TEMPERATURE = 325.0 F = 162.8 C   SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG   STACK TEMPERATURE = 325.0 F = 162.8 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.98 IN. OF HG   MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.7710E+00 GR/ACF   2.8093E+00 GR/DNCF   4.0526E+03 MG/ACM   6.4287E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.04	7.11	4.03	2.38	1.65	0.86	0.61	0.33	
MASS (MILLIGRAMS)	27.97	4.66	2.72	3.22	2.71	0.80	0.12	0.04	0.22
MG/DNCM/STAGE	4.23E+03	7.06E+02	4.12E+02	4.88E+02	4.10E+02	1.21E+02	1.82E+01	6.06E+00	3.33E+01
CUM. PERCENT OF MASS SMALLER THAN D50	34.13	23.16	16.75	9.17	2.78	0.90	0.62	0.52	
CUM. (MG/ACM) SMALLER THAN D50	1.38E+03	9.38E+02	6.79E+02	3.71E+02	1.13E+02	3.65E+01	2.50E+01	2.12E+01	
CUM. (MG/DNCM) SMALLER THAN D50	2.19E+03	1.49E+03	1.08E+03	5.89E+02	1.79E+02	5.79E+01	3.97E+01	3.36E+01	
CUM. (GR/ACF) SMALLER THAN D50	6.04E-01	4.10E-01	2.97E-01	1.62E-01	4.93E-02	1.59E-02	1.09E-02	9.26E-03	
CUM. (GR/DNCF) SMALLER THAN D50	9.59E-01	6.51E-01	4.71E-01	2.58E-01	7.82E-02	2.53E-02	1.73E-02	1.47E-02	
GEO. MEAN DIA. (MICROMETERS)	4.11E+01	8.45E+00	5.35E+00	3.10E+00	1.98E+00	1.19E+00	7.27E-01	4.51E-01	2.35E-01
DM/DLOGD (MG/DNCM)	3.46E+03	4.70E+03	1.67E+03	2.13E+03	2.56E+03	4.32E+02	1.22E+02	2.28E+01	1.11E+02
DN/DLOGD (NO. PARTICLES/DNCM)	3.98E+07	6.20E+09	8.68E+09	5.70E+10	2.63E+11	2.03E+11	2.52E+11	1.97E+11	6.79E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-31 1-19-76 1540 4UAI

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 320,0 F = 160,0 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 320,0 F = 160,0 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,98 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,3017E+00 GR/ACF 2,0518E+00 GR/DNCF 2,9788E+03 MG/ACM 4,6953E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,02	7,09	4,02	2,37	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	23,21	2,03	1,73	1,81	0,96	0,98	0,28	0,04	0,17
MG/DNCM/STAGE	3,49E+03	3,05E+02	2,60E+02	2,72E+02	1,44E+02	1,47E+02	4,21E+01	6,02E+00	2,56E+01
CUM, PERCENT OF MASS SMALLER THAN D50	25,64	19,13	13,59	7,79	4,72	1,58	0,68	0,55	
CUM, (MG/ACM) SMALLER THAN D50	7,64E+02	5,70E+02	4,05E+02	2,32E+02	1,40E+02	4,69E+01	2,02E+01	1,64E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,20E+03	8,98E+02	6,38E+02	3,66E+02	2,21E+02	7,40E+01	3,18E+01	2,58E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,34E-01	2,49E-01	1,77E-01	1,01E-01	6,14E-02	2,05E-02	8,82E-03	7,16E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,26E-01	3,93E-01	2,79E-01	1,60E-01	9,67E-02	3,23F-02	1,39E-02	1,13E-02	
GEO, MEAN DIA, (MICROMETERS)	4,10E+01	8,43E+00	5,34E+00	3,09E+00	1,97E+00	1,19E+00	7,26E-01	4,51E-01	2,35E-01
DM/DLOGD (MG/DNCM)	2,85E+03	2,03E+03	1,06E+03	1,19E+03	9,03E+02	5,26E+02	2,83E+02	2,27E+01	8,50E+01
DN/DLOGD (NO, PARTICLES/DNCM)	3,29E+07	2,70E+09	5,52E+09	3,21E+10	9,33E+10	2,49E+11	5,88E+11	1,97E+11	5,23E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-32 1-20-76 1004 11UAI

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 320,0 F = 160,0 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 320,0 F = 160,0 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,98 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,7097E+00 GR/ACF 2,6948E+00 GR/DNCF 3,9123E+03 MG/ACM 6,1666E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,02	7,09	4,02	2,37	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	32,63	2,50	1,83	1,35	1,40	0,91	0,17	0,05	0,15
MG/DNCM/STAGE	4,91E+03	3,76E+02	2,75E+02	2,03E+02	2,11E+02	1,37E+02	2,56E+01	7,52E+00	2,26E+01
CUM, PERCENT OF MASS SMALLER THAN D50	20,40	14,30	9,84	6,54	3,13	0,91	0,49	0,37	
CUM, (MG/ACM) SMALLER THAN D50	7,98E+02	5,60E+02	3,85E+02	2,56E+02	1,22E+02	3,55E+01	1,93E+01	1,45E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,26E+03	8,82E+02	6,07E+02	4,03E+02	1,93E+02	5,60E+01	3,04E+01	2,29E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,49E-01	2,45E-01	1,68E-01	1,12E-01	5,35E-02	1,55E-02	8,43E-03	6,34E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,50E-01	3,85E-01	2,65E-01	1,76E-01	8,43E-02	2,45E-02	1,33E-02	1,00E-02	
GEO, MEAN DIA, (MICROMETERS)	4,10E+01	8,43E+00	5,34E+00	3,09E+00	1,97E+00	1,19E+00	7,26E-01	4,51E-01	2,35E-01
DM/DLOGD (MG/DNCM)	4,01E+03	2,51E+03	1,12E+03	8,87E+02	1,32E+03	4,89E+02	1,72E+02	2,83E+01	7,50E+01
DN/DLOGD (NO, PARTICLES/DNCM)	4,62E+07	3,33E+09	5,84E+09	2,39E+10	1,36E+11	2,31E+11	3,57E+11	2,46E+11	4,61E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-33 1-20-76 0953 9UAI

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 320,0 F = 160,0 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 320,0 F = 160,0 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,98 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 2,7611E+00 GR/ACF 4,3521E+00 GR/DNCF 6,3184E+03 MG/ACM 9,9592E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,02	7,09	4,02	2,37	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	53,94	3,37	2,35	3,86	1,80	0,58	0,09	0,07	0,14
MG/DNCM/STAGE	8,11E+03	5,07E+02	3,54E+02	5,81E+02	2,71E+02	8,73E+01	1,35E+01	1,05E+01	2,11E+01
CUM, PERCENT OF MASS SMALLER THAN D50	18,52	13,43	9,88	4,05	1,33	0,46	0,32	0,22	
CUM, (MG/ACM) SMALLER THAN D50	1,17E+03	8,49E+02	6,25E+02	2,56E+02	8,43E+01	2,89E+01	2,04E+01	1,37E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,84E+03	1,34E+03	9,84E+02	4,04E+02	1,33E+02	4,56E+01	3,21E+01	2,16E+01	
CUM, (GR/ACF) SMALLER THAN D50	5,11E-01	3,71E-01	2,73E-01	1,12E-01	3,68E-02	1,27E-02	8,90E-03	5,98E-03	
CUM, (GR/DNCF) SMALLER THAN D50	8,06E-01	5,85E-01	4,30E-01	1,76E-01	5,81E-02	1,99E-02	1,40E-02	9,42E-03	
GEO, MEAN DIA, (MICROMETERS)	4,10E+01	8,43E+00	5,34E+00	3,09E+00	1,97E+00	1,19E+00	7,26E-01	4,51E-01	2,35E-01
DM/DLOGD (MG/DNCM)	6,63E+03	3,38E+03	1,44E+03	2,54E+03	1,69E+03	3,11E+02	9,10E+01	3,97E+01	7,00E+01
DN/DLOGD (NO, PARTICLES/DNCM)	7,64E+07	4,49E+09	7,50E+09	6,84E+10	1,75E+11	1,47E+11	1,89E+11	3,45E+11	4,30E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-34 1-20-76 0936 7UAI

