Particulate, Sulfur Dioxide, Nitrogen Oxides, and Carbon Monoxide Emission Measurements from Lime Kilns

EMB Projects Report No.
76-LIM-10

Plant Tested

Allied Products Company
Montevallo, Alabama

September 15, 16, and 17, 1975

Prepared for

Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park
North Carolina 27711

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INTRODUCTION

Under the Clean Air Act of 1970, the Environmental Protection Agency is given the responsibility of establishing performance standards for new installations or modifications to existing installations in stationary source categories. As a contractor, Monsanto Research Corporation (MRC), under the EPA's "Field Sampling of Atmospheric Emissions" Program, was asked to undertake a sampling program to provide emission data from the Allied Products Company in Montevallo, Alabama.

The field test work was directed by Jason Burbank, Field Testing Section, Emission Measurement Branch. The sampling was performed by MRC with Thomas L. Peltier as Team Leader.

This report tabulates the data collected from the exhaust of No. 3 lime kiln at the Allied Products Company during the sampling program of September 15, 16, and 17, 1975.

A venturi scrubber is used to control the particulate emissions from the kiln, which burns both natural gas and pulverized coal. Particulate, sulfur dioxide, nitrogen oxides, and carbon monoxide emissions were measured at the outlet of the venturi scrubber. Sulfur dioxide levels and particle size distribution at the inlet were also determined. Total sulfur content of the coal feed, calcined lime, and scrubber feed and discharge water was determined, as well as pH and total

suspended solids (TSS) of the scrubber feed and discharge water.

Particulate emissions from the scrubber were measured according to procedures described in the Federal Register, Vol. 36, No. 159, August, 1971, Method 5, "Determination of Particulate Emissions from Stationary Sources."

Method 1, "Sample and Velocity Traverses for Stationary Sources"; Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)"; and Method 3, "Gas Analysis for Carbon Dioxide, Excess Air and Dry Molecular Weight" are other procedures that were required for the Method 5 tests. Method 6, "Determination of Sulfur Dioxide Emissions from Stationary Sources" and Method 7, "Determination of Nitrogen Oxide Emissions from Stationary Sources" were performed according to the procedures in the Federal Register, Vol. 36, No. 247, December 23, 1971. Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources" of the Federal Register, Vol. 39, No. 219, November 12, 1974, was performed on the exhausts of the baghouse. The carbon monoxide sampling and analysis on the exhaust gases of the lime kiln were performed according to Method 10, "Determination of Carbon Monoxide Emissions from Stationary Sources," of the Federal Register, Vol. 39, No. 47, March 8, 1974.

The EPA also conducted a sampling project during the sampling at Allied Products Company. A continuous SO_2 monitoring device, a Dynascience Air Pollution Monitor, was used on both the inlet and outlet of the venturi. Results from that sampling program are included in Appendix C.

The following sections of this report include: (1) summary of results, (2) process description and operation, (3) location of sampling points, (4) sampling and analytical procedures. Appendices include all field data and analytical data from this sampling project.

SECTION II

SUMMARY OF RESULTS

Summaries of the particulate emissions from the No. 3 lime kiln are given in Tables 1 and 2. Three Method 5 tests were performed on the outlet of the venturi scrubber, which was used to control the particulate emissions from the kiln. Emissions of filterable particulate, as measured by the probe and filter catch, averaged 24.664 lb/hr or 10.232 Kg/hr, at a concentration of .0304 gr/dscf or 63.6 mg/Nm^3. The concentration data is reported in dry standard cubic feet (DSCF) where standard conditions are 68°F and 29.92 inches Hg. The metric conditions are 20°C and 760 mm Hg for normal cubic meters (Nm^3).

The Method 7 nitrogen oxide results are given in Table 3. Grab flasks were taken on two different days with eight flasks being used one day and four flasks the next for a total of twelve samples. Table 3 gives an average NO_x emission rate for each set of four samples taken on the two days and also an overall average for the two days of sampling. An average flow rate of 2693 Nm^3/min (95091 dscfm) was used to convert the concentration of grab flask to an emission rate for the kiln. All twelve grab flasks gave fairly close results, since none of the values deviates more than ± 30 ppm from the 103 parts per million (ppm) overall average for two days of sampling. However the NO_x concentration from a lime kiln can vary by as much as 100% during normal operation.

Table 1. SUMMARY OF PARTICULATE EMISSIONS (Metric)

Run Number	1	2	3	Average
Date	9-15-75	9-16-75	9-16-75	
Volume of Gas Sampled - Nm^3	1.73	1.73	1.66	1.71
Percent Moisture by Volume	19.86	18.77	20.91	19.85
Average Stack Temperature - °C	64	64	66	65
Stack Volumetric Flow Rate - Nm^3/min	2748	2747	2583	2693
Percent Isokinetic	100.5	100.5	102.6	
Run Time - Minutes	120	120	120	120
Particulates - Front Half				
mg	119.30	85.20	121.30	108.60
mg/Nm^3	68.8	49.1	72.9	63.6
Kg/hr	11.330	8.085	11.281	10.232
lb/ton prd	0.22	0.16	0.22	0.20
Particulates - Total				
mg	131.90	93.00	131.30	118.74
mg/Nm^3	76.0	53.6	78.9	69.5
Kg/hr	12.526	8.825	12.211	11.187
Cond. lb/ton prod	0.023	0.014	0.018	0.018
Percent Impinger Catch	9.5	8.4	7.6	8.5

Table 2. SUMMARY OF PARTICULATE EMISSIONS (English)

Run Number	1	2	3	Average
Date	9-15-75	9-16-75	9-16-75	
Volume of Gas Sampled - dscf	61.14	61.18	58.69	60.34
Percent Moisture by Volume	19.86	18.77	20.91	19.85
Average Stack Temperature - °F	148	147	151	149
Stack Volumetric Flow Rate - dscfm	97037	97021	91216	95091
Percent Isokinetic	100.5	100.5	102.6	
Run Time - Minutes	120	120	120	120
Particulates - Front Half				
mg	119.30	85.20	121.30	108.60
gr/dscf	0.0300	0.0214	0.0318	0.0277
lb/hr	24.977	17.824	24.870	22.557
Particulates - Total				
mg	131.90	93.00	131.30	118.74
gr/dscf	0.0332	0.0234	0.0345	0.0304
lb/hr	27.615	19.456	26.921	24.664
Percent Impinger Catch	9.6	8.4	7.6	8.5

Table 3. SUMMARY OF NO_x EMISSIONS

Date	Run No.	Time	ppm[a]	gr/Nm^3	lb/dscf x 10^{-5}	Kg/hr[b]	lb/hr[c]
9-16-75	1	936	107	0.203	1.27	32.80	72.46
9-16-75	2	937	129	0.245	1.53	39.59	82.29
9-16-75	3	938	119	0.226	1.41	36.52	80.45
9-16-75	4	939	131	0.248	1.55	40.07	88.43
			122	0.231	1.44	37.24	82.16
9-16-75	1	1404	101	0.192	1.20	31.02	68.46
9-16-75	2	1405	100	0.190	1.19	30.70	67.89
9-16-75	3	1406	104	0.197	1.23	31.83	70.18
9-16-75	4	1407	96	0.182	1.14	29.41	65.04
			100	0.190	1.19	30.74	67.89
9-17-75	1	1024	111	0.211	1.31	34.09	74.74
9-17-75	2	1044	77	0.146	0.91	23.59	51.92
9-17-75	3	1104	65	0.123	0.77	19.87	43.93
9-17-75	4	1124	104	0.197	1.23	31.83	70.18
			89	0.169	1.06	27.34	60.19
Total Average			104	0.197	1.23	31.77	70.08

a - parts per million by volume

b - Flow rate used was estimated to be 2693 Nm^3/min

c - Flow rate used was estimated to be 95,091 dscfm

While MRC personnel were performing the Method 6 sampling on the inlet to the venturi scrubber, EPA personnel were performing SO_2 sampling using the Dynasciences Continuous Monitor.

A report of this testing is included in Appendix C. A discussion of the sampling operations and the results of the sampling are included in the report. An average SO_2 concentration in ppm for the inlet and outlet is included in Table 4. Copies of the original strip charts are included in Appendix F. Figures 1, 2 and 3 are a graphical description of the Dynascience data.

The Method 6 sulfur dioxide results are also given in Table 5. As can be seen from Table 5, only the first run on the inlet to the venturi showed any sulfur dioxide by Method 6 testing. The results of the outlet coincide with the results of the Dynascience Continuous Monitor, which showed a zero concentration (<5 ppm, the zero drift during the test while spanned to 500 ppm full scale). However, the results for Runs 2-I and 3-I showed appreciable SO_2 concentrations with the Dynascience (65 to 212 ppm) but none with Method 6. However, we know this is impossible since the Dynascience Continuous Monitor was run simultaneously with the runs on the inlet.

These results can probably be best explained by the lime dust which is collected in the end of the SO_2 probe. The SO_2 probe has a glass wool plug for stopping particulates and the glass wool merely acted as a filter for the lime dust and the combination of the two scrubbed out the SO_2 giving zero concentration levels on Runs 2-I and 3-I. Since no velocity traverse

Table 4. SUMMARY OF SO_2 EMISSIONS BY THE DYNASCIENCE SO_2 MONITOR

Corrected 10-Minute Averages of SO_2 Measurements at the Allied Products Lime Plant, Montevallo, Alabama

Date	Test Site	Time	Corrected Average PPM	High Peak PPM	Low Point PPM	Stack Temperature °C
9/15/75	Scrubber Inlet	1:05 pm	139	177	117	
		1:15	139	164	122	
		1:25	137	194	122	449 (840°F)
		1:35	126	130	44	
		1:45	152	196	128	438 (820°F)
		1:55	142	163	115	
		2:05	126	142	114	
		2:15	144	157	128	427 (800°F)
		2:25	150	178	128	
		2:35	159	187	139	421 (790°F)
		2:45	236	290	170	427 (800°F)
		2:55	194	278	164	
		3:05	203	282	154	415 (780°F)
		3:15	252	280	221	427 (800°F)
		3:25	232	264	212	
		3:35	203	246	180	
		3:45	211	232	189	
		3:55	207	245	172	432 (810°F)
		4:05	243	312	157	
		4:15	150	167	125	
		4:25	174	200	150	

Table 4 (cont'd). SUMMARY OF SO_2 EMISSIONS BY THE DYNASCIENCE SO_2 MONITOR

Corrected 10-Minute Averages of SO_2 Measurements at the Allied Products Lime Plant, Montevallo, Alabama

Date	Test Site	Time	Corrected Average PPM	High Peak PPM	Low Point PPM	Stack Temperature °C
9/16/75	Scrubber Outlet	11:45 am	0	0	0	66 (150°F)
		↓				
		4:05 pm	0	0	0	
9/17/75	Scrubber Inlet	10:28 am	168	194	148	427 (800°F)
		10:38	159	190	139	
		10:48	183	212	158	
		10:58	190	202	161	
		11:08	159	175	141	
		11:18	124	142	105	
		11:28	101	111	88	
		11:38	86	127	65	
		11:48	156	173	128	
9/17/75	Scrubber Outlet	2:00 pm	0	0	0	66 (150°F)
		↓				
		3:15	0	0	0	

Figure 1 9/15/75 INLET

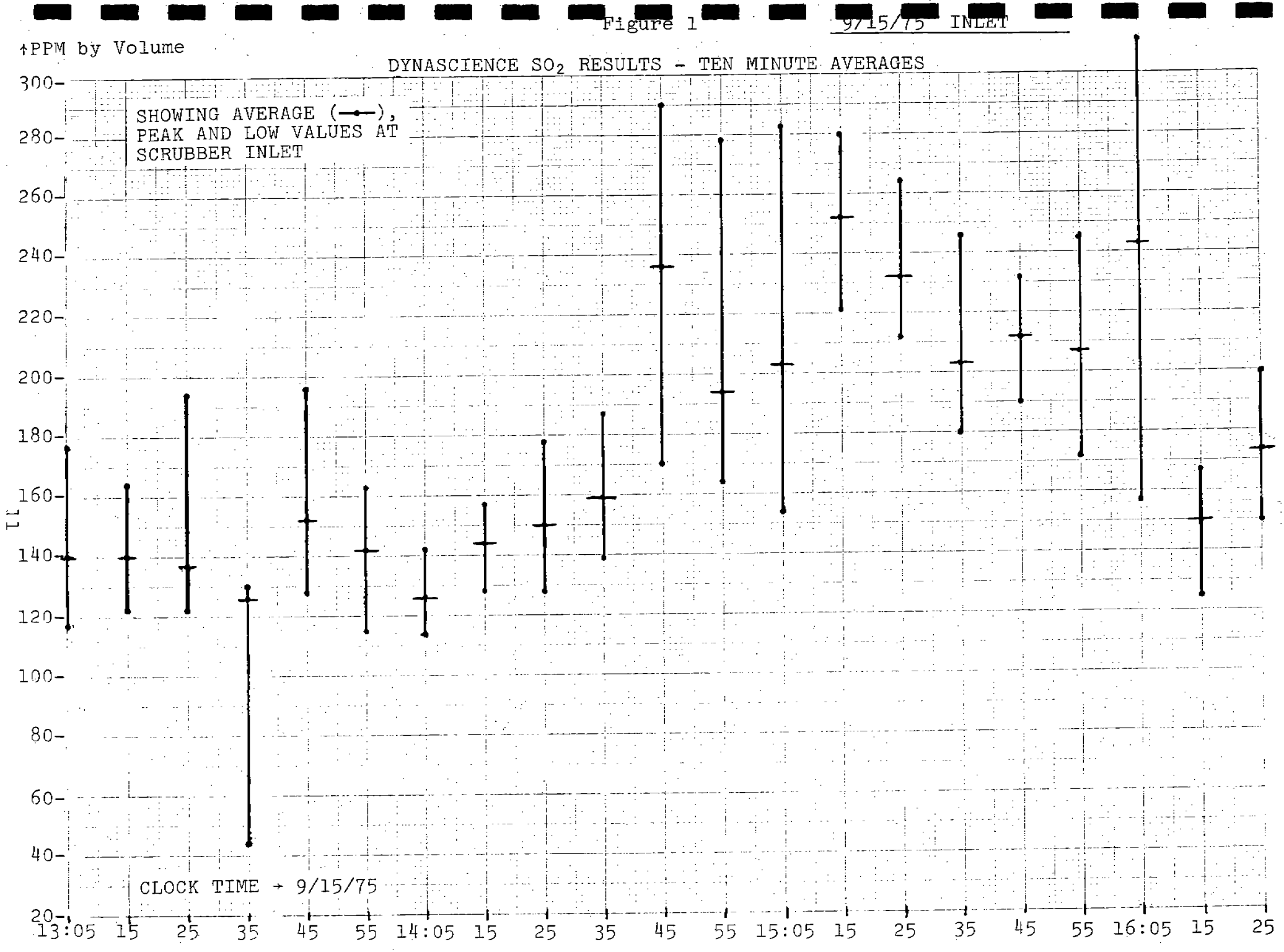

Figure 2 9/16, 9/17/75 OUTLET

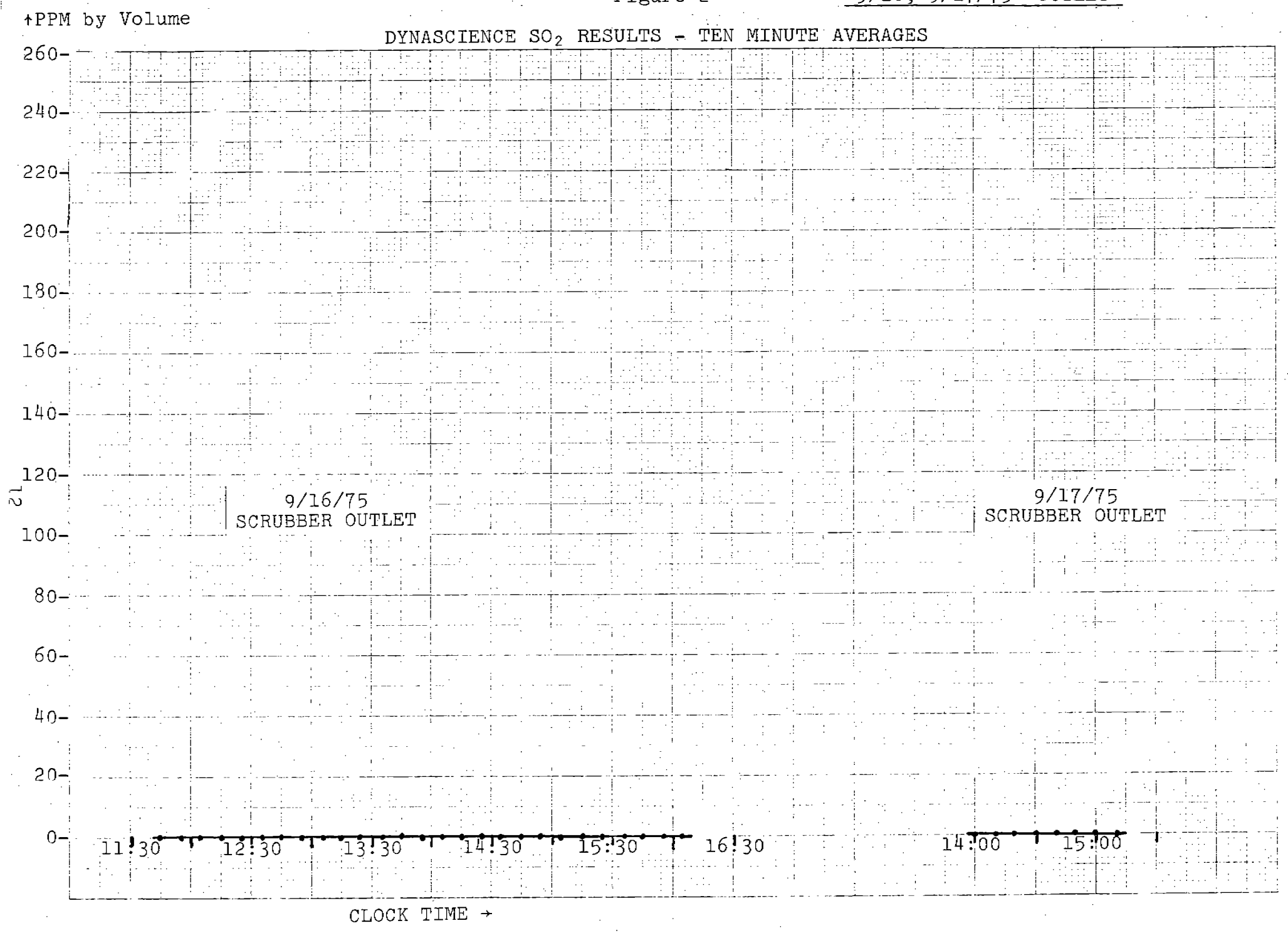

Figure 3 9/17/75 INLET

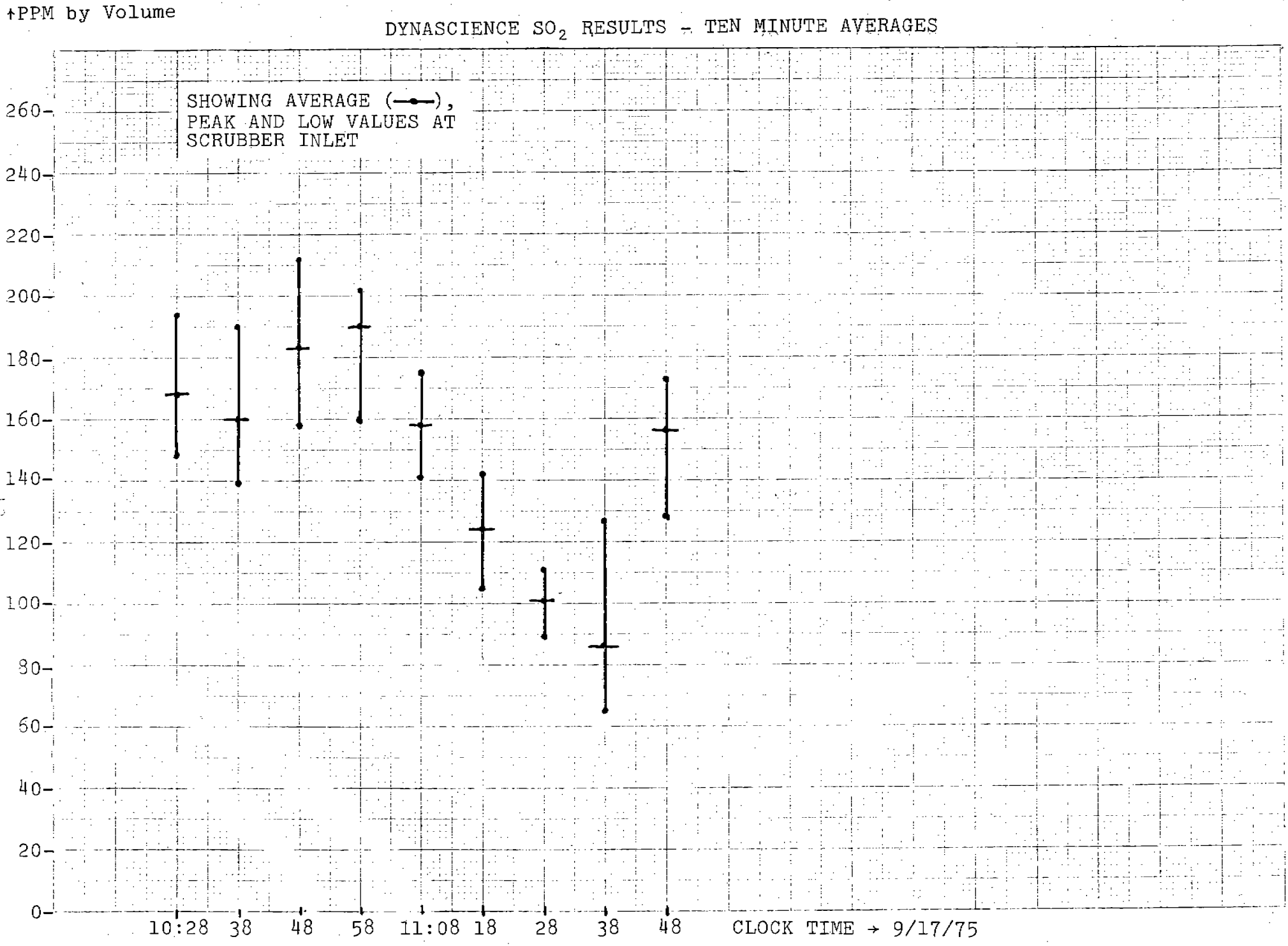

Table 5. SUMMARY OF SO_2 EMISSIONS BY EPA METHOD 6

Run Number	1-I	1-0	2-I	2-0	3-I	3-0
Date	9-16	9-16	9-17	9-17	9-17	9-17
Volume of Gas Sampled						
Nm^3	.0235	.0235	.0235	.0228	.0223	.0233
dscf	.829	.795	.832	.805	.788	.824
SO_2 Concentration						
ppm	61	0	0*	0	0*	0
g/Nm^3	.160	0	0*	0	0*	0
$lb/dscf \times 10^{-5}$	1.00	0	0*	0	0*	0
SO_2 Emissions						
Kg/hr^a	16.3	0	0	0	0	0
lb/hr^a	36	0	0	0	0	0

a - Flow rate used - 1699 Nm^3/min (Estimated - see explanation pp. 7)

b - Flow rate used - 60,000 dscfm (Estimated - see explanation pp. 7)

*Suspected sampling problems - see discussion pp. 8

was performed at the inlet, the flow rate used in the determination of the emission rate there is an estimated value.

It was seen from an earlier test (7-31 and 8-1-74) by the Alabama Air Pollution Control Commission that the flow in dscfm increased from inlet to outlet locations by an average factor of 1.35. This could be attributed to leakage of ambient air into the system between those two points, (a high negative pressure exists) as well as inaccuracies of velocity measurement due to turbulent or cyclonic flow. When this factor is applied to the situation here, taking into consideration the increased duct disintegration and numerous leaks seen which were not mentioned in that earlier report, a value of 60,000 dscfm for the inlet flow rate can be estimated. The design flow rate for the venturis, as given in the process description, amounts to 80,000 dscfm.

Table 6 gives the total sulfur results on the coal, product, scrubber feed water and scrubber exit water. The samples were collected during the Method 6 inlet runs and are referenced to the runs. The results in the table show the coal being burned had an average sulfur content of 1.86%. The product had an average sulfur content of .005%. The particulate in the scrubber feed water had an average sulfur content of 2.94%. The particulate in the scrubber exit water had an average sulfur content of 3.73%.

Table 7-10 presents a summary of the Brink® particle sizing results, Metric and English, respectively. Three runs were made on the inlet of the venturi scrubber. As can be seen from the tables, over 96 percent (weight basis) of the particles collected in all three runs were in the probe, cyclone and first stage of the impactor, corresponding to a mean aerodynamic diameter of >5.0 microns, or a mean actual diameter of >2.75 microns.

Table 6. SUMMARY OF TOTAL SULFUR CONTENT OF COAL, PRODUCT AND SCRUBBER WATER

Date	9-16	9-17	9-17
Corresponding EPA 6 Run	1-I	2-I	3-I
% Total Sulfur			
Coal	1.48	0.877	3.21
Product	0.002	0.002	0.011
Scrubber Feed H_2O			
pH	11.5	11.3	11.4
TSS, mg/l	246	222	342
g Sulfur/l filtrate	0.2236	0.3302	0.3053
% sulfur in particulate in H_2O	2.86	2.90	3.07
Scrubber Exit H_2O			
pH	12.2	12.2	12.1
TSS, mg/l	7406	6166	4318
g Sulfur/l filtrate	0.1795	0.1863	0.1955
% sulfur in particulate in H_2O	3.69	3.87	3.63

Table 7. SUMMARY OF BRINKS® PARTICLE SIZING RESULTS (METRIC) USING UNIT DENSITY

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 1

INPUT VARIABLE	UNITS	INPUT DAT.
SAMPLING TIME	MIN	10.0
PRESSURE DROP	CM HG	3.30
STATIC PRESSURE	CM H20	-18.60
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	CM HG	75.77
GAS MOL WT		28.0
GAS TEMPERATURE	DEG C	90.6
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00095

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	85.800		3.73	87.69	100.00
1	8.366	4.63	0.36	8.57	12.11
2	0.915	2.73	0.04	0.94	3.55
3	1.000	1.87	0.04	1.02	2.61
4	0.240	0.98	0.01	0.25	1.58
5	0.206	0.61	0.01	0.21	1.34
FILTER	1.100		0.05	1.13	1.13

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 2

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	CM HG	2.03
STATIC PRESSURE	CM H20	-15.62
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	CM HG	75.49
GAS MOL WT		28.0
GAS TEMPERATURE	DEG C	86.7
GAS VISCOSITY	POISE	0.00021
GAS DENSITY	G/CC	0.00096

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	70.800		9.56	94.07	100.00
1	2.060	5.06	0.28	2.74	5.93
2	1.210	3.00	0.16	1.61	3.19
3	0.490	2.05	0.07	0.65	1.58
4	0.150	1.09	0.02	0.20	0.93
5	0.150	0.70	0.02	0.20	0.73
FILTER	0.400		0.05	0.53	0.53

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 3

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	CM HG	2.79
STATIC PRESSURE	CM H20	-16.51
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	CM HG	75.23
GAS MOL WT		28.1
GAS TEMPERATURE	DEG C	93.3
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00094

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	73.800		8.59	93.91	100.00
1	2.431	4.79	0.28	3.09	6.09
2	1.004	2.83	0.12	1.28	2.99
3	0.137	1.94	0.02	0.17	1.72
4	0.120	1.02	0.01	0.15	1.54
5	0.092	0.64	0.01	0.12	1.39
FILTER	1.000		0.12	1.27	1.27

Table 8. SUMMARY OF BRINKS® PARTICLE SIZING RESULTS (ENGLISH) USING UNIT DENSITY

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 1

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	10.0
PRESSURE DROP	IN HG	1.30
STATIC PRESSURE	IN H2O	-7.40
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	IN HG	29.83
GAS MOL WT		28.0
GAS TEMPERATURE	DEG F	195.0
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00095

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	85.800		131.59	87.89	100.00
1	8.366	4.63	12.83	8.57	12.11
2	0.915	2.73	1.40	0.94	3.55
3	1.000	1.87	1.53	1.02	2.61
4	0.240	0.98	0.37	0.25	1.58
5	0.206	0.61	0.32	0.21	1.34
FILTER	1.100		1.69	1.13	1.13

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 2

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	IN HG	0.80
STATIC PRESSURE	IN H2O	-6.15
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	IN HG	29.72
GAS MOL WT		28.0
GAS TEMPERATURE	DEG F	188.0
GAS VISCOSITY	POISE	0.00021
GAS DENSITY	G/CC	0.00096

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	70.800		337.63	94.07	100.00
1	2.060	5.06	9.82	2.74	5.93
2	1.210	3.00	5.77	1.61	3.19
3	0.490	2.05	2.34	0.65	1.58
4	0.150	1.09	0.72	0.20	0.93
5	0.150	0.70	0.72	0.20	0.73
FILTER	0.400		1.91	0.53	0.53

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 3

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	IN HG	1.10
STATIC PRESSURE	IN H2O	-6.50
PARTICLE DENSITY	G/CC	1.00
BAROMETRIC PRESSURE	IN HG	29.62
GAS MOL WT		28.1
GAS TEMPERATURE	DEG F	200.0
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00094

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	73.800		303.55	93.91	100.00
1	2.431	4.79	9.99	3.09	6.09
2	1.004	2.83	4.13	1.28	2.99
3	0.137	1.94	0.5	0.17	1.72
4	0.120	1.02	0.49	0.15	1.54
5	0.092	0.64	0.38	0.12	1.39
FILTER	1.000		4.11	1.27	1.27

Table 9. SUMMARY OF BRINKS® PARTICLE SIZING RESULTS (METRIC) USING ACTUAL DENSITY

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 1

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	10.0
PRESSURE DROP	CM HG	3.30
STATIC PRESSURE	CM H2O	-18.80
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	CM HG	75.77
GAS MOL WT		28.0
GAS TEMPERATURE	DEG C	90.6
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00095

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	85.800		3.73	87.88	100.00
1	8.366	2.51	0.36	8.57	12.12
2	0.915	1.46	0.04	0.94	3.55
3	1.008	0.98	0.04	1.03	2.62
4	0.240	0.49	0.01	0.25	1.58
5	0.206	0.29	0.01	0.21	1.34
FILTER	1.100		0.05	1.13	1.13

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 2

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	CM HG	2.03
STATIC PRESSURE	CM H2O	-15.62
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	CM HG	75.49
GAS MOL WT		28.0
GAS TEMPERATURE	DEG C	86.7
GAS VISCOSITY	POISE	0.00021
GAS DENSITY	G/CC	0.00096

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	70.800		9.56	94.07	100.00
1	2.060	2.75	0.28	2.74	5.93
2	1.210	1.61	0.16	1.61	3.19
3	0.490	1.09	0.07	0.65	1.58
4	0.150	0.55	0.02	0.20	0.93
5	0.150	0.34	0.02	0.20	0.73
FILTER	0.400		0.05	0.53	0.53

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 3

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	CM HG	2.79
STATIC PRESSURE	CM H2O	-16.51
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	CM HG	75.23
GAS MOL WT		28.1
GAS TEMPERATURE	DEG C	93.3
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00094

STAGE	WT OF MATERIAL	DPC	MG/ACM	WT PCNT	CUM WT PCNT
CYCLONE	73.800		8.59	93.91	100.00
1	2.431	2.60	0.28	3.09	6.09
2	1.004	1.52	0.12	1.28	2.99
3	0.137	1.02	0.02	0.17	1.72
4	0.120	0.51	0.01	0.15	1.54
5	0.092	0.30	0.01	0.12	1.39
FILTER	1.000		0.12	1.27	1.27

Table 10. SUMMARY OF BRINKS® PARTICLE SIZING RESULTS (ENGLISH) USING ACTUAL DENSITY

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 1

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	10.0
PRESSURE DROP	IN HG	1.30
STATIC PRESSURE	IN H2O	-7.40
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	IN HG	29.83
GAS MOL WT		28.0
GAS TEMPERATURE	DEG F	195.0
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00095

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	85.800		131.59	87.88	100.00
1	8.366	2.51	12.83	8.57	12.12
2	0.915	1.46	1.40	0.94	3.55
3	1.008	0.98	1.55	1.03	2.62
4	0.240	0.49	0.37	0.25	1.58
5	0.206	0.29	0.32	0.21	1.34
FILTER	1.100		1.69	1.13	1.13

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 2

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	IN HG	0.80
STATIC PRESSURE	IN H2O	-6.15
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	IN HG	29.72
GAS MOL WT		28.0
GAS TEMPERATURE	DEG F	188.0
GAS VISCOSITY	POISE	0.00021
GAS DENSITY	G/CC	0.00096

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	70.800		337.47	94.07	100.00
1	2.060	2.75	9.82	2.74	5.93
2	1.210	1.61	5.77	1.61	3.19
3	0.490	1.09	2.34	0.65	1.58
4	0.150	0.55	0.71	0.20	0.93
5	0.150	0.34	0.71	0.20	0.73
FILTER	0.400		1.91	0.53	0.53

CASCADE IMPACTOR PARTICLE SIZE DISTRIBUTION FOR RUN 3

INPUT VARIABLE	UNITS	INPUT DATA
SAMPLING TIME	MIN	4.0
PRESSURE DROP	IN HG	1.10
STATIC PRESSURE	IN H2O	-6.50
PARTICLE DENSITY	G/CC	3.25
BAROMETRIC PRESSURE	IN HG	29.62
GAS MOL WT		28.1
GAS TEMPERATURE	DEG F	200.0
GAS VISCOSITY	POISE	0.00022
GAS DENSITY	G/CC	0.00094

STATE	WT OF MATERIAL	DPC	MG/ACF	WT PCNT	CUM WT PCNT
CYCLONE	73.800		303.40	93.91	100.00
1	2.431	2.60	9.99	3.09	6.09
2	1.004	1.52	4.13	1.28	2.99
3	0.137	1.02	0.56	0.17	1.72
4	0.120	0.51	0.49	0.15	1.54
5	0.092	0.30	0.38	0.12	1.39
FILTER	1.000		4.11	1.27	1.27

The characteristic particle diameter (listed in Tables 7-10 as DPC) is the diameter of a spherical particle of unit density (1b/cc) for which 50% of the particles will impact on a given stage and 50% will pass around to the succeeding stage. The equivalent aerodynamic diameter (diameter based on a spherical particle of unit density) is reported in Tables 7 and 8, and shown in Figures 4, 5, and 6. Not only does this method of reporting the data form a good standard for comparison between particles of varying shape and density, but also it is generally the aerodynamic particle size which is of interest to the tester. The actual diameter can be assumed to be as reported in Tables 9 and 10, and as shown in Figures 7, 8, and 9. These values are based on spherical particles with an actual density of 3.25 g/cc, which is derived from the density of CaO given in The Handbook of Chemistry and Physics, 53rd edition.

