Background Report Reference

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Reference Number: 32

Title: Emission Test Report: Texasgulf, Granger, Wyoming

US EPA

US EPA

May 1979

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United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EMB Report 79-SOD-1
May 1979

Air

Section 5.16
Reference #32

EPA

Sodium Carbonat

Emission Test Repor
Texasgulf
Granger, Wyoming

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
EMISSION MEASUREMENT BRANCH
MAIL DROP 13
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

DRAFT REPORT

EMISSION TEST PROGRAM: SODIUM CARBONATE MANUFACTURING PLANT

CONDUCTED AT

TEXASGULF, INC.
GRANGER, WYOMING 82934

CONTRACT NUMBER	68-02-2819
TASK ASSIGNMENT	14
PROJECT NUMBER	79-SOD-1
YORK PROJECT NUMBER	1-9517-14

AUGUST 1, 1979

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1.0 INTRODUCTION

York Research Corporation (YRC) under contract 68-02-2819 was requested by the United States Environmental Protection Agency (USEPA) to perform an emission test program at a sodium carbonate manufacturing plant. The test program was conducted at the Texasgulf Corporation located in Granger, Wyoming. Sampling was performed from May 21, 1979 to May 24, 1979. The sampling locations included:

- Product Dryer Inlet
- Product Dryer Outlet
- Trona Calciner Inlet
- Trona Calciner Outlet

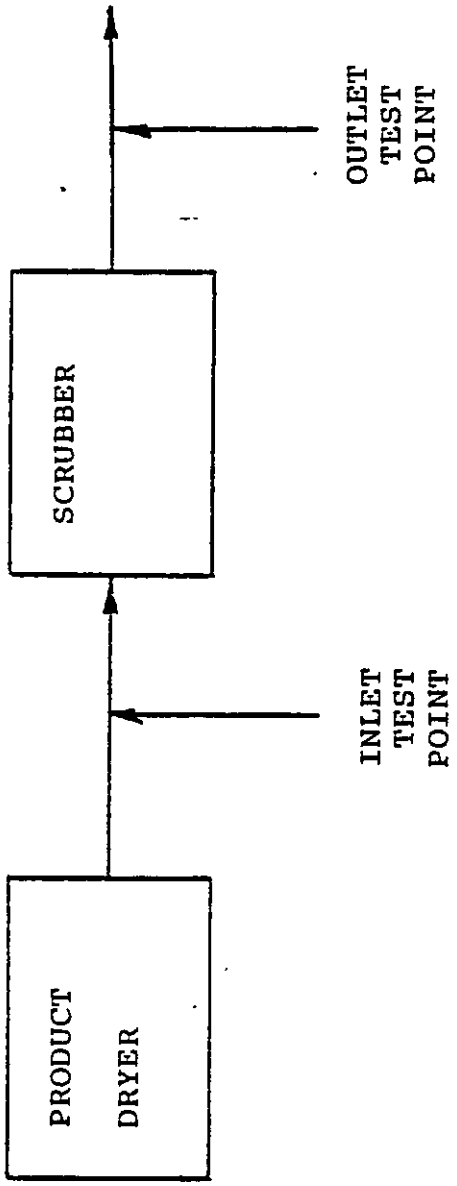
Figures 1-1 and 1-2 show the sampling locations in the process. Samples were collected for solid particulate organics, sulfur dioxide and particle size distribution. The objective of the test program was to determine the emission levels of controlled sodium carbonate production facilities to support planned source emission standards in the sodium carbonate industry.

The test team consisted of the following individuals:

Name	Affiliation	Title
Dennis Holzschuh	USEPA	Technical Manager
Roger A. Kniskern	YRC	Project Manager
William J. Cesareo	YRC	Project Director
John Breger	YRC	Test Engineer
Keith Synnestvedt	YRC	Test Technician
Albert Burton	YRC	Test Technician
Laurie Behr	YRC	Test Technician
Joseph Kuntz	YRC	Chemical Technician
Bruce Wuebber	YRC	Test Technician

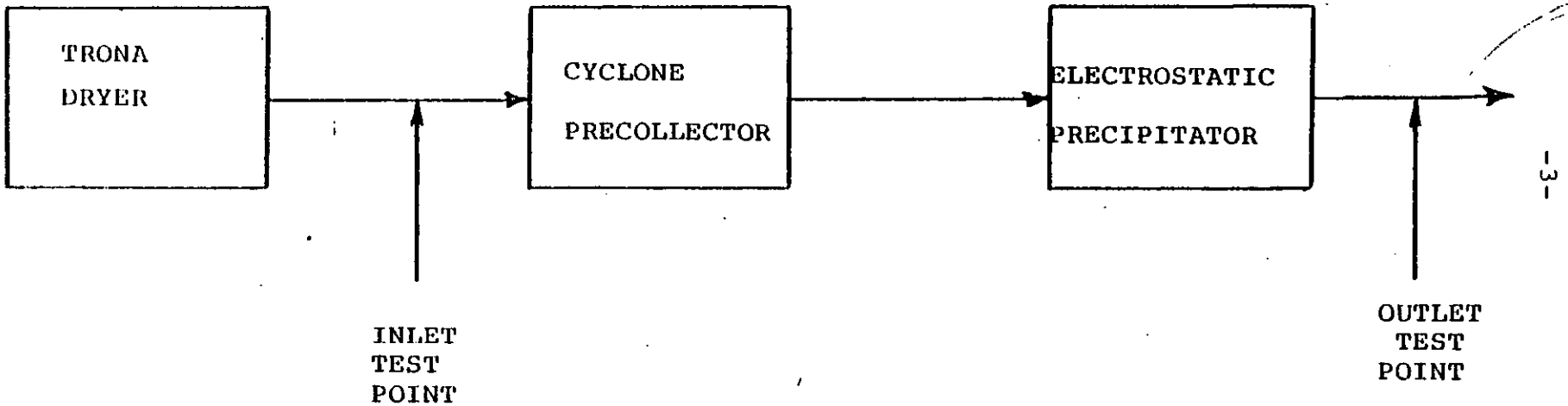
2.0 SUMMARY AND DISCUSSION OF TEST RESULTS

Tables 2-1 through 2-19 and Figures 2-1 through 2-4 summarize the results of the emission test program. These tables present the results of tests for the following parameters:



PRODUCT DRYER PROCESS DIAGRAM

FIGURE 1-1



TRONA DRYER PROCESS DIAGRAM

FIGURE 1-2

- Particulate
- Particle Size Distribution
- Visible Emissions
- Organics
- Sulfur Dioxide

Sample analysis for all parameters were performed at YRC laboratories in Stamford, Connecticut or Denver, Colorado with the exception of organics. A portable gas chromatograph with a flame ionization detector was set up at the test site for analysis of organic samples.

The following table details the isokinetic ratio results of the particulate tests conducted at the product dryer.

Test No.	1	2	3
Scrubber Inlet	146.5%	149.1%	120.9%
Scrubber Outlet	111.0%	94.2%	115.8%

Only outlet test 2 meets the isokinetic requirement (100 $\pm$ 10%) of the reference method.

In the majority of sampling situations encountered, the stack gas moisture can be estimated with an adequate degree of confidence so that isokinetic sampling can be easily achieved. This is the case when the moisture content of the gas stream is less than 30 percent by volume and is relatively constant. However, in those cases where the moisture content is greater than 30 percent, or when the moisture content varies significantly, such as is the case for the product dryer, a single average value is usually inadequate. Since the moisture content is not a linear variable in the isokinetic equation, the estimation error that is tolerable decreases as the absolute value of the moisture content increases or varies.

The moisture content of the flue gas at this product dryer sampling location varied from 51.1% to 61.1% at the inlet test location and from 31.7% to 52.3% at the outlet test location. These variations in moisture content were the cause of the anisokinetic sampling conditions at the sampling locations.

The anisokinetic conditions at each test location were such that the velocity in the nozzle was greater than the velocity in the stack ($V_n > V_s$). Under such conditions the measured concentration of particulate is less than the actual concentration in the stack gas. This is due to the inertial properties of the larger particles - they tend to pass the nozzle while the gas and the smaller particles are drawn into the nozzle. As a result, fewer particles are collected per unit volume. This being the case, it is important to sample isokinetically in streams where there are predominately large particles.

Correction factors for anisokinetic sampling are shown in Exhibit A. The following table detailing the test results is corrected for anisokinetic sampling.