IMPACTOR FLOWRATE = 0.037 ACFM IMPACTOR TEMPERATURE = 320.0 F = 160.0 C SAMPLING DURATION = 10.00 MIN

IMPACTOR PRESSURE DROP = 2.5 IN. OF HG STACK TEMPERATURE = 320.0 F = 160.0 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 29.98 IN. OF HG MAX. PARTICLE DIAMETER = 168.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 1.7384E+00 GR/ACF 2.7401E+00 GR/DNCF 3.9781E+03 MG/ACM 6.2704E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.02	7.09	4.02	2.37	1.64	0.86	0.61	0.33	
MASS (MILLIGRAMS)	32.42	3.15	2.17	1.75	1.30	0.55	0.07	0.14	0.13
MG/DNCM/STAGE	4.88E+03	4.74E+02	3.26E+02	2.63E+02	1.96E+02	8.27E+01	1.05E+01	2.11E+01	1.96E+01
CUM. PERCENT OF MASS SMALLER THAN D50	22.22	14.66	9.46	5.26	2.14	0.82	0.65	0.32	
CUM. (MG/ACM) SMALLER THAN D50	8.84E+02	5.83E+02	3.76E+02	2.09E+02	8.51E+01	3.27E+01	2.60E+01	1.26E+01	
CUM. (MG/DNCM) SMALLER THAN D50	1.39E+03	9.20E+02	5.93E+02	3.30E+02	1.34E+02	5.15E+01	4.09E+01	1.99E+01	
CUM. (GR/ACF) SMALLER THAN D50	3.86E-01	2.55E-01	1.64E-01	9.14E-02	3.72E-02	1.43E-02	1.13E-02	5.51E-03	
CUM. (GR/DNCF) SMALLER THAN D50	6.09E-01	4.02E-01	2.59E-01	1.44E-01	5.86E-02	2.25E-02	1.79E-02	8.68E-03	
GEO. MEAN DIA. (MICROMETERS)	4.10E+01	8.43E+00	5.34E+00	3.09E+00	1.97E+00	1.19E+00	7.26E-01	4.51E-01	2.35E-01
DM/DLOGD (MG/DNCM)	3.98E+03	3.16E+03	1.33E+03	1.15E+03	1.22E+03	2.95E+02	7.08E+01	7.93E+01	6.50E+01
DN/DLOGD (NO. PARTICLES/DNCM)	4.59E+07	4.20E+09	6.93E+09	3.10E+10	1.26E+11	1.40E+11	1.47E+11	6.89E+11	4.00E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

COLI-35 1-20-76 1454 1UAI

IMPACTOR FLOWRATE = 0,037 ACFM   IMPACTOR TEMPERATURE = 310,0 F = 154,4 C   SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG   STACK TEMPERATURE = 310,0 F = 154,4 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,96 IN, OF HG   MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 8,6463E-01 GR/ACF   1,3463E+00 GR/DNCF   1,9786E+03 MG/ACM   3,0807E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9,97	7,06	4,00	2,36	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	12,41	3,64	1,89	1,29	0,85	0,40	0,06	0,08	0,11
MG/DNCM/STAGE	1,84E+03	5,41E+02	2,81E+02	1,92E+02	1,26E+02	5,94E+01	8,92E+00	1,19E+01	1,63E+01
CUM, PERCENT OF MASS SMALLER THAN D50	40,14	22,58	13,46	7,24	3,14	1,21	0,92	0,54	
CUM, (MG/ACM) SMALLER THAN D50	7,94E+02	4,47E+02	2,66E+02	1,43E+02	6,21E+01	2,40E+01	1,82E+01	1,06E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,24E+03	6,96E+02	4,15E+02	2,23E+02	9,68E+01	3,73E+01	2,84E+01	1,65E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,47E-01	1,95E-01	1,16E-01	6,26E-02	2,72E-02	1,05E-02	7,97E-03	4,63E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,40E-01	3,04E-01	1,81E-01	9,75E-02	4,23E-02	1,63E-02	1,24E-02	7,21E-03	
GEO, MEAN DIA, (MICROMETERS)	4,09E+01	8,39E+00	5,32E+00	3,08E+00	1,97E+00	1,19E+00	7,24E-01	4,50E-01	2,34E-01
DM/DLOGD (MG/DNCM)	1,50E+03	3,61E+03	1,14E+03	8,37E+02	7,90E+02	2,12E+02	6,00E+01	4,49E+01	5,43E+01
DN/DLOGD (NO, PARTICLES/DNCM)	1,75E+07	4,86E+09	6,05E+09	2,29E+10	8,27E+10	1,02E+11	1,26E+11	3,93E+11	3,36E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-36 1-20-76 1442 3UAI

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 310,0 F = 154,4 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 310,0 F = 154,4 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,96 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,2759E+00 GR/ACF 1,9866E+00 GR/DNCF 2,9197E+03 MG/ACM 4,5460E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9,97	7,06	4,00	2,36	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	22,15	3,47	1,63	1,45	0,98	0,63	0,11	0,02	0,15
MG/DNCM/STAGE	3,29E+03	5,16E+02	2,42E+02	2,15E+02	1,46E+02	9,36E+01	1,63E+01	2,97E+00	2,23E+01
CUM, PERCENT OF MASS SMALLER THAN D50	27,60	16,25	10,92	6,18	2,98	0,92	0,56	0,50	
CUM, (MG/ACM) SMALLER THAN D50	8,06E+02	4,75E+02	3,19E+02	1,81E+02	8,70E+01	2,69E+01	1,64E+01	1,45E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,25E+03	7,39E+02	4,97E+02	2,81E+02	1,35E+02	4,18E+01	2,55E+01	2,25E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,52E-01	2,07E-01	1,39E-01	7,89E-02	3,80E-02	1,17E-02	7,15E-03	6,32E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,48E-01	3,23E-01	2,17E-01	1,23E-01	5,92E-02	1,83E-02	1,11E-02	9,84E-03	
GEO, MEAN DIA, (MICROMETERS)	4,09E+01	8,39E+00	5,32E+00	3,08E+00	1,97E+00	1,19E+00	7,24E-01	4,50E-01	2,34E-01
DM/DLOGD (MG/DNCM)	2,68E+03	3,44E+03	9,84E+02	9,41E+02	9,11E+02	3,34E+02	1,10E+02	1,12E+01	7,41E+01
DN/DLOGD (NO, PARTICLES/DNCM)	3,12E+07	4,64E+09	5,22E+09	2,57E+10	9,54E+10	1,60E+11	2,31E+11	9,82E+10	4,58E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

COLI-37 1-20-76 1430 5UAI

IMPACTOR FLOWRATE = 0,037 ACFM IMPACTOR TEMPERATURE = 312,0 F = 155,6 C SAMPLING DURATION = 10,00 MIN

IMPACTOR PRESSURE DROP = 2,5 IN, OF HG STACK TEMPERATURE = 312,0 F = 155,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,96 IN, OF HG MAX, PARTICLE DIAMETER = 168,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,7789E+00 GR/ACF 2,7770E+00 GR/DNCF 4,0707E+03 MG/ACM 6,3547E+03 MG/DNCM

IMPACTOR STAGE	CYC	S0	S1	S2	S3	S4	S5	S6	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9,98	7,06	4,01	2,37	1,64	0,86	0,61	0,33	
MASS (MILLIGRAMS)	34,39	2,21	1,54	2,16	1,20	0,59	0,35	0,07	0,14
MG/DNCM/STAGE	5,12E+03	3,29E+02	2,29E+02	3,22E+02	1,79E+02	8,79E+01	5,21E+01	1,04E+01	2,09E+01
CUM, PERCENT OF MASS SMALLER THAN D50	19,37	14,19	10,58	5,51	2,70	1,32	0,50	0,33	
CUM, (MG/ACM) SMALLER THAN D50	7,89E+02	5,78E+02	4,31E+02	2,24E+02	1,10E+02	5,37E+01	2,02E+01	1,36E+01	
CUM, (MG/DNCM) SMALLER THAN D50	1,23E+03	9,02E+02	6,72E+02	3,50E+02	1,72E+02	8,38E+01	3,16E+01	2,12E+01	
CUM, (GR/ACF) SMALLER THAN D50	3,45E-01	2,52E-01	1,88E-01	9,81E-02	4,81E-02	2,34E-02	8,85E-03	5,93E-03	
CUM, (GR/DNCF) SMALLER THAN D50	5,38E-01	3,94E-01	2,94E-01	1,53E-01	7,50E-02	3,66E-02	1,38E-02	9,25E-03	
GEO, MEAN DIA, (MICROMETERS)	4,09E+01	8,40E+00	5,32E+00	3,08E+00	1,97E+00	1,19E+00	7,24E-01	4,50E-01	2,34E-01
DM/DLOGD (MG/DNCM)	4,18E+03	2,19E+03	9,32E+02	1,41E+03	1,12E+03	3,14E+02	3,51E+02	3,94E+01	6,93E+01
DN/DLOGD (NO, PARTICLES/DNCM)	4,84E+07	2,95E+09	4,93E+09	3,83E+10	1,17E+11	1,50E+11	7,35E+11	3,44E+11	4,28E+12