Table 11 presents a summary of the carbon monoxide emissions from the kiln. The Method 10 testing was done on the exhaust gases collected in a Tedlar bag. The Orsat analysis was performed on the same gases as the carbon monoxide analysis. The integrated sample was collected during the respective Method 5 runs.

The table lists the CO concentration in ppm, which was obtained from the calibration curves for the Beckman NonDispersive Infrared (NDIR) instrument. Background CO was not measured at this source.

The same flow rate used to calculate SO_2 and NO_x emission rates was also used for CO emission rates. The CO concentration in the Tedlar bags was also determined by using Drager tubes which involves drawing a small amount of gas through a column of indicating material which changes color to indicate the concentration of CO present. The results from this method are also listed in Table 11.

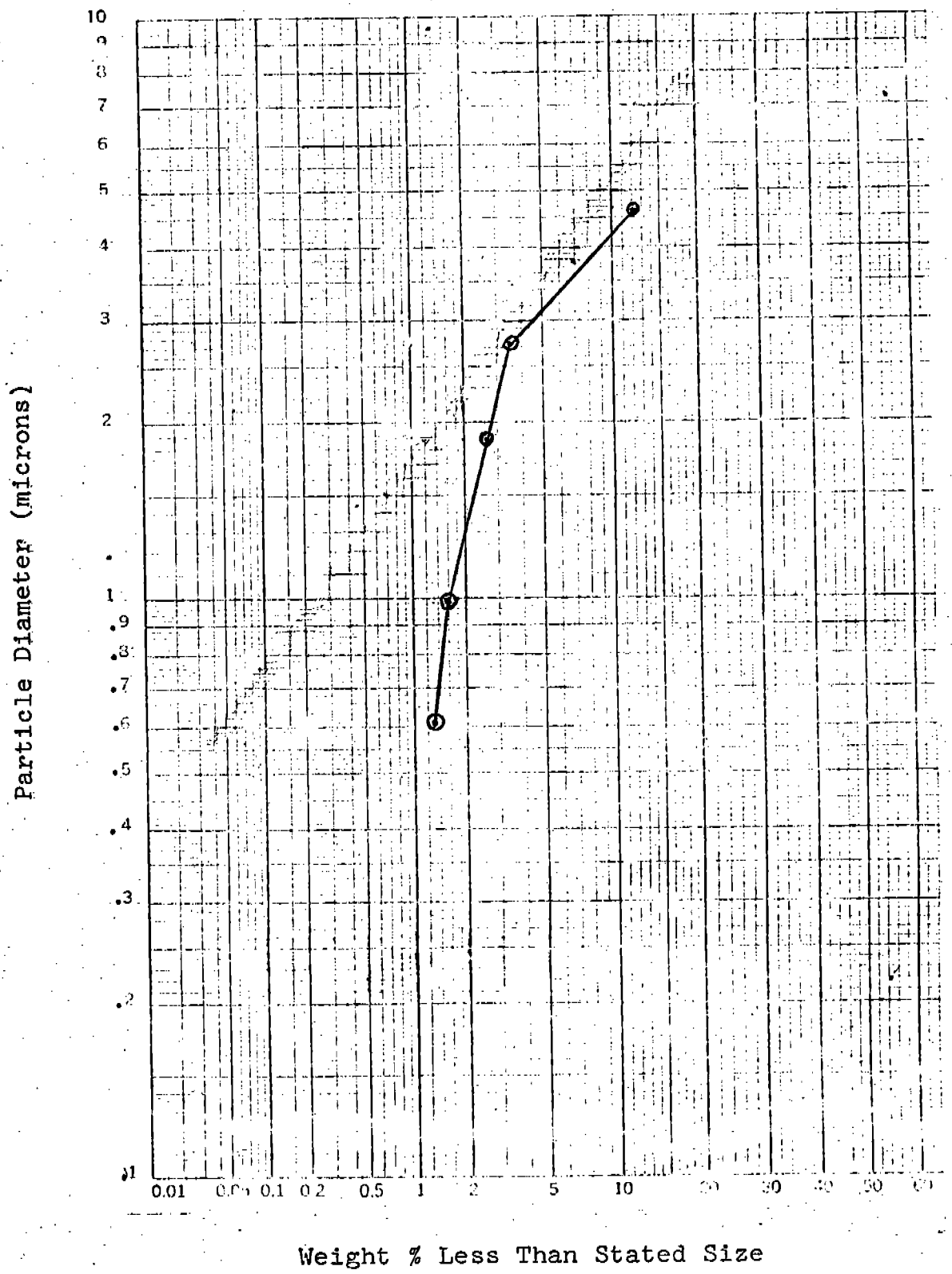

Figure 4. Particle size data (unit density) Run 1

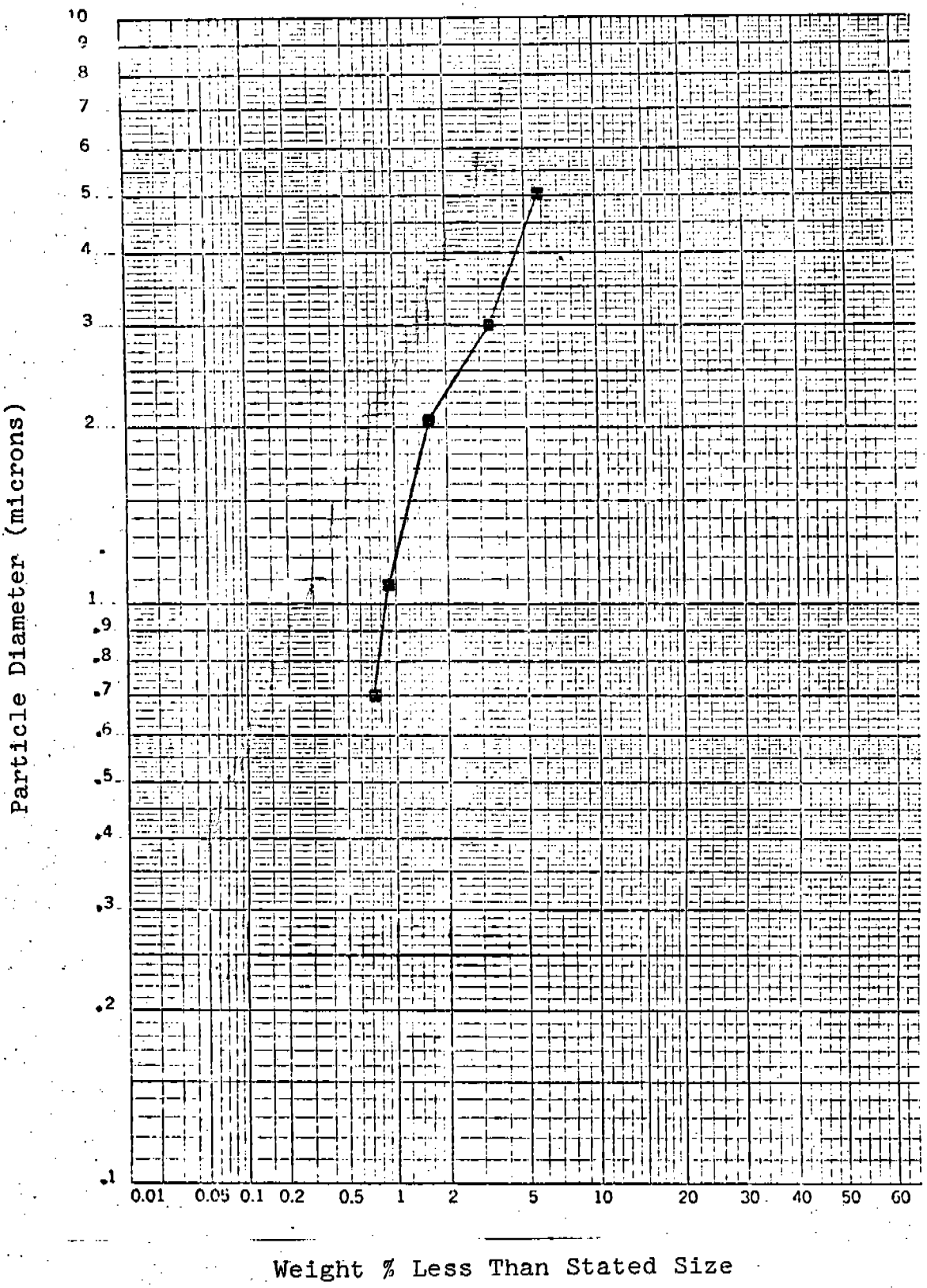

Figure 5. Particle size data (unit density) Run 2

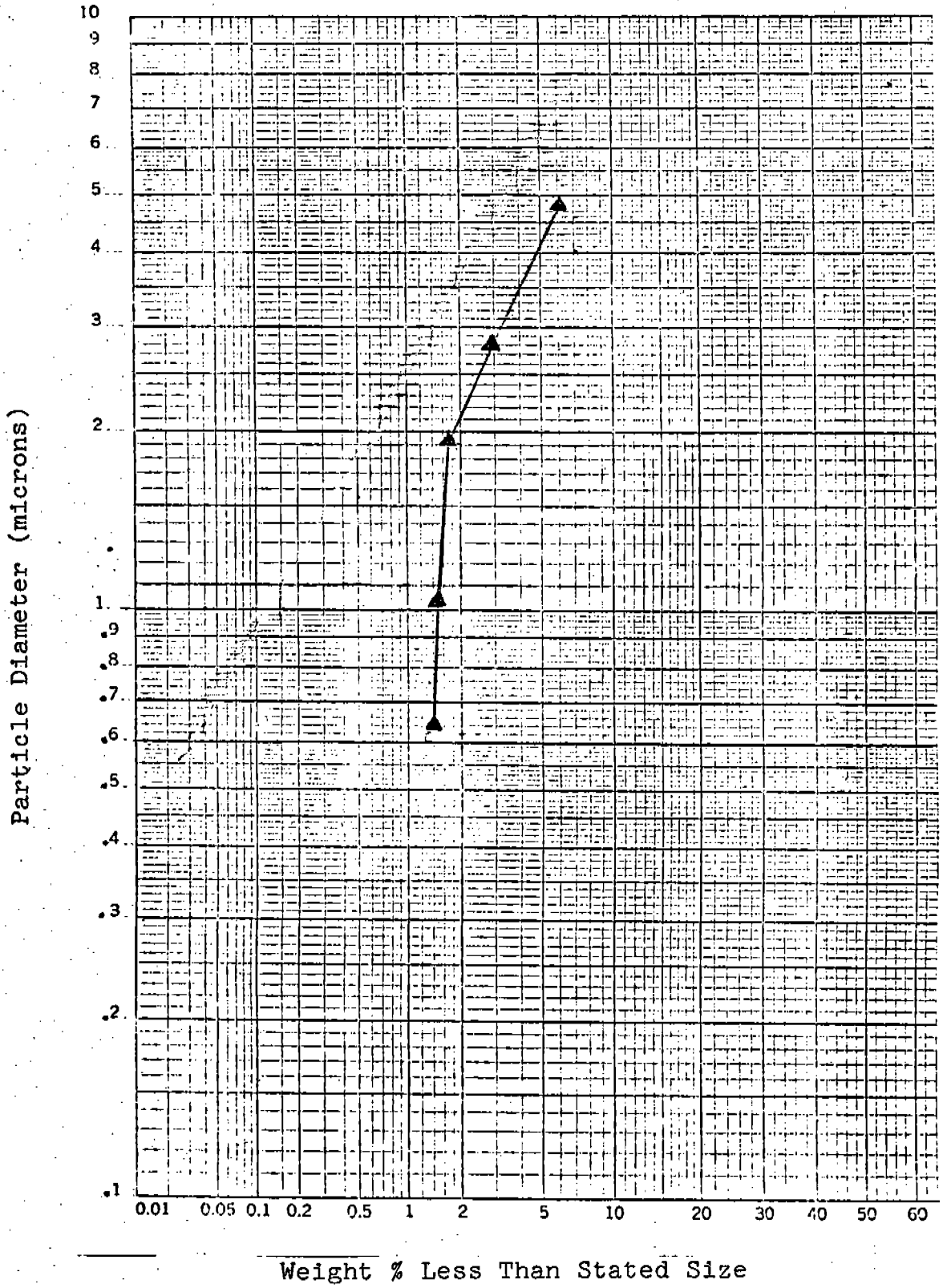

Figure 6. Particle size data (unit density) Run 3

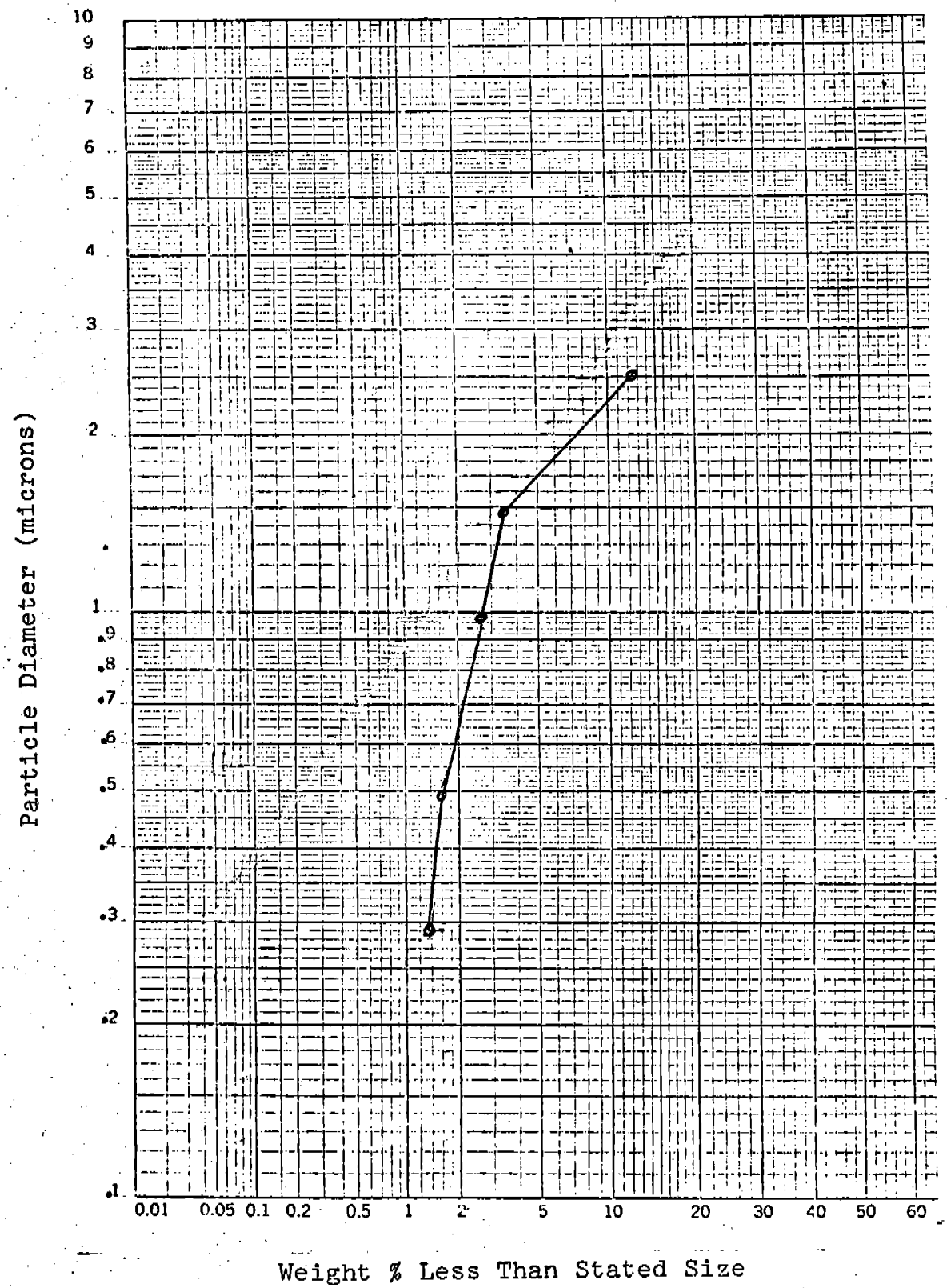

Figure 7. Particle size data (actual density) Run 1

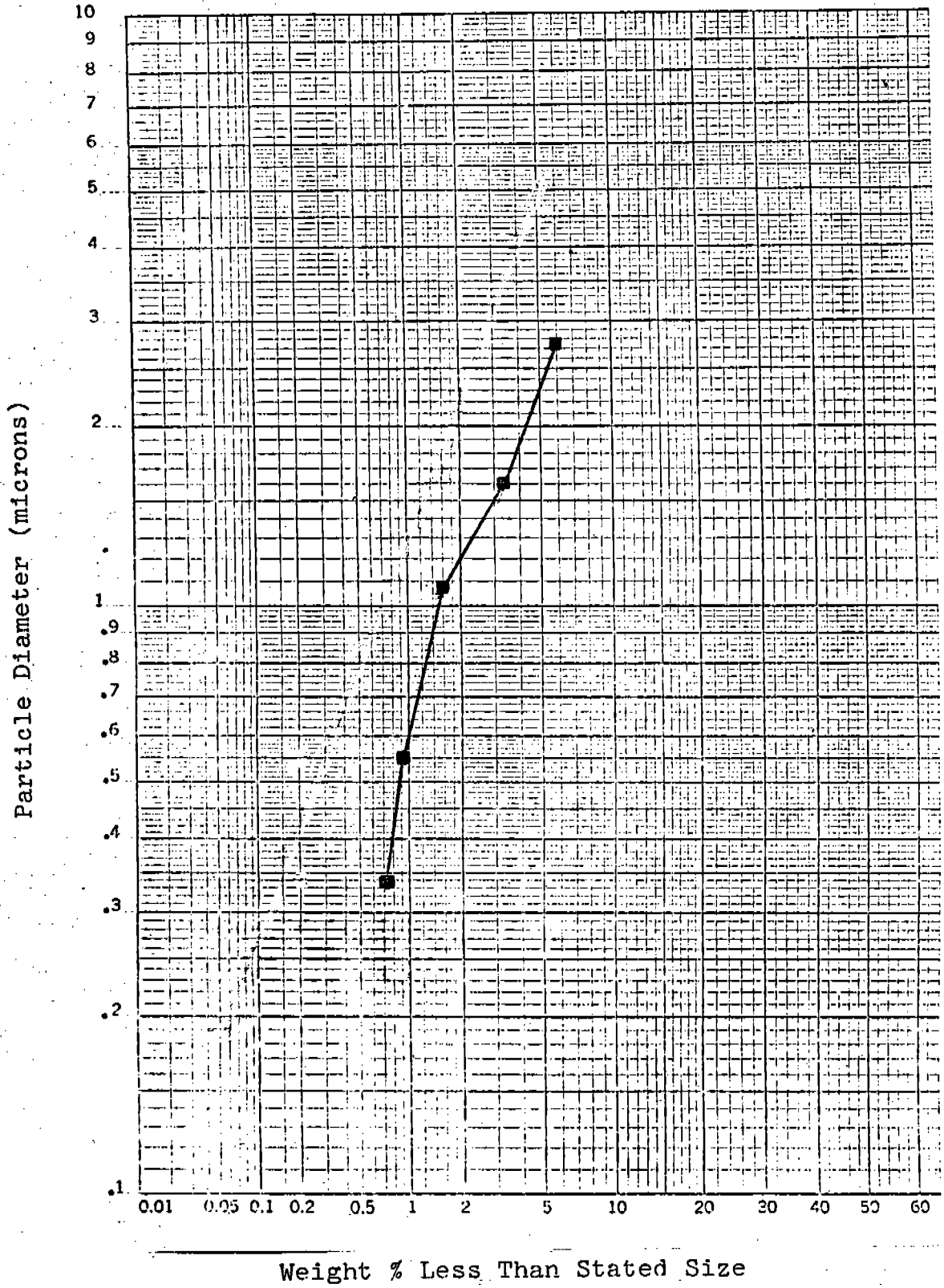

Figure 8. Particle size data (actual density) Run 2

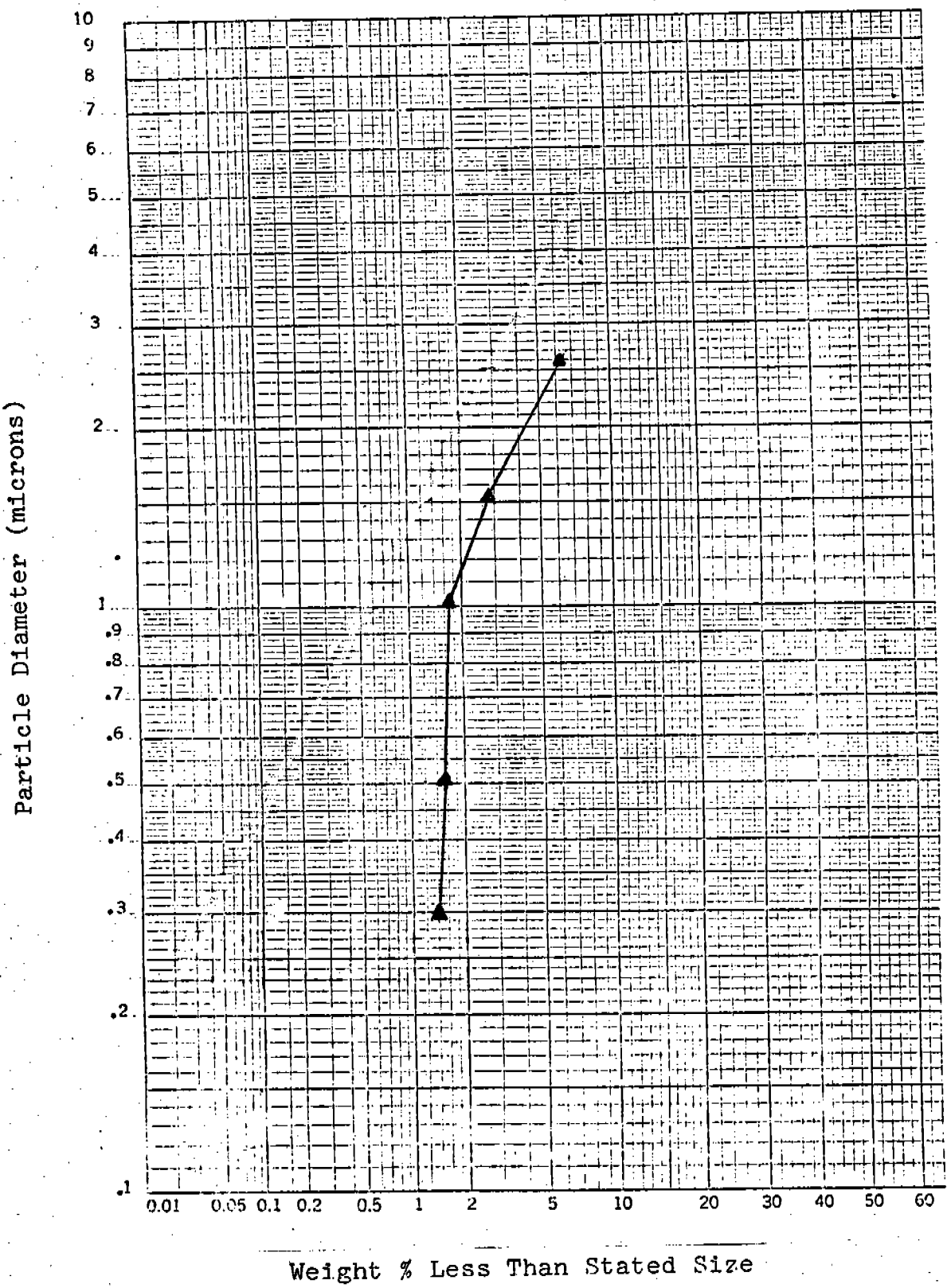

Figure 9. Particle size data (actual density) Run 3

Table 11. SUMMARY OF CO EMISSIONS

Run Number	1	2	3
Date	9-15	9-16	9-16
Sample Time (24 Hour Clock)	1500-1530	1000-1045	1300-1400
CO Concentration			
ppm	35	18	104
g/Nm^3	0.040	0.021	0.119
lb/dscf x 10^{-6}	2.497	1.284	7.420
CO Emissions			
Kg/hr[a]	6.46	3.39	19.23
lb/hr[b]	14.25	7.33	42.33
CO_2 lb/hr[b]	0.14	0.07	0.41
CO by Drager Tubes	1048	1015	1122
ppm	35-40	20	110

lb CO / ton prod →

a - Flow Rate used - 2693 Nm^3/min (Average of 3 Method 5 runs)

b - Flow Rate used - 95091 dscfm (Average of 3 Method 5 runs)

Table 12 presents a summary of the visible emissions. The table gives the opacity readings which correspond, in part, to the third run of the Method 5 tests. The readings were taken from 3:00-4:00 p.m. on September 15, 1975 by J. Burbank, Observer #1, P. Westlin, Observer #2, and K. C. Hustvedt, Observer #3, of the EPA. The opacity readings were not taken during each Method 5 run because of the difficulty in reading the opacity of the white steam plume against a white sky. This steam plume would not evaporate until it reached a height of approximately 75-150 feet. At this height, any particulates that did exist in the plume, were so well dispersed that no visible emissions could be detected. It was due to these reasons that visible emissions measurements were not taken as originally planned. Appendix E gives the Complete Visible Emissions Results including field data sheets, summary sheets with 6-minute averages, and graphs plotting opacity vs. time.

Table 12. SUMMARY OF VISIBLE EMISSIONS

Date	9/16/75	9/16/75	9/16/75
Observer Number	1	2	3
Duration of Observation (min.)	10	48	60
No. of readings at 0% opacity	38	192	238
No. of readings at 5% opacity	2	-	2

SECTION III

PROCESS DESCRIPTION AND OPERATION

Limestone consists primarily of calcium carbonate or combinations of calcium and magnesium carbonate with varying amounts of impurities. Lime is a calcined or burned form of limestone, commonly divided into two basic products -- quicklime and hydrated lime. Calcination expels carbon dioxide from the raw limestone, leaving calcium oxide (quicklime). With the addition of water, calcium hydroxide (hydrated lime) is formed.

The basic processes in production are (1) quarrying the limestone raw material, (2) preparing the limestone for kilns by crushing and sizing, (3) calcining the limestone, and (4) optionally processing the quicklime further by additional crushing and sizing and then hydration. The majority of lime is produced in rotary kilns which can be fired by coal, oil, or gas. Rotary kilns have the advantages of high production per man-hour and a uniform product but require higher capital investment and have higher unit fuel costs than most vertical kilns.

The Allied Products Company lime plant in Montevallo, Alabama, consists of three rotary kilns located on the edge of the high calcium limestone quarry. Two small older kilns (total production capacity about 500 tons of lime per day) are controlled by two Ducon scrubbers. The newest and largest kiln (number 3)

is controlled by twin ASE, Incorporated venturi scrubbers. This kiln is rated at 800 tons of lime per day, however, is only able to operate at 650 tons per day when coal is used as fuel.

Alabama coal is used in the kiln and they try to restrict it to less than 1.25 percent sulfur content because the lime is used in steel furnaces (U.S. Steel) and high sulfur in the lime effects the steel quality. The plant uses natural gas to the extent that it is available but there is never enough natural gas available to run the plant for several days without coal. The plant would need 10,000,000 cubic feet of natural gas per day if they had no coal (number 3 kiln would use half of it).

To reduce emissions, 12 Buell cyclones (2 parallel sets) are used as pre-cleaners and then the gases enter twin venturi scrubbers. Two 600 HP fans are located between the scrubbers and a nine foot diameter stack. The gas flow into the venturis at design amounts to 182,162 acfm @ 650°F, or approximately 80,000 dscfm. The actual flow rate was estimated to be 60,000 dscfm. The water flow through the venturis was about 1600 gallons per minute.