Test No.	1	2	3
Inlet Particulate Concentration (gr/SCFD)			
Measured	32.25525	29.98808	33.62483
Correction Factor	0.6875	0.6745	0.8246
Actual	46.91673	44.45972	40.77714
Outlet Particulate Concentration (gr/SCFD)			
Measured	0.03761	0.04252	0.03789
Correction Factor	0.99	1.0000	0.99
Actual	0.03780	0.04252	0.03827
Scrubber Efficiency (%)			
Based on Measured	99.88	99.86	99.89
Based on Actual	99.92	99.90	99.91

EXHIBIT A

Appendix C

Errors due to Anisokinetic Sampling

Failure to withdraw a sample from a flowing stream at the same velocity as that which exists locally in the stream will result in nonrepresentative sampling. If the sampling rate is much higher than the local stream velocity, a greater fraction of smaller rather than larger particles will be drawn into the probe. If sampling is much lower than the stream velocity, large particles will be impacted into the collecting probe.

Although theoretical and experimental data are available, a comprehensive study of these errors has not been made. The data is almost entirely empirical and reflects different techniques using different particles. The influence of probe shape and size has yet to be fully evaluated.

In Table C1 the errors due to anisokinetic sampling rates are given, which represent data composited from several workers' experiments.[4]

Particles used in the studies yielding the data shown were coal dust, dibutyl phthalate, and fungus spores, all of which are relatively low density materials, ranging from 1.3 for coal dust to about 1 or somewhat less for the spores. Since particle density will materially increase the inertial effects, the sampling error could be considerably larger than the tabled values for a given particle size. The last column

[4]GREEN, H. L.; LANE, W. R. *Particulate Clouds: Dusts, Smokes, and Mists*. London: E. and F. N. Spon, Ltd. 1964. 2nd ed. p 272.

Table C1

Ratio of Observed to Actual Concentration of Particles when Sampled at Various Fractions and Multiples of Isokinetic Flow

$\frac{U}{U_o}$ = Probe inlet velocity / Duct velocity	$\frac{C}{C_o}$ = Observed concentration in sample / Actual concentration					Limit for Very Large Particles
	d_p = 4μm	d_p = 12μm	d_p = 17μm	d_p = 31μm	d_p = 37μm	
0.5	1.06	1.14	1.20	1.33	1.46	2.00
0.6	1.03	1.09	1.13	1.23	1.41	1.67
0.7	1.02	1.05	1.08	1.14	1.32	1.44
0.8	1.01	1.02	1.04	1.06	1.16	1.25
0.9	1.00	1.01	1.01	1.03	1.07	1.11
1.0	1.00	1.00	1.00	1.00	1.00	1.00
1.1	0.99	0.98	0.98	0.95	0.93	0.90
1.2	0.98	0.96	0.95	0.92	0.87	0.83
1.3	0.97	0.94	0.94	0.88	0.84	0.77
1.4	0.97	0.92	0.93	0.83	0.81	0.72
1.5	0.96	0.89	0.93	*	0.76	0.67
1.6	0.95	0.83	*	*	0.74	0.63
1.7	0.94	0.78	*	*	0.71	0.59
1.8	0.92	0.72	*	*	0.68	0.55
1.9	0.90	0.65	*	*	0.66	0.53
2.0	0.86	*	*	*	0.64	0.50

*Data does not cover this range.

of the table shows the limit of the concentration ratio for very large or dense particles. If the sampling probe inlet velocity is only 50 percent of the duct velocity and all large (or dense) particles in the projected area of the probe inlet are impacted into the probe, twice as many will be collected as should have been. Similarly, should the sampling probe inlet velocity be twice the duct velocity and the particle inertia be such that only those particles approaching in the projected area of the probe are collected, then the observed concentration would be one-half the actual concentration.

It must be remembered that particles generated by most natural processes vary widely in size, and the sampling error will be the composite effect of all particle sizes present.

The correction factor was applied as follows:

$$Fc = \frac{C}{Ca}$$

where: Fc = Correction Factor
C = Measured Concentration
Ca = Actual Concentration

therefore: $Ca = \frac{C}{Fc}$

The correction factor for the inlet concentrations was for large particles since the Bahco analysis showed that 83% of the particles were greater than 63μ. The correction factor for the outlet concentration was for dp = 4μ as only small particles are expected to be present.

As shown by the analysis, correcting for anisokinetic sampling increased the scrubber efficiency by 0.034%.

The scheduled test program was not completed at the trona dryer due to two major upsets. These upsets occurred due to blasting in the adjacent calciner and a chemical spill which made it impossible to remain in the area of the inlet test location. Hence, the second inlet particulate test was aborted and the remainder of the test program aborted when a major breakdown in a conveyor gearbox occurred. The only tests not completed were two inlet sulfur dioxide tests and the outlet particle size distribution tests.

Particle size distribution tests were to be conducted at each test location. However, due to the high moisture at the product dryer test locations it was impossible to obtain a representative sample. The moisture dissolved the material as it was collected on the substrates. Sufficient sample was collected at the inlet such that an aliquot from each test was taken and composited for a sieve and Bahco particle size analysis. It is not feasible to conduct a particle size analysis on any outlet filters because of the small amount of particulate.

Any scraping of the filter would bias the particle size by introducing fiberglass material into the sample; also, any extraction of the filter by use of solvents such as water would dissolve the particulate matter and the subsequent crystallization would not be representative of actual test conditions.

The sulfur dioxide test results from the trona dryer were at the lower limit of detection of the analytical method. Since there is no process data available a material balance cannot be performed to verify these results.

TABLE 2-1

SUMMARY OF EMISSION TEST RESULTS
PRODUCT DRYER
ENGLISH UNITS

Location	Run 1		Run 2		Run 3		Average	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Inlet
Date	5/21		5/21		5/21			
Volume of Gas Sampled (DSCF)[a]	22.55	33.34	20.79	32.82	24.67	30.64	-	-
Percent Moisture by Volume	52.7	44.8	51.1	31.7	61.1	52.3	55.0	42.9
Average Stack Temperature (^{o}F)	187.0	160.0	186.8	160.0	188.5	160.8	187.4	160.4
Stack Volumetric Flow Rate (DSCFM)[b]	16875.	14076.	15292	16331.	12514.	12396.	14894.	14267
Percent Isokinetic	146.5	111.0	149.1	94.2	120.9	115.8	138.8	107.0
Total Particulate -								
Filter Catch and Front Half Acetone Wash								
gr/DSCF	32.25525	0.03671	29.98808	0.04252	33.62483	0.03443	31.95605	0.03789
lb/hr	4665.61	4.43	3930.81	5.95	3606.65	3.66	4067.69	4.68
Collection Efficiency, Percent	99.86		99.85		99.89		99.87	

[a] Dry Standard Cubic Feet at 68^{o}F, 29.92 inches Hg.

[b] Dry Standard Cubic Feet per minute at 68^{o}F, 29.92 inches Hg.

TABLE 2-2

SUMMARY OF EMISSION TEST RESULTS
PRODUCT DRYER
METRIC UNITS

Location	Run 1		Run 2		Run 3		Average	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	5/21		5/21		5/21			
Volume of Gas Sampled (DNm^3)[a]	0.64	0.94	0.59	0.93	0.70	0.87	-	-
Percent Moisture by Volume	52.7	44.8	51.1	31.7	61.1	52.3	55.0	42.9
Average Stack Temperature, (^oC)	86.1	71.1	86.0	71.1	86.9	71.6	86.3	71.3
Stack Volumetric Flow Rate (DNm^3/min)[b]	478	399	433	462	354	351	422	404
Percent Isokinetic	146.5	111.0	149.1	94.2	120.9	115.8	138.8	107.0
Insoluble Particulate -								
Filter Catch and Front Half Acetone Wash								
mg/DNm^3	73812.19	84.01	68624.05	97.31	76946.32	78.78	73127.52	86.70
Kg/hr	2116.32	2.01	1783.01	2.70	1635.97	1.66	1845.10	2.12
Collection Efficiency, Percent	99.86		99.85		99.89		99.87	

[a] Dry Normalized Cubic Meters at 20°C, 760mm Hg

[b] Dry Normalized Cubic Meters at 20°C, 760mm Hg

TABLE 2-3

SUMMARY OF EMISSION TEST RESULTS
TRONA DRYER
ENGLISH UNITS

Location	Run 1		Run 2		Run 3	Average	
	Inlet	Outlet	Inlet	Outlet	Outlet	Inlet	Outlet
Date	5/23		5/24		5/24		
Volume of Gas Sampled (DSCF)[a]	19.23	54.78	18.81	50.51	55.82	-	-
Percent moisture by Volume	19.8	17.6	21.5	16.9	18.4	20.6	17.6
Average Stack Temperature (^{o}F)	400.9	403.8	388.4	400.8	402.9	394.7	402.5
Stack Volumetric Flow Rate (DSCFM)[b]	103845	114857	98926	104257	111243	101386	110119
Percent Isokinetic	90.4	99.3	92.8	100.8	104.4	91.6	101.5
Total Particulate -							
Filter Catch and Front Half Acetone Wash							
gr/DSCF	51.20223	0.03402	53.11937	0.02686	0.00684	52.16080	0.02258
lb/hr	465575.65	33.49	45042.41	24.01	6.53	45309.04	21.34
Collection Efficiency, Percent	99.93		99.94			99.94	

[a] Dry Standard Cubic Feet at 68^{o}F, 29.92 inches Hg.