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

OUTLET IMPACTOR DATA

1COLO-12 1-12-76 1705

IMPACTOR FLOWRATE = 0.500 ACFM   IMPACTOR TEMPERATURE = 270.0 F = 132.2 C   SAMPLING DURATION = 90.00 MIN

IMPACTOR PRESSURE DROP = 0.7 IN. OF HG   STACK TEMPERATURE = 270.0 F = 132.2 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.68 IN. OF HG   MAX. PARTICLE DIAMETER = 50.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.4952E-03 GR/ACF   2.2582E-03 GR/DNCF   3.4216E+00 MG/ACM   5.1675E+00 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9.35	6.56	4.04	2.84	1.84	0.85	0.50	0.37	
MASS (MILLIGRAMS)	1.68	0.11	0.18	0.29	0.08	0.46	0.27	0.21	1.08
MG/DNCM/STAGE	1.99E+00	1.30E-01	2.13E-01	3.44E-01	9.48E-02	5.45E-01	3.20E-01	2.49E-01	1.28E+00
CUM. PERCENT OF MASS SMALLER THAN D50	61.47	58.95	54.82	48.17	46.34	35.78	29.59	24.78	
CUM. (MG/ACM) SMALLER THAN D50	2.10E+00	2.02E+00	1.88E+00	1.65E+00	1.59E+00	1.22E+00	1.01E+00	8.48E-01	
CUM. (MG/DNCM) SMALLER THAN D50	3.18E+00	3.05E+00	2.83E+00	2.49E+00	2.39E+00	1.85E+00	1.53E+00	1.28E+00	
CUM. (GR/ACF) SMALLER THAN D50	9.19E-04	8.81E-04	8.20E-04	7.20E-04	6.93E-04	5.35E-04	4.42E-04	3.70E-04	
CUM. (GR/DNCF) SMALLER THAN D50	1.39E-03	1.33E-03	1.24E-03	1.09E-03	1.05E-03	8.08E-04	6.68E-04	5.59E-04	
GEO. MEAN DIA. (MICROMETERS)	2.16E+01	7.83E+00	5.15E+00	3.38E+00	2.29E+00	1.25E+00	6.53E-01	4.30E-01	2.60E-01
DM/DLOGD (MG/DNCM)	2.73E+00	8.47E-01	1.01E+00	2.24E+00	5.07E-01	1.62E+00	1.41E+00	1.84E+00	4.25E+00
DN/DLOGD (NO. PARTICLES/DNCM)	2.15E+05	1.40E+06	5.91E+06	4.60E+07	3.37E+07	6.57E+08	4.02E+09	1.84E+10	1.93E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

1COLO-13 1-12-76 1711

IMPACTOR FLOWRATE = 0.538 ACFM   IMPACTOR TEMPERATURE = 270.0 F = 132.2 C   SAMPLING DURATION = 90.00 MIN

IMPACTOR PRESSURE DROP = 0.7 IN. OF HG   STACK TEMPERATURE = 270.0 F = 132.2 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 29.68 IN. OF HG   MAX. PARTICLE DIAMETER = 50.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 7.2349E-04 GR/ACF   1.0927E-03 GR/DNCF   1.6556E+00 MG/ACM   2.5004E+00 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	9.01	6.32	3.89	2.73	1.77	0.81	0.48	0.35	
MASS (MILLIGRAMS)	0.98	0.20	0.27	0.24	0.08	0.48	0.02	0.00	0.00
MG/DNCM/STAGE	1.08E+00	2.20E-01	2.97E-01	2.64E-01	8.81E-02	5.29E-01	2.20E-02	0.00E-01	0.00E-01
CUM. PERCENT OF MASS SMALLER THAN D50	56.83	48.02	36.13	25.56	22.03	0.89	0.01	0.01	
CUM. (MG/ACM) SMALLER THAN D50	9.41E-01	7.95E-01	5.98E-01	4.23E-01	3.65E-01	1.47E-02	8.28E-05	8.28E-05	
CUM. (MG/DNCM) SMALLER THAN D50	1.42E+00	1.20E+00	9.03E-01	6.39E-01	5.51E-01	2.22E-02	1.25E-04	1.25E-04	
CUM. (GR/ACF) SMALLER THAN D50	4.11E-04	3.47E-04	2.61E-04	1.85E-04	1.59E-04	6.41E-06	3.62E-08	3.62E-08	
CUM. (GR/DNCF) SMALLER THAN D50	6.21E-04	5.25E-04	3.95E-04	2.79E-04	2.41E-04	9.68E-06	5.46E-08	5.46E-08	
GEO. MEAN DIA. (MICROMETERS)	2.12E+01	7.55E+00	4.96E+00	3.26E+00	2.20E+00	1.20E+00	6.26E-01	4.11E-01	2.48E-01
DM/DLOGD (MG/DNCM)	1.45E+00	1.43E+00	1.41E+00	1.72E+00	4.70E-01	1.56E+00	9.63E-02	0.00E-01	0.00E-01
DN/DLOGD (NO. PARTICLES/DNCM)	1.21E+05	2.65E+06	9.20E+06	3.96E+07	3.50E+07	7.16E+08	3.13E+08	0.00E-01	0.00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