The slurry waste enters two settling tanks (only one in use at any time) from which the sludge is pumped to a slurry waste pond. Water from the waste pond evaporates or returns to the plant water sump in the bottom of the quarry. This waste water usually has a pH of greater than 9. Makeup water is estimated at less than 600 gallons per minute. The amount of waste generated is about 35 tons per day in the waste pond and about 35 tons per day of dry material collected from the multicyclones. Dry material is hauled to a spoil pile where it is wetted and forms a solid mass. The truck lanes are kept wet to reduce fugitive emissions.

Other process and handling emission control equipment consisted of a 28,000 cfm bag collector on a milling operation, a 10,000-12,000 cfm baghouse on handling operations, and a 5,000 acfm at 150°F Ducon scrubber on a 10 ton/hr hydrator. The slurry collected in the hydrator scrubber is returned to the process.

The operating parameters of the lime kiln were monitored during the testing. The process data recorded are listed on data sheets found in Appendix G. The lime kiln operated normally throughout the testing. A summary of the operating data taken during the sampling period appears in Table 13.

The Allied Products venturi scrubber had a large steam plume which made visible emission readings very difficult. A small amount of particulate was visible at times but it was difficult to quantify because of the distance from the stack at which the steam dissipated. The complete visible emission results are found in Appendix E.

Table 13. SUMMARY OF LIME KILN OPERATING DATA TAKEN DURING SAMPLING

Test	Date (1975)	Limestone Feed Rate (TPH)	Fuel (Coal) Feed Rate (TPH)	Fuel (Gas) Feed Rate (1000 CFM)	Stack Temp. °F	Oxygen %
1	9/15	51.6	6.7	15	345	0.5
2	9/16	51.6	6.5	15	340	0.5
3	9/16	51.6	5.9	34	340	0.5
			160×10^6 Btu/hr	90×10^6 Btu/hr		
			140	180		
			60%	40%		

12,000 Btu/lb coal

100 Btu/SCF gas

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SECTION IV

LOCATION OF SAMPLING POINTS

Figure 10 is a diagram of the inlet to the venturi scrubber on the No. 3 lime kiln. The steel rectangular duct has dimensions measuring 1.37 meters (54") by 2.74 meters (108"). The exhaust gases flow from the Buell cyclones into the duct before being diverted into the 2 venturis. The sampling location does not meet the requirements of Method 1 of the Federal Register. The location is presumed adequate for Method 6 testing, since SO_2 concentration can be assumed to be uniform. However, because of the possibility of particle stratification at the bend immediately preceding the inlet ports, this location leaves much to be desired for particle sizing. A sampling platform is located near the duct and has been used previously. The temperature of the exhaust gases at this location is 388°C (730°F) and the flow rate has been estimated to be 1699 Nm^3/min. (60,000 DSCFM).

Locations were available to collect the coal before it was pulverized and the product after it was cooled. The water being used in the scrubbers was collected before and after the venturi and analyzed for total suspended solids and acidity.

Figure 11 is a diagram of the outlet of the venturi scrubber. The stack has an inside diameter of 2.72 meters (107") and has an overall height of approximately 25.91 meters (85'). The nearest upstream disturbance is below the sampling ports,

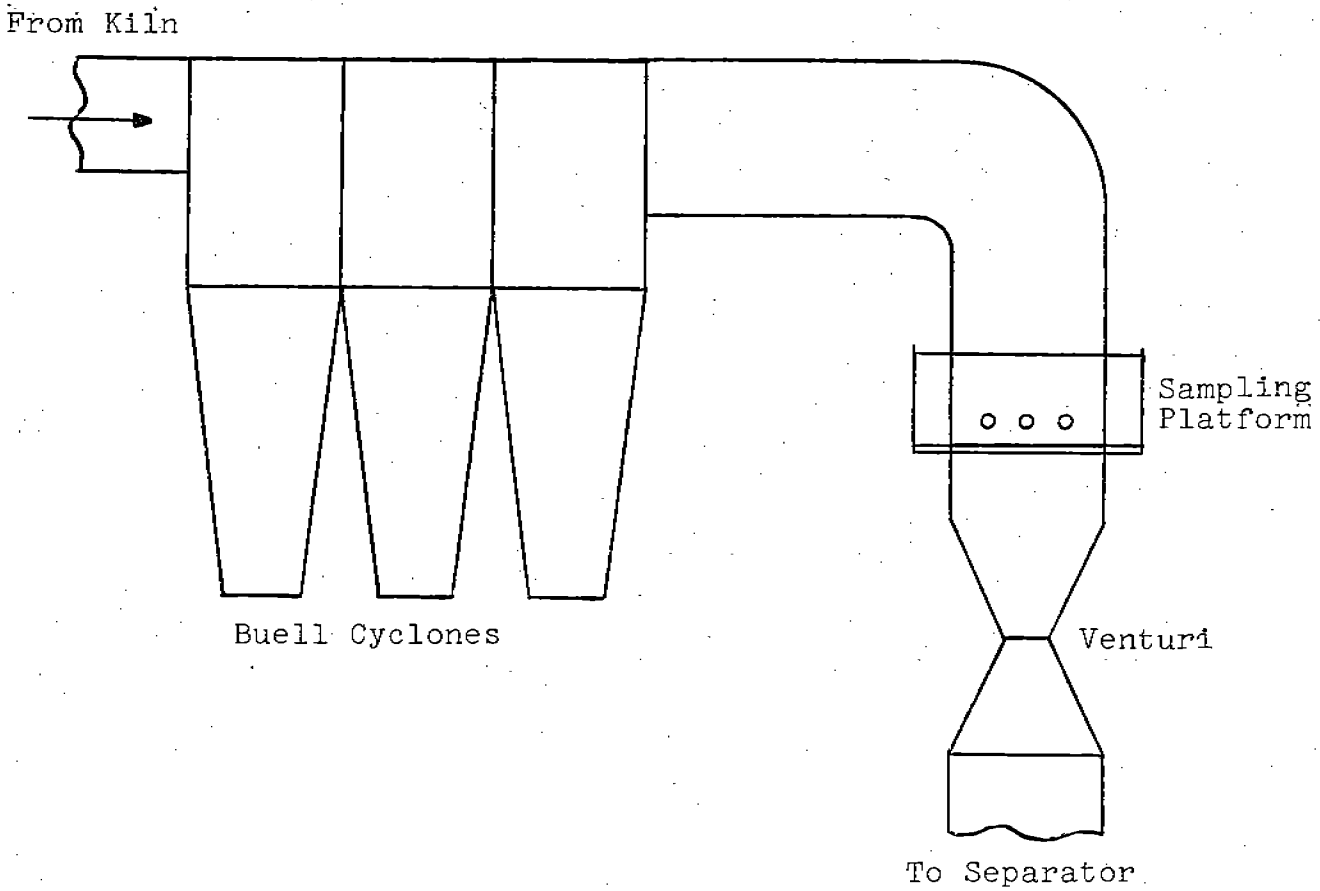


Figure 10. Inlet to Venturi on No. 3 Kiln

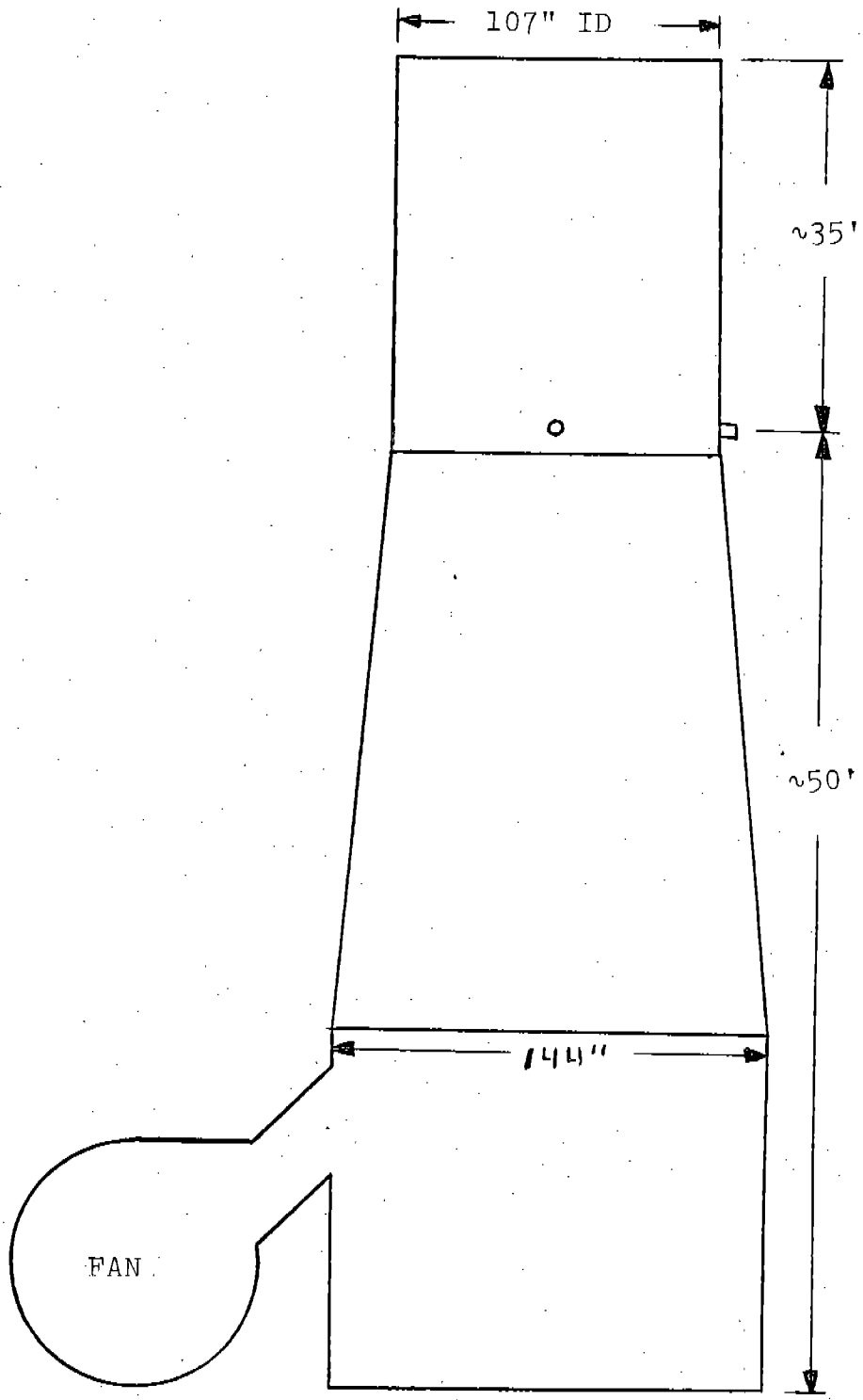


Figure 11. Outlet of Venturi Scrubbers

because the inside diameter expands from 2.72 meters (107"), at the sampling ports, to an inside diameter of 3.66 meters (144") at approximately 12.91 meters (40') below the ports. For this reason, a 48 point traverse was employed on this stack. The nearest downstream disturbance, the outlet, is approximately 10.67 meters (35 feet) from the sampling ports. The sampling on this stack was performed on scaffolding set up in front of each 90° port.

Both sets of scaffolding were approximately 15.24 meters (50') high with sampling platforms 3.66 meters (12') by 1.83 meters (6') approximately .30 meters (12") away from the edge of the stack. The two 24-point traverses were performed through two 7.6 cm (3 inch) nipples. The sampling for Methods 5, 6, 7 and 10 was performed through the ports provided in each stack.

SECTION V

SAMPLING AND ANALYTICAL PROCEDURES

1. Methods 1 through 4 and 6 and 7 from the Federal Register, Vol. 36, No. 247, December 23, 1971, were followed during the sampling at Allied Products in Montevallo, Alabama.

2. Method 5 from the Federal Register, Vol. 36, No. 159, August 17, 1971, was followed during the particulate sampling at Allied Products. The clean-up procedures used followed the guidelines of the above Federal Register, and "Specifications for Incinerator Testing at Federal Facilities," U. S. Department of Health, Education, and Welfare publication, October 1967. Analysis of sample was performed according to the aforementioned August 17 Federal Register, with the addition of back half water evaporation, dessication, and weighing for inorganic matter following ether/chloroform extraction, as defined in the HEW publication.

3. Method 9 from the Federal Register, Vol. 39, No. 219, November 12, 1974, was used to determine the visible emissions.

4. Method 10 from the Federal Register, Vol. 39, No. 47, March 8, 1974, was followed during the carbon monoxide sampling and analysis.

5. The total sulfur analysis of the coal collected during the Method 6 runs was performed according to ASTM D271-70.

6. The total sulfur analysis of the product and the particulate in the scrubber water was performed according to ASTM Designation: C25-72, "The Standard Methods of Chemical Analysis of Limestone, Quicklime, and Hydrated Lime," Section 23-1, Standard Bromine Method. (See copy in Appendix K.)

7. The analyses for pH, total suspended solids, and total dissolved sulfur on the scrubber water was performed according to the 1971 edition of "Standard Methods for the Examination of Water and Wastewater," 13th Edition, Method #156, pages 330-336 and Method 224C, pages 531-538.

APPENDIX A

COMPLETE PARTICULATE RESULTS & SAMPLE CALCULATION

Table A-1. PARTICULATE EMISSION DATA (METRIC)

15 JAN 1976

ALLIED PRODUCTS - 6912-20
PARTICULATE SAMPLING

ABBR	DESCRIPTION (20 DEG C)	UNITS	1	2	3
TT	DURATION OF RUN	MINUTES	120.0	120.0	120.0
PB	BAROMETRIC PRESSURE	CM HG	75.77	75.44	75.44
DELH	AVG ORIFICE PRESS DROP	CM H2O	2.566	2.550	2.464
VM	VOL DRY GAS(METER CON)	DCM	1.772	1.780	1.731
TM	AVG GAS METER TEMP	DEG C	26.8	26.6	30.8
VMSTD	VOL DRY GAS (STD COND)	DNCM	1.73	1.73	1.66
VW	TOTAL H2O COLLECTED	ML	319.6	298.3	327.3
VWG	VOL H2O VAPOR(STD CON)	NCM	0.429	0.400	0.439
PCNTM	PERCNT MOISTURE BY VOL		19.86	18.77	20.91
MD	MOLE FRACTION DRY GAS		0.801	0.812	0.791
CO2	PERCENT CO2		12.7	12.3	13.6
O2	PERCENT O2		11.8	11.8	11.2
N2	PERCENT N2		75.6	75.9	75.2
MWD	MOL WT OF DRY GAS		30.5	30.4	30.6
MW	MOL WT OF STACK GAS		28.0	28.1	28.0
DELP	AVG STACK VELOCITY HEAD	CM H2O	0.987	0.966	0.912
CP	PITOT COEFFICIENT		0.828	0.828	0.828
TS	STACK TEMPERATURE	DEG C	64.	64.	66.
PM	STACK PRESSURE(STATIC)	CM H2O	-0.66	-0.66	-0.66
PS	STACK PRESSURE (ABS)	CM HG	75.72	75.39	75.39
VS	AVG STACK GAS VELOCITY	MPM	680.	673.	654.
DS	STACK DIAMETER	CM	271.78	271.78	271.78
AS	STACK AREA	SQ CM	58016.5	58016.5	58016.5
QS	STACK FLOW RT(DRY STD)	DNCMPM	2747.	2746.	2582.
QA	STACK FLOW RT(ACTUAL)	ACMPM	3943.	3905.	3792.
DN	PROBE TIP DIAMETER	CM	0.622	0.622	0.622
PCTI	PERCENT ISOKINETIC		100.5	100.5	102.6
MF	PARTICULATE (FRONT)	MG	119.30	85.20	121.30
MT	PARTICULATE (TOTAL)	MG	131.90	93.60	131.30
CAN	PARTICULATE (FRONT)	G/DNCM	0.0688	0.0491	0.0729
CAO	PARTICULATE (TOTAL)	G/DNCM	0.0760	0.0536	0.0789
CAT	PARTICULATE (FRONT)	G/ACM	0.0477	0.0348	0.0494
CAU	PARTICULATE (TOTAL)	G/ACM	0.0528	0.0375	0.0535
CAW	PARTICULATE (FRONT)	KG/HR	11.330	8.065	11.281
CAX	PARTICULATE (TOTAL)	KG/HR	12.526	8.825	12.211

Table A-2. PARTICULATE EMISSION DATA (ENGLISH)

15 JAN 1976

ALLIED PRODUCTS - 6912-20
PARTICULATE SAMPLING

ABBR	DESCRIPTION (68 DEG F)	UNITS	1	2	3
TT	DURATION OF RUN	MINUTES	120.0	120.0	120.0
PB	BAROMETRIC PRESSURE	IN HG	29.83	29.70	29.70
DELH	AVG ORIFICE PRESS DROP	IN H2O	1.010	1.004	0.970
VM	VOL DRY GAS(METER CON)	DCF	62.578	62.851	61.134
TM	AVG GAS METER TEMP	DEG F	80.2	79.9	87.4
VMSTD	VOL DRY GAS (STD COND)	DSCF	61.14	61.18	58.69
VW	TOTAL H2O COLLECTED	ML	319.6	298.3	327.3
VWG	VOL H2O VAPOR(STD CON)	SCF	15.149	14.139	15.514
PCNTM	PERCNT MOISTURE BY VOL		19.86	18.77	20.91
MD	MOLE FRACTION DRY GAS		0.801	0.812	0.791
CO2	PERCENT CO2		12.7	12.3	13.6
O2	PERCENT O2		11.8	11.8	11.2
N2	PERCENT N2		75.6	75.9	75.2
MWD	MOL WT OF DRY GAS		30.5	30.4	30.6
MW	MOL WT OF STACK GAS		28.0	28.1	28.0
DELP	AVG STACK VELOCITY HEAD	IN H2O	0.389	0.380	0.359
CP	PITOT COEFFICIENT		0.828	0.828	0.828
TS	STACK TEMPERATURE	DEG F	148.	147.	151.
PM	STACK PRESSURE(STATIC)	IN H2O	-0.26	-0.26	-0.26
PS	STACK PRESSURE (ABS)	IN HG	29.81	29.68	29.68
VS	AVG STACK GAS VELOCITY	FPM	2230.	2209.	2145.
DS	STACK DIAMETER	INCHES	107.00	107.00	107.00
AS	STACK AREA	SQ IN	8992.0	8992.0	8992.0
QS	STACK FLOW RT(DRY STD)	DSCFM	96992.	96979.	91172.
QA	STACK FLOW RT(ACTUAL)	ACFM	139236.	137903.	133899.
DN	PROBE TIP DIAMETER	INCHES	0.245	0.245	0.245
PCTI	PERCENT ISOKINETIC		100.5	100.5	102.6
MF	PARTICULATE (FRONT)	MG	119.30	85.20	121.30
MT	PARTICULATE (TOTAL)	MG	131.90	93.00	131.30
CAN	PARTICULATE (FRONT)	GR/DSCF	0.0300	0.0214	0.0318
CAO	PARTICULATE (TOTAL)	GR/DSCF	0.0332	0.0234	0.0345
CAT	PARTICULATE (FRONT)	GR/ACF	0.0209	0.0150	0.0216
CAU	PARTICULATE (TOTAL)	GR/ACF	0.0231	0.0164	0.0234
CAW	PARTICULATE (FRONT)	LB/HR	24.977	17.824	24.870
CAX	PARTICULATE (TOTAL)	LB/HR	27.615	19.456	26.921

METHOD 5 CALCULATIONS

Plant: Allied Products Company Date: 9/15/75

Run # 1 Location Sampled: Outlet of Venturi

Volume of gas at meter conditions (CF) = Vm = 62.578

Average meter temperature (°F) = Tm = 80.2

Barometric pressure absolute (in Hg) = Pb = 29.83

Average orifice pressure drop (in H_2O) = ΔH = -0.26

$$Vms = \frac{(17.65)(Vm)}{(Tm + 460)}\left(Pb + \frac{\Delta H}{13.6}\right) = \frac{(17.65)(62.578)}{(80.2 + 460)}\left(29.83 + \frac{-0.26}{13.6}\right)$$

Volume of gas sampled at std. cond. (SCF) = Vms = 60.95

Volume of liquid collected (ml) = Vl = 319.6

Vw = (.0474) (Vl) = (.0474) (319.6)

Volume of water vapor at std. cond. (CF) = Vw = 15.15

$$M = \frac{(Vw)}{(Vms) + (Vw)} = \frac{(15.15)}{(60.95) + (15.15)}$$ = M = .1991

Percent moisture = (100) (M) = (100) (.1991) = % M = 19.91

Mole fraction of dry gas = 1-(M) = 1-(.1991) = MF = 0.8009

% O_2 = 11.8

% CO_2 = 12.7

% CO = 0

% N_2 = 100-(%O_2+ %CO_2+ %CO) = 100-(+ +) = % N_2 = 75.6

Md = 0.44 (% CO_2) + 0.32 (% O_2) + 0.28 (% N_2 + % CO)

Md = 0.44 (12.7) + 0.32 (11.8) + 0.28 (75.6 + 0) = Md = 30.53

Molecular weight of dry gas (lbs/lb-mole)

Ms = (Md) (MF) + 18 (M) = (30.53) (0.8009) + 18 (.1991)

Molecular weight of wet stack gas (lbs/lb-mole) = Ms = 28.04

$$\% EA = \frac{(\% O_2) - [0.5\ (\% CO)]}{[0.264(\%N_2)]-(\% O_2)+[0.5(\% CO)]} \times 100$$

$$= \frac{(\ 11.8\ )-[0.5(\ 0\ )}{[0.264(\ 75.6)]-(\ 11.8\ )+[0.5(\ 0\ )]} \times 100$$

Percent excess air = % EA = 144.6

Average stack temperature (°F) = Ts = 148

Average of the sq root of velocity head (in H_2O)$^{1/2}$ = $\sqrt{\Delta p}$ = 0.616

Absolute pressure of stack (in Hg) = Ps = 29.81

Pitot Tube coefficient = Cp = 0.828

$$Vs = (85.48)(CP)(\sqrt{\Delta p})\left(\frac{(Ts+460)}{(Ps)(Ms)}\right)^{1/2} = (85.48)\ (0.828)(\ \ )\left(\frac{(\ 148\ +\ 460)}{(29.81)(28.84)}\right)^{1/2}$$

Average velocity of the stack gas (FPS) = Vs = 37.184

Test Time (min.) = T = 120

Stack area (SF) = A = 62.4

$$Q = \frac{(1063)\ (MF)\ (A)\ (Vs)\ (Ps)}{(Ts\ +\ 460)} = \frac{(1063)\ (\ 0.8409)\ (\ 62.4)\ (37.184)\ (29.81)}{(\ \ 148\ +\ 460)}$$

Volumetric flow rate of stack (DSCFM) = Q = 96852

Diameter of sampling nozzle (in.) = d = 0.245

Area of nozzle = $54.54 \times 10^{-4}(d)^2 = 54.54 \times 10^{-4}(.245)^2$ = An = 3.27×10^{-4}

$$I = \frac{(1.667)\ (Ts\ +\ 460)\left[[0.00267(Vl)\ +\ \frac{(Vm)}{(Tm\ +\ 460)}\left(P_b\ +\ \frac{\Delta H}{13.6}\right)\right]}{(T)\ (Vs)\ (Ps)\ (An)}$$

$$I = \frac{(1.667)(\ 148\ +\ 460)\left[0.00267(\ 319.6\ )\ +\ \frac{(\ 62.578\ )}{(\ 80.2+\ 460)}\left(29.83\ +\ \frac{(-.26)}{13.6}\right)\right]}{(\ \ 120\ \ )(\ 37.184\ )(\ 29.81\ )(\ 3.27 \times 10^{-4}\ )}$$

Percent Isokinetic (%) = I = 100.4

Particulate - probe, filter, and cyclone - front half (mg) = Mp = 119.3

Particulate - total (mg) = Mt = 131.9

$C_{AP} = (.0154) \frac{(Mp)}{(Vms)} = (.0154) \frac{(119.3)}{(60.95)}$

Concentration front half (gr/DSCF) = C_{AP} = 0.0301

$C_{AT} = (.0154) \frac{(Mt)}{(Vms)} = (.0154) \frac{(131.9)}{(60.95)}$

Concentration total (gr/DSCF) = C_{AT} = 0.0333

$C_{BP} = (2.205 \times 10^{-6}) \frac{(Mp)}{(Vms)} = (2.205 \times 10^{-6}) \frac{(119.3)}{(60.95)}$

Concentration front half (lbs/DSCF) = C_{BP} = 4.32×10^{-6}

$C_{BT} = (2.205 \times 10^{-6}) \frac{(Mt)}{(Vms)} = (2.205 \times 10^{-6}) \frac{(131.9)}{(60.95)}$

Concentration total (lbs/DSCF) = C_{BT} = 4.77×10^{-6}

$Ep = (60)(C_{BP})(Q) = (60)(4.32 \times 10^{-6})(96852)$

Emission rate front half (lbs/Hr) = Ep = 24.99

$E_T = (60)(C_{BT})(Q) = (60)(4.77 \times 10^{-6})(96852)$

Emission rate total (lbs/Hr) = E_T = 27.72

APPENDIX B

COMPLETE NO_x RESULTS AND SAMPLE CALCULATION

Table B-1. NO_x RESULTS

NOX CALCULATION (68 DEG F)

ALLIED PRODUCTS
28 JAN 1976

VSC - SAMPLE VOLUME AT STANDARD CONDITIONS (DRY BASIS),ML
MASS - MASS OF NO2 IN GAS SAMPLE,UG
PPM - PPM,NOX AS NO2
LB/DSCF - CONCENTRATION OF NOX AS NO2 (DRY BASIS),LB/DSCF

VSC	MASS	PPM	LB/DSCF	KG/HR	G/NCM	LB/HR
0.181682E+04	0.371669E+03	0.107195E+03	0.126854E-04	0.207115E+02	0.203146E+00	0.456602E+02
0.161664E+04	0.447770E+03	0.129157E+03	0.152819E-04	0.249547E+02	0.244765E+00	0.550148E+02
0.185206E+04	0.421678E+03	0.119305E+03	0.141162E-04	0.230512E+02	0.226095E+00	0.508184E+02
0.177493E+04	0.443421E+03	0.130908E+03	0.154891E-04	0.252931E+02	0.248084E+00	0.557608E+02
0.173236E+04	0.334705E+03	0.101241E+03	0.119789E-04	0.195611E+02	0.191862E+00	0.431240E+02
0.175655E+04	0.336879E+03	0.100381E+03	0.118772E-04	0.193949E+02	0.190233E+00	0.427578E+02
0.171677E+04	0.341228E+03	0.104151E+03	0.123232E-04	0.201233E+02	0.197377E+00	0.443635E+02
0.179654E+04	0.328182E+03	0.962571E+02	0.113892E-04	0.185981E+02	0.182417E+00	0.410011E+02
0.175049E+04	0.371669E+03	0.111257E+03	0.131640E-04	0.214963E+02	0.210844E+00	0.473905E+02
0.184773E+04	0.271650E+03	0.770375E+02	0.911513E-05	0.148846E+02	0.145994E+00	0.328145E+02
0.191683E+04	0.236881E+03	0.646828E+02	0.765331E-05	0.124976E+02	0.122581E+00	0.275519E+02
0.178601E+04	0.354274E+03	0.103941E+03	0.122984E-04	0.200828E+02	0.196979E+00	0.442742E+02

METHOD 7

NO_x CALCULATIONS

Plant Allied Products

Date 9/16/75

Test No. 1

Volume of flask and value (ml)	= VF =	2058
Initial absolute pressure of flask (in Hg)	= PI =	2.2
Final absolute pressure of flask (in Hg)	= PF =	28.91
Initial temperature of flask (°F)	= TI =	70
Final temperature of flask (°F)	= TF =	68
Mass of NO_x as NO_2 in gas sample (µg)	= M =	371.67

Volume of sample at standard conditions, dry basis(ml) = VS

$$VS = 17.71 \times (VF-25)\left(\frac{PF}{TF+460} - \frac{PI}{TI+460}\right)$$

$$VS = 17.71 \times (2058 \quad -25)\left(\frac{28.91}{68+460} - \frac{2.2}{70+460}\right) = 1821.93 \text{ ml}$$

Concentration of NO_x as NO_2 (dry basis) (lbs/scf) = C

$$C = 6.2 \times 10^{-5} \times \left(\frac{M}{VS}\right)$$

$$C = 6.2 \times 10^{-5} \times \left(\frac{371.67}{1821.93}\right) = 1.26 \times 10^{-5} \text{ lbs/scf}$$

APPENDIX C

SO_2 CONTINUOUS MONITORING REPORT AND METHOD 6 CALCULATIONS

I. INTRODUCTION

Measurement of SO_2 emissions were conducted at the Allied Products lime plant in Montevallo, Alabama, during the week of September 15. An Environmental Protection Agency test crew used a Dynascience SO_2 monitor to perform SO_2 measurements of the inlet and outlet gases at a venturi water scrubber designed for particulate control. The scrubber effluent recycled through a holding pond, and water samples were taken at feed discharge to determine TSS, pH, and total sulfur content. The process consists of calcination of limestone in a rotary kiln fired with coal and natural gas. Approximately 90% of the heat input was due to coal during the sampling period. The purpose of the testing was two-fold: (1) to determine inlet and outlet SO_2 concentrations across the scrubber in order to calculate the SO_2 removal efficiency, and (2) to obtain SO_2 measurements that could be compared with simultaneous Method 6 measurements made by a contractor test crew. The Method 6 results are contained elsewhere in this appendix.

II. LOCATION OF SAMPLING POINTS

Scrubber inlet sampling was conducted in a vertical duct where the gas flow was downward and the stack pressure was negative. This sampling point was the same as used for Method 6 and particle size tests, located after mechanical cyclone dust collectors and prior to the induced draft fan. Outlet sampling was performed in the duct following the scrubber and I.D. fan and leading to the stack at an opening where duct material had eroded away.

III. SAMPLING AND ANALYTICAL PROCEDURES

The SO_2 measurements were performed with a Dynascience Air Pollution Monitor. The sensor in this unit operates on the principle of a fuel cell, where the pollutant diffuses through a semipermeable membrane and is detected by a special sensing electrode capable of undergoing electro-oxidation or electro-reduction. The resulting current is directly proportional to the partial pressure of the pollutant in the gas mixture, and is amplified and displayed on a meter.

A special in-stack filter and condenser system was constructed so that a gas sample could be drawn from the stack and the particulate and moisture could be removed prior to entering the monitoring unit. The in-stack filter holder contained glass wool and a glass-fiber mat filter. The 0.8 m. long probe of stainless steel tubing was not heated, but mounted in the stack so as to be at stack conditions. The condenser was a teflon coil in an ice bath and with a moisture trap.

The sample gas was drawn out of the stack by a leakless diaphragm pump at the rate of about 0.8 lpm. Output from the Dynascience monitor was recorded with a strip chart recorder. Calibration was performed prior to each sampling period and immediately following each period. The calibration gases were 450 ppm SO_2 and 185 ppm SO_2 in nitrogen.

The strip chart readout was divided into 10-minute intervals and the average was determined for each interval. High and low values were also noted. This data is shown in Section II of the main body of this report.