[b] Dr6 Standard Cubic Feet per minute at 68^{o}F, 29.92 inches Hg.

TABLE 2-4

SUMMARY OF EMISSION TEST RESULTS
TRONA DRYER
METRIC UNITS

	Run 1		Run 2		Run 3	Average	
Location	Inlet	Outlet	Inlet	Outlet	Outlet	Inlet	Outlet
Date	5/23		5/24		5/24		
Volume of Gas Sampled (DNm^3)[a]	0.54	1.55	0.53	1.43	1.58	-	-
Percent Moisture by Volume	19.8	17.6	21.5	16.9	18.4	20.6	17.6
Average Stack Temperature (^oC)	205.0	206.5	198.0	204.9	206.1	201.5	205.8
Stack Volumetric Flow Rate (DNm^3/Min)[b]	2941.	3252	2801	2952	3150	2871	3118
Percent Isokinetic	90.4	99.3	92.8	100.8	104.4	91.6	101.5
Insoluble Particulate -							
Filter Catch and Front Half Acetone Wash							
mg/DNm^3	117170.00	77.85	121557.19	61.47	15.66	119363.63	51.66
Kg/hr	20673.12	15.19	20431.24	10.89	2.96	20552.18	9.68
Collection Efficiency, percent	99.93		99.94			99.94	

[a] Dry Normalized Cubic Meters at 20°C, 760mm Hg

[b] Dry Normalized Cubic Meters at 20°C, 760mm Hg

Table 2-5

SUMMARY OF SO_2 AND ORGANIC EMISSION TEST RESULTS
TRONA DRYER

English Units

	Run 1		Run 2		Run 3		Average	
Location	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Date	5/23	5/23	5/24	5/23	-	5/24		
SO_2 Emissions								
ppm	-	0.80	1.61	0.82	-	0.77	1.61	0.80
lbs/hour	-	0.91	1.58	0.85	-	0.85	1.58	0.87
Organic Emissions								
ppm	30	28	22	32	-	-	26	30

TABLE 2-6

SUMMARY OF OPACITY OBSERVATIONS
PRODUCT DRYER
1515-1614
5-21-79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

TABLE 2-7.

SUMMARY OF OPACITY OBSERVATIONS
PRODUCT DRYER
1615-1715
5-21-79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

TABLE 2-8

SUMMARY OF OPACITY OBSERVATIONS
PRODUCT DRYER
0900-1000
5-22-79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

TABLE 2-9

SUMMARY OF OPACITY OBSERVATIONS
PRODUCT DRYER
1000-1100
5-22-79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

TABLE 2-10

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
1118-1218
5/23/79

Six Minute Interval	Average Opacity (%)
1	3
2	2
3	3
4	2
5	0
6	2
7	0
8	2
9	1
10	2

TABLE 2-11

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
1218-1248
5/23/79

Six Minute Interval	Average Opacity (%)
1	3
2	2
3	2
4	2
5	2
6	0
7	-
8	-
9	-
10	-

TABLE 2-12

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
1612-1712
5/23/79

Six Minute Interval	Average Opacity (%)
1	2
2	3
3	1
4	0
5	0
6	0
7	2
8	1
9	1
10	1

TABLE 2-13

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
1712-1812
5/23/79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	-

TABLE 2-14

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
0815-0915
5-24-79

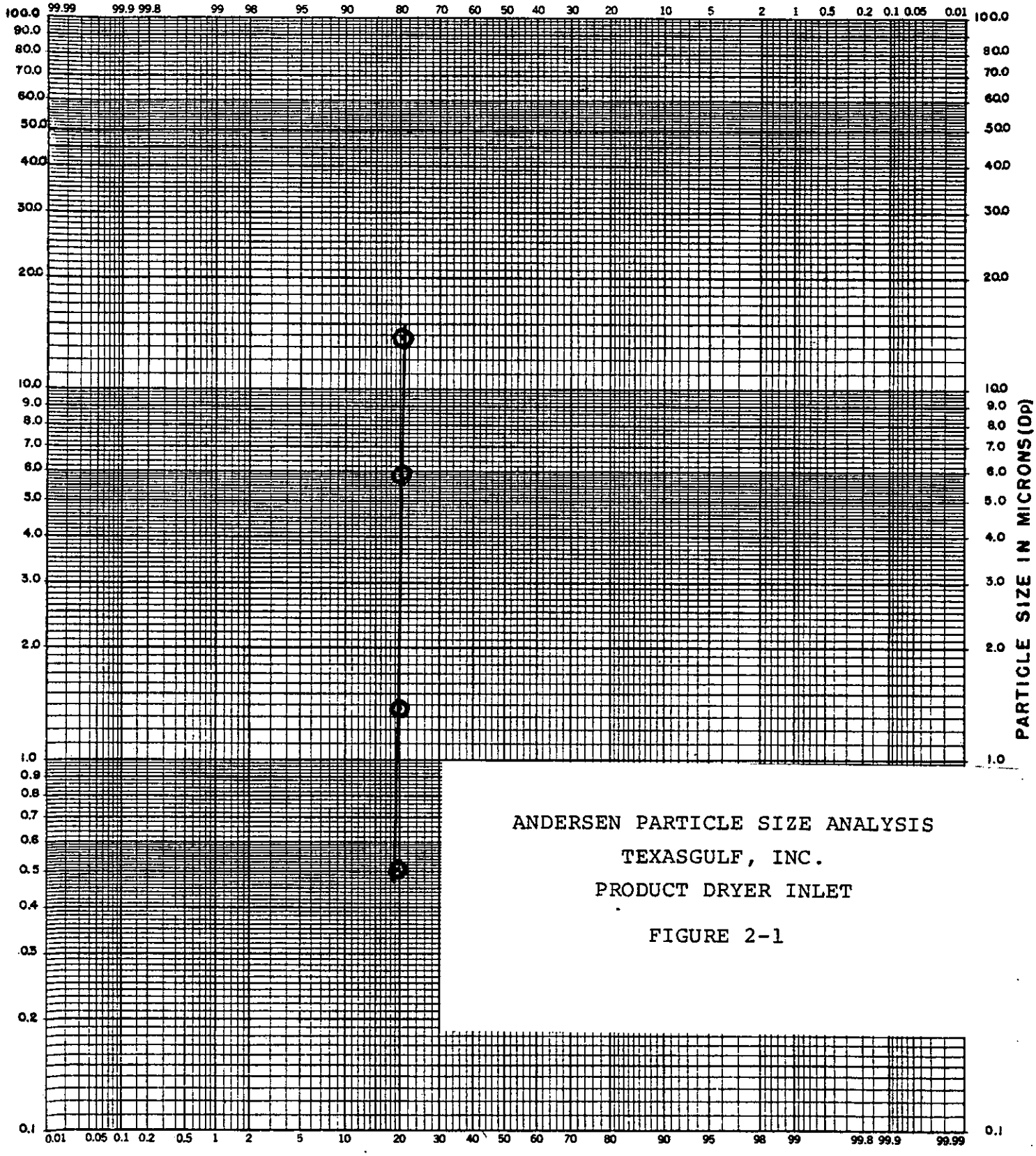
Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