1COLO-15 1-13-76 1218 PORTS 1,2,3

IMPACTOR FLOWRATE = 0,398 ACFM IMPACTOR TEMPERATURE = 280,0 F = 137,8 C SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG STACK TEMPERATURE = 280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,50 IN, OF HG MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 2,9437E-03 GR/ACF 4,5342E-03 GR/DNCF 6,7361E+00 MG/ACM 1,0376E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,55	7,40	4,56	3,21	2,09	0,97	0,58	0,43	
MASS (MILLIGRAMS)	0,82	0,50	1,12	1,00	1,23	1,70	1,61	0,68	0,45
MG/DNCM/STAGE	9,34E-01	5,69E-01	1,28E+00	1,14E+00	1,40E+00	1,94E+00	1,83E+00	7,74E-01	5,13E-01
CUM, PERCENT OF MASS SMALLER THAN D50	91,00	85,52	73,22	62,24	48,74	30,08	12,41	4,94	
CUM, (MG/ACM) SMALLER THAN D50	6,13E+00	5,76E+00	4,93E+00	4,19E+00	3,28E+00	2,03E+00	8,36E-01	3,33E-01	
CUM, (MG/DNCM) SMALLER THAN D50	9,44E+00	8,87E+00	7,60E+00	6,46E+00	5,06E+00	3,12E+00	1,29E+00	5,13E-01	
CUM, (GR/ACF) SMALLER THAN D50	2,68E-03	2,52E-03	2,16E-03	1,83E-03	1,43E-03	8,86E-04	3,65E-04	1,46E-04	
CUM, (GR/DNCF) SMALLER THAN D50	4,13E-03	3,88E-03	3,32E-03	2,82E-03	2,21E-03	1,36E-03	5,63E-04	2,24E-04	
GEO, MEAN DIA, (MICROMETERS)	2,30E+01	8,84E+00	5,81E+00	3,82E+00	2,59E+00	1,42E+00	7,45E-01	4,95E-01	3,01E-01
DM/DLOGD (MG/DNCM)	1,38E+00	3,70E+00	6,06E+00	7,45E+00	7,52E+00	5,78E+00	8,16E+00	5,94E+00	1,70E+00
DN/DLOGD (NO, PARTICLES/DNCM)	9,08E+04	4,27E+06	2,46E+07	1,06E+08	3,45E+08	1,61E+09	1,57E+10	3,89E+10	4,95E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-16 1-13-76 1224 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,403 ACFM IMPACTOR TEMPERATURE = 280,0 F = 137,8 C SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG STACK TEMPERATURE = 280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,50 IN, OF HG MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 4,3878E-03 GR/ACF 6,7587E-03 GR/DNCF 1,0041E+01 MG/ACM 1,5466E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,48	7,36	4,53	3,19	2,07	0,96	0,57	0,42	
MASS (MILLIGRAMS)	1,97	1,21	3,14	2,10	1,55	1,96	1,27	0,44	0,11
MG/DNCM/STAGE	2,22E+00	1,36E+00	3,53E+00	2,36E+00	1,74E+00	2,20E+00	1,43E+00	4,95E-01	1,24E-01
CUM, PERCENT OF MASS SMALLER THAN D50	85,68	76,88	54,04	38,77	27,50	13,24	4,00	0,80	
CUM, (MG/ACM) SMALLER THAN D50	8,60E+00	7,72E+00	5,43E+00	3,89E+00	2,76E+00	1,33E+00	4,02E-01	8,08E-02	
CUM, (MG/DNCM) SMALLER THAN D50	1,33E+01	1,19E+01	8,36E+00	6,00E+00	4,25E+00	2,05E+00	6,19E-01	1,25E-01	
CUM, (GR/ACF) SMALLER THAN D50	3,76E-03	3,37E-03	2,37E-03	1,70E-03	1,21E-03	5,81E-04	1,76E-04	3,53E-05	
CUM, (GR/DNCF) SMALLER THAN D50	5,79E-03	5,20E-03	3,65E-03	2,62E-03	1,86E-03	8,95E-04	2,71E-04	5,44E-05	
GEO, MEAN DIA, (MICROMETERS)	2,29E+01	8,78E+00	5,77E+00	3,80E+00	2,57E+00	1,41E+00	7,40E-01	4,91E-01	2,99E-01
DM/DLOGD (MG/DNCM)	3,27E+00	8,85E+00	1,68E+01	1,55E+01	9,35E+00	6,58E+00	6,35E+00	3,79E+00	4,11E-01
DN/DLOGD (NO, PARTICLES/DNCM)	2,17E+05	1,04E+07	6,94E+07	2,24E+08	4,38E+08	1,87E+09	1,25E+10	2,54E+10	1,22E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-18 1-13-76 1634 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,394 ACFM   IMPACTOR TEMPERATURE = 280,0 F = 137,8 C   SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,42 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 4,2922E-03 GR/ACF   6,6294E-03 GR/DNCF   9,8221E+00 MG/ACM   1,5170E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,60	7,44	4,58	3,22	2,10	0,97	0,58	0,43	
MASS (MILLIGRAMS)	2,45	2,04	2,21	1,75	1,39	1,58	1,16	0,57	0,00
MG/DNCM/STAGE	2,83E+00	2,35E+00	2,55E+00	2,02E+00	1,60E+00	1,82E+00	1,34E+00	6,58E-01	0,00E-01
CUM, PERCENT OF MASS SMALLER THAN D50	81,37	65,86	49,05	35,75	25,18	13,16	4,34	0,01	
CUM, (MG/ACM) SMALLER THAN D50	7,99E+00	6,47E+00	4,82E+00	3,51E+00	2,47E+00	1,29E+00	4,26E-01	4,91E-04	
CUM, (MG/DNCM) SMALLER THAN D50	1,23E+01	9,99E+00	7,44E+00	5,42E+00	3,82E+00	2,00E+00	6,58E-01	7,59E-04	
CUM, (GR/ACF) SMALLER THAN D50	3,49E-03	2,83E-03	2,11E-03	1,53E-03	1,08E-03	5,65E-04	1,86E-04	2,15E-07	
CUM, (GR/DNCF) SMALLER THAN D50	5,39E-03	4,37E-03	3,25E-03	2,37E-03	1,67E-03	8,72E-04	2,88E-04	3,31E-07	
GEO, MEAN DIA, (MICROMETERS)	2,30E+01	8,88E+00	5,84E+00	3,84E+00	2,60E+00	1,43E+00	7,49E-01	4,98E-01	3,03E-01
DM/DLOGD (MG/DNCM)	4,20E+00	1,53E+01	1,21E+01	1,32E+01	8,61E+00	5,44E+00	5,96E+00	5,05E+00	0,00E-01
DN/DLOGD (NO, PARTICLES/DNCM)	2,74E+05	1,74E+07	4,84E+07	1,85E+08	3,89E+08	1,49E+09	1,13E+10	3,25E+10	0,00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-19 1-13-76 1630 PORTS 1,2,3

IMPACTOR FLOWRATE = 0,401 ACFM   IMPACTOR TEMPERATURE = 280,0 F = 137,8 C   SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,42 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 6,4558E-03 GR/ACF   9,9711E-03 GR/DNCF   1,4773E+01 MG/ACM   2,2817E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,51	7,37	4,54	3,19	2,08	0,96	0,57	0,42	
MASS (MILLIGRAMS)	5,50	2,87	2,57	1,69	1,60	3,13	1,82	0,37	0,58
MG/DNCM/STAGE	6,23E+00	3,25E+00	2,91E+00	1,92E+00	1,81E+00	3,55E+00	2,06E+00	4,19E-01	6,57E-01
CUM, PERCENT OF MASS SMALLER THAN D50	72,68	58,43	45,66	37,26	29,31	13,77	4,72	2,89	
CUM, (MG/ACM) SMALLER THAN D50	1,07E+01	8,63E+00	6,75E+00	5,50E+00	4,33E+00	2,03E+00	6,98E-01	4,26E-01	
CUM, (MG/DNCM) SMALLER THAN D50	1,66E+01	1,33E+01	1,04E+01	8,50E+00	6,69E+00	3,14E+00	1,08E+00	6,59E-01	
CUM, (GR/ACF) SMALLER THAN D50	4,69E-03	3,77E-03	2,95E-03	2,41E-03	1,89E-03	8,89E-04	3,05E-04	1,86E-04	
CUM, (GR/DNCF) SMALLER THAN D50	7,25E-03	5,83E-03	4,55E-03	3,72E-03	2,92E-03	1,37E-03	4,71E-04	2,88E-04	
GEO, MEAN DIA, (MICROMETERS)	2,29E+01	8,80E+00	5,79E+00	3,81E+00	2,58E+00	1,41E+00	7,42E-01	4,93E-01	3,00E-01
DM/DLOGD (MG/DNCM)	9,20E+00	2,12E+01	1,38E+01	1,25E+01	9,73E+00	1,06E+01	9,17E+00	3,21E+00	2,18E+00
DN/DLOGD (NO, PARTICLES/DNCM)	6,08E+05	2,47E+07	5,68E+07	1,81E+08	4,52E+08	2,98E+09	1,79E+10	2,14E+10	6,45E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-28 1-16-76 0917 PORTS 4,6

IMPACTOR FLOWRATE = 0,415 ACFM   IMPACTOR TEMPERATURE = 300,0 F = 148,9 C   SAMPLING DURATION = 80,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,45 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,1374E-02 GR/ACF   1,8025E-02 GR/DNCF   2,6029E+01 MG/ACM   4,1247E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,43	7,32	4,51	3,17	2,06	0,95	0,56	0,42	
MASS (MILLIGRAMS)	5,38	2,51	3,02	2,41	2,84	4,48	2,41	0,93	0,49
MG/DNCM/STAGE	9,07E+00	4,23E+00	5,09E+00	4,06E+00	4,79E+00	7,55E+00	4,06E+00	1,57E+00	8,26E-01
CUM, PERCENT OF MASS SMALLER THAN D50	78,02	67,76	55,42	45,57	33,96	15,66	5,81	2,01	
CUM, (MG/ACM) SMALLER THAN D50	2,03E+01	1,76E+01	1,44E+01	1,19E+01	8,84E+00	4,08E+00	1,51E+00	5,23E-01	
CUM, (MG/DNCM) SMALLER THAN D50	3,22E+01	2,79E+01	2,29E+01	1,88E+01	1,40E+01	6,46E+00	2,40E+00	8,28E-01	
CUM, (GR/ACF) SMALLER THAN D50	8,87E-03	7,71E-03	6,30E-03	5,18E-03	3,86E-03	1,78E-03	6,61E-04	2,28E-04	
CUM, (GR/DNCF) SMALLER THAN D50	1,41E-02	1,22E-02	9,99E-03	8,21E-03	6,12E-03	2,82E-03	1,05E-03	3,62E-04	
GEO, MEAN DIA, (MICROMETERS)	2,28E+01	8,74E+00	5,74E+00	3,78E+00	2,56E+00	1,40E+00	7,33E-01	4,85E-01	2,95E-01
DM/DLOGD (MG/DNCM)	1,33E+01	2,75E+01	2,42E+01	2,66E+01	2,56E+01	2,25E+01	1,80E+01	1,19E+01	2,74E+00
DN/DLOGD (NO, PARTICLES/DNCM)	8,90E+05	3,28E+07	1,02E+08	3,92E+08	1,22E+09	6,52E+09	3,64E+10	8,30E+10	8,51E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-29 1-16-76 0914 PORTS 1,3