Some variation in the SO_2 concentration in the scrubber inlet gas was recorded. Plant operation data showed the coal rate at a constant 6.7 tons/hour on the first day of inlet monitoring (9/15), and 6.5 tons/hour during inlet monitoring on 9/17. The stone feed rate was also constant over the test period. This variation could be explained by changes in air feed through coal pulverizer and rock feed. Excess O_2 allows SO_2 to oxidize to SO_3 which combines with the calcined lime (CaO) forming Ca SO_4.

The Dynascience SO_2 monitor operated satisfactorily during the test program. The instrument, designed as a continuous monitor, performed as a source test device with no apparent difficulties. Operation of the instrument, including calibration, was simple and straightforward and the supporting equipment was somewhat less trouble to handle than the sampling equipment required for a Method 6 test.

IV. SUMMARY AND DISCUSSION OF RESULTS

On September 15, the Dynascience equipment was mounted at the Allied scrubber inlet. The sampling port was upstream from the induced draft fan, so the static pressure was negative. The stack temperature was about 425°C (800°F). Sampling began after calibration at about 1:00 p.m. Early problems with leaks in the sampling system and improper seals in the filter holder were overcome. Sampling continued until about 4:30 p.m. Recalibration of the Dynascience monitor showed that span drift and zero drift were minimal.

The sampling equipment was set up at the outlet of the scrubber on September 16. This was a high moisture gas stream and the

glass-fiber filter mat was removed from the in-stack filter because of moisture condensation. The glass wool was left in place. Static pressure was positive and temperature was about 65°C (150°F). Sampling began after calibration at about 11:30 a.m. and continued until 4:30 p.m.

The sampling train was mounted at the scrubber inlet on September 17. Sampling began at about 10:30 a.m. and continued until about 12:00 noon. The equipment was then moved to the scrubber outlet and sampling started about 2:00 p.m. The stack conditions at both locations were approximately the same as for the previous days.

Table C-1 shows the results of the sampling as daily averages. Ten-minute averages with peaks and lows are shown in Section II of the main body of this report. Copies of the strip chart data are included in this Appendix.

Table C-1. Results of SO_2 Monitoring at Allied Products Lime Plant

Date	Sampling Location	SO_2 Concentration (10-Minute Averages)		
		Average (ppm)	High (ppm)	Low (ppm)
9/15	Scrubber Inlet	177	252	126
9/16	Scrubber Outlet	0	0	0
9/17	Scrubber Inlet	147	190	86
9/17	Scrubber Outlet	0	0	0

These results have been corrected for span drift and zero drift. The SO_2 measurements at the scrubber outlet were below 5 ppm which was within the range of zero drift during the testing.

Results from the testing at the Allied Products scrubber are significant. While the SO_2 concentration at the inlet averaged about 160 ppm over nearly 5 hours of sampling, the outlet concentration was negligible. This should be expected after examining the operation of the scrubber and lime-dust control system. A mixture of water, SO_2, and caustic lime dust enters the high energy scrubber and exhausts as a high moisture gas stream. Liquid effluent contains lime dust and, likely, all the SO_2 as Ca SO_4.

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/75

Location Inlet No 1 Extruder Run# 1-2

Barometric Pressure Absolute (in Hg)	BP =	29.72
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	580
Volume Through Dry Gas Meter (CF)	V_m =	0.917
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	2.97
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	0.0099
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = \cancel{17.71}\ 17.65 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(.917)(29.72)}{(580)} = 0.829$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(2.97)(0.0099)(200)}{(.829)(50)}$$

$C = 1.00 \times 10^{-5}$ lbs/SCF

ppm SO_2 = 61

* Velocity of Stack Gas (Actual)(FPS)	V =	36.58
% Moisture in Stack Gas	M =	19.85
Area of Stack (ft^2)	A =	62.444
Absolute Stack Temperature (°R)	T_s =	609
Absolute Stack Pressure (in Hg)	P_s =	29.72

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{\cancel{6.377}\ 6.3523 \times 10^4\ (.8015)(36.58)(62.444)(29.72)(1.00 \times 10^{-5})}{(609)}$$

S = 57.1 (lbs/hr)

* Flow rate from Average of three Method 5 Run used

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/75

Location Outlet of venturi Run# 1-0

Barometric Pressure Absolute (in Hg)	BP =	29.70
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	528.5
Volume Through Dry Gas Meter (CF)	V_m =	0.802
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	0
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	.0079
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = 17.71 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(\quad)(\quad)}{(\quad)} = \quad$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(\quad)(\quad)(\quad)}{(\quad)(\quad)}$$

C = 0 lbs/SCF

Velocity of Stack Gas (Actual)(FPS)	V =	
% Moisture in Stack Gas	M =	
Area of Stack (ft^2)	A =	
Absolute Stack Temperature (°R)	T_s =	
Absolute Stack Pressure (in Hg)	P_s =	

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{6.377 \times 10^{4} (\quad)(\quad)(\quad)(\quad)(\quad)}{(\quad)}$$

S = 0 (lbs/hr)

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/75

Location Inlet to venturi Run# 2-I

Barometric Pressure Absolute (in Hg)	BP =	29.51
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	581.5
Volume Through Dry Gas Meter (CF)	V_m =	0.929
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	0
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	0.0049
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = 17.71 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(\quad)(\quad)}{(\quad)} = \quad$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(\quad)(\quad)(\quad)}{(\quad)(\quad)}$$

C = 0 lbs/SCF

Velocity of Stack Gas (Actual)(FPS)	V =	
% Moisture in Stack Gas	M =	
Area of Stack (ft^2)	A =	
Absolute Stack Temperature (°R)	T_s =	
Absolute Stack Pressure (in Hg)	P_s =	

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{6.377 \times 10^{4} (\quad)(\quad)(\quad)(\quad)(\quad)}{(\quad)}$$

S = 0 (lbs/hr)

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/-75

Location Outlet of venturi Run# 2-C

Barometric Pressure Absolute (in Hg)	BP =	29.51
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	531
Volume Through Dry Gas Meter (CF)	V_m =	0.821
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	0
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	.0099
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = 17.71 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(\quad)(\quad)}{(\quad)} = \_\_\_\_$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(\quad)(\quad)(\quad)}{(\quad)(\quad)}$$

C = 0 lbs/SCF

Velocity of Stack Gas (Actual)(FPS)	V =	
% Moisture in Stack Gas	M =	
Area of Stack (ft^2)	A =	
Absolute Stack Temperature (°R)	T_s =	
Absolute Stack Pressure (in Hg)	P_s =	

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{6.377 \times 10^{4}\ (\quad)(\quad)(\quad)(\quad)(\quad)}{(\quad)}$$

S = 0 (lbs/hr)

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/75

Location Inlet To eventuri Run# 3-I

Barometric Pressure Absolute (in Hg)	BP =	29.51
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	585
Volume Through Dry Gas Meter (CF)	V_m =	0.885
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	0
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	.0099
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = 17.71 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(\quad)(\quad)}{(\quad)} = \quad$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(\quad)(\quad)(\quad)}{(\quad)(\quad)}$$

C = 0 lbs/SCF

Velocity of Stack Gas (Actual)(FPS)	V =	
% Moisture in Stack Gas	M =	
Area of Stack (ft^2)	A =	
Absolute Stack Temperature (°R)	T_s =	
Absolute Stack Pressure (in Hg)	P_s =	

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{6.377 \times 10^{4}\ (\quad)(\quad)(\quad)(\quad)(\quad)}{(\quad)}$$

S = 0 (lbs/hr)

METHOD 6

SO_2 CALCULATION

Plant Allied Products Date 9/25/75

Location Outlet of venturi Run# 3-0

Barometric Pressure Absolute (in Hg)	BP =	29.51
Average Meter Temperature (°R) Absolute (°F + 460)	T_m =	530.5
Volume Through Dry Gas Meter (CF)	V_m =	.639
Volume of $Ba(ClO_4)_2$ to Titrate Sample (ml)	V_t =	0
Volume of $Ba(ClO_4)_2$ to Titrate Blank (ml)	V_b =	0
Normality of $Ba(ClO_4)_2$ Solution (g-eq/l)	N =	.0077
Total Volume of Solution (ml)	V_s =	200
Volume of Aliquot (ml)	V_a =	50
Volume of Gas at Standard Conditions (SCF) = V_g		

$$V_g = 17.71 \frac{(V_m)(BP)}{(T_m)} = 17.71 \frac{(\quad)(\quad)}{(\quad)} = \_\_\_\_\_$$

Concentration of SO_2 (lbs/SCF) dry basis = C

$$C = 7.05 \times 10^{-5} \frac{(V_t - V_b)(N)(V_s)}{(V_g)(V_a)} = 7.05 \times 10^{-5} \frac{(\quad)(\quad)(\quad)}{(\quad)(\quad)}$$

C = 0 lbs/SCF

Velocity of Stack Gas (Actual)(FPS)	V =	
% Moisture in Stack Gas	M =	
Area of Stack (ft^2)	A =	
Absolute Stack Temperature (°R)	T_s =	
Absolute Stack Pressure (in Hg)	P_s =	

SO_2 Flow Rate (lbs/hr) = S

$$S = \frac{6.377 \times 10^{+4}(1-(M \times 10^{-2}))(V)(A)(P_s)(C)}{(T_s)}$$

$$S = \frac{6.377 \times 10^{4} (\quad)(\quad)(\quad)(\quad)(\quad)}{(\quad)}$$

S = 0 (lbs/hr)

APPENDIX D

COMPLETE CO RESULTS

Table D-1. CO RESULTS

Stack #	Run #	CO by NDIR (ppm)	% CO_2 by Orsat	Volume Fraction of CO_2 (1)	CO in Stack (2) (ppm)	CO ppm Drager tubes
Scrubber Outlet AP	1	40	12.7%	.127	34.9	35-40
Scrubber Outlet AP	2	20	12.3%	.123	17.5	20
Scrubber Outlet AP	3	120	13.6%	.136	103.7	110

(1) Volume Fraction of CO_2 = % CO_2/100

(2) % CO in Stack = [% CO by NDIR][1 - (Volume Fraction of CO_2)]

FIELD DATA SHEET - METHOD 10

LOCATION Outlet Scrubber - Allied

TEST Run # 1

DATE 9/15/75

OPERATOR Thalman

TUNE METER READING 36

CALIB. METER READING

GAIN TURNS NUMBER 2.81

COMMENTS:

CLOCK TIME	ROTAMETER SETTING (Cubic ft/min, cubic ft/hr)	CO ANALYZER Meter Reading	RUN NUMBER
5:05-5:15 P.M.	3.0	4.5%	
5:15-5:25 P.M.	3.0	4.5%	

FIELD DATA SHEET - METHOD 10

LOCATION Outlet Scrubber-Allied

TEST Run #2

DATE 9/16/75

OPERATOR Thalman

TUNE METER READING 36

CALIB. METER READING

GAIN TURNS NUMBER 2.85

COMMENTS:

CLOCK TIME	ROTAMETER SETTING (Cubic ft/min, cubic ft/hr)	CO ANALYZER Meter Reading	RUN NUMBER
3:05-3:15 P.M.	3.0	2%	
3:55-4:05 P.M.	3.0	2%	

FIELD DATA SHEET - METHOD 10

LOCATION Outlet Scrubber - Allied

TEST Run # 3

DATE 9/16/75

OPERATOR Thalman

TUNE METER READING 36

CALIB. METER READING

GAIN TURNS NUMBER 2.85

COMMENTS:

CLOCK TIME	ROTAMETER SETTING (Cubic ft/min, cubic ft/hr)	CO ANALYZER Meter Reading	RUN NUMBER
3:20-3:30 P.M.	3.0	13.5%	
3:35-3:50 P.M.	3.0	14%	

APPENDIX E

COMPLETE VISIBLE EMISSIONS RESULTS

Summary of Visible Emissions Observer #1

Date: Sept. 16, 1975 3:00 P.M

Type of Plant: Lime

Type of Discharge: Outlet of Venturi Scrubber

Distance from Observer to Discharge Point: 30'

Location of Discharge: #3 Kiln Outlet

Height of Observation Point: Ground Level

Height of Point of Discharge: 85'

Direction of Observer from Discharge Point: ESE

Description of Background: Partly Cloudy Sky

Description of Sky: Dark clouds at times

Wind Direction: NE

Wind Velocity: 5 mph

Color of Plume: White (Steam)

Detached Plume: No

Duration of Observation: 10 minutes

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
1	1500	1505	10	.42
2	1506	1509		
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				

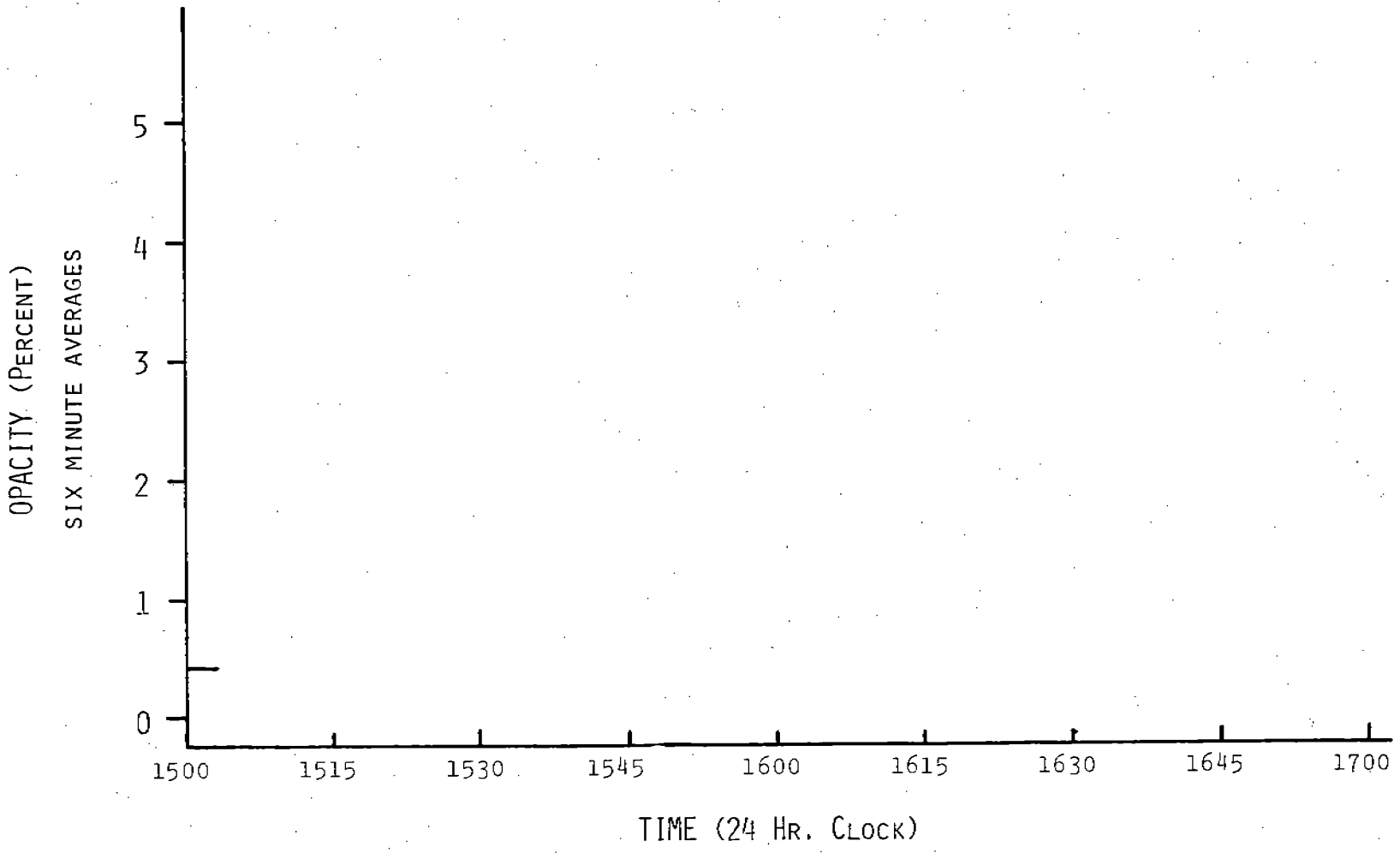


Figure E-1. Summary of visible emissions for Observer 1

(1)

RECORD OF VISIBLE EMISSIONS

Company Name ALLIED — Date Sept 16 - 3:00 pm

Plant Address CALERA ALA — Observer PEW Weston and Jason Burks

Stack Location #3 kiln scrubber — Observer's Location ESE 300 yds

Weather Conditions Partly cloudy wind NE 5 mph.

HR	MIN	SECONDS 00	15	30	45	COMMENTS
3	00	0	0	0	0	White clouds in background
	01	0	0	0	0	Plume mostly steam
	02	0	0	0	0	Difficult viewing of
	03	0	0	0	0	dust in plume because
	04	0	0	0	0	of steam and background
	05	5	5	0	5	
	06	0	0	0	0	
	07	0	0	0	0	
	08	0	0	0	0	
	09	0	0	0	0	→ Against a very dark cloud background, a light brown haze can be seen to persist after steam plume evaporation. Steam plume persists for 75 - 150 ft under these weather conditions (attached plume) J. Burks
	10					
	11					
	12	0	0	0	0	
	13	0	0	0	0	
	14	0	0	0	0	
	15	0	0	0	0	
	16	0	0	0	0	
	17	0	0	0	0	
	18	0	0	0	0	
	19	0	0	0	0	
	20	0	0	0	0	
	21	0	0	0	0	
	22	0	0	0	0	
	23	0	0	0	0	
	24	0	0	0	0	
	25	0	0	0	0	
	26	0	0	0	0	
	27	0	0	0	0	
	28	0	0	0	0	
	29	0	0	0	0	

Burbank

NEW READER

Summary of Visible Emissions
Observer #2

Date: Sept. 16, 1975

Type of Plant: Lime

Type of Discharge: Outlet of Venturi Scrubber

Location of Discharge: #3 Kiln, Outlet

Distance from Observer to Discharge Point: 300'

Height of Point of Discharge: 85'

Height of Observation Point: Ground Level

Description of Background: Partly Cloudy Sky

Direction of Observer from Discharge Point: ESE

Description of Sky: Dark clouds at times

Wind Direction: NE

Wind Velocity: 5mph

Color of Plume: White (steam

Detached Plume: No

Duration of Observation: 48 minutes

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
1	1512	1517	0	0
2	1518	1523	0	0
3	1524	1529	0	0
4	1530	1535	0	0
5	1536	1541	0	0
6	1542	1547	0	0
7	1548	1553	0	0
8	1554	1559	0	0
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				

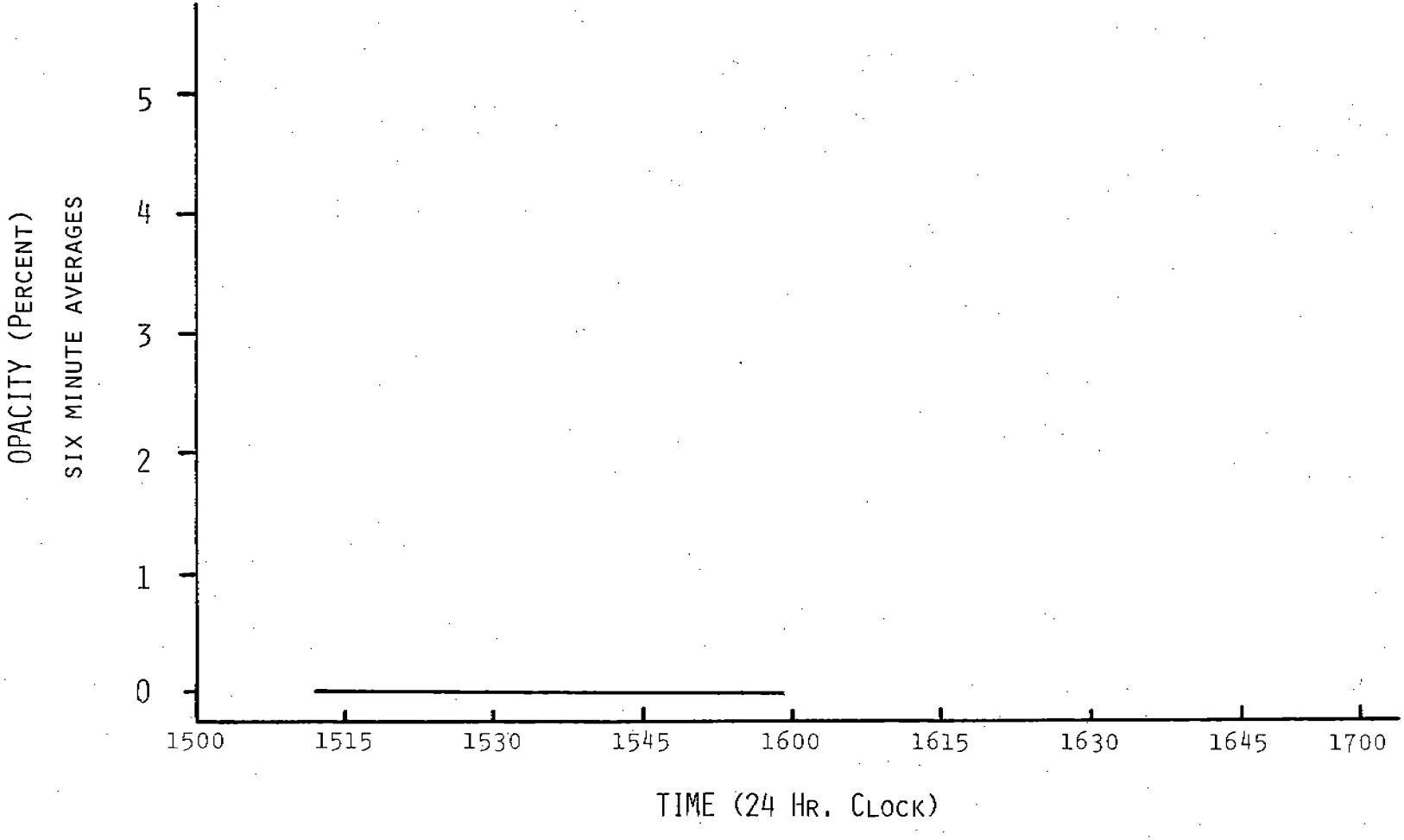


Figure E-2. Summary of visible emissions for Observer 2

(2)

RECORD OF VISIBLE EMISSIONS

Company Name ALLIED Date Sept 16 3:30

Plant Address AGA Observer PRW

Stack Location #3 Kiln scrubber Observer's Location —

Weather Conditions —

TIME HR	MIN	SECONDS 00	15	30	45	COMMENTS
3	30	0	0	0	0	
	31	0	0	0	0	
	32	0	0	0	0	
	33	0	0	0	0	
	34	0	0	0	0	
	35	0	0	0	0	
	36	0	0	0	0	
	37	0	0	0	0	
	38	0	0	0	0	
	39	0	0	0	0	
	40	0	0	0	0	
	41	0	0	0	0	
	42	0	0	0	0	
	43	0	0	0	0	
	44	0	0	0	0	
	45	0	0	0	0	
	46	0	0	0	0	
	47	0	0	0	0	
	48	0	0	0	0	
	49	0	0	0	0	
	50	0	0	0	0	
	51	0	0	0	0	
	52	0	0	0	0	
	53	0	0	0	0	
	54	0	0	0	0	
	55	0	0	0	0	
	56	0	0	0	0	
	57	0	0	0	0	
	58	0	0	0	0	
	59	0	0	0	0	

Summary of Visible Emissions

Observer #3

Date: Sept. 16, 1975

Type of Plant: Lime

Type of Discharge: Outlet of Venturi Scrubber

Distance from Observer to Discharge Point: 300

Location of Discharge: #3 Kiln Outlet

Height of Observation Point: Ground Level

Height of Point of Discharge: 85'

Direction of Observer from Discharge Point: ESE

Description of Background: Partly Cloudy Sky

Description of Sky: Dark Clouds at Times

Wind Direction: NE

Wind Velocity: 5 mph

Color of Plume: White (Steam)

Detached Plume: No

Duration of Observation: 60 minutes

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
1	1500	1505	10	.42
2	1506	1511	0	0
3	1512	1517	0	0
4	1518	1523	0	0
5	1524	1529	0	0
6	1530	1535	0	0
7	1536	1541	0	0
8	1542	1547	0	0
9	1548	1553	0	0
10	1554	1559	0	0
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

SUMMARY OF AVERAGE OPACITY

Set Number	Time		Opacity	
	Start	End	Sum	Average
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				

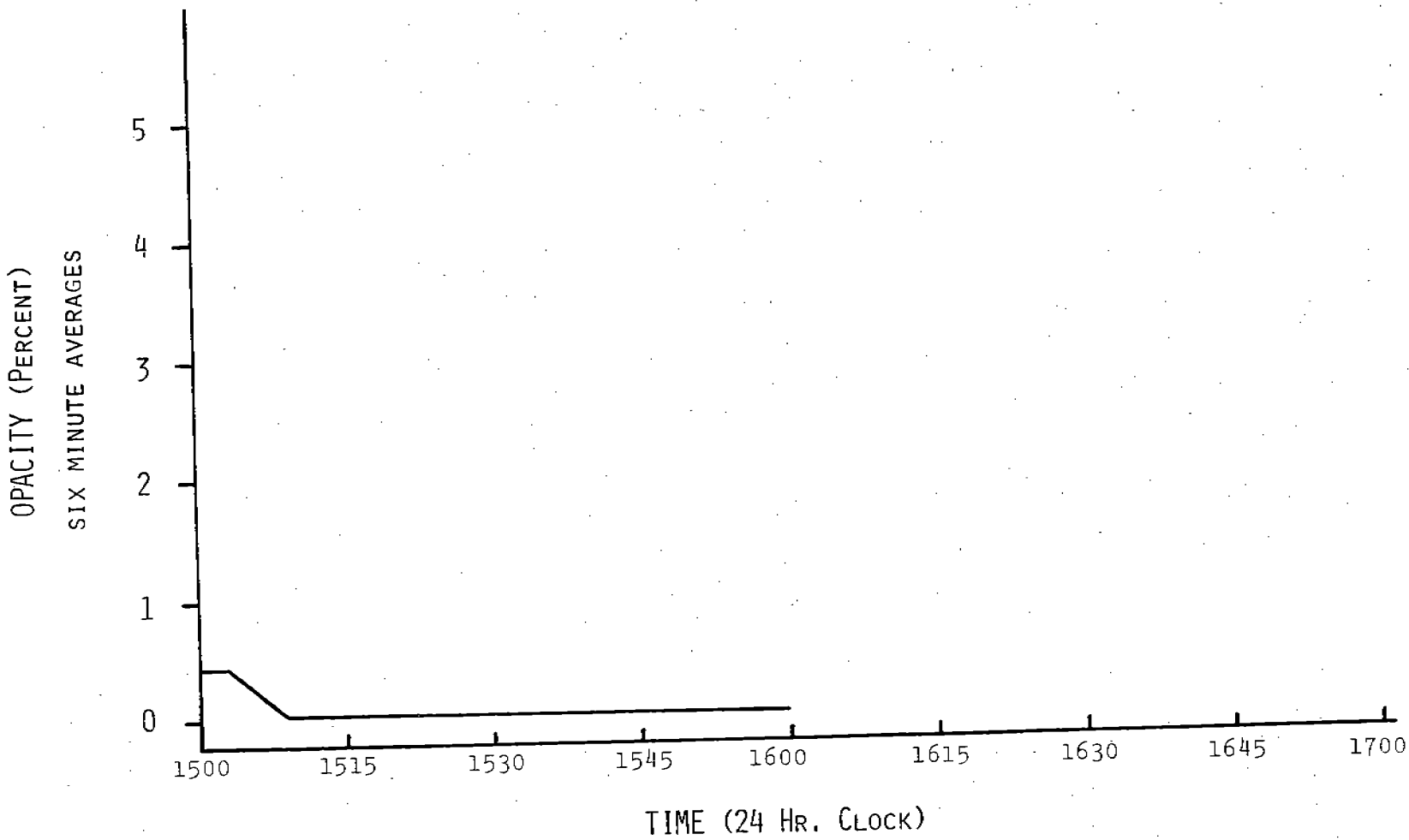


Figure E-3. Summary of visible emissions for Observer 3

RECORD OF VISIBLE EMISSIONS

Company Name ALLIED PRODUCTS — Date 16 SEPT 75

Plant Address MONTEVALLO, ALA. — Observer J.C. HUSTWOOT

Stack Location #3 kiln scrubber — Observer's Location SSE 300 yds

Weather Conditions PARTLY CLOUDY

HR	MIN	TIME SECONDS 00	15	30	45	COMMENTS
3	00	0	0	0	0	BEING READ WHERE STEAM
	01	0	0	0	0	DISAPPEARS
	02	0	0	0	0	WHITE BACKGROUND & STEAM
	03	0	0	0	0	MAKE IT DIFFICULT TO DETERMINE
	04	0	0	0	0	
	05	0	5	5	0	AGAINST BLACK CLOUD
	06	0	0	0	0	
	07	0	0	0	0	
	08	0	0	0	0	
	09	0	0	0	0	
	10	0	0	0	0	
	11	0	0	0	0	
	12	0	0	0	0	
	13	0	0	0	0	
	14	0	0	0	0	
	15	0	0	0	0	
	16	0	0	0	0	
	17	0	0	0	0	
	18	0	0	0	0	
	19	0	0	0	0	
	20	0	0	0	0	
	21	0	0	0	0	
	22	0	0	0	0	
	23	0	0	0	0	
	24	0	0	0	0	
	25	0	0	0		
	26	0	0	0	0	
	27	0	0	0	0	
	28	0	0	0	0	
	29	0	0	0	0	

RECORD OF VISIBLE EMISSIONS

Company Name _____ Date _____

Plant Address _____ Observer _____

Stack Location #3 kiln scrubber Observer's Location ESE Bag

Weather Conditions _____

TIME HR	MIN	SECONDS 00	15	30	45	COMMENTS
13	30	0	0	0	0	
	31	0	0	0	0	
	32	0	0	0	0	
	33	0	0	0	0	
	34	0	0	0	0	
	35	0	0	0	0	
	36	0	0	0	0	
	37	0	0	0	0	
	38	0	0	0	0	
	39	0	0	0	0	
	40	0	0	0	0	
	41	0	0	0	0	
	42	0	0	0	0	
	43	0	0	0	0	
	44	0	0	0	0	
	45	0	0	0	0	
	46	0	0	0	0	
	47	0	0	0	0	
	48	0	0	0	0	
	49	0	0	0	0	
	50	0	0	0	0	
	51	0	0	0	0	
	52	0	0	0	0	
	53	0	0	0	0	
	54	0	0	0	0	
	55	0	0	0	0	
	56	0	0	0	0	
	57	0	0	0	0	
	58	0	0	0	0	
	59	0	0	0	0	

APPENDIX F

FIELD DATA SHEETS FOR METHODS 5, 6, 7, SO_2 CONTINUOUS MONITORING, AND BRINKS® PARTICLE SIZING

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Allied Products
DATE 9-5-75
SAMPLING LOCATION Outlet of Scrubber
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A) 113
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B) 6
STACK I.D., (DISTANCE A - DISTANCE B) 107
NEAREST UPSTREAM DISTURBANCE
NEAREST DOWNSTREAM DISTURBANCE
CALCULATOR

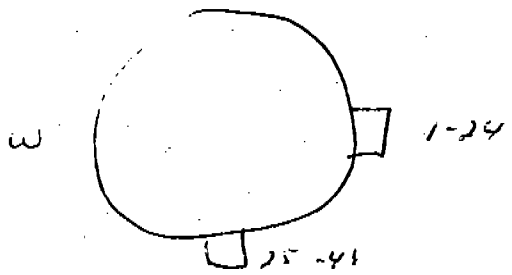
SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	.1011	107	1 1/8	6"	7 1/8
2	.1032		3 3/8		9 3/8
3	.055		5 7/8		11 7/8
4	.079		8 1/2		14 1/2
5	.105		11 1/4		17 1/4
6	.132		14 1/8		20 1/8
7	.161		17 1/4		23 1/4
8	.194		20 3/4		26 3/4
9	.230		24 5/8		30 5/8
10	.272		29 1/8		35 1/8
11	.323		34 1/2		40 1/2
12	.398		42 5/8		48 5/8
13	.607		64 3/8		70 3/8
14	.677		72 1/2		78 1/2
15	.728		77 7/8		83 7/8
16	.770		82 3/8		88 3/8
17	.806		86 1/4		92 1/4
18	.839		89 3/4		95 3/4
19	.868		92 7/8		98 7/8
20	.895		95 3/4		101 3/4
21	.921		98 1/2		104 1/2
22	.945		101 1/8		107 1/8
23	.968		103 5/8		109 5/8
24	.989		105 7/8		111 7/8

EPA (Dur) 232
4/72

PRELIMINARY VELOCITY TRAVERSE

PLANT Allied Products
DATE 9-15-75
LOCATION Outlet of Venturi
STACK I.D. 107"
BAROMETRIC PRESSURE, in. Hg 29.83
STACK GAUGE PRESSURE, in. H_2O -0.26
OPERATORS McDonald & McDonald.



SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	0.02	120
2	0.26	134
3	0.48	143
4	0.56	143
5	0.58	144
6	0.58	145
7	0.60	144
8	0.55	144
9	0.54	144
10	0.55	144
11	0.49	145
12	0.43	145
13	0.34	145
14	0.32	145
15	0.31	145
16	0.28	145
17	0.30	145
18	0.33	145
19	0.36	145
20	0.36	145
21	0.38	145
22	0.40	145
23	0.30	145
24	0.10	144
AVERAGE	.611	144

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
25	—	—
26	0.27	145
27	0.28	146
28	0.25	146
29	0.25	146
30	0.24	146
31	0.24	146
32	0.25	146
33	0.24	146
34	0.22	145
35	0.27	145
36	0.28	146
37	0.38	146
38	0.38	146
39	0.44	146
40	0.44	145
41	0.45	145
42	0.52	145
43	0.52	145
44	0.56	145
45	0.58	145
46	0.56	145
47	0.33	145
48	—	—
AVERAGE	.619	146

EPA (Dur) 233
4/72

AVE 615 145

NOMOGRAPH DATA

PLANT Allied Products

DATE 9-15-75

SAMPLING LOCATION _____

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	2.012
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m_{avg.}}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	22.4
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.83
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.81
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	1
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	146
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.38
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.60
C FACTOR		.76
CALCULATED NOZZLE DIAMETER, in.		.290
ACTUAL NOZZLE DIAMETER, in.		.245
REFERENCE Δp, in. H_2O		0.70

EPA (Dur) 234
4/72

FIELD DATA

PLANT Allied Products
DATE 7-15-25
SAMPLING LOCATION Outlet of venturi
SAMPLE TYPE EPA #5
RUN NUMBER 1
OPERATOR McKendree / McDonald
AMBIENT TEMPERATURE 90
BAROMETRIC PRESSURE 29.83
STATIC PRESSURE, (P_s) -0.26
FILTER NUMBER (s) 38-14

PROBE LENGTH AND TYPE 12' Pitot 103
NOZZLE I.D. 0.245
ASSUMED MOISTURE, % 12.5%
SAMPLE BOX NUMBER 4
METER BOX NUMBER 3
METER $\Delta H_@$ 2.012
C FACTOR 0.76
PROBE HEATER SETTING 4
HEATER BOX SETTING 4
REFERENCE Δp 0.705

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 2.5 MINUTES LEAK RATE 0.006 CFM @ 15" Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
			435.362										
1	0	1945	435.360	0.23	0.61	0.61	147	79	78	2.8	235	72	132
2	2.5	1946	436.375	0.24	0.65	0.65	147	79	79	2.0	235	69	129
3	5	1949	437.425	0.52	1.38	1.38	147	81	80	2.0	256	76	131
4	7.5	1413	438.910	0.55	1.45	1.45	148	82	81	3.0	256	67	134
5	10.0	1415	440.450	0.60	1.58	1.58	148	82	81	3.2	260	61	134
6	12.5	1418	442.500	0.60	1.58	1.58	148	82	81	3.3	279	60	135
7	15.0	1421	443.750	0.55	1.54	1.54	148	82	81	3.3	278	60	137
8	17.5	1423	445.400	0.55	1.45	1.45	148	82	81	3.3	272	60	137
9	20.0	1425	446.925	0.52	1.38	1.38	148	82	80	3.3	269	59	134
10	22.5	1428	448.730	0.48	1.28	1.35	148	81	80	3.3	269	60	133
11	25	1430	449.950	0.42	1.12	1.12	148	81	80	3.2	267	61	132
12	27.5	1432	451.475	0.34	0.91	0.91	148	82	81	3.0	267	63	131
13	30	1435	452.625	0.30	0.80	0.80	148	81	80	2.9	267	63	131
14	32.5	1437	453.850	0.30	0.80	0.80	149	82	80	3.0	274	65	135
15	35	1440	455.050	0.30	0.80	0.80	149	81	80	3.0	265	64	138
16	37.5	1442	456.225	0.33	0.83	0.83	150	81	80	3.0	265	64	138

PLANT Allied Products DATE 9-15-75 RUN NO. 1 Pg 2

	TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp °F
						DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
ap.75	17	40	1445	457.375	0.36	0.90	0.90	150	82	80	3.3	264	63	134
	18	42.5	1447	458.700	0.35	0.88	0.88	151	82	80	3.3	265	64	136
	19	45	1450	459.900	0.39	0.97	0.97	150	82	80	3.7	263	63	140
	20	47.5	1452	461.025	0.41	1.02	1.02	150	82	80	3.9	265	62	142
	21	50	1455	462.525	0.44	1.10	1.10	150	82	80	4.0	267	62	145
	22	52.5	1457	463.925	0.27	0.67	0.67	149	81	80	3.2	268	65	147
	23	55	1500	465.100	0.27	0.67	0.67	147	82	80	3.2	271	65	148
ap.7	24	57.5	1502	466.165	0.26	0.70	0.70	147	81	80	3.4	271	65	149
				467.250										
p.67	25	60	1540	467.250	0.29	0.78	0.78	146	80	79	3.3	290	73	142
	26	62.5	1542	468.300	0.24	0.65	0.65	146	79	79	3.2	294	68	143
	27	65	1545	469.325	0.32	0.87	0.87	146	79	79	3.9	282	65	148
	28	67.5	1547	470.550	0.31	0.81	0.81	146	80	79	3.9	266	65	141
	29	70	1550	471.745	0.24	0.65	0.65	146	80	79	3.7	260	65	135
	30	72.5	1552	472.875	0.24	0.65	0.65	147	80	79	3.7	258	66	135
	31	75	1555	473.915	0.22	0.59	0.59	147	80	79	3.4	246	66	132
	32	77.5	1557	474.985	0.24	0.65	0.65	148	80	79	3.7	251	66	132
ap.75	33	80	1600	476.040	0.23	0.58	0.58	148	81	79	3.7	255	66	133
	34	82.5	1602	477.070	0.31	0.78	0.78	148	81	79	4.0	246	66	133
	35	85	1605	478.180	0.33	0.84	0.84	149	81	79	4.3	244	66	131
	36	87.5	1607	479.440	0.38	0.95	0.95	148	80	79	4.6	250	67	130
	37	90	1610	480.675	0.41	1.02	1.02	149	80	79	4.9	249	65	130
	38	92.5	1612	482.010	0.38	0.95	0.95	149	80	79	4.9	251	66	129
	39	95	1615	483.315	0.45	1.06	1.06	148	80	79	5.1	254	67	129
	40	97.5	1617	484.710	0.45	1.13	1.13	148	80	79	5.3	241	66	129
	41	100	1620	486.025	0.49	1.22	1.22	148	81	79	5.8	258	65	130

PLANT Allied Products DATE 9-15-75 RUN NO 1 pg 3

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	PROBE TEMP of
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
ap .75 42	102.5	1622	487.500	0.53	1.32	1.32	148	81	79	6.0	260	65	131
43	105	1625	488.960	0.55	1.36	1.36	146	81	80	6.3	259	64	131
op .70 44	107.5	1627	490.536	0.62	1.64	1.64	145	81	79	7.2	259	64	129
45	110	1630	492.140	0.59	1.57	1.57	145	81	79	7.2	256	64	127
46	112.5	1632	493.825	0.33	0.84	0.84	144	80	79	5.5	256	66	128
47	115	1635	495.125	0.47	1.25	1.25	143	81	79	6.7	255	66	128
48	117.5	1637	496.530	0.48	1.28	1.28	142	80	79	6.8	252	66	129
	120	1640	497.940										

12.7
.11
508
8

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Allied
DATE 9/15/75
SAMPLING TIME (24-hr CLOCK) 1500 1530
SAMPLING LOCATION Scrubber outlet
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Bag
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 78°F
OPERATOR J. Clark

COMMENTS:

1 = 0
24.4
75.6

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	12.6	12.6	12.6		12.7		12.7	44/100	5.59
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	24.4	11.8	24.4		24.5		11.8 ~~24.4~~	32/100	3.78
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	24.4	0	24.4		24.5		0	28/100	~~2.80~~
N_2 (NET IS 100 MINUS ACTUAL CO READING)							75.6	28/100	21.17
								TOTAL	30.53

EPA (Dur) 230
4/72

CLEAN-UP DATA

Plant Allied

Date 9/15/75

Sampling Location Scrub Outlet

Sample Type Train 5

Run Number 1

Sample Box Number

Clean-up Man E. Cook

Comments:

Filter S-75-002-501

F ½ Ace S-75-002-502

B ½ HOH S-75-002-503

B ½ Ace S-75-002-504

B ½ H_2O-Et_2O-C Ext S-75-002-505

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	375 ml	128.0 ml	1.0 ml	ml	ml
Initial Vol.	100.0 ml	100.0 ml	0 ml	ml	ml
Net Vol.	275 ml	28 ml	1.0 ml	ml	ml

Total Net Volume in Impingers 304 ml

SILICA GEL

Final Weight	315.6 g	g	g
Initial Weight	300.0 g	g	g
Net Weight	15.6 g	g	g

Total Net Weight in Silica Gel 15.6 g

Total Moisture 319.6 g

Filter Number(s) 38-14

97 100
31 98
128 97
80
375

MRC 7/73

FIELD DATA

PLANT Allied Products
DATE 9/16/75
SAMPLING LOCATION
SAMPLE TYPE EPA #5
RUN NUMBER 2
OPERATOR McKendree / McDonald
AMBIENT TEMPERATURE 90°F
BAROMETRIC PRESSURE 29.70 "Hg
STATIC PRESSURE, (P_s) −0.26
FILTER NUMBER (s) 53-15

PROBE LENGTH AND TYPE 12' Pitot 10B
NOZZLE I.D. 0.245
ASSUMED MOISTURE, % 22.5
SAMPLE BOX NUMBER 4
METER BOX NUMBER 3
METER $\Delta H_@$ 2.012
C FACTOR 078
PROBE HEATER SETTING 4i
HEATER BOX SETTING
REFERENCE Δp 0.70

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 2.5 MINUTES LEAK RATE 0.003 CFM @ 15 "Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	PROBE TEMP °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
1	0	0940	498.262	0.31	0.84	0.84	142	70	69	1.7	247	69	139
2	2.5	0942	499.510	0.31	0.84	0.84	138	72	71	1.7	253	62	137
3	5.0	0945	500.800	0.45	1.20	1.20	143	72	71	2.0	256	60	136
4	7.5	0947	501.800	0.52	1.52	1.52	144	72	71	2.1	257	58	136
5	10.0	0950	503.800	0.57	1.52	1.52	144	72	71	2.1	260	58	134
6	12.5	0952	505.450	0.59	1.57	1.57	143	73	72	2.2	287	59	142
7	15.0	0955	506.990	0.57	1.52	1.52	144	74	72	2.1	292	60	140
8	17.5	0957	508.700	0.52	1.38	1.38	144	75	72	2.0	286	61	138
9	20.0	1006	510.175	0.47	1.25	1.25	145	75	73	2.4	286	63	141
10	22.5	1002	511.700	0.50	1.34	1.34	145	76	74	2.2	278	64	142
11	25.0	1005	513.400	0.45	1.20	1.20	146	76	74	2.1	283	64	140
12	27.5	1007	514.650	0.42	1.13	1.13	145	76	74	2.1	282	63	143
13	30	1010	516.000	0.32	0.87	0.87	145	77	75	2.0	276	64	141
14	32.5	1012	517.475	0.28	0.75	0.75	146	77	75	1.9	274	65	143
15	35	1015	518.755	0.29	078	0.78	145	78	75	2.0	282	66	143
16	37.5	1017	519.640	0.30	0.81	0.81	146	78	76	2.0	287	66	145

PLANT Allied Products DATE 9/16/25 RUN NO 2 pg 2

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	PROBE TEMP °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
17	40.0	1020	520.815	0.31	0.83	0.83	146	78	76	2.1	286	66	151
18	42.5	1022	522.035	0.33	0.89	0.89	146	79	76	2.2	285	66	154
19	45	1025	523.250	0.36	0.96	0.96	147	80	77	2.4	283	67	156
20	47.5	1027	524.600	0.38	1.01	1.01	147	81	78	2.5	278	67	154
21	50	1030	525.900	0.38	1.01	1.01	147	82	78	2.8	282	69	156
22	52.5	1032	527.280	0.42	1.14	1.14	147	83	79	3.0	282	68	160
23	55	1035	528.635	0.25	0.67	0.67	146	83	80	2.3	278	70	160
24	57.5	1037	529.825	0.25	0.67	0.67	145	83	80	2.3	283	70	160
	60.0	1040	530.893										
25	60.0	1050	530.892	0.18	0.49	0.49	142	83	81	2.0	220	72	127
26	62.5	1052	531.750	0.15	0.42	0.42	142	83	81	2.0	226	70	128
27	65.0	1055	532.640	0.26	0.70	0.70	147	82	81	2.0	235	68	133
28	67.5	1057	533.700	0.25	0.67	0.67	147	82	81	2.3	238	68	137
29	70.0	1100	534.780	0.27	0.72	0.72	148	82	81	2.4	251	67	146
30	72.5	1102	535.900	0.25	0.67	0.67	149	83	82	2.6	255	68	148
31	75.0	1105	536.975	0.25	0.67	0.67	149	84	82	2.7	257	69	147
32	77.5	1107	538.100	0.27	0.72	0.72	150	86	83	2.9	262	70	155
33	80.0	1110	539.130	0.27	0.72	0.72	150	86	83	2.9	261	69	154
34	82.5	1112	540.275	0.29	0.78	0.78	151	87	84	3.0	255	69	158
35	85.0	1115	541.410	0.36	0.96	0.96	152	87	83	3.4	259	68	155
36	87.5	1117	542.750	0.36	0.96	0.96	152	86	84	3.3	262	68	153
37	90.0	1120	544.115	0.36	0.99	0.99	153	86	84	3.5	272	69	153
38	92.5	1122	545.325	0.39	0.99	0.99	153	86	84	3.6	272	69	153
39	95.0	1125	546.630	0.42	1.06	1.06	152	86	84	3.9	275	69	161
40	97.5	1127	548.025	0.40	1.02	1.02	152	86	84	3.9	273	69	164

4p 25

PLANT Allied Products DATE 9/16/75 RUN NO. 2 (pg 3)

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	PROBE TEMP °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
41	100.0	1130	549.350	0.49	1.23	1.23	152	86	84	4.2	276	70	163
42	102.5	1132	550.825	0.49	1.23	1.23	152	86	84	4.2	270	70	165
43	105.0	1135	552.250	0.55	1.39	1.39	151	85	84	4.5	271	70	154
44	107.5	1137	553.850	0.60	1.50	1.50	152	85	84	4.9	274	71	150
45	110.0	1140	555.385	0.59	1.48	1.48	152	85	84	4.9	270	71	151
46	112.5	1142	557.025	0.42	1.08	1.08	150	86	85	4.4	273	72	155
47	115.0	1145	558.385	0.40	1.07	1.07	149	86	84	4.3	264	73	156
48	117.5	1147	559.800	0.46	1.07	1.07	148	86	85		261	73	159
	120	1150	561.113										

561.113
498.262
62.851

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Allied
DATE 9/16/75
SAMPLING TIME (24-hr CLOCK) 10[illegible] - 1045
SAMPLING LOCATION To Scrub on Kiln
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Bag
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 81
OPERATOR L. Cash.

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	12.2		12.4		12.3		12.3	44/100	5.412
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	24.0		24.1		24.1		11.8	32/100	3.776
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	24.0		24.1		24.1			28/100	—
N_2 (NET IS 100 MINUS ACTUAL CO READING)							75.9	28/100	21.252
								TOTAL	30.44

EPA (Dur) 230
4/72

Filter - 5-75-002-506
F ½ Acetone 5-75-002-507
B ½ H2O 5-75-002-508
B ½ Acetone 5-75-002-509
ETHER chloroform EXT = 510

CLEAN-UP DATA

Plant Allied Products Comments:
Date 9-16-75
Sampling Location Outlet of venturi
Sample Type EPA-5
Run Number 2
Sample Box Number 4
Clean-up Man Peltier & McDonald-Cook

207.8
53.5
14.3

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	350 ml	131 ml	3 ml	ml	ml
Initial Vol.	100 ml	100 ml	0 ml	ml	ml
Net Vol.	250 ml	31 ml	3 ml	ml	ml

250
31
3
14.3
298.3

Total Net Volume in Impingers 284.0 ml

SILICA GEL

Final Weight	214.3 g	g	g
Initial Weight	200 g	g	g
Net Weight	14.3 g	g	g

Total Net Weight in Silica Gel 14.3 g

Total Moisture 298.3 g

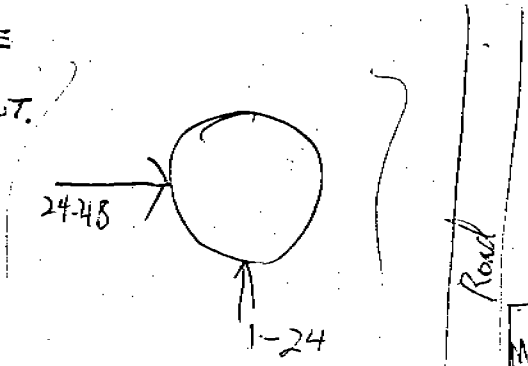
Filter Number(s) 53-15

99
95
94
99
62
0

MRC 7/73

FIELD DATA

PLANT ALLIED PRODUCTS LIME
DATE 9/16/75
SAMPLING LOCATION #3 KILN SCRUBBER OUT.
SAMPLE TYPE METHOD 5
RUN NUMBER 3
OPERATOR T. THALMAN
AMBIENT TEMPERATURE 75°
BAROMETRIC PRESSURE 29.70
STATIC PRESSURE, (P_s) -.026
FILTER NUMBER (s) 40-21



SCHEMATIC OF TRAVERSE POINT LAYOUT

Pitot tube ID 10-B
PROBE LENGTH AND TYPE 12' GLASS
NOZZLE I.D. 0.245
ASSUMED MOISTURE, % 22.5
SAMPLE BOX NUMBER 4
METER BOX NUMBER 3
METER $\Delta H_@$ 2.012
C FACTOR
PROBE HEATER SETTING HI
HEATER BOX SETTING HI
REFERENCE Δp .70 → .675 (A.3)
(A. 1-2, P. 12→

READ AND RECORD ALL DATA EVERY 25 MINUTES LEAK RATE .002 CFM @ 15 "Hg

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
1	0	1300	561.332	.06	.165	.165	133	85	84	0.5	217	81	140
2	2.5	1302.5	562.345	.33	.89	.89	144	87	85	2.5	234	71	153
3	5	1305	563.721	.45	1.25	1.25	145	87	85	3.5	242	68	152
4	7.5	1307.5	564.547	.45	1.25	1.25	145	87	85	3.5	242	65	152
5	10	1310	565.542	.55	1.52	1.52	146	87	85	4.0	247	68	152
6	12.5	1312.5	566.984	.55	1.52	1.52	146	87	85	4.0	248	69	153
7	15	1315	568.942	.58	1.6	1.6	149	87	85	4.5	288	67	146
8	17.5	1317.5	570.421	.52	1.45	1.45	151	87	85	4.5	293	68	147
9	20	1320	572.045	.51	1.40	1.40	151	87	86	4.5	290	68	148
10	22.5	1322.5	573.599	.47	1.3	1.3	153	89	86	4.5	289	68	145
11	25	1325	575.295	.45	1.25	1.25	153	89	86	4.5	298	67	146
12	27.5	1327.5	576.875	.40	1.08	1.08	153	88	86	4.2	291	71	145
13	30	1330	578.149	.31	.835	.835	152	88	86	3.40	290	77	142
14	32.5	1332.5	579.194	.27	.72	.72	153	87	86	3.5	292	72	143
15	35	1335	580.280	.27	.72	.72	153	87	86	3.5	301	72	144
16	37.5	1337.5	581.475	.27	.72	.72	153	87	86	3.5	307	72	146

(152)

PLANT Allied Products Lime DATE 9/16/75 RUN NO. 3, #3 Kiln Scrubber Out

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp.
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
17	40	1340	582.650	.31	.84	.84	153	87	86	3.0	299	72	154
18	42.5	1342.5	583.835	.27	.72	.72	153	87	86	3.0	298	71	155
19	45	1345	585.249	.33	.89	.89	149	89	87	3.0	298	73	156
20	47.5	1347.5	586.256	.33	.89	.89	149	90	87	4.0	293	73	163
21	50	1350	587.410	.33	.89	.89	149	90	87	4.5	278	74	162
22	52.5	1352.5	588.625	.40	1.08	1.08	151	89	87	4.5	278	70	162
23	55	1355	589.970	.40	1.08	1.08	150	89	87	5.5	292	70	167
24	57.5	1357.5	591.445	.40	1.08	1.08	149	89	87	5.5	292	70	167
1	60	1415	592.863	.06	.17	.17	147	86	86	1.0	293	86	141
2	62.5	1417.5	593.480	.21	.57	.57	151	86	86	1.0	279	84	141
3	65	1420	594.410	.27	.72	.72	152	86	86	4.0	212	76	128
4	67.5	1422.5	595.500	0.27	0.72	0.72	153	87	87	4.3	229	77	137
5	70.	1425	596.700	0.26	0.70	0.70	154	89	87	4.2	252	77	146
6	72.5	1427.5	597.850	0.27	0.72	0.72	153	90	87	4.3	247	77	150
7	75.0	1430	598.875	0.25	0.67	0.67	153	90	87	4.3	245	76	149
8	77.5	1432.5	600.000	0.28	0.58	0.58	153	90	87	4.1	243	75	150
9	80.0	1435	601.025	0.20	0.54	0.54	153	90	87	4.0	250	74	150
10	82.5	1437.5	602.050	0.25	0.67	0.67	154	89	87	4.5	257	73	151
11	85.0	1440	603.115	0.29	0.77	0.77	153	89	88	4.8	248	73	152
12	87.5	1442.5	604.300	0.31	0.82	0.82	154	89	88	5.1	255	73	149
13	90.0	1445	605.500	0.35	0.94	0.94	154	89	88	5.8	254	72	153
14	92.5	1447.5	606.825	0.33	0.88	0.88	154	89	88	5.8	258	73	149
15	95.0	1450	608.075	0.34	0.91	0.91	154	89	88	5.9	259	72	146
16	97.5	1452.5	609.475	0.41	1.10	1.10	153	90	88	6.4	259	73	146
17	100.0	1455	610.735	0.40	1.08	1.08	154	90	88	6.6	256	74	146
18	102.5	1457.5	612.145	0.45	1.20	1.20	153	90	88	6.9	261	73	147
19	105.0	1500	613.515	0.52	1.38	1.38	153	89	88	7.7	251	73	147

PLANT Allied Products DATE 9/16/25 RUN NO. 3

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	PROBE TEMP °F
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
20	107.5	1502.5	615.075	0.55	1.45	1.45	149	88	88	8.0	269	73	147
21	110.0	1505	616.625	0.56	1.49	1.49	148	88	88	8.8	271	74	148
22	112.5	1507.5	618.245	0.53	1.40	1.40	151	88	88	8.8	270	75	149
23	115.0	1510	619.775	0.38	1.01	1.01	151	87	87	7.6	276	76	149
24	117.5	1512.5	621.250	0.35	0.93	0.93	150	86	87		262	78	149
	120.0	1515	622.466										

Filter 5-75-002-~~514~~ 511
F 1/2 Acet 5-75-002-512
B 1/2 H_2O 5-75-002-513
B 1/2 Acet = 5-75-002-514
B 1/2 HOH - Et_2O Ext 5-75-002-515

CLEAN-UP DATA

Plant Allied Products Comments:
Date 9/16/75
Sampling Location Scrub outlet
Sample Type method 5
Run Number 3
Sample Box Number 4
Clean-up Man OR -

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	378 ml	131 ml	20 ml	ml	ml
Initial Vol.	100 ml	100 ml	0 ml	ml	ml
Net Vol.	278 ml	31 ml	2.0 ml	ml	ml

Total Net Volume in Impingers _____ ml

98
96
98
86
378

SILICA GEL

Final Weight	216.3 g	g	g
Initial Weight	200.0 g	g	g
Net Weight	16.3 g	g	g

Total Net Weight in Silica Gel 16.3 g

Total Moisture 377.3 g

Filter Number(s) 40-21 _____

MRC 7/73

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Allied
DATE 9/16/75
SAMPLING TIME (24-hr CLOCK) 1300 & 1400
SAMPLING LOCATION Scrub Outlet
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Bag
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 83°F
OPERATOR J. Cook

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	13.5		13.6		13.6		13.6	44/100	5.984
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	24.8		24.8		24.8		11.2	32/100	3.584
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	24.8		24.8		24.8			28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)							75.2	28/100	21.056
								TOTAL	30.62

EPA (Dur) 230
4/72

GENERAL DATA SHEET

TYPE RUN - SO_2 (D)

DATE: 9-16-75 RUN NO. 1

LOCATION: Inlet to venturi OPERATORS: Relthey

	INITIAL	FINAL	
METER TEMPERATURE	120	120	120
METER READING	176.288	177.205	0.917
TIME	852	922	30
FLOW RATE	2 cfh		
BAROMETRIC PRESSURE	29.72		

Leak check 12" Hg ~OK

COMMENTS:

Vacuum initial - 3"
" final - 7"

$$0.917 \times \frac{29.72}{29.92} \times \frac{530}{580} = 0.832 \text{ scf}$$

GENERAL DATA SHEET

TYPE RUN - EPA #6 Allied Products

DATE: 9/16/75 RUN NO. 1

LOCATION: Venturi Outlet OPERATORS: McKendree

	INITIAL	FINAL	
METER TEMPERATURE	65°F	72°F	68.5
METER READING	860.094	860.896	0.802
TIME	0842 hrs	0913 hrs	30 min end purge 0929 hrs
FLOW RATE	~~35~~ 2.0 cfh		
BAROMETRIC PRESSURE	29.70 "Hg		

Leak check 0 cfm @ 15" Hg

COMMENTS:

$$0.802 \times \frac{29.70}{29.92} \times \frac{530}{528.5} = 0.7985 \text{ SFI}$$

GENERAL DATA SHEET

TYPE RUN - EPA #6 Allied Products

DATE: 9/17/75 RUN NO. 2

LOCATION: Scrubber Inlet OPERATORS: Thalman

	INITIAL	FINAL	
METER TEMPERATURE	119°F	124°F	121.5
METER READING	177.682	178.611	0.929
TIME	~~1025~~ 1027	1057	30 min
FLOW RATE	2.0	2.0	
BAROMETRIC PRESSURE	29.51 "Hg	29.51	

COMMENTS:

$$0.929 \times \frac{29.51}{29.92} \times \frac{530}{581.5} = 0.835 \text{ SCF}$$

GENERAL DATA SHEET

TYPE RUN - EPA #6 Allied Products

DATE: 9/17/75 RUN NO. 2

LOCATION: Scrubber Outlet OPERATORS: McKendree

	INITIAL	FINAL	
METER TEMPERATURE	69 ~~68~~ °F	73° F	71
METER READING	861.575 ~~861.473~~	862.396	0.821 end purge
TIME	1026 hrs	1056 hrs 30 min	1112 hrs
FLOW RATE	2.0 cfh		
BAROMETRIC PRESSURE	29.51" Hg		

Leak check 0 @ 15" Hg

COMMENTS:

$.821 \times \frac{29.51}{29.92} \times \frac{530}{531} = 0.808\ ft^3$

GENERAL DATA SHEET

TYPE RUN - EPA-6 - Allied Products

DATE: 9/17/75 RUN NO. 3

LOCATION: Scrubber Inlet OPERATORS: Thulman

	INITIAL	FINAL	
METER TEMPERATURE	124°F	126°F	125
METER READING	179.494	180.379	0.885
TIME	1153	1223	30 min
FLOW RATE	2.0	2.0	
BAROMETRIC PRESSURE	29.51 "Hg	29.51 "Hg	

COMMENTS:

$$0.885 \times \frac{29.51}{29.92} \times \frac{530}{585} = 0.791 \text{ SCF}$$

GENERAL DATA SHEET

TYPE RUN - EPA #6 Allied Products

DATE: 9/17/25 RUN NO. 3

LOCATION: Scrubber Outlet OPERATORS: McKendree

	INITIAL	FINAL	
METER TEMPERATURE	64.5°F	76.5°F	70.5
METER READING	862.722	863.561	0.839 end purge
TIME	1152 hrs	1222 hrs 30 min	1237 hrs
FLOW RATE	2 cfh		
BAROMETRIC PRESSURE	29.51 "Hg		

Leak check < 0.001 cfm at 15" Hg

COMMENTS:

$$SCF \quad 0.839 \times \frac{29.51}{29.92} \times \frac{530}{530.3} = 0.827 \text{ ft}^3$$

SOURCE SAMPLING PROCEDURE – EPA METHOD 7 – NOx

Date 9/16/75

Company Allied

Project Nox (EPA

Sample Point Scrub Outlet

Analyst L. CARR W. McDonald

Sample Day	Time	No.	Top Flask No.	Initial Bar. Press. in Hg	Initial Flask Vacuum in Hg	Initial Temp. °F	Clean Up Analysis Day	Clean Up Analysis Time	Final Bar. Press. in Hg	Final Flask Vacuum in Hg	Final Temp. °F	ABS @ 420	TOTAL Dil. ml	FLASK Vol.-ABS ml	NOx Conc. lb/scf	NOx Conc. ppm
9/16	9/36 AM	1	50/50	29.70	27.5	70°F			29.51	+0.60	68°					
✓	937 AM	2	9/9	✓	28.2	70			"	+1.30	"					
✓	938 AM	3	10/10	✓	28.0	70			"	+0.70	"					
✓	939 AM	4	11/11	✓	27.9	70			"	+1.25	"					
	1404	5	3/3	29.62	27.6	83°F			"	+2.8	"					
	1405	6	11/11	✓	27.5	83°F			"	+1.60	"					
	1406	7	2/2	✓	27.8	83°F			"	+2.80	"					
	1407	8	15/15	✓	27.8	83°F			"	+2.45	"					
9/17	1024	9	42/4	29.51	27.8	68°F	9/17	1010 AM	29.31	+1.3	72° 72°					
✓	1044	10	7/7	↓	28.4	↓		1120 AM	"	+1.0	"					
"	1104	11	8/8	↓	28.0	↓		1125 AM	"	+.6	"					
"	1124	12	12/12	↓	27.3	↓		1130 AM	"	+.8	"					

29.83
.37
46

Brink BMS-11 Calculations

Date 9-15-75 Run # 1 Location Inlet to venturi

Plant Allied Products Company

29.72
37
35

Data:

Duct press Pd 29.46 "Hg Molecular Wt Md ~30

Duct Temp Td 800 °F Vel head Δp .09 "H_2O

$$\text{Velocity } V_d = 85.48 \times C_p \times \sqrt{\frac{(T_d+460)\times \Delta p}{M_d \times P_d}}$$

$$V_d \text{ (ft/sec)} = 85.48\,(.85)\sqrt{\frac{(800+460)(.9)}{(29.46)(30)}} = 82.3$$

Probe nozzle selection for a flow rate of F_s = .094 ft^3/m

Nozzle = 1.5 mm $Q_I = Q_n \frac{T_s}{T_n} = .094 \frac{460+250}{460+800} = .053$

Δpc from Calibration curve = 1.1 "Hg

Sampling Δp calculation: (Est box temp = 250 °F)

$$\Delta ps = \Delta pc \times \frac{Md}{29} \times \frac{Pd}{29.92} \times \frac{460+77}{460+T_{box}} = \Delta pc\,(.6189)\frac{Md\,Pd}{T_{box}}$$

$$\Delta ps = (1.1)\,0.6189\,\frac{(30)(29.46)}{(460+250)} = \frac{0.85}{M \sim 0.9} \text{ "Hg}$$

Comments:

Operator Peltier

Brink Data Sheet

Date 9-15-75 Run# 1 Location Inlet to venturi

Plant Allied Products Company

Data: Stack gas molecular wt ~ 30

Stack Temp 800 °F, Stack static press -5 "H_2O

Barometric Press 29.83 "Hg, Ambient Temp 200 °F

Probe tip diameter 1.5 mm, Probe immersion 14 in

Sample box temp:

Start-in 175 °F, out 268 °F; Stop - in 215 °F, out 210 °F

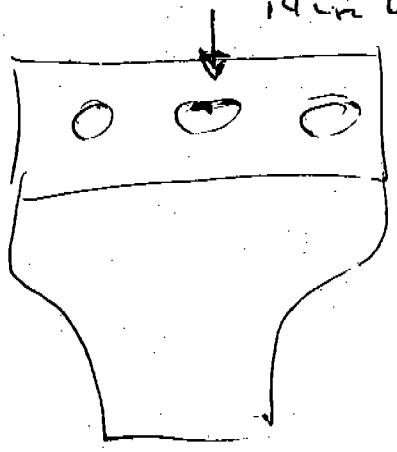
Impactor pressure drop (Aps)-calculated .85 "H_2O Real 1.3 "Hg

Impactor Static inlet pressure - Start 6.9 "H_2O, Stop 7.9 "H_2O

Start time 1623 End time 1633

Sample run time ~~1623~~ 10 min

Comments + sketches:



Stage	
1	46-21
2	" 22
3	" 23
4	" 24
5	" 25
final	103

(over)

Operator [signature]

Sampled for 10 minutes - loading was very heavy
10 minutes was too long since first filter was
almost completely covered with dust. While
removing the filters (1-3) some of the dust & was
~~seal~~ released from the filter and went into the
impactor as the ~~was~~ small mound broke up.
Visually, the first filter had 3 times that of the 2nd
and the second had twice as much as the 3rd.
The probe and cyclone were rinsed, and then the whole
system was rinsed and collected.