TABLE 2-15

SUMMARY OF OPACITY OBSERVATIONS
TRONA DRYER
0915-1015
5-24-79

Six Minute Interval	Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

PARTICLE SIZE DISTRIBUTION



ANDERSEN PARTICLE SIZE ANALYSIS
TEXASGULF, INC.
PRODUCT DRYER INLET

FIGURE 2-1

PARTICLE SIZE DISTRIBUTION

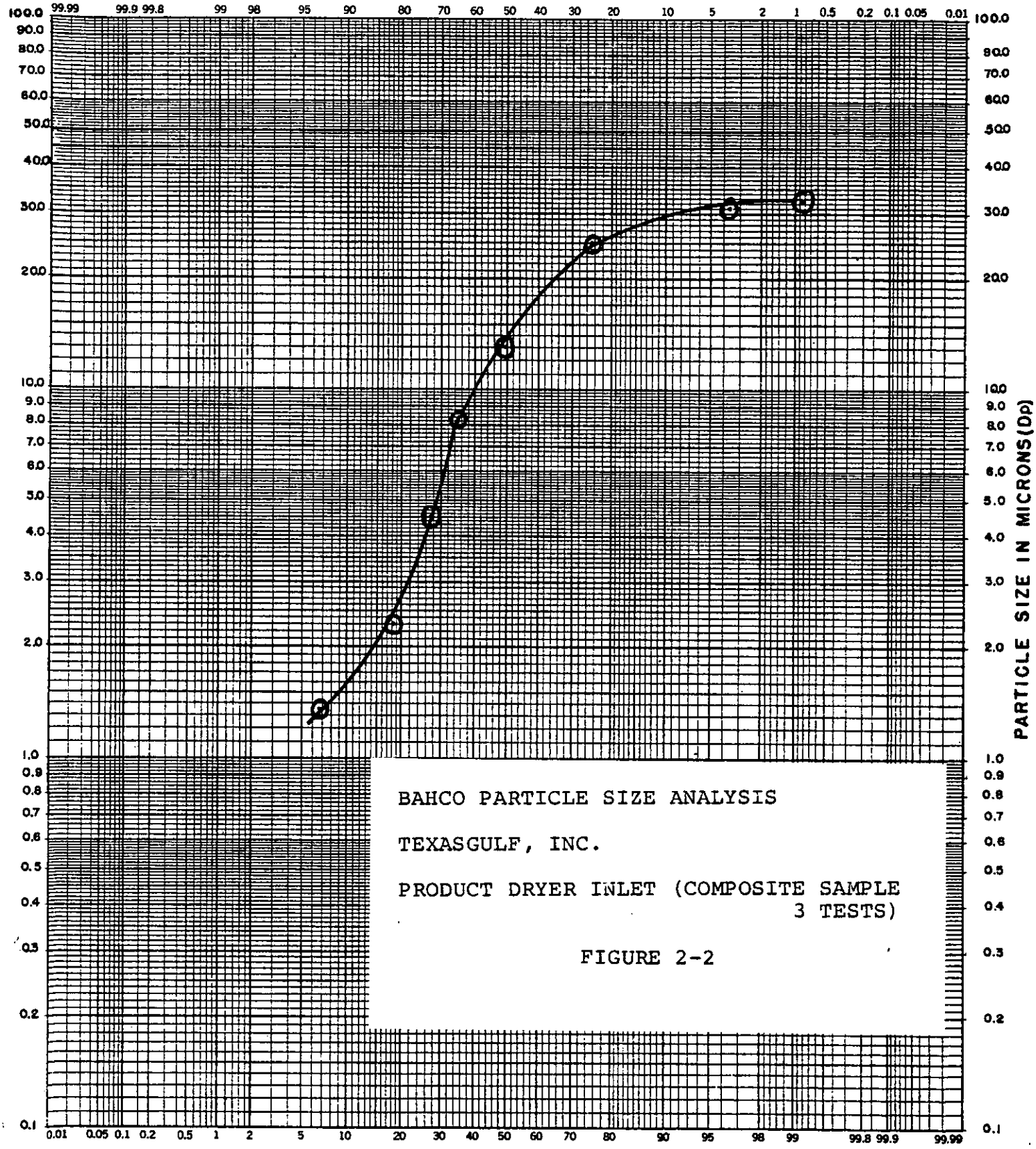
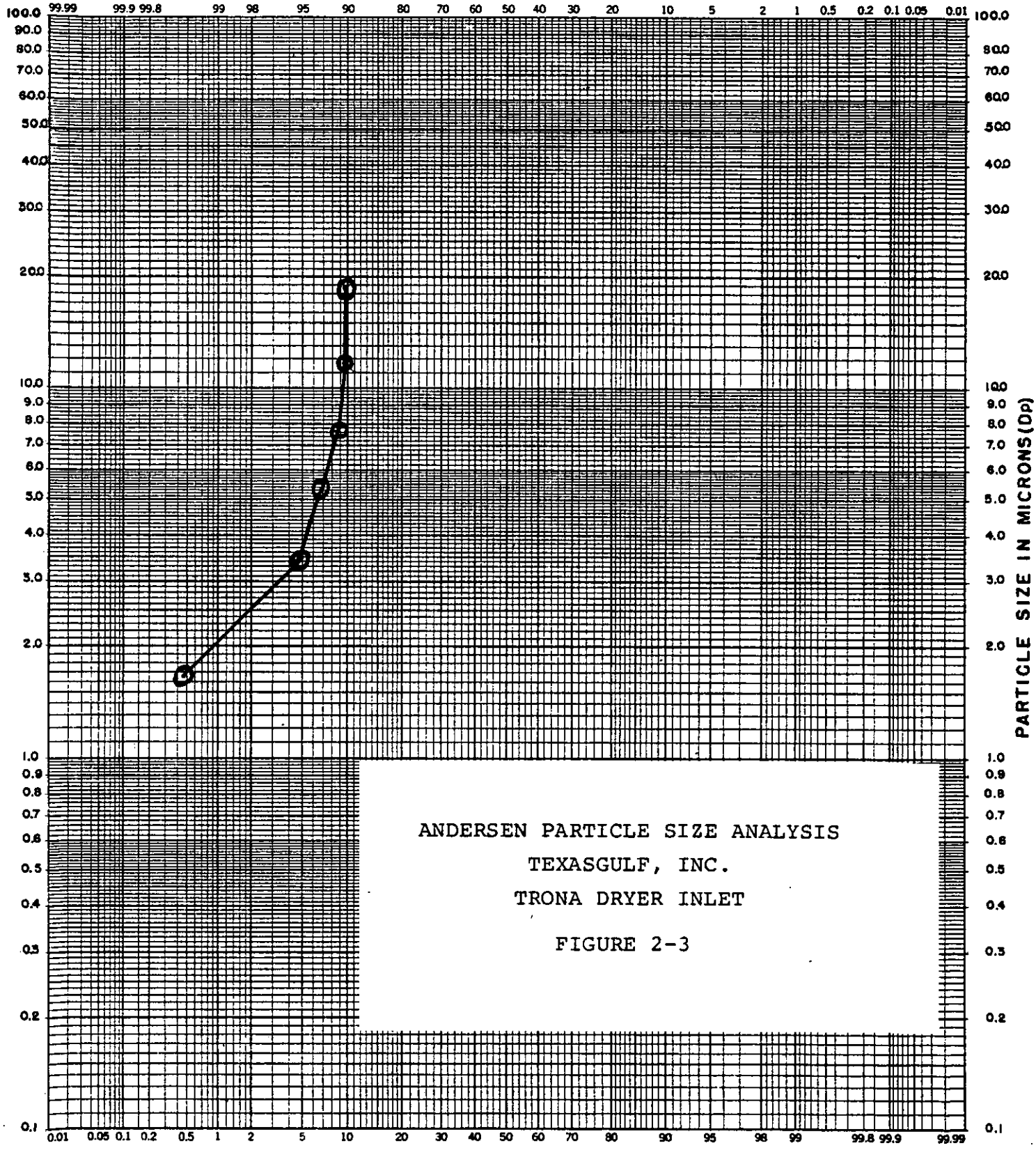
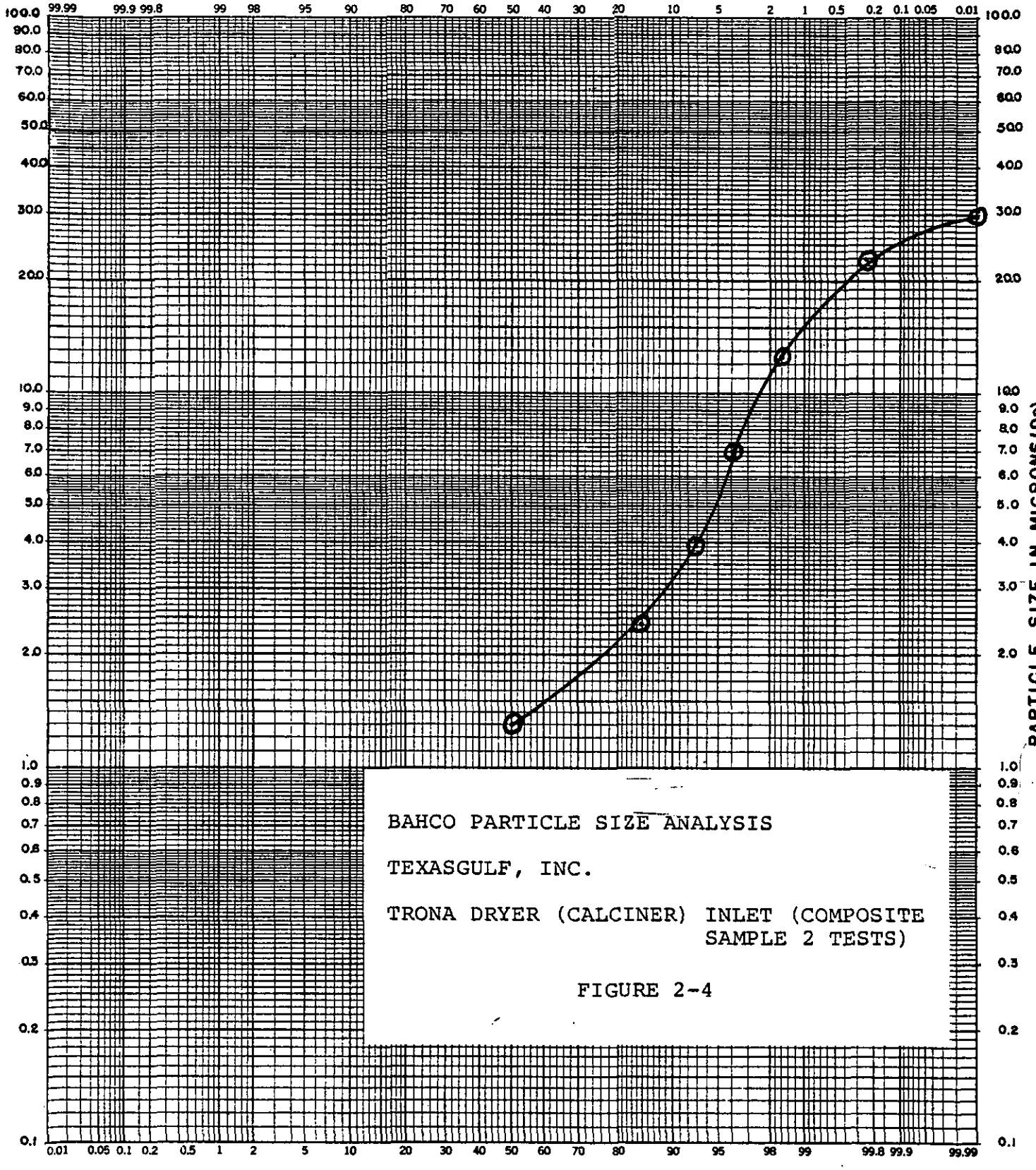