IMPACTOR FLOWRATE = 0,394 ACFM   IMPACTOR TEMPERATURE = 300,0 F = 148,9 C   SAMPLING DURATION = 80,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 29,45 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 8,8570E-03 GR/ACF   1,4035E-02 GR/DNCF   2,0268E+01 MG/ACM   3,2118E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,71	7,51	4,63	3,25	2,12	0,98	0,58	0,43	
MASS (MILLIGRAMS)	0,00	2,46	1,33	2,16	2,47	5,19	2,39	0,67	1,42
MG/DNCM/STAGE	0,00E-01	4,37E+00	2,36E+00	3,83E+00	4,39E+00	9,21E+00	4,24E+00	1,19E+00	2,52E+00
CUM, PERCENT OF MASS SMALLER THAN D50	**,**	86,41	79,05	67,11	53,46	24,77	11,56	7,85	
CUM, (MG/ACM) SMALLER THAN D50	2,03E+01	1,75E+01	1,60E+01	1,36E+01	1,08E+01	5,02E+00	2,34F+00	1,59E+00	
CUM, (MG/DNCM) SMALLER THAN D50	3,21E+01	2,78E+01	2,54E+01	2,16E+01	1,72E+01	7,96E+00	3,71E+00	2,52E+00	
CUM, (GR/ACF) SMALLER THAN D50	8,86E-03	7,65E-03	7,00E-03	5,94E-03	4,73E-03	2,19E-03	1,02E-03	6,96E-04	
CUM, (GR/DNCF) SMALLER THAN D50	1,40E-02	1,21E-02	1,11E-02	9,42E-03	7,50E-03	3,48E-03	1,62E-03	1,10E-03	
GEO, MEAN DIA, (MICROMETERS)	2,31E+01	8,97E+00	5,90E+00	3,88E+00	2,63E+00	1,44E+00	7,55E-01	5,01E-01	3,05E-01
DM/DLOGD (MG/DNCM)	0,00E-01	2,84E+01	1,12E+01	2,51E+01	2,35E+01	2,75E+01	1,88E+01	9,09E+00	8,38E+00
DN/DLOGD (NO, PARTICLES/DNCM)	0,00E-01	3,13E+07	4,35E+07	3,42E+08	1,03E+09	7,33E+09	3,49E+10	5,76E+10	2,36E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-30 1-16-76 1342 PORTS 1,2,3

IMPACTOR FLOWRATE = 0.418 ACFM IMPACTOR TEMPERATURE = 300.0 F = 148.9 C SAMPLING DURATION = 90.00 MIN

IMPACTOR PRESSURE DROP = 0.5 IN. OF HG STACK TEMPERATURE = 300.0 F = 148.9 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM. STACK PRESSURE = 29.45 IN. OF HG MAX. PARTICLE DIAMETER = 50.0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12.88 CO = 0.00 N2 = 73.60 O2 = 5.52 H2O = 8.00

CALC. MASS LOADING = 1.1367E-02 GR/ACF 1.8013E-02 GR/DNCF 2.6012E+01 MG/ACM 4.1220E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.39	7.29	4.49	3.16	2.05	0.95	0.56	0.42	
MASS (MILLIGRAMS)	3.29	2.60	5.02	3.14	4.84	5.47	2.30	0.25	0.80
MG/DNCM/STAGE	4.89E+00	3.87E+00	7.47E+00	4.67E+00	7.20E+00	8.14E+00	3.42E+00	3.72E-01	1.19E+00
CUM. PERCENT OF MASS SMALLER THAN D50	88.13	78.75	60.63	49.30	31.83	12.09	3.79	2.89	
CUM. (MG/ACM) SMALLER THAN D50	2.29E+01	2.05E+01	1.58E+01	1.28E+01	8.28E+00	3.15E+00	9.87E-01	7.52E-01	
CUM. (MG/DNCM) SMALLER THAN D50	3.63E+01	3.25E+01	2.50E+01	2.03E+01	1.31E+01	4.99E+00	1.56E+00	1.19E+00	
CUM. (GR/ACF) SMALLER THAN D50	1.00E-02	8.95E-03	6.89E-03	5.60E-03	3.62E-03	1.37E-03	4.31E-04	3.29E-04	
CUM. (GR/DNCF) SMALLER THAN D50	1.59E-02	1.42E-02	1.09E-02	8.88E-03	5.73E-03	2.18E-03	6.83E-04	5.21E-04	
GEO. MEAN DIA. (MICROMETERS)	2.28E+01	8.70E+00	5.72E+00	3.76E+00	2.55E+00	1.39E+00	7.30E-01	4.83E-01	2.94E-01
DM/DLOGD (MG/DNCM)	7.17E+00	2.51E+01	3.55E+01	3.05E+01	3.86E+01	2.42E+01	1.51E+01	2.82E+00	3.95E+00
DN/DLOGD (NO. PARTICLES/DNCM)	4.82E+05	3.03E+07	1.51E+08	4.56E+08	1.86E+09	7.10E+09	3.10E+10	1.99E+10	1.24E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

1COLO-31 1-16-76 1336 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,415 ACFM IMPACTOR TEMPERATURE = 300,0 F = 148,9 C SAMPLING DURATION = 90,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG STACK TEMPERATURE = 300,0 F = 148,9 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM, STACK PRESSURE = 29,45 IN, OF HG MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT) CO2 = 12,88 CO = 0,00 N2 = 73,60 O2 = 5,52 H2O = 8,00

CALC, MASS LOADING = 1,1569E-02 GR/ACF 1,8333E-02 GR/DNCF 2,6474E+01 MG/ACM 4,1953E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,43	7,32	4,51	3,17	2,06	0,95	0,56	0,42	
MASS (MILLIGRAMS)	4,13	2,83	3,19	3,79	2,97	4,73	2,81	1,24	2,31
MG/DNCM/STAGE	6,19E+00	4,24E+00	4,78E+00	5,68E+00	4,45E+00	7,09E+00	4,21E+00	1,86E+00	3,46E+00
CUM, PERCENT OF MASS SMALLER THAN D50	85,25	75,15	63,75	50,22	39,61	22,72	12,68	8,25	
CUM, (MG/ACM) SMALLER THAN D50	2,26E+01	1,99E+01	1,69E+01	1,33E+01	1,05E+01	6,01E+00	3,36E+00	2,19E+00	
CUM, (MG/DNCM) SMALLER THAN D50	3,58E+01	3,15E+01	2,67E+01	2,11E+01	1,66E+01	9,53E+00	5,32E+00	3,46E+00	
CUM, (GR/ACF) SMALLER THAN D50	9,86E-03	8,69E-03	7,38E-03	5,81E-03	4,58E-03	2,63E-03	1,47E-03	9,55E-04	
CUM, (GR/DNCF) SMALLER THAN D50	1,56E-02	1,38E-02	1,17E-02	9,21E-03	7,26E-03	4,17E-03	2,33E-03	1,51E-03	
GEO, MEAN DIA, (MICROMETERS)	2,28E+01	8,74E+00	5,74E+00	3,78E+00	2,56E+00	1,40E+00	7,33E-01	4,85E-01	2,95E-01
DM/DLOGD (MG/DNCM)	9,09E+00	2,76E+01	2,27E+01	3,71E+01	2,38E+01	2,11E+01	1,86E+01	1,41E+01	1,15E+01
DN/DLOGD (NO, PARTICLES/DNCM)	6,08E+05	3,29E+07	9,54E+07	5,48E+08	1,14E+09	6,12E+09	3,77E+10	9,83E+10	3,57E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-36 1-19-76 1541 PORTS 1,2,3