TLP 8-15-75
5:30 pm

Brink BMS-11 Calculations

Date 9-16-75 Run # 2 Location Inlet to Venturi

Plant Allied Products Comp.

Data:

Duct press Pd 29.35 "Hg Molecular Wt Md ~30.4

Duct Temp Td 800 °F Vel head Δp 0.9 "H_2O

$$\text{Velocity } V_d = 85.48 \times C_p \times \sqrt{\frac{(T_d+460)\times \Delta p}{M_d \times P_d}}$$

$$V_d \text{ (ft/sec)} = 85.48\,(.85)\sqrt{\frac{(800+460)(.9)}{(30.4)(29.35)}} = 81.9$$

Probe nozzle selection for a flow rate of F_s = .094 $ft^3/$

Nozzle = 1.5 mm C_I $.94\left(\frac{460+210}{460+800}\right)$ = .053

Δpc from Calibration curve = 0.9 "Hg

Sampling Δp calculation: (Est box temp = 210 °F)

$$\Delta ps = \Delta pc \times \frac{Md}{29} \times \frac{Pd}{29.92} \times \frac{460+77}{460+T_{box}} = \Delta pc\,(.6189)\frac{Md\,Pd}{T_{box}}$$

$$\Delta ps = (0.9)\,0.6189\,\frac{(30.4)(29.35)}{(460+210)} = 0.824 \text{ "Hg}$$

Comments:

Operator Pulliam

Brink Data Sheet

Date 9-16-75 Run# 2 Location Inlet to Venturi

Plant Allied Products Co.

Data: Stack gas molecular wt 30.4

Stack Temp 800 °F, Stack static press 5 "H_2O

Barometric Rress 29.72 "Hg, Ambient Temp 150 °F

Probe tip diameter 1.5 mm, Probe immersion 14 in

2.6
3.1

Sample box temp:

Start-in 237 °F, out 165 °F; Stop - in ~~210~~ 210 °F, out 280 °F

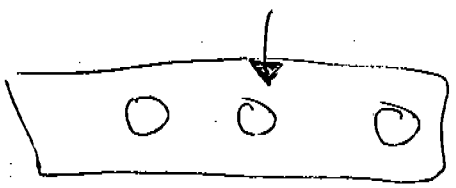
Impactor pressure drop (Δps)-calculated .8 "H_2O Real .8 "Hg

Impactor Static inlet pressure - Start 5.7 "H_2O, Stop 6.6 "H_2O

Start time 1000 End time 1004

Sample run time 4 min

Comments + sketches:



Operator Pelton

Brink BMS-II Calculations

Date 9 Run # 3 Location Inlet to Venturi

Plant Allied Products

29.72 − 37 = 29.35

Data:

Duct press Pd 29.35 "Hg Molecular Wt Md 30.4

Duct Temp Td 800 °F Vel head Δp 1.2 "H_2O

$$\text{Velocity } Vd = 85.48 \times Cp \times \sqrt{\frac{(Td+460)\times \Delta P}{Md \times Pd}}$$

$$Vd\ (ft/sec) = 85.48\ (.85)\ \sqrt{\frac{(800+460)(1.2)}{(30.4)(29.35)}} = 94.6$$

Probe nozzle selection for a flow rate of F_s = .109 ft^3/min

Nozzle = 1.5 mm $Q_J = Q_n \frac{T_J}{T_n} = .109 \frac{460+220}{460+800} = .0259$

Δpc from Calibration curve = 1.35 "Hg

Sampling Δp calculation: (Est box temp = °F)

$$\Delta ps = \Delta pc \times \frac{Md}{29} \times \frac{Pd}{29.92} \times \frac{460+77}{460+T_{box}} = \Delta pc\,(.6189)\,\frac{Md\ Pd}{T_{box}}$$

$$\Delta ps = (1.35)\,0.6189\,\frac{(30.4)(29.35)}{(460+220)} = 1.1 \text{ "Hg}$$

Comments:

Operator Pethel

Brink Data Sheet

Date 9-16-25 Run # 3 Location Inlet to venturi

Plant Allied Products

Data: Stack gas molecular wt 30.4 29.62

Stack temp 800 °F, Stack static press 5 ~~29.25~~ "H_2O 37.5

Barometric Press 29.62 "Hg, Ambient Temp 150 °F

Probe tip diameter 1.5 mm, Probe immersion 14 in

Sample box temp:

Start - in 190 °F, out 250 °F; Stop - in 240 °F, out ~~280~~ °F

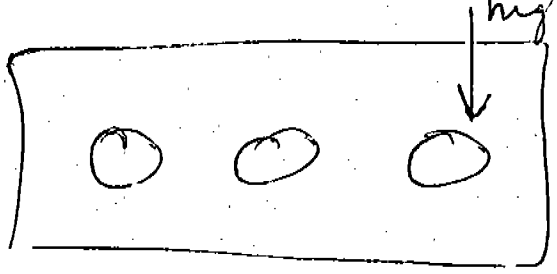
Impactor pressure drop (Δp_s) - calculated 1.1 "H_2O Real 1.0 "Hg

Impactor Static inlet pressure - Start 6.0 "H_2O, Stop 7.0 "H_2O

Start time 1347 End time 1351 23 2--

Sample run time 4 min

Comments + sketches:



– some of the dust fell from the #3rd stage filter

final filter – 107

1
2
3
4
5

Operator

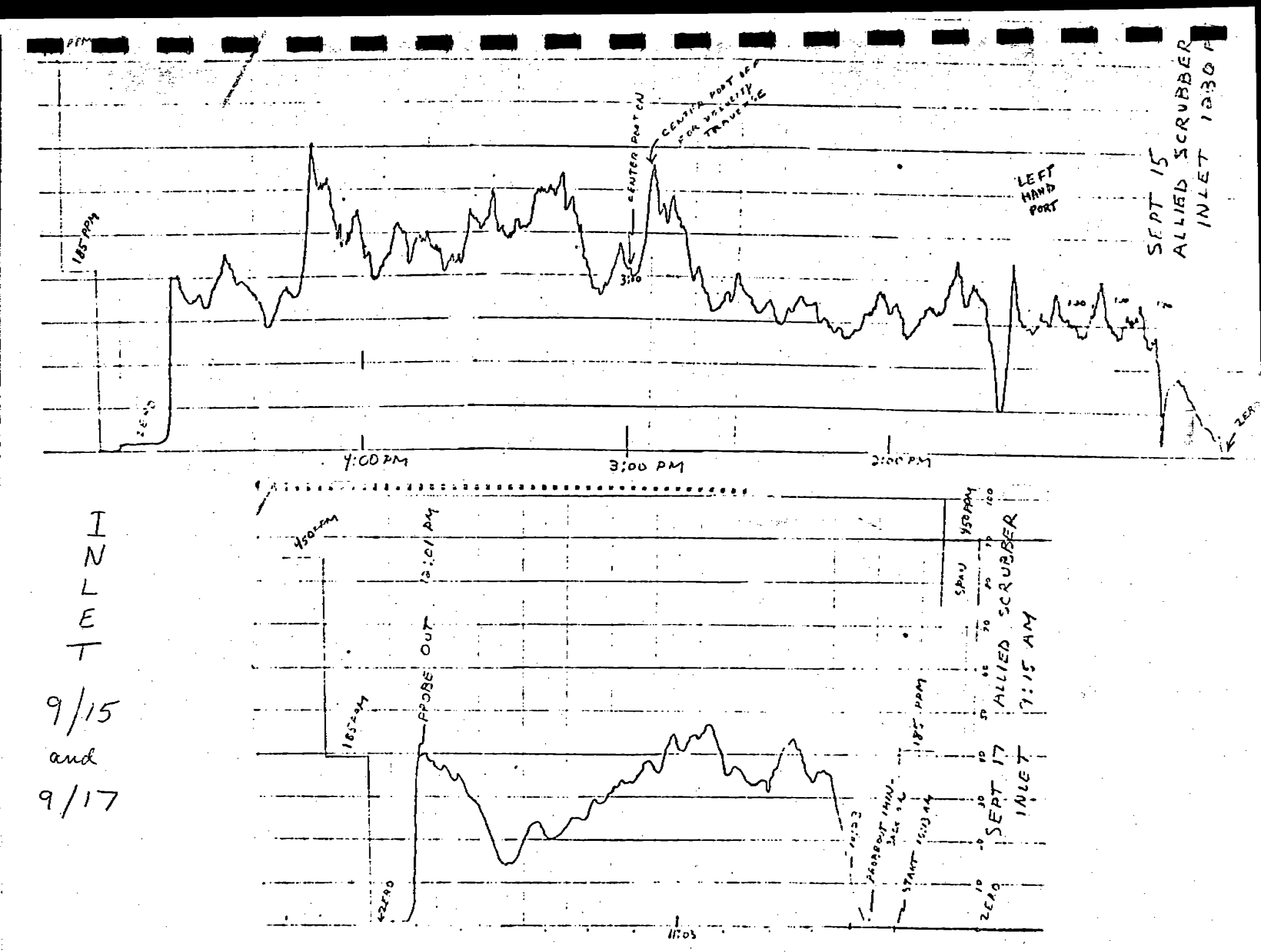


Figure F-1. SO_2 Data from Dynascience Strip Chart - Inlet

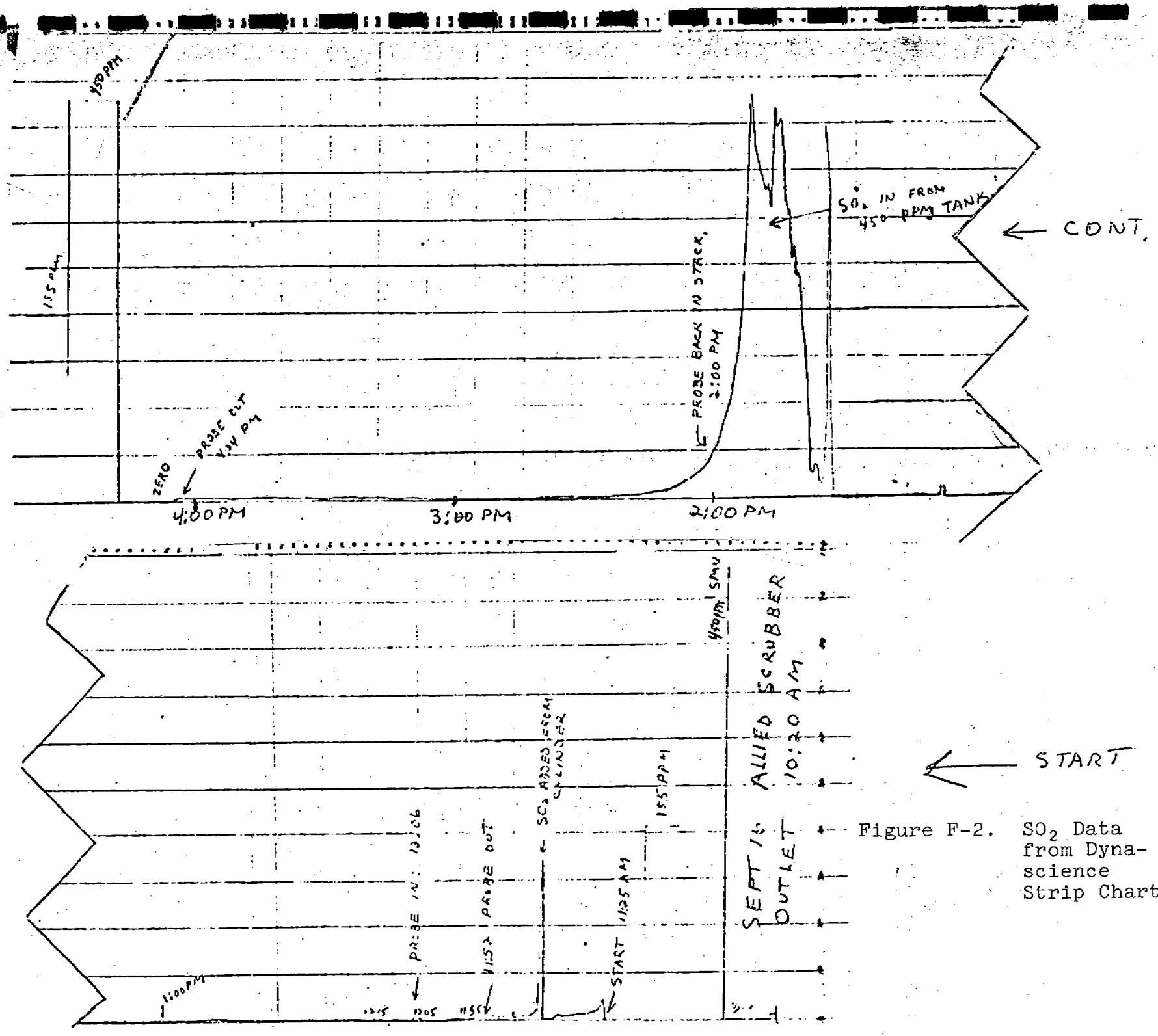


Figure F-2. SO_2 Data from Dynascience Strip Chart

APPENDIX G

PROCESS OPERATION FIELD DATA SHEETS

Facility LIME KILN AND VENTURI SCRUBBER | Unit No. 3

Operators

Date 15 SEPT 75

Data Set No. 3 | Page 1

KCA

	Units	12:00	1300	1400	1500	1600	1700	
KILN DRIVE	AMPS	250	250	250	260	260	260	
KILN SPEED	(SEC/REV)	44	44	44	44	44	44	
STONE FEED	SEC/REV	34	34	34	34	34	34	
STONE FEED	T/HR	54.6	54.6	54.6	54.6	54.6	54.6	
STACK TEMP.	°F	340	340	340	340	350	350	
FEED END TEMP	°F	1220	1240	1210	1200	1220	1220	
GAS ANALYZER · O_2	%	0.5	0.5	0.5	0.5	0.5	0.5	
COAL FEED	SEC/REV	108	108	108	108	108	108	
COAL FEED	T/HR	6.7	6.7	6.7	6.7	6.7	6.7	
STONE	VOLTS	130	130	130	130	130	130	
GAS	1000 C.F.H./HR	15	15	15	15	15	15	
NIEMS COOLER TEMPS								
1	°F	150	150	150	150	150	150	
2	°F	150	150	150	150	150	150	
3	°F	150	150	150	150	150	OFF	
4	°F	150	150	150	150	150	150	

Facility LIME KILN AND VENTURI SCRUBBER | Unit No. 3

Operators

Date 16 SEPT 75

Data Set No. 3 | Page 2

KCH

	Units	900	1000	1100	1200	1300	1400	1500	1
KILN DRIVE	AMPS	250	250	250	250	250	250	250	2
KILN SPEED	SEC/REV	44	44	44	44	44	44	44	
STONE FEED	SEC/REV	34	34	34	34	34	34	34	
STONE FEED	T/HR	51.6	51.6	51.6	51.6	51.6	51.6	51.6	
STACK TEMP.	°F	340	340	340	340	340	340	340	
FEED END TEMP.	°F	1220	1220	1200	1200	1210	1200	1220	
GAS ANALYZER O_2	%	0.5	0.5	0.4	0.5	0.5	0.5	0.5	
COAL FEED	SEC/REV	114	110	108	120	120	120	120	
COAL FEED	T/HR	6.3	6.5	6.7	5.9	5.9	5.9	5.9	
STONE	VOLTS	130	130	130	130	130	130	130	1
GAS	1000 CU FT/HR	15	15	15	34	34	34	34	
NIEMS COOLER TEMP 1	°F	150	150	150	150	150	150	150	1
2	°F	150	150	150	150	150	150	150	2
3	°F	200	200	150	150	150	150	255	1
4	°F	150	150	150	150	150	225	415	1

... ELECTRIC PRODUCTS ... TUSCUMBIA, ALABAMA

Facility LIME KILN & VENTURI SCRUBBER. | Unit No. 3

Operators

Date 17 SEPT 75

Data Set No. 3 | Page

KUH

	Units	900	1000	1100	1200	1250		
KILN DRIVE	AMPS	250	250	250	250	250		
KILN SPEED	SEC/REV	44	44	44	44	44		
STONE FEED	SEC/REV	34	34	34	34	34		
STONE FEED	T/HR	51.6	51.6	51.6	51.6	51.6		
STACK TEMP.	°F	340	340	340	340	340		
FEED END TEMP	°F	1230	1230	1220	1200	1220		
GAS ANALYZER - O_2	%	0.5	0.5	0.5	0.5	0.5		
COAL FEED	SEC/REV	108	110	110	110	110		
COAL FEED	T/HR	6.7	6.5	6.5	6.5	6.5		
STONE	VOLTS	130	130	130	130	130		
GAS	1000 CU FT/HR	15	15	15	15	15		
(KILN COOLER TEMPS) 1	°F	150	150	150	150	150		
2	°F	150	150	150	150	150		
3	°F	150	150	150	150	150		
4	°F	150	150	150	150	150		

APPENDIX H

SAMPLE IDENTIFICATION LOG

SAMPLE IDENTIFICATION LOG

EPA Number	Sample Location	Run	Contents	Comments
S-75-002-501	SCRUBBER OUT.	ONE	FILTER # 38-14	9/15/75; 13:44 - 16:40
S-75-002-502	" OUTLET	"	FRONT 1/2 ACETONE	
S-75-002-503	" "	"	BACK 1/2 WATER	BEAKER S-75-002-503
S-75-002-504	" "	"	BACK 1/2 ACETONE	
S-75-002-505	" "	"	BACK 1/2 E/C EXTRACT	PLACED IN BEAKER S-75-002-50[illegible]
S-75-002-506	" "	TWO	FILTER, #53-15	9/16/75; 9:40 - 11:50
S-75-002-507	" "	"	FRONT 1/2 ACETONE	
S-75-002-508	" "	"	BACK 1/2 WATER	BEAKER S-75-002-50[illegible]
S-75-002-509	" "	"	BACK 1/2 ACETONE	
S-75-002-510	" "	"	BACK 1/2 E/C EXTRACT	BEAKER S-75-002-5[illegible]
S-75-002-511	" "	THREE	FILTER, #40-21	9/16/75; 13:00 - 15:[illegible]
S-75-002-512	" "	"	FRONT 1/2 ACETONE	
S-75-002-513	" "	"	BACK 1/2 WATER	BEAKER S-75-002-51[illegible]
S-75-002-514	" "	"	BACK 1/2 ACETONE	
S-75-002-515	" "	"	BACK 1/2 E/C EXT.	BEAKER S-75-002-5[illegible]
S-75-002-516	INLET	ONE	H_2O_2 METHOD SIX	
S-75-002-517	OUTLET	"	" " "	
~~S-75~~				
S-75-002-518	INLET	TWO	" " "	
S-75-002-519	OUTLET	"	" " "	
S-75-002-520	INLET	THREE	" " "	
S-75-002-521	OUTLET	"	" " "	
S-75-002-555	SCRUBBER OUTLET	1	METHOD SEVEN (NO_x)	9/16/75 9:30
S-75-002-556	" "	2	REAGENT + WASH	9/16 9:37
S-75-002-557	" "	3	↓	9/16 9:35
S-75-002-558	" "	4	↓	9/16 9:39
S-75-002-559	" "	5	↓	9/16 14:[illegible]
S-75-002-560	" "	6	↓	9/16 14:[illegible]

SAMPLE IDENTIFICATION LOG

EPA Number	Sample Location	Run	Contents	Comments
S-75-002-561	SCRUBBER OUTLET	7	METHOD SEVEN (NO_x)	9/16 10:01
S-75-002-562	" "	8	REAGENT + WASH	9/16 10:07
S-75-002-563	" "	9	"	9/17 10:24
S-75-002-564	" "	10	"	9/17 10:44
S-75-002-565	" "	11	"	9/17 11:04
S-75-002-566	" "	12	"	9/17 11:24
S-75-002-525	COAL FEED	1	COAL	RUNS ARE SIMUL-
S-75-002-526	" "	2	"	TANEOUS WITH SO_2
S-75-002-527	" "	3	"	RUNS
S-75-002-528	SCRUBBER FEED	1	WATER	
S-75-002-529	" "	2	"	
S-75-002-530	" "	3	"	
S-75-002-531	SCRUBBER SLURRY	1	"	
S-75-002-532	" "	2	"	
S-75-002-533	" "	3	"	
S-75-002-534	PRODUCT (LIME)	1	LIME	
S-75-002-535	" "	2	"	
S-75-002-536	" "	3	"	✓
S-75-002-537	INLET	1	CYCLONE + PROBE ACE. WASH	9/15/75 16:23-16:33
S-75-002-543	TO SCRUBBER	2	" " " "	9/16/75 10.00-10:04
S-75-002-549	PARTICLE SIZING	3	" " " "	9/16/75 13:47-13.51
S-75-002-538		1	1st STAGE	
S-75-002-544		2	" "	
S-75-002-550		3	" "	
S-75-002-539		1	2nd STAGE	
S-75-002-545		2	" "	
S-75-002-551		3	" "	
S-75-002-540		1	3rd STAGE	
S-75-002-546		2	" "	
S-75-002-552		3	" "	
S-75-002-541		1	4th STAGE	

SAMPLE IDENTIFICATION LOG

EPA Number	Sample Location	Run	Contents	Comments
S-75-002-547		2	4th STAGE	
S-75-002-553		3	" "	
S-75-002-542		1	5th STAGE	
S-75-002-548		2	" "	
S-75-002-554	↓	3	" "	
				NO NUMBER ASSIGNED TO FINAL FILTERS

APPENDIX I

ANALYTICAL DATA SHEETS

ANALYTICAL DATA

PLANT Allied Products

DATE 9/15/75

SAMPLING LOCATION Outlet

SAMPLE TYPE EPA-5

RUN NUMBER 1

SAMPLE BOX NUMBER 4

CLEAN-UP MEN T Cook

ANALYST L Kulik

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER S75-002-502 210 mg

FILTER NUMBER 0.5302

0.4319

0.0883

CONTAINER S75-002-501 98.3 mg

FRONT HALF SUBTOTAL 119.3 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-503 9.2 mg

ETHER-CHLOROFORM EXTRACTION 0.3 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-504 3.1 mg

BACK HALF SUBTOTAL 12.6 mg

TOTAL WEIGHT 131.9 mg

MOISTURE

IMPINGERS

FINAL VOLUME _____ ml

INITIAL VOLUME _____ ml

NET VOLUME _____ ml

SILICA GEL

FINAL WEIGHT	_____ g	_____ g	_____ g
INITIAL WEIGHT	_____ g	_____ g	_____ g
NET WEIGHT	_____ g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Allied Products

DATE 9/16/75

SAMPLING LOCATION

SAMPLE TYPE EPH-5

RUN NUMBER 2 / 1

SAMPLE BOX NUMBER

CLEAN-UP MEN Potter, McDonald, Carl

ANALYST L. Kulik

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER S-75-002-507 17.1 mg

FILTER NUMBER 0.4908

0.4227

0.0681

CONTAINER S-75-002-502 68.1 mg

FRONT HALF SUBTOTAL 85.2 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-508 1.5 mg

ETHER-CHLOROFORM EXTRACTION 1.1 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-509 5.2 mg

BACK HALF SUBTOTAL 7.8 mg

TOTAL WEIGHT 93.0 mg

MOISTURE

IMPINGERS

FINAL VOLUME ml

INITIAL VOLUME ml

NET VOLUME ml

SILICA GEL

FINAL WEIGHT	g	g	g
INITIAL WEIGHT	g	g	g
NET WEIGHT	g	g	g

TOTAL MOISTURE g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Allied Product

DATE 9/16/75

SAMPLING LOCATION #3 Kiln Outlet

SAMPLE TYPE EPA-5

RUN NUMBER 3

SAMPLE BOX NUMBER 4

CLEAN-UP MEN L. Bush

ANALYST F. Kulik

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER S-75-002-512 12.7 mg

FILTER NUMBER 0.5314 _____

0.4228 _____

0.1086 _____

CONTAINER S-75-002-511 108.6 mg

FRONT HALF SUBTOTAL 121.3 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-513 5.0 mg

ETHER-CHLOROFORM EXTRACTION 1.2 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER S-75-002-514 3.8 mg

BACK HALF SUBTOTAL 10.0 mg

TOTAL WEIGHT 131.3 mg

MOISTURE

IMPINGERS

FINAL VOLUME _____ ml

INITIAL VOLUME _____ ml

NET VOLUME _____ ml

SILICA GEL

FINAL WEIGHT	_____ g	_____ g	_____ g
INITIAL WEIGHT	_____ g	_____ g	_____ g
NET WEIGHT	_____ g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYSIS REPORT	PROJECT NUMBER 13-000760.01-6912-20
TO Tom Peltier	FROM T. A. Kulik
DATE 11/25/75	CC

MEC-NB Pg 167399

% Sulfur by ASTM C-25-72 Standard Bromine Method for Total Sulfur

Sample #	g Sample	mg $BaSO_4$	%S	Avg %S
S75-002-534	1.0007	0	0	0.002
"	1.0004	0.3	0.004	
S-75-002-535	1.0017	0	0	0.002
"	1.0004	0.2	0.003	
S-75-002-536	1.0008	~~0.010~~ 0.7	~~0.7~~ 0.010	0.011
"	1.0021	~~0.012~~ 0.9	~~0~~ 0.012	

Calculation: $\frac{wt\ BaSO_4(s) - wt\ BaSO_4(g)\ in\ Blank \times 13.734}{g\ sample} = \%S$

ANALYSIS REPORT	PROJECT NUMBER 13-800-760.01-6912-20
TO Tom Peltier	FROM F. A. Kulik
DATE 11/25/75	CC

Water feed and Slurry samples for pH, %S on filtrate, and %S on suspended particulate and Total Suspended Solids

Sample #	pH	TSS (avg) mg/l	gm S/l filtrate	%S particulate
S-75-002-528	11.5	246	0.2236	2.77
"			0.2236	2.94
S-75-002-529	11.3	222	0.3317	2.41
"			0.3287	3.39
S-75-002-530	11.4	342	0.3056	3.15
"			0.3050	2.99
S-75-002-531	12.2	7406	0.1814	3.60
"			0.1775	3.66
S-75-002-532	12.2	6166	0.1866	3.87
			0.1860	3.87
S-75-002-533	12.1	4318	0.1958	3.71
"			0.1952	3.66

$$\frac{\text{wt } BaSO_4(g) \times .13734}{\text{(sample Vl}} = g\ S/l$$

ANALYSIS REPORT	PROJECT NUMBER 13-000-7600-6912-20
TO Tom Pellier	FROM P.O.Kulik
DATE 11/25/75	CC

Total % Sulfur of combusted coal sample
Method: Parr Bomb Calorimeter Manual, Manual No 130 pg. 71

Sample #	g Sample	g $BaSO_4$	% S	Avg % S
S-75-002-525	1.0255	0.0999	1.34	1.48
S-75-002-525	1.0752	0.1257	1.61	
S-75-002-526	1.0941	0.0689	0.865	
S-75-002-526	1.0605	0.0686	0.888	0.577
S-75-002-527	1.0025	0.2391	3.28	
S-75-002-527	0.9993	0.2279	3.13	~~1.31~~ 3.21

Calculation: $\frac{wt_g BaSO_4 \times 13.734}{wt_g sample_g} = \%S$

APPENDIX J

THE BRINKS® CASCADE IMPACTOR

A reprint from I&EC Industrial & Engineering Chemistry

Vol. 50, No. 4, April 1958, Pages 645-648

Cascade Impactor for Adiabatic Measurements

J. A. BRINK, Jr.[1] Monsanto Chemical Co., Everett, Mass.

Data on development, design, and use of a practical instrument in the field make it possible to build a convenient tested device for special purposes. Particle-size measurements make possible determination of acceptable stack discharges of aerosols, evaluation of installed collection equipment, rational selection and design of equipment, and recognition of potential problems early in the development of new processes.