FIGURE 2-2

PARTICLE SIZE DISTRIBUTION



PARTICLE SIZE DISTRIBUTION



BAHCO PARTICLE SIZE ANALYSIS

TEXASGULF, INC.

TRONA DRYER (CALCINER) INLET (COMPOSITE SAMPLE 2 TESTS)

FIGURE 2-4

3.0 SAMPLING METHODS

3.1 Test Port Locations and Sampling Point Determination

The location of the test ports and sampling points at each location was determined in accordance with guidelines outlined in EPA Method 1 (Sample and Velocity Traverses for Stationary Sources).

The sampling ports at the Product Dryer Scrubber Inlet are located in the straight run of duct immediately following the transition at the outlet of the product dryer. The dimension of the duct at this location is 48 inches in diameter. Two ports are installed 90° to each other. Originally 24 traverse points were to be sampled in each port, but due to extremely high grain loading, ten points were sampled for three minutes each resulting in a total test time of sixty minutes. (Figure 4-1)

The sampling ports at the Product Dryer Scrubber Outlet are located in the stack which vents the exhaust gases from the scrubber to the atmosphere. Two sampling ports are located 90° intervals around the stack. The stack diameter at this location is 51 inches;six traverse points were sampled in each port for five minutes each, resulting in a test time of 60 minutes. (Figure 4-2).

The Trona Dryer Cyclone Inlet ports are located in the ductwork between the fan and the cyclone inlet and the duct dimensions at this location are 12.21 feet by 5.04 feet. Eight ports were utilized and four points sampled at two minutes each were used because of the high grain loading. The resulting test time was 64 minutes. (Figure 4-3).

The sampling ports at the Trona Dryer Electrostatic Precipitator Outlet are located in the stack that vents the exhaust gases from the precipitator to the atmosphere. Four sampling ports were installed at 90° apart around the stack, whose diameter measures 114 inches. A total of 12 traverse points were sampled for 8 minutes each resulting in a test time of 96 minutes. (Figure 4-4)

3.2 Gas Velocity

The gas velocity at each location was determined in accordance with guidelines outlined in EPA Method 2 (Determination of Stack Gas Velocity and Volumetric Flow Rate). A precalibrated type "S" pitot tube and thermocouple were rigidly attached to each sampling probe. The velocity pressure was measured on an inclined manometer, and the temperature on a pyrometer. Readings were recorded at each traverse point.

3.3 Gas Composition

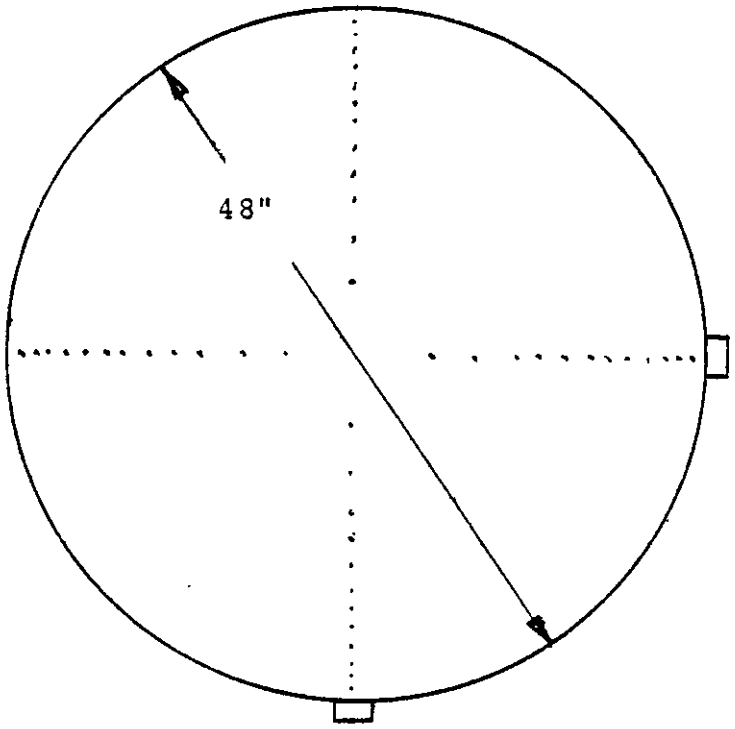
The gas composition was determined in accordance with guidelines outlined in EPA Method 3 (Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight). Since there is no combustion involved at the product dryer, the gas composition was assumed to be air. A check was made with Fyrite analyzer for carbon dioxide and oxygen content.

Since the trona dryer is fired with coal, combustion does take place and the gas composition is not air. The carbon dioxide and oxygen content of the flue gas was measured with a Fyrite analyzer at several points in the duct. The final values are an average of the readings taken at each point.

3.4 Particulate

The particulate concentrations were determined in accordance with guidelines outlined in EPA Method 5 (Determination of Particulate Emissions from Stationary Sources).

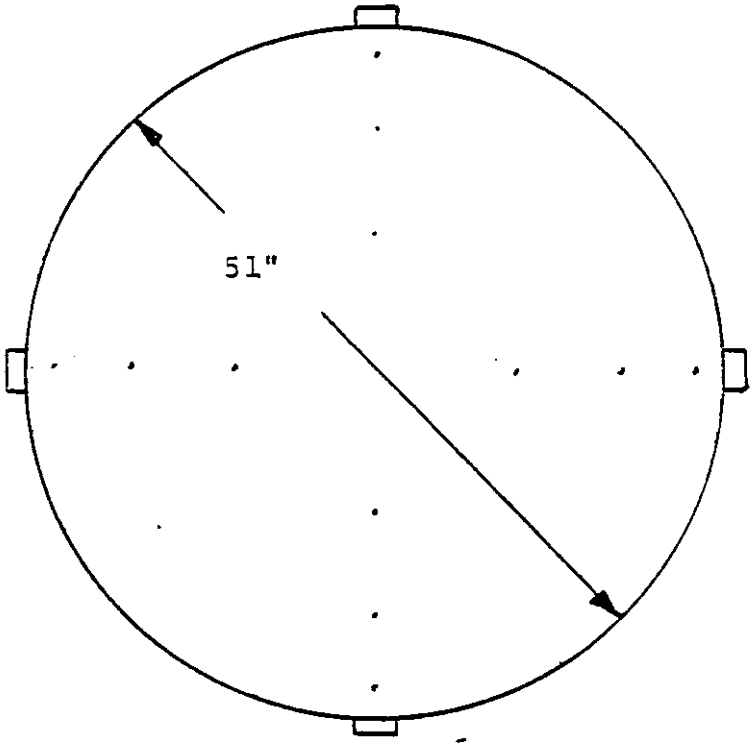
The sampling train consisted of a nozzle, stainless steel probe, heated sample box that contained the filter, impingers, vacuum pump, dry gas meter and calibrated orifice (Figure 4-5). The nozzle was rigidly connected to the probe. The probe consisted of 5/8" O.D. tubing which is wrapped with heater tape and attached to one end is a ground balljoint. Attached to the probe were an "S" type pitot tube and thermocouple used for monitoring the velocity pressure and temperature. The probe and heater box were attached to the impinger train by means of a flexible sample line.