IMPACTOR FLOWRATE = 0,399 ACFM   IMPACTOR TEMPERATURE = 285,0 F = 140,6 C   SAMPLING DURATION = 84,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 285,0 F = 140,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,06 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,6203E-02 GR/ACF   2,4659E-02 GR/DNCF   3,7078E+01 MG/ACM   5,6428E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,56	7,41	4,57	3,21	2,09	0,97	0,58	0,43	
MASS (MILLIGRAMS)	3,53	3,78	4,87	4,65	4,80	6,99	4,23	1,18	1,16
MG/DNCM/STAGE	5,66E+00	6,06E+00	7,81E+00	7,46E+00	7,70E+00	1,12E+01	6,78E+00	1,89E+00	1,86E+00
CUM, PERCENT OF MASS SMALLER THAN D50	89,97	79,23	65,39	52,18	38,54	18,68	6,65	3,30	
CUM, (MG/ACM) SMALLER THAN D50	3,34E+01	2,94E+01	2,42E+01	1,93E+01	1,43E+01	6,92E+00	2,47E+00	1,22E+00	
CUM, (MG/DNCM) SMALLER THAN D50	5,08E+01	4,47E+01	3,69E+01	2,94E+01	2,17E+01	1,05E+01	3,76E+00	1,86E+00	
CUM, (GR/ACF) SMALLER THAN D50	1,46E-02	1,28E-02	1,06E-02	8,45E-03	6,24E-03	3,03E-03	1,08E-03	5,35E-04	
CUM, (GR/DNCF) SMALLER THAN D50	2,22E-02	1,95E-02	1,61E-02	1,29E-02	9,50E-03	4,61E-03	1,64E-03	8,14E-04	
GEO, MEAN DIA, (MICROMETERS)	2,30E+01	8,85E+00	5,82E+00	3,83E+00	2,59E+00	1,42E+00	7,47E-01	4,97E-01	3,03E-01
DM/DLOGD (MG/DNCM)	8,38E+00	3,94E+01	3,71E+01	4,88E+01	4,13E+01	3,35E+01	3,02E+01	1,46E+01	6,18E+00
DN/DLOGD (NO, PARTICLES/DNCM)	5,50E+05	4,53E+07	1,50E+08	6,91E+08	1,89E+09	9,25E+09	5,76E+10	9,44E+10	1,77E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-37 1-19-76 1544 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,396 ACFM   IMPACTOR TEMPERATURE = 285,0 F = 140,6 C   SAMPLING DURATION = 84,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 285,0 F = 140,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,06 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 1,3403E-02 GR/ACF   2,0398E-02 GR/DNCF   3,0671E+01 MG/ACM   4,6677E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,60	7,44	4,58	3,23	2,10	0,97	0,58	0,43	
MASS (MILLIGRAMS)	5,40	2,32	2,95	2,61	3,27	5,73	3,52	2,01	1,08
MG/DNCM/STAGE	8,72E+00	3,75E+00	4,77E+00	4,22E+00	5,28E+00	9,26E+00	5,69E+00	3,25E+00	1,74E+00
CUM, PERCENT OF MASS SMALLER THAN D50	81,31	73,28	63,07	54,04	42,72	22,88	10,70	3,74	
CUM, (MG/ACM) SMALLER THAN D50	2,49E+01	2,25E+01	1,93E+01	1,66E+01	1,31E+01	7,02E+00	3,28E+00	1,15E+00	
CUM, (MG/DNCM) SMALLER THAN D50	3,80E+01	3,42E+01	2,94E+01	2,52E+01	1,99E+01	1,07E+01	4,99E+00	1,75E+00	
CUM, (GR/ACF) SMALLER THAN D50	1,09E-02	9,82E-03	8,45E-03	7,24E-03	5,73E-03	3,07E-03	1,43E-03	5,02E-04	
CUM, (GR/DNCF) SMALLER THAN D50	1,66E-02	1,49E-02	1,29E-02	1,10E-02	8,71E-03	4,67E-03	2,18E-03	7,64E-04	
GEO, MEAN DIA, (MICROMETERS)	2,30E+01	8,88E+00	5,84E+00	3,85E+00	2,60E+00	1,43E+00	7,50E-01	4,99E-01	3,04E-01
DM/DLOGD (MG/DNCM)	1,30E+01	2,44E+01	2,27E+01	2,76E+01	2,84E+01	2,77E+01	2,54E+01	2,50E+01	5,80E+00
DN/DLOGD (NO, PARTICLES/DNCM)	8,45E+05	2,77E+07	9,05E+07	3,87E+08	1,28E+09	7,55E+09	4,77E+10	1,60E+11	1,64E+11

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-39 1-20-76 0943 PORTS 1,2,3

IMPACTOR FLOWRATE = 0.410 ACFM   IMPACTOR TEMPERATURE = 280.0 F = 137.8 C   SAMPLING DURATION = 120.00 MIN

IMPACTOR PRESSURE DROP = 0.5 IN. OF HG   STACK TEMPERATURE = 280.0 F = 137.8 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 30.00 IN. OF HG   MAX. PARTICLE DIAMETER = 50.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 4.6674E-03 GR/ACF   7.0694E-03 GR/DNCF   1.0681E+01 MG/ACM   1.6177E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.39	7.29	4.49	3.16	2.06	0.95	0.57	0.42	
MASS (MILLIGRAMS)	2.48	1.23	1.68	1.92	1.91	2.82	1.89	0.73	0.22
MG/DNCM/STAGE	2.70E+00	1.34E+00	1.83E+00	2.09E+00	2.08E+00	3.07E+00	2.05E+00	7.94E-01	2.39E-01
CUM. PERCENT OF MASS SMALLER THAN D50	83.34	75.07	63.78	50.88	38.04	19.09	6.39	1.48	
CUM. (MG/ACM) SMALLER THAN D50	8.90E+00	8.02E+00	6.81E+00	5.43E+00	4.06E+00	2.04E+00	6.82E-01	1.58E-01	
CUM. (MG/DNCM) SMALLER THAN D50	1.35E+01	1.21E+01	1.03E+01	8.23E+00	6.15E+00	3.09E+00	1.03E+00	2.40E-01	
CUM. (GR/ACF) SMALLER THAN D50	3.89E-03	3.50E-03	2.98E-03	2.37E-03	1.78E-03	8.91E-04	2.98E-04	6.92E-05	
CUM. (GR/DNCF) SMALLER THAN D50	5.89E-03	5.31E-03	4.51E-03	3.60E-03	2.69E-03	1.35E-03	4.52E-04	1.05E-04	
GEO. MEAN DIA. (MICROMETERS)	2.28E+01	8.71E+00	5.72E+00	3.77E+00	2.55E+00	1.40E+00	7.34E-01	4.88E-01	2.97E-01
DM/DLOGD (MG/DNCM)	3.95E+00	8.70E+00	8.68E+00	1.37E+01	1.11E+01	9.15E+00	9.14E+00	6.10E+00	7.95E-01
DN/DLOGD (NO. PARTICLES/DNCM)	2.66E+05	1.05E+07	3.68E+07	2.03E+08	5.35E+08	2.66E+09	1.84E+10	4.17E+10	2.41E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

1COLO-40 1-20-76 0945 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,381 ACFM   IMPACTOR TEMPERATURE = 280,0 F = 137,8 C   SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 280,0 F = 137,8 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,00 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 5,5796E-03 GR/ACF   8,4511E-03 GR/DNCF   1,2768E+01 MG/ACM   1,9339E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,78	7,57	4,66	3,28	2,14	0,99	0,59	0,44	
MASS (MILLIGRAMS)	3,08	2,16	2,18	2,48	2,33	2,71	1,52	0,07	0,00
MG/DNCM/STAGE	3,60E+00	2,53E+00	2,55E+00	2,90E+00	2,73E+00	3,17E+00	1,78E+00	8,19E-02	0,00E-01
CUM, PERCENT OF MASS SMALLER THAN D50	81,37	68,31	55,12	40,11	26,02	9,62	0,43	0,01	
CUM, (MG/ACM) SMALLER THAN D50	1,04E+01	8,72E+00	7,04E+00	5,12E+00	3,32E+00	1,23E+00	5,47E-02	6,38E-04	
CUM, (MG/DNCM) SMALLER THAN D50	1,57E+01	1,32E+01	1,07E+01	7,76E+00	5,03E+00	1,86E+00	8,29E-02	9,67E-04	
CUM, (GR/ACF) SMALLER THAN D50	4,54E-03	3,81E-03	3,08E-03	2,24E-03	1,45E-03	5,37E-04	2,39E-05	2,79E-07	
CUM, (GR/DNCF) SMALLER THAN D50	6,88E-03	5,77E-03	4,66E-03	3,39E-03	2,20E-03	8,13E-04	3,62E-05	4,23E-07	
GEO, MEAN DIA, (MICROMETERS)	2,32E+01	9,03E+00	5,94E+00	3,91E+00	2,65E+00	1,46E+00	7,65E-01	5,10E-01	3,11E-01
DM/DLOGD (MG/DNCM)	5,41E+00	1,64E+01	1,21E+01	1,90E+01	1,46E+01	9,48E+00	7,95E+00	6,34E-01	0,00E-01
DN/DLOGD (NO, PARTICLES/DNCM)	3,44E+05	1,77E+07	4,60E+07	2,53E+08	6,27E+08	2,45E+09	1,41E+10	3,80E+09	0,00E-01