IMPINGEMENT DEVICES have been used for years for sampling gas-borne particles (*4–6*). Owens (*9*) and Ferry, Farr, and Hartmann (*1*) used a single jet and a dry glass slide to collect samples of gas particulates suspended in a gaseous medium, and measured the sizes of impacted particles with a microscope by laborious particle counts. In May's cascade system of impactor stages (*8*) particles were separated into five fractions ranging in particle size from 1 to 50 microns. Laskin (*7*) used May's impactor on heavy aerosol particles of micron and submicron sizes. A modified cascade impactor extended measurements into the submicron range (*13*).

Extensive theoretical and experimental work with cascade impactors has been done by Ranz and Wong (*11*, *12*), Gillespie and Johnstone (*2*, *3*), and others at the University of Illinois. Pilcher, Mitchell, and Thomas (*10*) and Wilcox (*14*, *15*) investigated the characteristics of impactors and made significant improvements in design.

In many industrial plants aerosols are found in high concentrations in gases saturated with vapor at 30° to 200° C. For measuring particle-size distributions of aerosols in such gases, special equipment is required. An "in-line" cascade impactor and accessory equipment for adiabatic measurements on industrial processes were developed at Monsanto in 1954. They are small, light, and compact, and can be carried in a suitcase for tests at plants throughout the country.

[1] Present address, Research Department, Monsanto Chemical Co., St. Louis, Mo.

Impactor and Auxiliary Apparatus

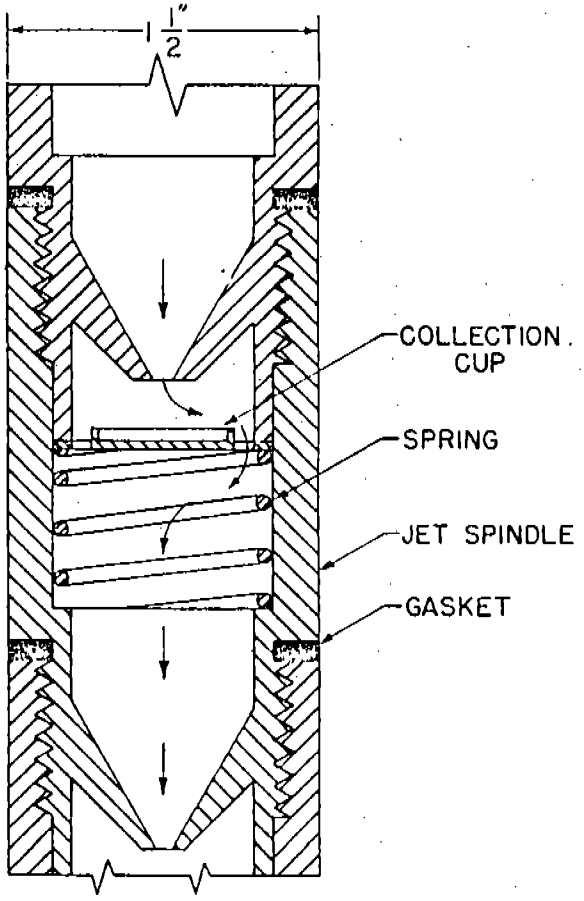
The cascade impactor has five in-line stages, each of which has a jet that utilizes a collection cup as an impaction plate. A spring holds each collection cup in place. The particles suspended in the gases pass through a jet, particles with sufficient inertia impact against a cup, and the remainder pass through annular slots located around the cup. Each collection cup has annular slots with a total cross-sectional area 30 times the area of the largest jet; turbulent effects at the slots were negligible with this design. The dimensions of the impactor jets (Table I) were selected as described by Ranz and Wong (*11*). The impactor is 15½ inches long and was machined from 316 stainless steel. Particles in the 0.3- to 3.0-micron range are collected.

A glass cyclone, with the same dimensions as that described by Gillespie (*2*, *3*), is used upstream from the impactor. Two filters, consisting of Corning No. 9480 filter tubes packed tightly with No. 800 Pyrex glass wool, collect particles less than 0.3 micron in diameter. The cyclone, impactor, and filters are mounted in a box with a removable side. A No. 2½ L-R Manufacturing Co. blower, inside the box, is driven by a 8000 r.p.m. Fairchild Industries (Model

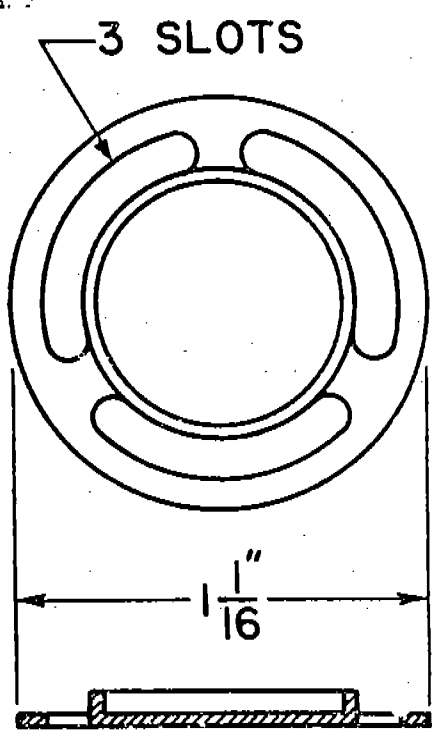
Table I. Dimensions of Cascade Impactor Jets

Jet No.	Dimensions, Cm. Jet diam.	Spacing of jet opening[a]
1	0.249	0.747
2	0.1775	0.533
3	0.1396	0.419
4	0.0946	0.282
5	0.0731	0.220

[a] From collection cup surface.



The in-line impactor has five stages. Particles in the range of 0.3 to 3.0 microns are collected by successive impingement



Collection cups are positioned so that the distance from the jet decreases as the jet diameter becomes smaller. Annular slots around cup minimize turbulence

1401) motor on the back side of the box. A heater, consisting of three 12-inch sections of Nichrome resistance wire (Catalog No. 416, Size 1, coiled type, Eagle Electric Mfg. Co.), is mounted in the box. The three sections of the heater are connected in series and operated on 110 volts. The air temperature is controlled with a 100° to 400° F. thermostat (Fenwall, Inc., Catalog No. 1731-0). The box was designed so that air could be circulated at a high velocity past the cyclone, impactor, and filters. The blower discharges air through a duct below the heater and then over the heater, impactor, and cyclone back to the blower inlet. Thermometers, mounted on the removable side of the box, indicate the temperature of the air entering the blower and leaving the heater. Two manometers, mounted on the removable side of the box and connected to the impactor, measure the static pressure at the inlet and the pressure drop across the impactor.

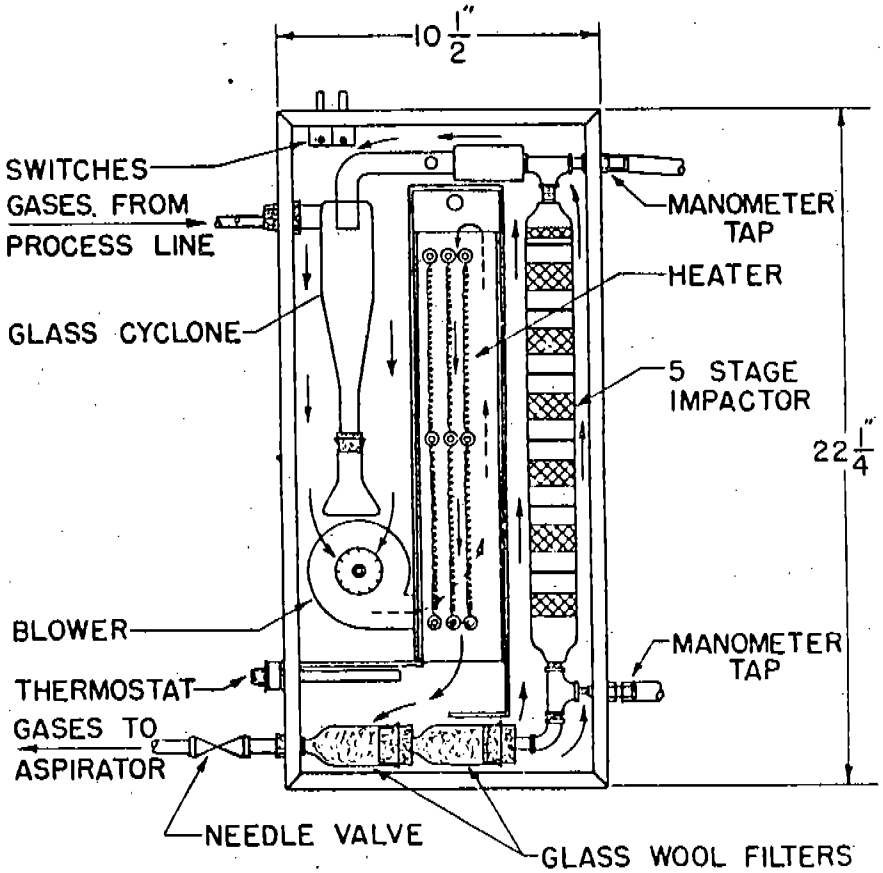
A sample line, heated with flexible tape heaters (electromagnetic heating tape, Howe and French), is controlled with a Variac. Sample probes and lines are sized for isokinetic sampling.

Experimental Procedure

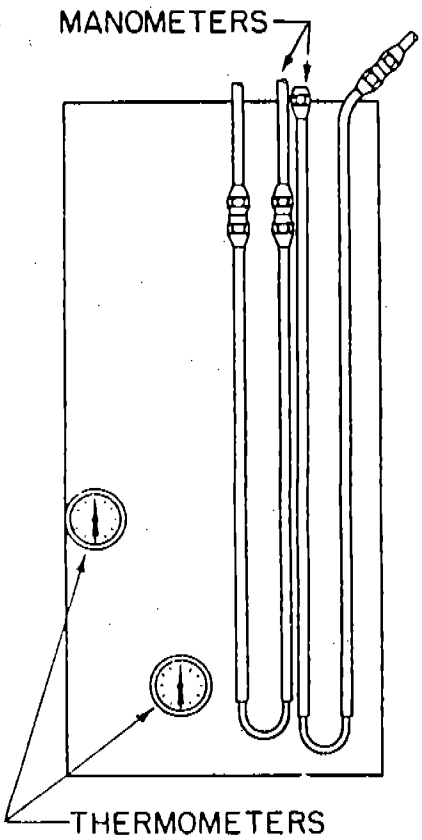
Prior to each test, the impactor and auxiliary apparatus were tested for leaks under 8-inch mercury vacuum. Then the sample line and the impactor box were heated to the temperature of the process stream. The sample probe was inserted in the process stream and gas flow through the impactor was started and held constant until the end of the test. A vacuum of 4 to 8 inches of mercury was usually required, giving flow rates of 2700 to 3700 cc. per minute.

Usually, 40 to 80% of the aerosol was collected on one cup or stage of the impactor. The sample time was limited by re-entrainment from this cup; a 25- to 50-mg. sample could be collected on one cup without re-entrainment. The maximum sample time was used, so that reasonable quantities were collected on other cups. With one trial run, the flow rate for subsequent runs was set at a level that would give maximum collection on the third or middle stage of the impactor, and the sample time was set at the maximum time feasible without re-entrainment.

After each test the sample cups were removed from the impactor with tweezers. The quantity collected on each cup was determined by weighing and or chemical analyses. The glass cyclone was washed with water and the solution analyzed. The glass wool filters were leached with water and the resulting solution was analyzed; or the glass wool was removed, the filter holder was rinsed, and the glass wool and solution were analyzed either volumetrically or gravimetrically, depending on the type of aerosol. Both weighing and chemical analyses were used when condensation or evaporation was a potential source of



Compact make-up of impactor and its auxiliary equipment make it suitable for tests throughout the plant



Temperature and pressure during sampling period are controlled by observing and adjusting instruments. Interpretation of data aids in identifying aerosols collected

error; double analyses showed that errors due to condensation or evaporation were negligible and sampling was adiabatic.

Calibration of Impactor

The in-line impactor was designed with the internal dimensions used by Ranz and Wong (*11*), except that the gases leaving any stage passed through annular slots around the collection cups rather than out the side. As the velocities through the slots were $^1/_{30}$ to $^1/_{350}$ the jet velocities, the in-line impactor was expected to perform in the same way as impactors used by Ranz and Wong.

Sulfuric acid mists were generated in the laboratory and passed through different retention chambers in the manner described by Gillespie (*2, 3*). Particle-size determinations were made on these mists with the in-line impactor (Figure 1). These data are in good agreement with data reported by Gillespie, who used impactors calibrated by Ranz and Wong (*11*). This work showed that the in-line impactor should have the same calibration as determined by them.

With a gas meter, the in-line impactor was calibrated as a flowmeter. The relationship between gas flow through the impactor and pressure drop across the impactor, for air at 25° C. and 14.7 p.s.i.a., was determined to be:

$$V_0 = 24.5\ (\Delta P)^{0.540} \qquad (1)$$

The gas flow, V_0, for process gases at different temperatures and pressures, was calculated from this equation, using suitable corrections for differences in gas density.

Particle-Size Distribution Calculations

Calculation of particle-size distributions was based on the generalized calibration curve determined by Ranz and Wong (*11*). The characteristic diameter, D_{pc}, for each stage of the impactor may be calculated from

$$D_{pc} = \left(\frac{18\,\mu D_c}{C\,\rho_P\,v_2}\right)^{1/2} (\psi_{50})^{1/2}\,(10)^4 \qquad (2)$$

where $(\psi_{50})^{1/2} = 0.38$ for round jets (*11*). However, as the C factor is a function of D_p, calculation of D_{pc} is not as straightforward as indicated by Equation 2. C is defined in general as:

$$C = 1 + \left(\frac{2L}{D_p}\right)[1.23 + 0.41e^{-0.44D_p\,(10)^{-4}/L}]\,(10)^4 \qquad (3)$$

for $\quad 0.1 < [2L(10)^4/D_p] < 134$

When

$$\left(\frac{D_p(10)^{-4}}{L}\right) > 2.7,$$

the exponential term in Equation 3 may be neglected and

$$C = 1 + (2.46)(10)^4\,(L/D_p) \qquad (4)$$

This condition existed in most applications of the impactor. For air at normal room temperature and pressures, Equation 4 becomes

$$C = 1 + 0.165/D_p \qquad (5)$$

When gases are expanded through a jet, the temperature change can be estimated on the basis of frictionless adiabatic flow for a perfect gas (*3*). However, in most cases this temperature change is negligible and the velocity of the gases at the jet throat, v_2, can be estimated as follows:

$$v_2 = \frac{4\,V_0}{\pi(D_c)^2}\,\frac{(P_0)}{(P_2)} \qquad (6)$$

When D_p is taken equal to D_{pc}, Equations 2, 4, and 6 can be combined to give

$$D_{pc} = \frac{-15.3\,\mu}{\sqrt{g_c\rho P_2}} + \sqrt{\frac{234\,\mu^2}{g_c\rho P_2} + \frac{(2.05)(10)^8\mu D_c^3 P_2}{\rho_P V_0 P_0}} \qquad (7)$$

The characteristic diameters for each stage of the impactor can be calculated directly from Equation 7. When $D_p/L \times (10)^{-4} < 2.7$, Equations 2, 3, and 6 must be solved by approximation. For any test, after Dpc was calculated for

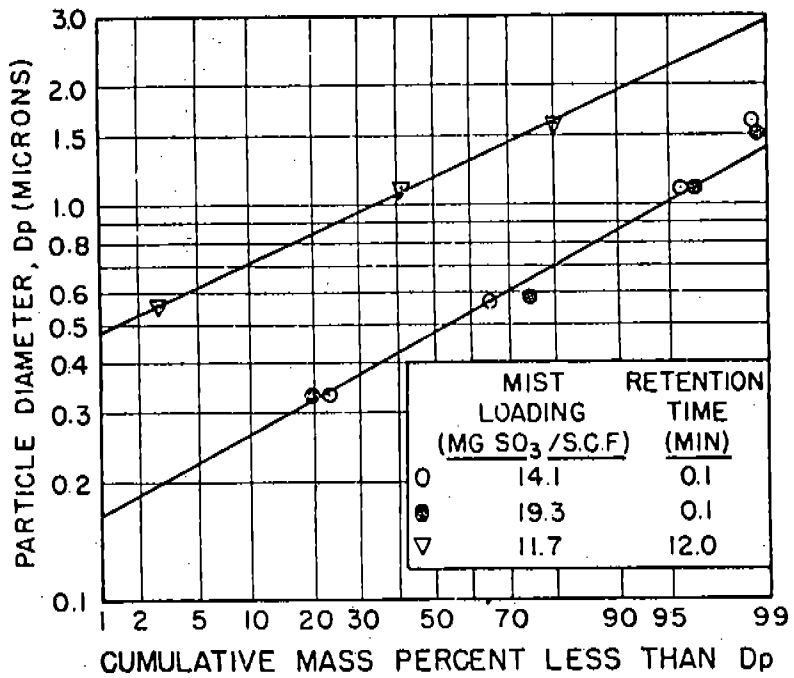


Figure 1. Cumulative particle size distribution of sulfuric acid mist generated in the laboratory is a function of mist loading and retention time

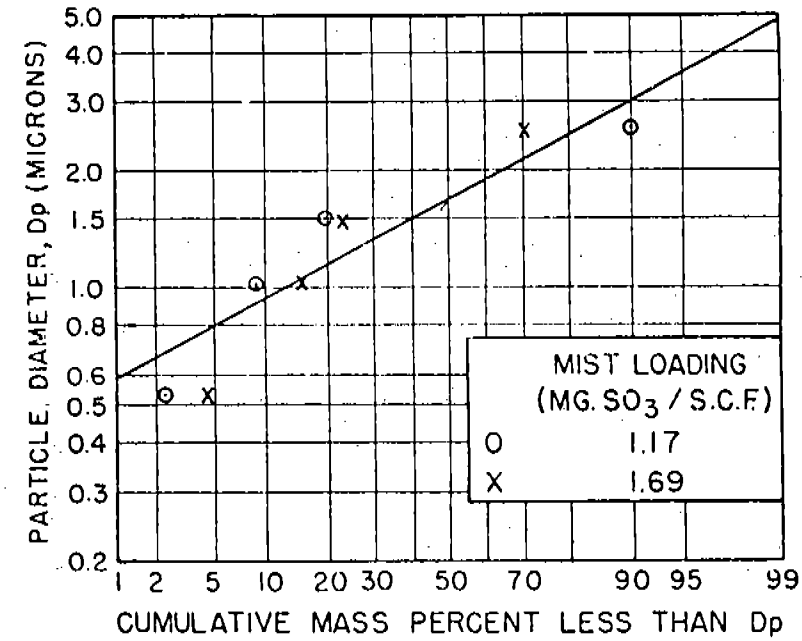


Figure 2. Cumulative particle size distribution of sulfuric acid plant aerosols

Table II. Particle-Size Distribution Curve Calculation

Jet No.	D_{pc}	% Collected	Cumulative % $< D_{pc}$
1	3.14	0.39	99.61
2	1.63	0.68	98.93
3	1.10	2.74	96.19
4	0.57	21.60	74.59
5	0.33	54.73	19.86
Glass filter			
1	...	19.86	
2	...	0	

each stage, cumulative distributions as shown in Figures 1 to 3 were calculated. For example, consider the curve given for a mist loading of 19.3 mg. of sulfur trioxide per standard cubic foot and a retention time of 0.1 minute in Figure 1. The data for this test are given in Table II. As 19.86% of the mist was not collected by the last stage, this percentage of the mist has diameters smaller than 0.33 micron, the D_{pc} for the last stage. The cumulative per cent not collected by stage 4 was 19.86% + 54.73% = 74.59%. This calculation was continued as shown in Table II and then the curve was plotted as shown in Figure 1.

Field Measurements

The impactor and auxiliary apparatus have been used extensively at plants throughout the country. Measurements of particle-size distributions of aerosols within and leaving eight different acid plants have been measured, and collection efficiencies of different types of full-scale dust and mist collectors for different particle sizes have shown that the impactor is a valuable and practical instrument for field use.

The particle-size distribution and loading of the mist leaving a new contact sulfuric acid plant are shown in Figure 2. This plant is of the Leonard-Monsanto design, a single unit with a rated capacity of 400 tons per day on a 100% sulfuric acid basis. Process gases in phosphoric acid plants are usually saturated with 5 to 40% water vapor, depending on the process design and operation, and adiabatic measurements are required. A typical particle-size distribution for the acid mist leaving a phosphoric acid plant is given in Figure 3.

Particle-size determinations by chemical company personnel make possible determination of acceptable stack discharges of aerosols, evaluation of installed collection equipment, rational selection and design of equipment, and recognition of potential problems early in the development of new processes.

Acknowledgment

The many helpful suggestions made by H. F. Johnstone, W. E. Ranz, Herbert Kraemer, J. B. Wong, and G. R. Gillespie on the design and operation of cascade impactors are gratefully acknowledged.

H. P. Willett and other engineers at the Chemical Construction Corp. assisted in the design of the in-line impactor.

D. A. Moore assisted in the experimental aspects of the work and in the preparation of a company report on which this discussion is based. W. M. Davis made several helpful suggestions.

Nomenclature

C = empirical correction factor for resistance of gas to movement of small particles as defined in Equation 3, 4, or 5

D_c = diameter of impactor jet, cm.

D_p = diameter of aerosol particle, microns

D_{pc} = characteristic diameter of aerosol particle for impactor stage, microns

g_c = 1 (g.)/(atm.)(cm.)(sec.)^2

L = mean free path for gas molecules, cm. $L = 2\mu/\rho\bar{v}$

P_0 = absolute pressure at inlet to impactor, atm.

P_2 = pressure after jet, atm.

ΔP = pressure drop across impactor, inches Hg

T_2 = temperature after jet, °K.

V_0 = gas flow at inlet to impactor, cc./second. $V_0 = 24.5\,(\Delta P)^{0.440}$ for air at 25° C. and 14.7 p.s.i.a.

v_2 = average linear velocity of gas through jet, at P_2 and T_2, cm. per second

$\bar{v}$ = average molecular velocity of gas, cm. per second $\bar{v} = (10)^3 \sqrt{\frac{8 g_c P_2 (1.013)}{\pi \rho}}$

ψ = dimensionless inertial parameter, $= C\rho_p v_2 D_p^2 / 18\,\mu D_c\,(10)^8$

ψ_{50} = inertial parameter for impactor efficiency of 50%

ρ = gas density after jet at T_2 and P_2, gram per cc.

ρ_p = density of aerosol particle, gram per cc.

μ = viscosity of gas after jet at T_2 and P_2, g./(cm.)(sec.)

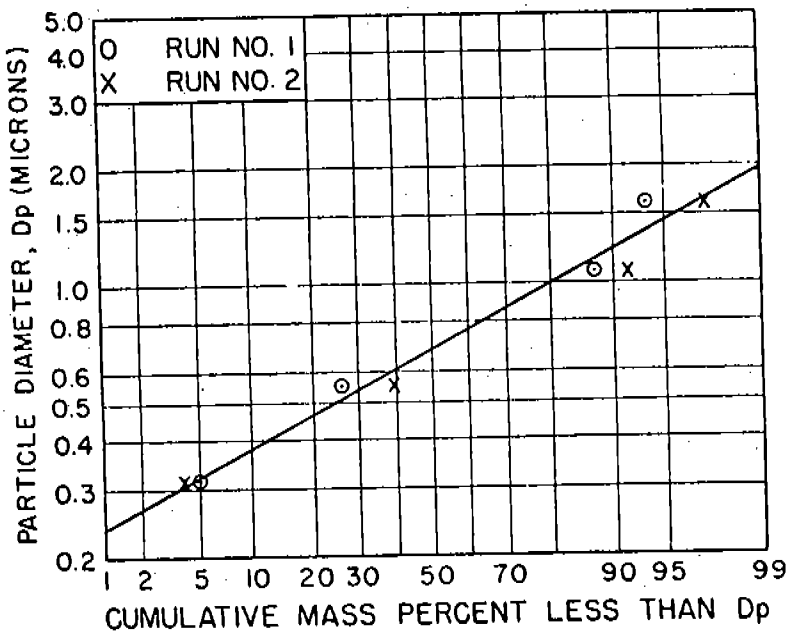


Figure 3. Distribution of phosphoric acid mist leaving typical plant can be used to control process. Analysis of aerosols under varying plant conditions aids in the selection of new equipment

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Received for review March 21, 1957
Accepted August 14, 1957

Annual Meeting; AIChE, Boston, Mass., December 1956.

APPENDIX K

SAMPLING AND ANALYTICAL PROCEDURES

Designation: C 25 – 72

American National Standard K67.3
American National Standards Institute

Standard Methods of CHEMICAL ANALYSIS OF LIMESTONE, QUICKLIME, AND HYDRATED LIME[1]

This Standard is issued under the fixed designation C 25; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

23. Total Sulfur

23.1 *Standard Bromine Method*—Weigh 1 g of the prepared sample. Add approximately 0.5 g of Na_2CO_3. Mix thoroughly in a porcelain crucible (Note 27) and heat gently until sintered. Then ignite for 15 min at a temperature of approximately 1000 C, taking care to allow access of air to the contents of the crucible. Cool and place the crucible in a 250-ml beaker and cover with hot water. Add 10 ml of bromine water, then 30 ml HCl (1+1) and boil until solution is complete and all bromine has been expelled. Remove the crucible, washing it with water. Add a few drops of methyl red and render the solution alkaline with NH_4OH (1+1). Boil the solution for 1 or 2 min, filter, and wash with hot water. To the filtrate add 5 ml of HCl (1+1), adjust the volume to about 200 ml, bring the solution to boiling, and while boiling add 10 ml of hot $BaCl_2$ (10 percent). Allow to stand overnight. Filter, wash with hot water, ignite, and weigh as $BaSO_4$.

NOTE 27—It is usually desirable to make a fusion in a platinum crucible. However, it has been found that with limestones very high in impurities, when the fusion is made in a muffle, the damage to platinum ware is considerable. It has been proved that the use of porcelain crucibles introduces no appreciable error.

23.2 *Alternative Leco Method:*

23.2.1 *Description*—The total sulfur in various types of materials can be determined accurately by the Leco automatic titrator and high frequency induction furnace. The sulfur in the sample burns to SO_2 in the furnace and is carried to the titrator by the oxygen stream. The gas enters a titration vessel containing HCl, KI, starch, and just enough KIO_3 to release some free iodine to turn the starch blue. The SO_2 bleaches the blue color and KIO_3 solution is added automatically to maintain the blue color. When all the SO_2 has been released, the blue color no longer fades and the amount of KIO_3 solution used is read on a buret directly as percent sulfur.

NOTE 28—The Leco instrument should be standardized by using a calcium oxide of known sulfur content as determined by the bromine method in 21.1.

23.2.2 *Apparatus:*

23.2.2.1 *Induction Furnace*, "S" modification, Leco Model No. 521.

23.2.2.2 *Automatic Titrator*, Leco Model No. 532.

23.2.2.3 *Oxygen Tank and Regulators.*

23.2.2.4 *Purifying Train*, Leco Model No. 516.

23.2.2.5 *Combustion Crucibles*, Leco Model No. 528-120.

23.2.2.6 *Crucible Covers*, Leco Model No. 528-41.

23.2.2.7 *Glass Accelerator Scoop*, Leco Model No. 503-32.

23.2.2.8 *Starch Dispenser.*

23.2.2.9 *Timer*, Leco Model No. 593-100.

23.2.2.10 *Loading Funnel*, Leco Model No. 503-31.

23.2.3 *Reagents:*

23.2.3.1 *Copper Ring Accelerator*, Leco Catalog No. 550-184.

23.2.3.2 *Hydrochloric Acid* (HCl) 35 percent, Baker Catalog No. 9535.

23.2.3.3 *Low-Sulfur Powdered Iron*, Leco Catalog No. 501-78.

23.2.3.4 *Phenylmercuric Acetate*, MC&B Catalog No. P 5027.

23.2.3.5 *Potassium Iodate* (KIO_3) crystal, Baker Catalog No. 3156.

23.2.3.6 *Potassium Iodide* (KI) crystal, Baker Catalog No. 3162.

23.2.3.7 *Starch*, water-soluble, Baker Catalog No. 4006.

23.2.3.8 *Tin Metal Accelerator*, Leco Catalog No. 501-76.

23.2.4 *Solutions:*

23.2.4.1 *Hydrochloric Acid*—Dilute 15 ml of hydrochloric acid to 1 liter with water.

23.2.4.2 *Starch*—Weigh 9.0 g of starch into small beaker. Add 5 to 10 ml of water and stir into a smooth paste. Add starch slowly while stirring into 500 ml of boiling water. Cool and add 15 g of KI. Transfer the solution to a 1-liter volumetric flask, shake well, and dilute to volume. Discard any starch solution that imparts a red tinge to the blue color when titrating. To help preserve the starch solution, add 0.01 g of phenylmercuric acetate.

23.2.4.3 *Potassium Iodate, Standard Solution*—Accurately weigh 0.22269 g of KIO_3. Correct this mass for purity. Transfer carefully into a 1-liter volumetric flask and dilute to volume with water. The solution is stable for at least 3 months. For a 0.500-g sample mass, the buret reads directly in percent sulfur.

23.2.5 *Procedure:*

23.2.5.1 Allow 15 min for the electronics in the furnace and titrator to warm up.

23.2.5.2 Weigh 0.500 ± 1.0 mg of prepared sample and brush carefully into the crucible using the loading funnel.

23.2.5.3 Add accelerators to the crucible using level scoops in the following order: (*1*) 1 scoop of tin metal, (*2*) 1 scoop of iron powder, and (*3*) 1 copper ring.

23.2.5.4 Cover the crucible with a crucible cover. Do not reuse crucibles or covers.

23.2.5.5 Run a blank determination for each series of determination, that is, all accelerators and no sample.

23.2.5.6 Place the sample on the pedestal and lift into position in the combustion tube.

23.2.5.7 With the oxygen flow set at 1.0 liter/min, add the HCl to the middle of the bell-shaped portion of the titration vessel. Always fill to the same point.

23.2.5.8 Add one measure of starch solution to the titration vessel.

23.2.5.9 Turn the double throw switch to the END POINT position (down). Allow the instrument to set the end point. After the indicator light (for solenoid valve) has stopped blinking, place the switch in the NEUTRAL position and fill the KIO_3 buret. Turn the switch to the TITRATE position.

23.2.5.10 Set the GRID CURRENT TAP Switch to "Low," "Medium," or "High" position. Determine the position on a test run, with the sample and accelerators that will give a complete burn-off above 350 mA as indicated on the PLATE CURRENT AMMETER.