SAMPLING POINT	DISTANCE FROM STACK WALL (INCHES)
1	1.00
2	1.54
3	2.64
4	3.79
5	5.04
6	6.34
7	7.73
8	9.31
9	11.04
10	13.06
11	15.50
12	19.10
13	28.90
14	32.50
15	34.94
16	36.96
17	38.69
18	40.27
19	41.66
20	42.96
21	44.21
22	45.36
23	46.46
24	47.00

PRODUCT DRYER SCRUBBER INLET SAMPLING
POINT LOCATION

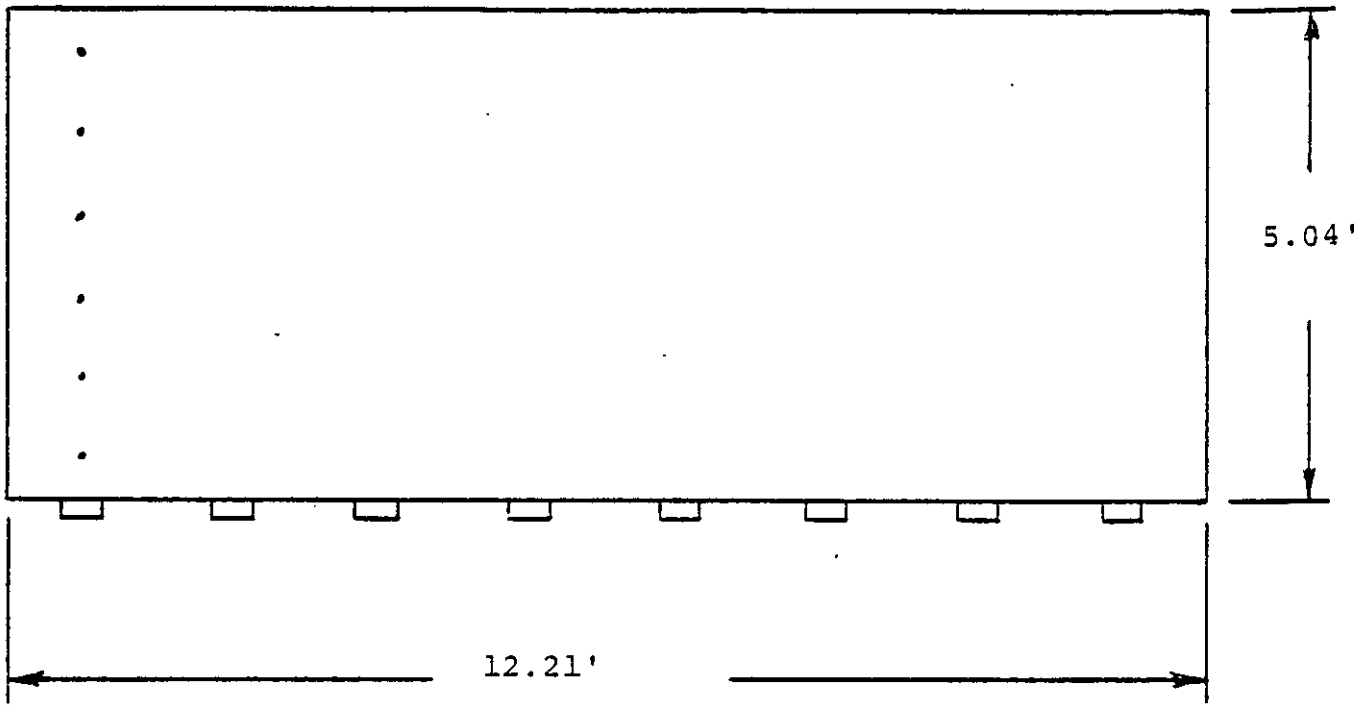
FIGURE 4-1



SAMPLING POINT	DISTANCE FROM STACK WALL (INCHES)
1	2.24
2	7.45
3	15.10

PRODUCT DRYER SCRUBBER OUTLET SAMPLING POINT LOCATIONS

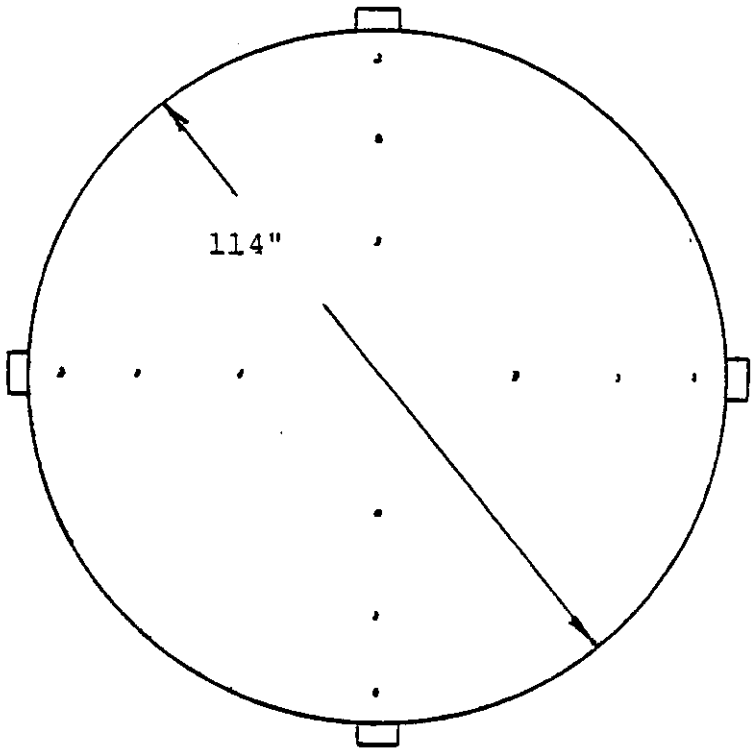
FIGURE 4-2.



Sampling Point	Distance From Stack Wall (inches)
1	5.04
2	15.12
3	25.20
4	35.28
5	45.56
6	55.64

TRONA DRYER CYCLONE INLET SAMPLING POINT LOCATIONS
ORIGINAL FIGURE - NOT USED FOR TEST)