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-41 1-20-76 1417 PORTS 4,5,6

IMPACTOR FLOWRATE = 0,398 ACFM   IMPACTOR TEMPERATURE = 276,0 F = 135,6 C   SAMPLING DURATION = 120,00 MIN

IMPACTOR PRESSURE DROP = 0,5 IN, OF HG   STACK TEMPERATURE = 276,0 F = 135,6 C

ASSUMED PARTICLE DENSITY = 2,40 GM/CU,CM,   STACK PRESSURE = 30,00 IN, OF HG   MAX, PARTICLE DIAMETER = 50,0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12,88   CO = 0,00   N2 = 73,60   O2 = 5,52   H2O = 8,00

CALC, MASS LOADING = 4,5851E-03 GR/ACF   6,9073E-03 GR/DNCF   1,0492E+01 MG/ACM   1,5806E+01 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10,53	7,39	4,55	3,20	2,09	0,97	0,58	0,43	
MASS (MILLIGRAMS)	2,53	1,26	3,05	1,83	1,72	2,20	0,98	0,33	0,29
MG/DNCM/STAGE	2,82E+00	1,40E+00	3,40E+00	2,04E+00	1,92E+00	2,45E+00	1,09E+00	3,68E-01	3,23E-01
CUM, PERCENT OF MASS SMALLER THAN D50	82,18	73,30	51,80	38,91	26,78	11,28	4,37	2,05	
CUM, (MG/ACM) SMALLER THAN D50	8,62E+00	7,69E+00	5,44E+00	4,08E+00	2,81E+00	1,18E+00	4,59E-01	2,15E-01	
CUM, (MG/DNCM) SMALLER THAN D50	1,30E+01	1,16E+01	8,19E+00	6,15E+00	4,23E+00	1,78E+00	6,91E-01	3,24E-01	
CUM, (GR/ACF) SMALLER THAN D50	3,77E-03	3,36E-03	2,38E-03	1,78E-03	1,23E-03	5,17E-04	2,01E-04	9,39E-05	
CUM, (GR/DNCF) SMALLER THAN D50	5,68E-03	5,06E-03	3,58E-03	2,69E-03	1,85E-03	7,79E-04	3,02E-04	1,42E-04	
GEO, MEAN DIA, (MICROMETERS)	2,29E+01	8,82E+00	5,80E+00	3,82E+00	2,58E+00	1,42E+00	7,46E-01	4,96E-01	3,02E-01
DM/DLOGD (MG/DNCM)	4,16E+00	9,13E+00	1,62E+01	1,33E+01	1,03E+01	7,32E+00	4,87E+00	2,83E+00	1,07E+00
DN/DLOGD (NO, PARTICLES/DNCM)	2,74E+05	1,06E+07	6,59E+07	1,91E+08	4,74E+08	2,04E+09	9,35E+09	1,85E+10	3,09E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG,

1COLO-42 1-20-76 1415 PORTS 1,2,3

IMPACTOR FLOWRATE = 0.417 ACFM   IMPACTOR TEMPERATURE = 276.0 F = 135.6 C   SAMPLING DURATION = 120.00 MIN

IMPACTOR PRESSURE DROP = 0.5 IN. OF HG   STACK TEMPERATURE = 276.0 F = 135.6 C

ASSUMED PARTICLE DENSITY = 2.40 GM/CU.CM.   STACK PRESSURE = 30.00 IN. OF HG   MAX. PARTICLE DIAMETER = 50.0 MICROMETERS

GAS COMPOSITION (PERCENT)   CO2 = 12.88   CO = 0.00   N2 = 73.60   O2 = 5.52   H2O = 8.00

CALC. MASS LOADING = 1.7394E-03 GR/ACF   2.6203E-03 GR/DNCF   3.9803E+00 MG/ACM   5.9961E+00 MG/DNCM

IMPACTOR STAGE	S1	S2	S3	S4	S5	S6	S7	S8	FILTER
STAGE INDEX NUMBER	1	2	3	4	5	6	7	8	9
D50 (MICROMETERS)	10.28	7.22	4.45	3.13	2.04	0.94	0.56	0.42	
MASS (MILLIGRAMS)	1.12	0.64	0.50	0.38	0.67	0.97	0.55	0.56	0.25
MG/DNCM/STAGE	1.19E+00	6.80E-01	5.32E-01	4.04E-01	7.12E-01	1.03E+00	5.85E-01	5.95E-01	2.66E-01
CUM. PERCENT OF MASS SMALLER THAN D50	80.15	68.80	59.93	53.20	41.32	24.12	14.37	4.44	
CUM. (MG/ACM) SMALLER THAN D50	3.19E+00	2.74E+00	2.39E+00	2.12E+00	1.64E+00	9.60E-01	5.72E-01	1.77E-01	
CUM. (MG/DNCM) SMALLER THAN D50	4.81E+00	4.13E+00	3.59E+00	3.19E+00	2.48E+00	1.45E+00	8.61E-01	2.66E-01	
CUM. (GR/ACF) SMALLER THAN D50	1.39E-03	1.20E-03	1.04E-03	9.25E-04	7.19E-04	4.20E-04	2.50E-04	7.72E-05	
CUM. (GR/DNCF) SMALLER THAN D50	2.10E-03	1.80E-03	1.57E-03	1.39E-03	1.08E-03	6.32E-04	3.76E-04	1.16E-04	
GEO. MEAN DIA. (MICROMETERS)	2.27E+01	8.61E+00	5.66E+00	3.73E+00	2.52E+00	1.38E+00	7.26E-01	4.83E-01	2.94E-01
DM/DLOGD (MG/DNCM)	1.73E+00	4.43E+00	2.53E+00	2.64E+00	3.82E+00	3.08E+00	2.60E+00	4.57E+00	8.83E-01
DN/DLOGD (NO. PARTICLES/DNCM)	1.18E+05	5.51E+06	1.11E+07	4.06E+07	1.89E+08	9.24E+08	5.40E+09	3.24E+10	2.77E+10

NORMAL (ENGINEERING STANDARD) CONDITIONS ARE 21 DEG C AND 760MM HG.

APPENDIX B

Figures 1 and 2 show penetration-efficiency curves for half-normal and normal current density operation. In these figures data are plotted for measurements made with calibrated and uncalibrated impactors and ultrafine measurements made with the ultrafine particle sizing system.

Since these data were first reduced, the impactors used in field test measurements have been calibrated according to the procedures given in EPA reports 600/2-76-118[1] and 600/2-77-004[2]. In addition the upper stages of each type of impactor used were calibrated with ammonium fluorescein aerosols in the size range from 2 μm to 8 μm. Typical impactor calibrations were reported in EPA report 600/2-76-280[3], "Particulate Sizing Techniques for Control Device Evaluation: Cascade Impactor Calibrations".

The effect of these calibrations is shown in the figures. Data recalculated for calibrated impactors are shown as solid circles with 50% confidence intervals. Data for uncalibrated impactors are shown with solid triangles with no confidence intervals drawn. Ultrafine data are plotted with open circles and 50% confidence intervals. In general calibrated and uncalibrated impactor data follow approximately the same shape curve with the notable difference of uncalibrated impactor data at 0.45 μm.