FIGURE 4-3



Sampling Point	Distance From Stack Wall (inches)
1	5.02
2	16.64
3	33.74

TRONA DRYER ELECTROSTATIC PRECIPITATOR OUTLET SAMPLING POINT LOCATION

FIGURE 4-4

MODIFIED PARTICULATE SAMPLING TRAIN

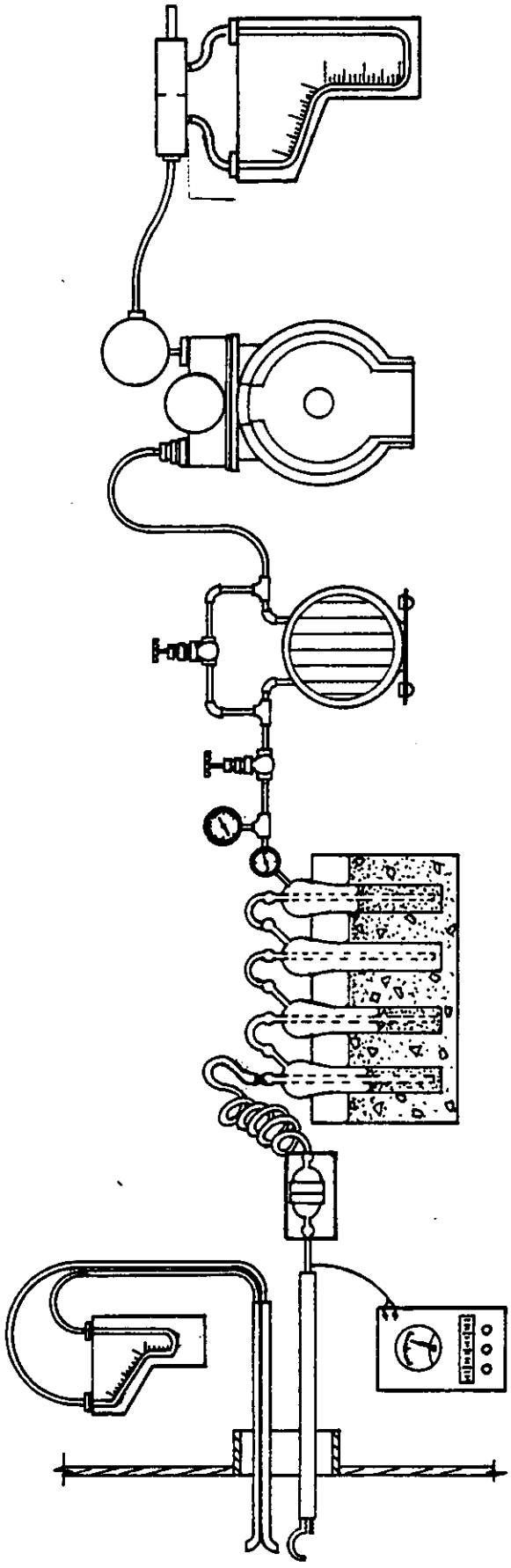


FIGURE 4-5

ES-093

The impinger train consisted of five Greenburg-Smith impingers connected in series. The first impinger was modified by replacing the impinger tip with a blank stem. This impinger was initially filled with 100 milliliters of distilled water. The second impinger was a standard Greenburg-Smith impinger containing 100 milliliters of distilled water. The third and fourth impingers were identical to the first and were left dry while the fifth contained 300 grams of indicating type silica gel.

The remainder of the train consisted of a check valve, vacuum gauge, dry gas meter and calibrated orifice.

From the fifth impinger, the effluent stream flowed through a check valve, flexible rubber vacuum tubing, a vacuum gauge, a needle valve, a leakless vacuum pump and a dry gas meter.

A calibrated orifice completed the train and was used to measure instantaneous flow rates. The dual manometer across the calibrated orifice was an inclined verticle type graduated in hundredths of an inch of water from 0 to 1 inches and in tenths from 1 to 10 inches.

During the test the following data was recorded at each traverse point:

- Traverse Point
- Sampling Time
- Clock Time
- Gas Meter Reading (cf)
- Velocity Pressure (in H_2O)
- Orifice Pressure Drop (in. H_2O)
- Stack Temperature (^oF)
- Dry Gas Meter Temperature - Inlet and Outlet (^oF)
- Pump Vacuum (in. Hg)
- Sample Box Temperature (^oF)
- Impinger Temperature (^oF)

The relationship of ΔP reading with the ΔH reading is a function of the following variables:

- Orifice Calibration Factor
- Gas Meter Temperature
- Moisture Content of Flue Gas
- Ratio of Flue Gas Pressure to Barometric Pressure
- Stack Temperature
- Sampling Nozzle Diameter

A nomograph was used to correlate all the above variables such that a direct relationship between ΔP and ΔH was determined by the sampler and isokinetic conditions could be maintained.

At the completion of the test, the samples were recovered in the following manner:

Container #1: The filter was removed from the filter holder and placed in its original container and sealed.

Container #2: The nozzle, probe, cyclone bypass and front half filter holder were rinsed with acetone. The acetone was placed in a glass jar and sealed.

Container #3: The silica gel was returned to its original container and sealed.

3.5 Organics

A gaseous sample was withdrawn from the source using a heated, glass lined stainless steel probe. Samples were drawn into a prepurged, evacuated, heated (to above the dew point of the sample gas) 250 ml glass grab flask until a positive pressure was obtained in the flask. The sample was injected into an AID model 621 portable Gas Chromatograph (GC) directly from the heated grab flask using the positive pressure obtained while sampling to fill the sample loop of the G.C. Two injections per flask were made to

determine the reproducability of the sample.

The samples were analyzed for Total Hydrocarbons as methane using a 1 cc gas sample loop and a flame ionization detector. The column temperature was 125°C. The G.C. was standardized employing a range of certified analyzed methane standards prepared in helium. Comparison of peak heights of the sample gas with those of the standards gave the following results:

Calculations

$$S_F = \text{The Sensitivity Factor} = \frac{\text{ppm Standard}}{\text{peak ht(mm) x (attenuation x range)}}$$

$$\text{ppm total Hydrocarbons} = \frac{S_F \text{ x peak ht (mm) of sample x}}{\text{(attenuation x range)}}$$

3.6 Sulfur Dioxide

Sulfur oxide emissions were determined in accordance with EPA Method 6. A glass lined heated probe was attached to the sample train by means of a three way stopcock tee. The sample train consisted of a midget bubbler containing 15 ml of 80% isopropanol, a blank impinger to catch carryover, two midget impingers each with 15 ml of 3% hydrogen peroxide and a fifth blank impinger for carryover from the two previous. A dry gas meter was used to meter the sample volume and a roto-meter monitored the sample rate. The sample was taken over a 20 minute period at a rate of 0.1 CFM. After sampling, the train, (Figure 4-6), was purged with activated charcoal filtered ambient air for 20 minutes.

3.7 Particle Size Distribution

The particle size distribution samples were collected using an Andersen Cascade Impactor. The impactor consists of multiple stages which collect different particle sizes

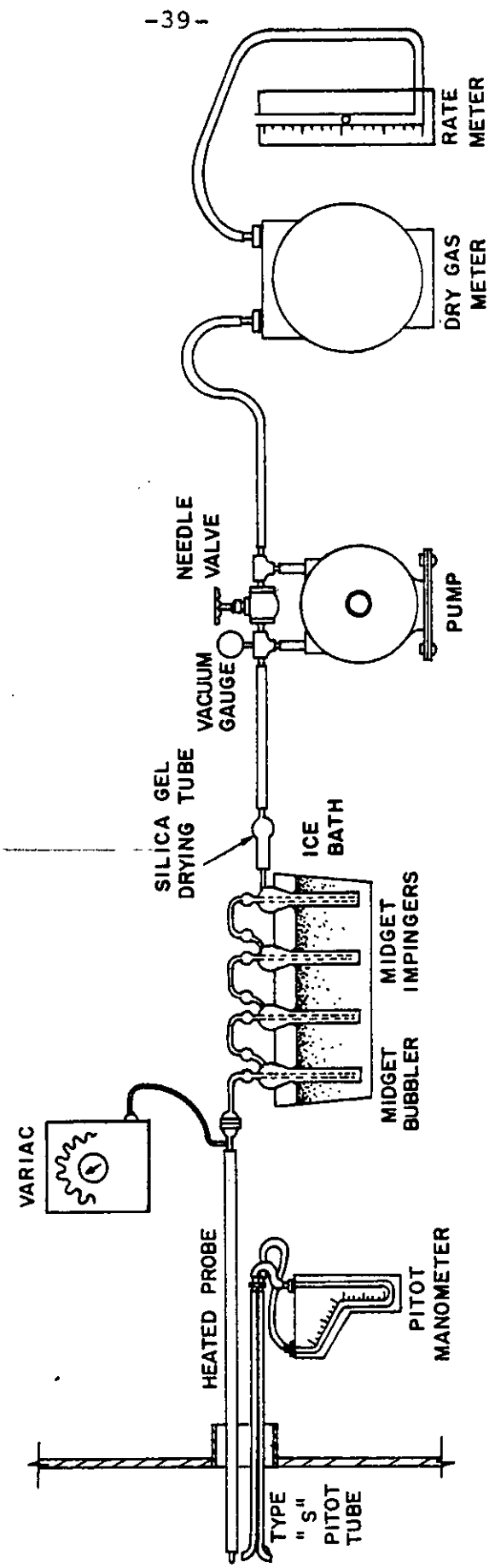

SO₂ SAMPLING TRAIN
RATE METER
DRY GAS METER
NEEDLE VALVE
PUMP
VACUUM GAUGE
SILICA GEL DRYING TUBE
ICE BATH
MIDGET IMPINGERS
MIDGET BUBBLER
VARIAC
HEATED PROBE
PITOT MANOMETER
TYPE "S" PITOT TUBE

FIGURE 4-6

(Figure 4-7). Each stage consists of an orifice of a specific diameter above a collection plate. The orifice sizes of each stage are different and are arranged in descending order, the largest being stage 1. The sampling system was set up as shown in Figure 4-8. The stack conditions were determined and the sample was extracted isokinetically.

As the sample flows through each orifice, and is deflected off a glass fiber substrate filter placed on the collection plate, particles of a specific size become impacted on the substrate while the remaining particles entrained in the gas stream proceed to the next collection stage. The range of particle sizes retained on the substrate varies according to the velocity of the gas (as determined by the sampling rate and orifice diameter), the gas viscosity and the particle density. Since the orifices are arranged in descending diameters, the gas velocity increases and the particle size collected on each stage decreases.