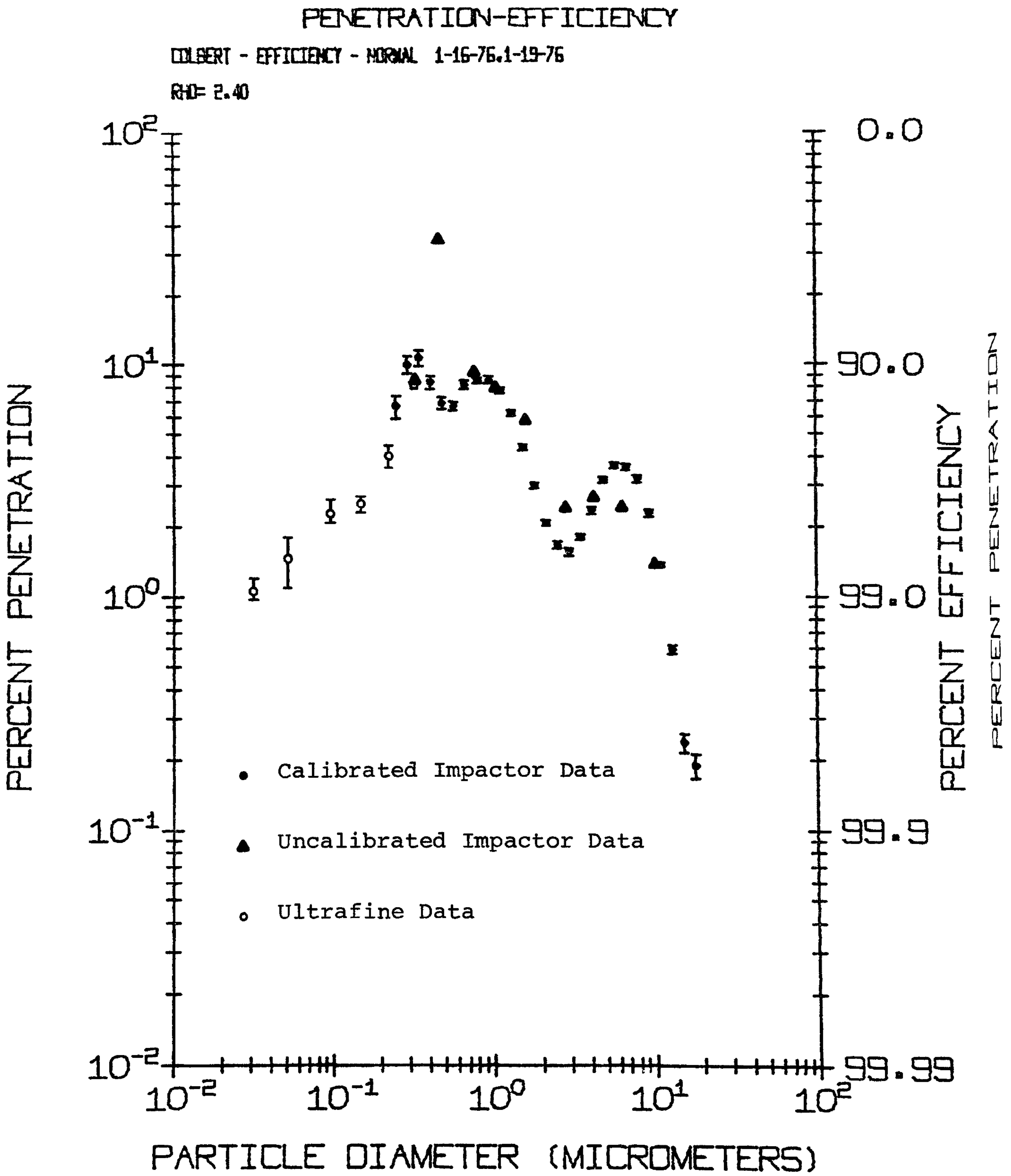


Figure 1. Half normal current density penetration-efficiency graph with calibrated and uncalibrated cascade impactor and ultrafine data shown. The uncalibrated impactor data is shown without confidence intervals. 50% confidence intervals are shown for all other data.

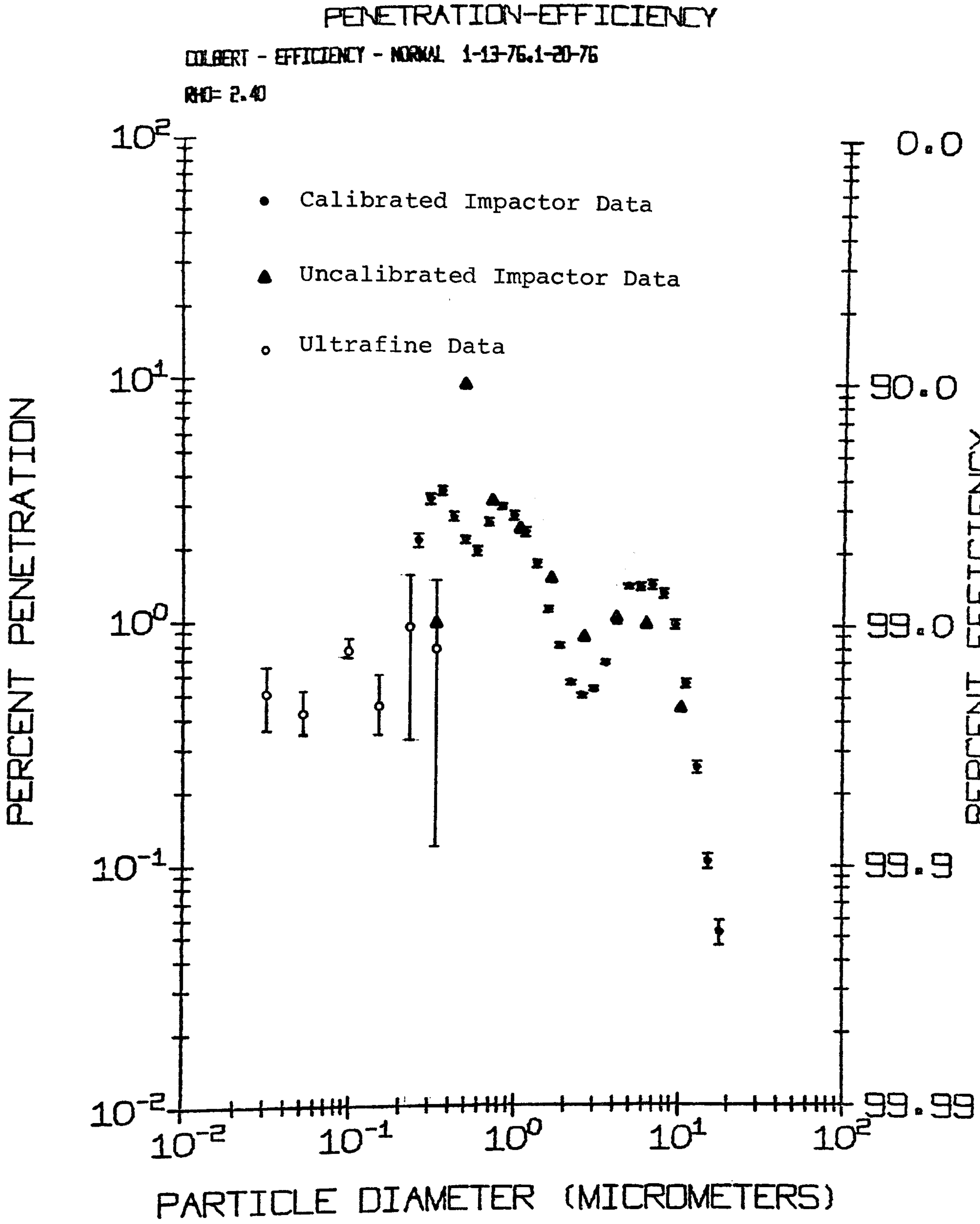


Figure 2. Normal current density penetration-efficiency graph with calibrated and uncalibrated cascade impactor and ultrafine data shown. The uncalibrated impactor data is shown without confidence intervals. 50% confidence intervals are shown for all other data.

REFERENCES

1. Calvert, S., Lake, C., and Parker, R., "Cascade Impactor Calibration Guidelines", Air Pollution Technology, Inc. EPA Contract No. 68-02-1869, U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Report EPA-600/2-76-118. Research Triangle Park, N.C., April, 1976.

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3. Cushing, K., Lacey, G., McCain, J., and Smith, W., "Particulate Sizing Techniques for Control Device Evaluation: Cascade Impactor Calibrations", Southern Research Institute, EPA Contract No. 68-02-0273. U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Report EPA-600/2-76-280, Research Triangle Park, N.C., October, 1976.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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16. ABSTRACT The report gives results of fractional and overall collection efficiency measurements of an electrostatic precipitator collecting fly ash from a coal-fired boiler burning high-sulfur coal. The mass median diameter of the particulate entering the collector was approximately 40 micrometers; that leaving the collector was between 3 and 4 micrometers. Measurements were conducted at two levels of precipitator operating current density. Measured efficiencies were compared with those predicted from a computer model of electrostatic precipitation. Measured efficiencies are higher than predicted.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Air Pollution	Coal	Air Pollution Control	13B	21D
Measurement	Fly Ash	Stationary Sources	14B	21B
Dust	Mathematical Models	Particulate	11G	12A
Electrostatic precipitation		Collection Efficiency	13H	
Boilers			13A	

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