During the sampling a cyclone preseparator was used to precut particles above 10 microns and avoid overloading the collection substrates. At the completion of each test the contents of the preseparator and an acetone wash were placed in a sample bottle. The glass fiber substrate filters were returned to their original containers and sealed.

3.8 Visible Emissions

The visible emissions were determined in accordance with guidelines outlined in EPA Method 9 (Visual Determination of the Opacity of Emissions from Stationary Sources).

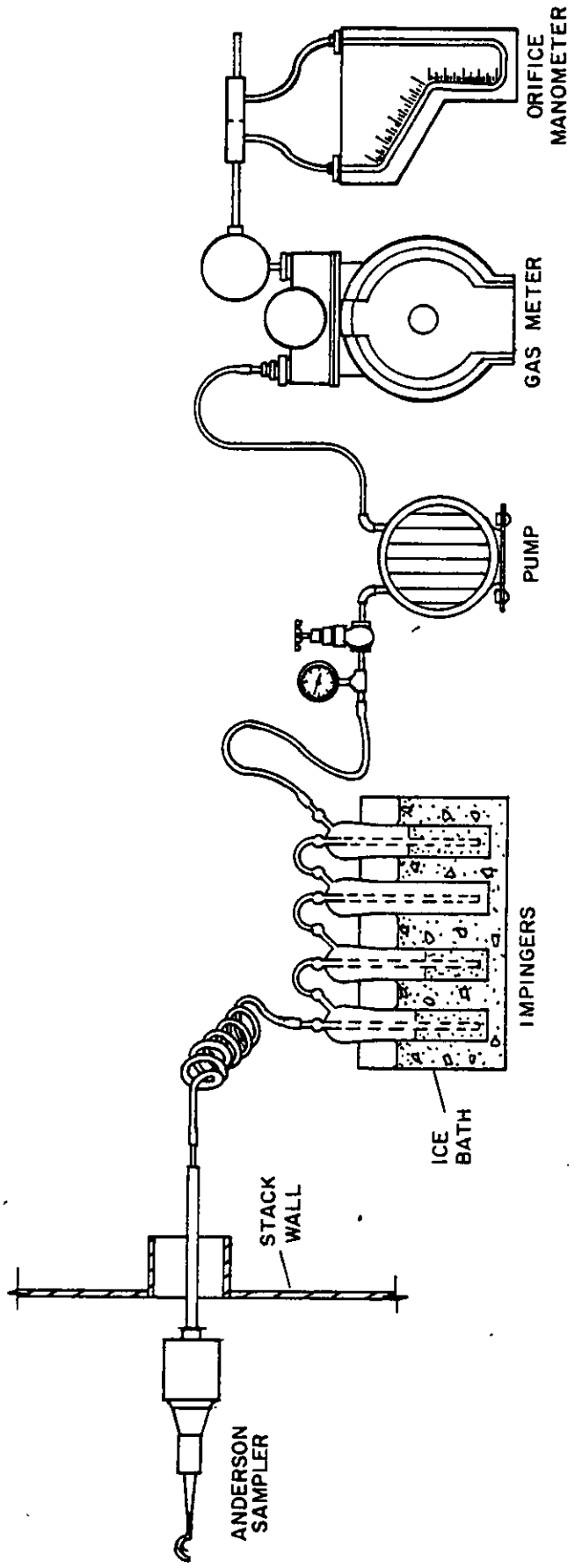


FIGURE 4-7

ES-094

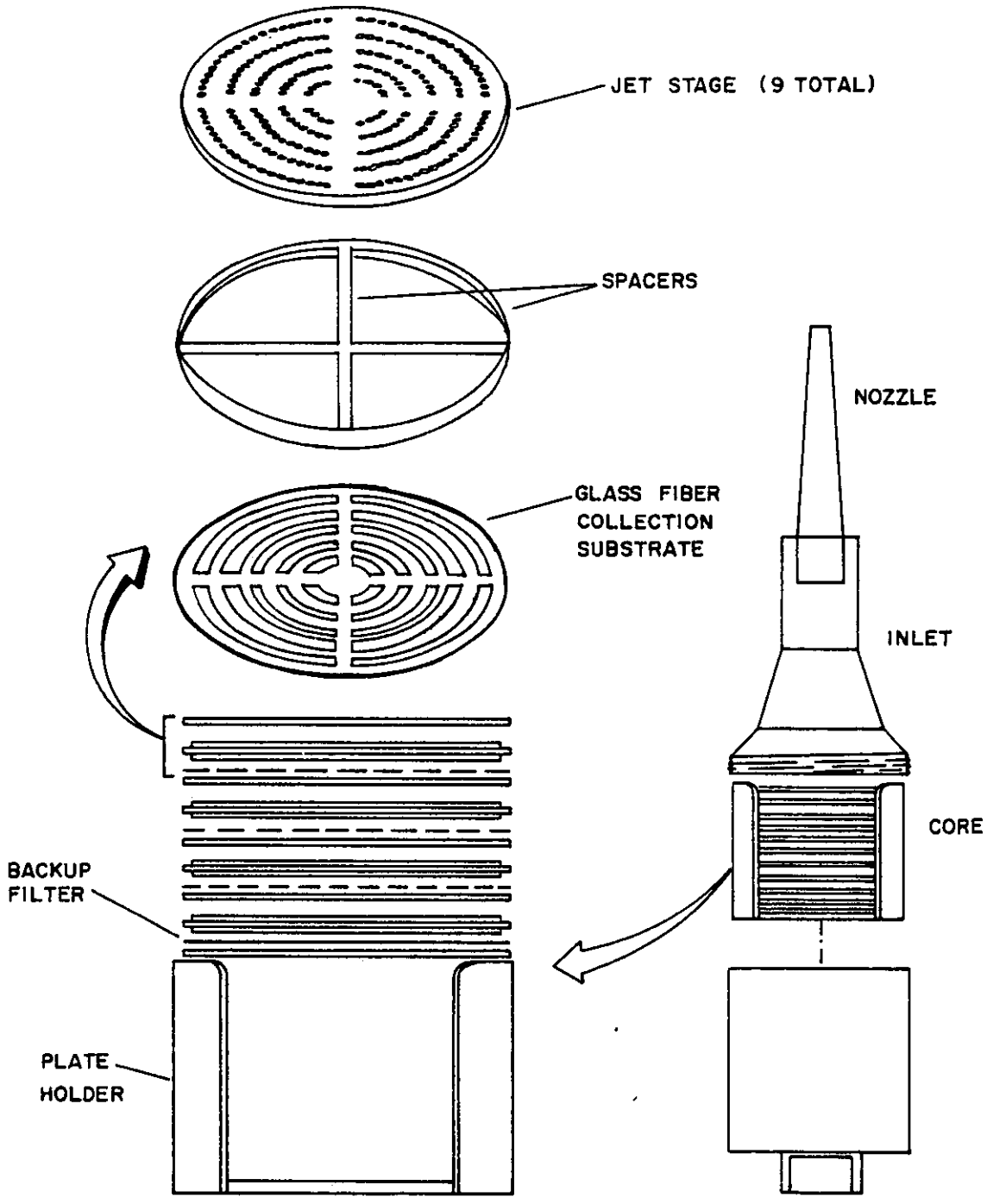


FIGURE 4-8

ES-095

4.0 ANALYTICAL PROCEDURES

4.1 Particulate

Each sample from the particulate test was analyzed in the following manner:

Container #1: The filter was removed from its sealed container and placed on a tared watch glass. The filter and watch glass were dessicated with anhydrous $CaSO_4$ and weighed to a constant weight. The weight was recorded to the nearest 0.01 mg.

Container #2: The acetone washings were transferred to a tared beaker. The acetone was then evaporated at ambient temperature and pressure, dessicated and weighed to a constant weight. The weight was recorded to the nearest 0.01 mg.

Container #3: The silica gel was weighed to the nearest 0.1 gram on a beam balance.

4.2 Sulfur Dioxide

The contents of the first two impingers along with washes were discarded and the contents of the last three impingers along with washes were saved for analysis for SO_2. The sulfur oxide samples were analyzed titrimetrically using barium perchlorate. Calculations for sulfur oxide emissions appear in the Appendix.

4.3 Particle Size Distribution

The fiberglass substrate filters were dessicated and weighed to a constant weight. The net weight gain was recorded to the nearest 0.01 mg.

The acetone rinse of the cyclone preseparator was transferred to a tared beaker. The beaker was heated to a temperature well below the boiling point until the water was evaporated. The beaker was then dessicated and weighed to a constant weight. The net weight gain was recorded to

the nearest 0.01 mg. Bahco analysis was also performed on the inlet samples due to the high moisture content restricting use of the Andersen Impactor.

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