23.2.5.11 Set the automatic timer to the time required to combust the sample completely as follows:

Sample	Time, min
Quicklime	8
Hydrated lime	10
Limestone	12

23.2.5.12 After the furnace has shut off, read directly in percent sulfur.

23.2.5.13 Report the analysis as percent total sulfur.

Designation: D 271 – 70[e]

American National Standard K18.1
American National Standards Institute

Standard Methods of LABORATORY SAMPLING AND ANALYSIS OF COAL AND COKE[1]

This Standard is issued under the fixed designation D 271; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval.

NOTE—An editorial change was made in Section 48 in April 1972.

Scope

1.1 These methods cover the laboratory preparation of coke and the analysis of coal and coke.

1.2 The procedures appear in the following order:

NOTE 1—The value stated in U.S. customary units are to be regarded as the standard.

PREPARATION OF LABORATORY SAMPLES

Apparatus for Preparing Coke Samples

2.1 *Pans for Total Moisture Determination*—Galvanized iron pans 24 by 24 by 4 in. (610 by 610 by 102 mm) in depth.

2.2 *Balance or Solution Scale*—A balance or scale having a capacity of 10 kg and sensitive to 1 g for weighing the galvanized iron pans with samples.

2.3 *Crusher*—See Section 4.2 of ASTM Method D 2013, for Preparing Coal Samples for Analysis.[2]

2.4 *Roller-Crusher*—A hard-steel roll crusher suitable for reducing the material passing a No. 4 (4.75-mm) sieve to pass a No. 20 (850-μm) sieve.

2.5 *Pulverizer*—A porcelain jar ball mill, hard-steel roll crusher, or hard-steel diamond mortar for reducing the product passing a No. 20 (850-μm) sieve to pass a No. 60 (250-μm) sieve. The porcelain jars for the ball mill should be approximately 9 in. (229 mm) in diameter and 10 in. (254 mm) in height. The flint pebbles should be smooth, hard, and well-rounded. The rolls of the hard-steel roll crusher should revolve at the same speed.

2.6 *Large Riffle Sampler*—See Method D 2013, Section 4.5.2.

2.7 *Small Riffle Sampler*—See Method D 2013, Section 4.5.2.

2.8 *Sieves*—See Method D 2013, Section 4.7.

2.9 *Containers*—See Method D 2013, Section 4.8.

2.10 *Oven, Stove, or Hot Plate*—An oven, stove, or hot plate for drying coke samples in the determination of total moisture. If an oven is used, it should have openings provided for natural ventilation and should be capable of being regulated between 104 C and 200 C. If the coke is dried on a stove or hot plate, a thermometer should be placed in it, and care exercised that the temperature does not exceed 200 C at any point in the pan of coke.

[1] These methods are under the jurisdiction of ASTM Committee D-5 on Coal and Coke.

Current edition effective Nov. 6, 1970. Originally issued 1927. Replaces D 271 – 68.

[2] *Annual Book of ASTM Standards*, Part 19.

3. Sample Preparation for Coke

3.1 *Total Moisture Determination*—Without any preliminary crushing, dry the entire sample received at the laboratory to constant weight at not less than 104 C nor more than 200 C.[3] Calculate the loss in weight to percentage of moisture, which shall constitute the total moisture in the coke as received at the laboratory. The permissible difference in duplicate determinations by the same analyst is 0.5 percent.

3.2 *Reduction of Sample*—Crush the dried sample mechanically with a jaw or roll crusher, or by hand on a chilled iron or hard-steel plate by impact of a hard bar or sledge, avoiding all rubbing action, since otherwise the ash content will be materially increased by the addition of iron from the sampling apparatus, even though hardened iron or steel is used. Continue the crushing until all the sample passes through a No. 4 (4.75-mm) sieve, mix, and reduce on the large riffle sampler to not less than 5 lb (2.3 kg); again crush the 5-lb (2.3-kg) sample sufficiently fine to pass a No. 20 (850-μm) sieve, mix, and reduce on the small riffle sampler to 200 g. Transfer this 200-g portion to the porcelain jar of the ball mill and pulverize to pass a No. 60 (250-μm) sieve. When pulverization is complete, pour the contents of the jar on a ½-in. (12.5-mm) sieve and separate the sample from the pebbles by sieving. Pass all the material through a No. 60 (250-μm) sieve, pulverizing any coarse particles by impact in a hard-steel diamond mortar, and mix with the remainder of the sample. Reduce the sample through the small riffle sampler to about 50 g and transfer to a rubber-stoppered glass bottle.

3.3 In case a ball mill is not available for fine grinding, quarter the 5-lb (2.3-kg) sample passing a No. 20 (850-μm) sieve to 200 g, and pulverize to pass a No. 60 (250-μm) sieve by means of a hard-steel roll crusher in which the rolls revolve at the same speed, or by impact in a hard-steel diamond mortar. The use of rubbing surfaces such as a disk pulverizer or a bucking board is never permissible for grinding coke.

4. Sample of Coal

4.1 The samples of coal used for the following tests shall be the material pulverized to pass the No. 60 (250-μm) sieve and well mixed according to Method D 2013.

METHODS OF ANALYSIS

NOTE 2—Results of analyses may be calculated to the dry coal basis as provided in Section 56.

5. Purity of Reagents

5.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to ASTM Specification D 1193, for Reagent Water.[5]

MOISTURE

6. Apparatus

6.1 *Moisture Oven, for Coal*—For determining the moisture for coal, the oven shall be so constructed as to have a uniform temperature in all parts and a minimum of air space. It may be of the form shown in Fig. 1

[3] Experiments made at the U. S. Bureau of Mines have shown that results checking within 0.5 percent are obtained between these temperature limits. See Fieldner, A. C., and Selvig, W. A., "The Determination of Moisture in Coke," U. S. Bureau of Mines, *Technical Paper No. 148* (1917).

[4] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, D.C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N.Y., and the "United States Pharmacopeia."

[5] *Annual Book of ASTM Standards*, Part 23.

Provision shall be made for renewing the air n the oven at the rate of two to four times a ninute, with the air dried by passing it hrough H_2SO_4.

6.2 In the oven shown in Fig. 1, the door hould contain a hole of approximately 1/8-in. 3.2-mm) diameter near the bottom to permit ree flow of air through the oven space.

6.3 *Moisture Oven, for Coke*—For deter- ining the moisture of coke, an ordinary ying oven with openings for natural air cir- ulation and capable of temperature regula- on between limits of 104 and 110 C may be sed.

6.4 *Capsules with Covers*—A convenient rm, which allows the ash determination to made on the same sample, is a porcelain psule, 7/8 in. (22.2 mm) in depth and 1 3/4 in. 44.4 mm) in diameter, or a fused silica cap- le of similar shape. This shall be used with well-fitting flat aluminum cover, illustrated Fig. 2. Platinum crucibles or glass capsules ith ground-glass caps may also be used. hey should be as shallow as possible, con- stent with convenient handling.

Materials

7.1 *Desiccant*—Sulfuric acid (H_2SO_4, sp gr 84).

Procedure for Coal or Coke Passing a No. 60 Sieve

8.1 Heat the empty capsules under the con- ions at which the sample is to be dried, place stopper or cover on the capsule, cool over SO_4 for 30 min, and weigh. Dip out with a oon or spatula from the sample bottle ap- oximately 1 g of the sample. Put this quickly to the capsule, close, and weigh at once.

8.2 An alternative procedure for weighing t the sample (more subject to error) is as lows: After transferring an amount of the mple slightly in excess of 1 g, bring to ex- tly 1 g in weight (±0.5 mg) by quickly re- oving the excess weight of the sample with a atula. The utmost dispatch must be used in der to minimize the exposure of the sample til the weight is found.

8.3 After removing the covers, quickly ace the capsules in a preheated oven (at 104 110 C) through which passes a current of dried by H_2SO_4 (sp gr 1.84) (the current of dry air is not necessary for coke). Close the oven at once and heat for 1 h. Open the oven, cover the capsules quickly, cool in a desic- cator over H_2SO_4 (sp gr 1.84), and weigh.

8.4 Use the percentage of moisture in the sample passing a No. 60 (250-μm) sieve to calculate the results of the other analyses to a dry basis.

9. Procedure for Coal Passing a No. 20 Sieve

9.1 Use 5 g of the sample, weighed to the nearest 2 mg, and heat for 1½ h. Complete the determination as described in Section 8.

Ash

10. Apparatus

10.1 *Gas or Electric Muffle Furnace for Coal*—For determination of ash of coal, the muffle shall have good air circulation and be capable of having its temperature regulated between 700 and 750 C.

10.2 *Gas or Electric Muffle Furnace or Meker Burner for Coke*—For determination of ash of coke, the muffle shall have good air circulation and be capable of having its tem- perature regulated not to exceed 950 C.

10.3 *Porcelain Capsules*, 7/8 in. (22.2 mm) in depth, and 1 3/4 in. (44.4 mm) in diameter, or similar shallow dishes or platinum cruci- bles.

11. Procedure for Coal

11.1 Place the porcelain capsules con- taining the dried coal from the moisture de- termination in a cold muffle furnace, or on the hearth at a low temperature, and grad- ually heat to redness at such a rate as to avoid mechanical loss from too rapid expul- sion of volatile matter (Note 3). Finish the ignition to constant weight (±0.001 g) at a temperature between 700 and 750 C. Cool in a desiccator, and weigh as soon as cold (Notes 4 and 5).

NOTE 3—Before replacing the capsules in the muffle for ignition to constant weight, the ash should be stirred with a platinum or Nichrome wire. Stirring once or twice before the first weighing hastens complete ignition.

NOTE 4—The result obtained by this method is "uncorrected" ash. For "corrected" ash see the pre- liminary report.[6] The actual mineral matter in the original coal is usually very different in weight and composition from the weight of the "uncorrected" ash.

NOTE 5—Difficulty may be experienced in se- curing satisfactory check determinations of ash in the same or different laboratories for coals unu- sually high in calcite and pyrite. This is caused by varying amounts of sulfate sulfur being retained in the ash. When such difficulty is encountered, or when coals of relatively high ash content whose mineral matter composition is unknown are encoun- tered, the ash should be determined by the follow- ing modified procedures:

(*1*) Place the porcelain capsules containing the dried coal from the moisture determination in a cold muffle furnace and heat gradually so that the temperature reaches 500 C in 1 h, and 750 C in 2 h. Heat to constant weight at 750 C. By this means pyritic sulfur will be oxidized and expelled before the calcite is decomposed. An ample supply of air in the muffle must be assured at all times to ensure complete oxidation of the pyritic sulfur and proper circulation through the muffle must be assured to remove the SO_3 formed.

(*2*) The modified procedure described in Para- graph (*1*) should be adequate for determining ash in all troublesome commercial samples. However, samples may be encountered in certain special studies whose ash values are quite high and whose mineral matter contains much greater than normal amounts of calcite and pyrite. In such cases sulfate sulfur should be determined on the ash obtained by the modified cold muffle method and the value prop- erly corrected, or the Parr[7] sulfated ash method as modified by Rees[8] should be used.

12. Procedure for Coke

12.1 Place the capsules containing the dried coke from the moisture determination in a muffle furnace or over a burner, and heat to redness at such a rate as to avoid mechanical loss (Note 3). Finish the ignition to constant weight (±0.001 g) at a temperature not ex- ceeding 950 C. Cool in a desiccator, and weigh.

NOTE 6—Test the ash for unburned carbon, by moistening it with alcohol; any carbon remaining will show as black particles.

Volatile Matter

13. Apparatus

13.1 *Platinum Crucible with Closely Fitting Cover, for Coal*, of not less than 10 nor more than 20-ml capacity, not less than 25 nor more than 35 mm in diameter, and not less than 30 nor more than 35 mm in height.

13.2 *Platinum Crucible with Closely Fitting Cover, for Coke*, of 10-ml capacity, with cap- sule cover having thin flexible sides fitting down into crucible. Or the double-crucible method may be used, in which the sample is placed in a 10 or 20-ml platinum crucible, which is then covered with another crucible of such a size that it will fit closely to the sides of the outer crucible, and its bottom will rest 1/8 to 1/2 in. (8.5 to 12.7 mm) above the bottom of the outer crucible.

13.3 *Vertical Electric Tube Furnace, or a Gas or Electrically Heated Muffle Furnace, for Coal or Coke*, may be of the form shown in Fig. 3. It shall be regulated to maintain a temperature of 950 ± 20 C in the crucible, as shown by a thermocouple kept in the furnace. If the determination of volatile matter is not an essential feature of the specifications under which the coal or coke is bought, a Meker burner may be used.

14. Procedure for Coal and Coke, Usual Method

14.1 Weigh 1 g of the sample in a weighed platinum crucible, close with a cover (Note 7), and place on platinum or Nichrome-wire sup- ports in the furnace chamber, which shall be at a temperature of 950 ± 20 C (Note 8). After the more rapid discharge of volatile matter has subsided (Note 9) as shown by the disappearance of the luminous flame, or in the case of coke, after heating 2 or 3 min, tap the cover lightly to more perfectly seal the crucible and thus guard against the admission of air. After heating for exactly 7 min, re- move the crucible from the furnace and, without disturbing the cover, allow it to cool. Coke should be cooled in a desiccator. Weigh as soon as cold. The loss of weight minus moisture equals the volatile matter.

NOTE 7—The cover should fit closely enough so that the carbon deposit from bituminous, subbitu- minous, and lignitic coals does not burn away from the under side.

NOTE 8—Regulation of temperature to within the prescribed limits is important.

NOTE 9—With some strongly caking low-volatile and medium-volatile bituminous coals, the coke button may be broken with explosive violence, due to the liberation of volatile matter within the button. This is usually designated as "popping." Such popping may blow the lid off the crucible and cause mechanical losses of the coked material. When such popping is observed, the determination shall be rejected and the test repeated until popping does not occur.

[6] Report on Fixed Carbon and Ash, *Proceedings*, Am. Soc. Testing Mats., Vol XIV, Part I, 1914, p. 426.

[7] Parr, S. W., "Chemical Study of Illinois Coal," *Bulletin No. 3*, BIGSA, p. 35, Illinois Coal Mining Investiga- tions, State Geological Survey, Urbana, Ill. (1916).

[8] Rees, O. W., "Determining Ash in High Carbonate Coals. Study of the Modified Method," *Industrial and Engineering Chemistry*, Analytical Edition, IENAA, Vol 9, 1937, pp. 307-309.

15. Modified Procedure for All Sparking Fuels

15.1 Mechanical losses are incurred on suddenly heating many fuels. This mechanical loss is usually designated as "sparking" and is caused by particles of the fuel being ejected from the crucible by the too rapid escape of steam or volatile matter. These particles become incandescent in the flame of the burning volatile constituents and may be seen around the edge of the crucible cover, sometimes only ¼ in. (6.3 mm) above the crucible and at other times shooting several inches to the top of the furnace. In severe cases of sparking, ash deposits and sometimes unburned material will be found on the crucible cover. Small amounts of ash deposits are sometimes found on the crucible cover in case of moderately sparking fuels. All fuels that do not cake when volatile matter is determined shall be watched closely for sparking during the heating period; also, at the end of the test the crucible cover shall be inspected for ash deposits, and the presence of such deposits shall be considered as evidence of sparking.

15.2 All fuels that spark when the volatile matter is determined by the methods described in Sections 14 and 16 shall be treated as follows: The sample shall be given a preliminary gradual heating such that a temperature of 600 ± 50 C is reached in 6 min (Notes 10, 11, 12). After this preliminary heating the sample shall be heated for exactly 6 min at 950 ± 20 C. If sparking is then observed the determination shall be rejected and the test repeated until no sparking occurs either during the preliminary heating or during the 6-min period at 950 C. Remove the crucible from the furnace, cool on a metal cooling block (Note 13), and weigh. The percentage loss in weight minus the percent moisture is the volatile matter. All analyses by this method shall be marked to indicate that the modified procedure was used.

NOTE 10—If a tubular furnace of the Fieldner type is used for the determination of volatile matter, the preliminary gradual heating may be accomplished by moving the crucible to predetermined positions in the cooler top zone of the furnace. Due to variations in the heating characteristics of the furnace, the operator must determine by the thermocouple method in Section 6 for each furnace the proper position to meet preliminary heating rate as specified. It is also possible to use a mechanical device to lower the crucible into the furnace.

NOTE 11—If electric muffle furnaces are used the heating may be accomplished by using two furnaces situated side by side, one furnace being controlled at 550 ± 10 C, the other at 950 ± 10 C. The crucible containing the sample is placed on a Nichrome support ⅛ to ½ in. (9.5 to 12.7 mm) high, and placed in the muffle furnace controlled at 550 ± 10 C for exactly 6 min, after which time it is rapidly transferred along with its nichrome support to the second muffle furnace, controlled at 950 ± 10 C, and allowed to remain for exactly 6 min.

NOTE 12—If the Meker burner method described in 15.3 is used, the rate of heating specified in 15.2 shall be observed.

NOTE 13—To ensure uniformity of results the cooling period should be kept constant and should not be prolonged beyond 15 min.

15.3 If the Meker burner method described in Section 16 is used for the volatile matter determination, the preliminary heating shall be done by playing the flame of a burner upon the bottom of the crucible in such a manner as to bring about the discharge of volatile matter at a rate not sufficient to cause sparking. After this preliminary heating, the crucible shall be heated for exactly 6 min at 950 C as described in Section 16. If sparking occurs during this 6-min heating period, the determination shall be rejected and another made.

16. Procedure for Coal and Coke, Using Meker Burner

16.1 Weigh 1 g of the sample in a weighed platinum crucible and close with a cover or, in the case of coke, another crucible as described in Section 13.2. Place in the flame of a No. 4 Meker burner, having an outside diameter at the top of approximately 25 mm and giving a flame not less than 15 cm in height. The temperature should be 950 ± 20 C as determined by placing a thermocouple through the perforated cover, which for this purpose may be of nickel or asbestos. The junction of the couple should be placed in contact with the center of the bottom of the crucible; or the temperature may be indicated by the fusion of pure potassium chromate (K_2CrO_4) in the covered crucible (fusion of K_2CrO_4, 968 C).[9] The crucible shall be placed in the flame about 1 cm above the top of the burner and the heating continued 7 min. Where the gas pressure is variable it is well to use a U-tube attachment to the burner.

[9] U. S. Bureau of Mines, *Reports of Investigations*, Serial No. 2917 (1929).

FIXED CARBON

17. Calculation

17.1 Calculate fixed carbon in coal or coke, as follows:

Fixed carbon, percent = 100 − (moisture + ash + volatile matter)

SULFUR BY THE ESCHKA METHOD

18. Apparatus

18.1 *Gas or Electric Muffle Furance, or Burners*, for igniting the sample with the Eschka mixture and for igniting the barium sulfate ($BaSO_4$).

18.2 *Crucibles or Capsules*—Porcelain capsules, ⅞ in. (22.2 mm) in depth and 1¾ in. (44.4 mm) in diameter, or porcelain crucibles of 30-ml capacity, high or low form, or platinum crucibles of similar size shall be used for igniting the sample with the Eschka mixture. Porcelain, platinum, Alundum, or silica crucibles of 10 to 15-ml capacity, shall be used for igniting the $BaSO_4$.

19. Reagents

19.1 *Barium Chloride Solution (100 g/liter)*—Dissolve 100 g of barium chloride ($BaCl_2 \cdot 2H_2O$) in 1 liter of water.

19.2 *Bromine Water (saturated)*—Add an excess of bromine to 1 liter of water.

19.3 *Eschka Mixture*—Thoroughly mix 2 parts by weight of light calcined magnesium oxide (MgO) with 1 part of anhydrous sodium carbonate (Na_2CO_3). Both materials should be as free as possible from sulfur.

19.4 *Hydrochloric Acid (1+1)*—Mix equal volumes of concentrated hydrochloric acid (HCl, sp gr 1.19) and water.

19.5 *Hydrochloric Acid (1+9)*—Mix 1 volume of concentrated hydrochloric acid (HCl, sp gr 1.19) with 9 volumes of water.

19.6 *Methyl Orange Indicator Solution (0.2 g/liter)*—Dissolve 0.02 g of methyl orange in 100 ml of hot water and filter.

19.7 *Sodium Carbonate, Saturated Solution*—Dissolve approximately 60 g of crystallized sodium carbonate ($Na_2CO_3 \cdot 10H_2O$) or 22 g of anhydrous sodium carbonate (Na_2CO_3) in 100 ml of water, using a sufficient excess of Na_2CO_3 to ensure a saturated solution.

19.8 *Sodium Hydroxide Solution (100 g/liter)*—Dissolve 100 g of sodium hydroxide (NaOH) in 1 liter of water. This solution may be used in place of the Na_2CO_3 solution.

20. Procedure for Coal and Coke

20.1 *Preparation of Sample and Mixture*—Thoroughly mix on glazed paper approximately 1 g of the sample and 3 g of Eschka mixture. The amount of sample to be taken will depend on the amount of $BaCl_2$ solution required in accordance with 20.3. Transfer to a porcelain capsule or porcelain crucible, or a platinum crucible, and cover with about 1 g of Eschka mixture.

20.2 *Ignition*—On account of the amount of sulfur contained in artificial gas, the crucible shall be heated over an alcohol, gasoline, or natural gas flame as described in 20.2.1, or in a gas or electrically heated muffle as described in 20.2.2 for coal and in 20.2.3 for coke. The use of artificial gas for heating the sample and Eschka mixture is permissible only when the crucibles are heated in a muffle.

20.2.1 Heat the crucible, placed in a slanting position on a triangle, over a very low flame to avoid rapid expulsion of the volatile matter which tends to prevent complete absorption of the products of combustion of the sulfur. Heat the crucible slowly for 30 min, gradually increasing the temperature and stirring after all black particles have disappeared, which is an indication of the completeness of the procedure.

20.2.2 *For Coal*—Place the crucible in a cold muffle and gradually raise the temperature to 800 ± 25 C in about 1 h. Maintain this maximum temperature for about 1½ h.

20.2.3 *For Coke*—Place the crucible in a warm muffle and gradually raise the temperature to 800 ± 25 C in about 30 min. Maintain this maximum temperature until on stirring all black particles have disappeared.

20.3 *Subsequent Treatment:*

20.3.1 Remove the crucible and empty the contents into a 200-ml beaker and digest with 100 ml of hot water for ½ to ¾ h, while stirring occasionally. Filter and wash the insoluble matter by decantation. After several washings in this manner, transfer the insoluble matter to the filter and wash five times, keeping the mixture well agitated. Treat the filtrate, amounting to about 250 ml, with 5 to 20 ml of saturated bromine water, make slightly acid with HCl, and boil to expel the liberated bromine. Make just neutral to methyl orange with NaOH or Na_2CO_3 so-

tion; then add 1 ml of HCl (1+9). Boil again and add slowly from a pipet, while stirring constantly, 10 ml or more of $BaCl_2$ solution. The $BaCl_2$ solution must be in excess. Whenever more than 10 ml of $BaCl_2$ solution is required, the weight of sample (see 20.1) shall be reduced to about 0.5 g depending on the sulfur content. Continue boiling for 15 min and allow to stand for at least 2 h, or preferably overnight, at a temperature just below boiling. Filter through an ashless paper and wash with hot water until silver nitrate ($AgNO_3$) solution shows no precipitate with a drop of the filtrate.

20.3.2 Place the wet filter containing the precipitate of barium sulfate ($BaSO_4$) in a weighed platinum, porcelain, silica, or Alundum crucible, allowing a free access of air by folding the paper over the precipitate loosely to prevent spattering. Smoke the paper off gradually and at no time allow it to burn with flame. After the paper is practically consumed, raise the temperature to approximately 925 C and heat to constant weight.

20.3.3 Dissolve the residue of magnesium oxide (MgO), etc., after leaching, in HCl and test with great care for sulfur. When an appreciable amount is found this should be determined quantitatively. The amount of sulfur retained is by no means a negligible quantity.[10]

20.4 *Blanks and Corrections*—In all cases, a correction must be applied either by running a blank exactly as described above, using the same amount of all reagents that were employed in the regular determination, or more accurately by determining a known amount of sulfate added to a solution of the reagents after these have been put through the prescribed series of operations. If this latter procedure is adopted and carried out once a week or whenever a new supply of a reagent must be used, and for a series of solutions covering the range of sulfur content likely to be met with in the samples, it is only necessary to add to or subtract from the weight of $BaSO_4$ obtained from a sample, whatever deficiency or excess may have been found in the appropriate "check" in order to obtain a result that is more certain to be correct than if a "blank" correction as determined by the former procedure is applied. This is due to the fact that the solubility error for $BaSO_4$, for the amounts of sulfur in question and the conditions of precipitation prescribed, is probably the largest one to be considered. Barium sulfate is soluble[11] in acids and even in pure water, and the solubility limit is reached almost immediately on contact with the solvent. Hence, in the event of using reagents of very superior quality, or of exercising more than ordinary precautions, there may be no apparent "blank" because the solubility limit for the solution for $BaSO_4$ has not been reached or at any rate not exceeded.

21. Calculation

21.1 Calculate the sulfur content as follows:

$$\text{Sulfur, percent} = [(A - B) \times 13.735]/C$$

where:

A = grams of $BaSO_4$ precipitated,
B = grams of $BaSO_4$ in the blank, and,
C = grams of sample used.

NOTE 14—As shown in the preliminary report,[12] the Atkinson and sodium peroxide methods give results in close agreement with the Eschka method. Regester[13] has shown that if 5 percent of nitrogen is present in the gases contained in the bomb calorimeter the sulfur of a sample is almost completely oxidized to sulfuric acid (H_2SO_4) and the washings of the calorimeter may be used for the determination of sulfur.

Sulfur by the Bomb Washing Method[14]

22. Reagents

22.1 *Ammonium Hydroxide (sp gr 0.90)*—Concentrated ammonium hydroxide (NH_4OH).

22.2 *Bromine Water (saturated)*—See 19.2.

22.3 *Hydrochloric Acid (1+1)*—See 19.4.

22.4 *Sodium or Potassium Hydroxide, Standard Solution*—See 43.1.

22.5 *Wash Solution*—Dilute 1 ml of a saturated solution of methyl orange to 1 liter with water.

23. Procedure for Coal and Coke

23.1 *Ignition*—Sulfur is determined in the washings from the oxygen-bomb calorimeter following the calorimetric determination (Section 46). The type of bomb, amount of water in the bomb, oxygen pressure, and amount of sample taken shall be the same as specified under the calorimetric determination (Sections 43 to 46). The bomb shall stand in the calorimeter water for not less than 5 min after firing.

23.2 *Subsequent Treatment:*

23.2.1 Remove the bomb from the calorimeter water and open the valve carefully so as to allow the gases to escape at an approximately even rate so the pressure is reduced to atmospheric in not less than 1 min. Bombs equipped with valves other than needle valves, such as compression valves, shall be provided with a device so the valve can be controlled to permit a slow and uniform release of the gases. Open the bomb and examine the inside for traces of unburned material or sooty deposit. If these are found, the determination shall be discarded. Wash carefully all parts of the interior of the bomb, including the tray, with a fine jet of water containing methyl orange (see 22.5) until no acid reaction is observed. It is essential to wash through the valve opening in the case of bombs equipped with compression valves, or other types of valves with large openings, as considerable spray may collect in such valve openings.

23.2.2 Collect the washings in a 250-ml beaker and titrate with standard sodium or potassium hydroxide solution to obtain the "acid correction" for the heating value, as specified under the calorimetric determination. Add 1 ml of NH_4OH, heat the solution to boiling, and filter through a qualitative paper. Wash the residue and paper thoroughly five or six times with hot water. To the filtrate and washings, amounting to about 250 ml, add 1 ml of saturated bromine water and sufficient HCl to make it slightly acid. Boil the solution to expel the excess bromine. Adjust the acidity, precipitate, and determine the sulfur as specified under the Eschka method, Section 20.

Sulfur by the Sodium Peroxide Fusion Method[14]

24. Apparatus

24.1 *Combustion Bomb*—The Parr coal-sulfur bomb, or its equivalent, shall be used. The bomb shall have an inner surface that is not attacked by the chemicals on ignition of the charge.

25. Reagents

25.1 *Benzoic Acid*, powdered.

25.2 *Hydrochloric Acid (sp gr 1.19)*—Concentrated hydrochloric acid (HCl).

25.3 *Potassium Chlorate* ($KClO_3$), powdered.

25.4 *Potassium Perchlorate* ($KClO_4$), powdered.

25.5 *Sodium Peroxide* (Na_2O_2), powdered, sulfur-free.

26. Procedure for Coal and Coke

26.1 Place 1 g of $KClO_4$ or $KClO_3$ in a dry sulfur bomb and break up any lumps that occur. Add 0.5 g of the sample and mix thoroughly with a glass rod. Then add about 15 g of Na_2O_2 (**Caution**, Note 15) close the bomb and mix thoroughly by shaking. In the case of cokes or anthracites, or coals excessively high in ash that fail to ignite or fuse properly (as indicated by the fusion being honeycombed in appearance), add 0.3 g of benzoic acid to the bomb at the time the chlorate and sample are added.

NOTE 15: **Caution**—It should be noted that a mixture of $KClO_3$ and organic matter alone produces a mixture of extremely explosive properties. One of the important functions of the Na_2O_2 is to provide a diluent, thus slowing down the reaction, so care should be taken that it is not omitted in the charge. Potassium perchlorate is fully equal if not superior to the $KClO_3$, and is without turbulence in its reaction.

26.2 Fasten the cover securely to the bomb and ignite the charge (**Caution**, Note 16) by applying a sharply pointed flame from a blast lamp to the bottom of the bomb for a brief period, or by electric ignition, according to the type of bomb used. Allow 1 min for complete combustion to take place after ignition; then cool under the tap or in a vessel of water.

NOTE 16: **Caution**—Place the bomb inside a piece of steel pipe when the charge is ignited to prevent possible injury to the operator if the bomb should burst.

26.3 Remove the cover from the bomb, place the bomb on its side in a 400-ml beaker, and wash the cover with a fine jet of hot

[10] *Journal*, Am. Chemical Soc., JACSA, Vol 21, 1899, p. 1125.
[11] *Journal*, Am. Chemical Soc., JACSA, Vol 32, 1910, p. 588, Vol 33, 1911, p. 829.
[12] *Journal of Industrial and Engineering Chemistry*, JIECA, Vol 5, 1913, p. 5.
[13] *Ibid.*, Vol 6, 1914, p. 812.
[14] Selvig, W. A., and Fieldner, A. C., "Check Determinations of Sulfur in Coal and Coke by the Eschka, Bomb-Washing, and Sodium Peroxide Fusion Methods," *Industrial and Engineering Chemistry*, IECHA, Vol 29, 1927, pp. 729, 733.

APPENDIX L

TEST LOG

SAMPLING TASK LOG

Plant Allied Products
Date

Plant Location Montevallo, Alabama
Recorded by

Comments	Date	Run	Sampling location (Port)	Pollutant	Clock Time Began	Clock Time Ended	Elapsed Time (min)	Sample Nos.
Preliminary Traverse in A.M.	9/15	1	Outlet of Venturi	Particulate	1344	1640	120	
	9/15	1	Outlet of Venturi	Brink	1623	1633	10	
	9/16	2	Outlet of Venturi	Particulate	0940	1150	120	
	9/16	1	Scrubber Inlet	SO_2	0852	0922	30	
	9/16	2	Scrubber Outlet	SO_2	0843	0913	30	
	9/16	4	Outlet	NO_x	1936	0939	Leak	
	"	2	Outlet	Brink	1000	1004	4	
	"	3	Outlet of Venturi	Particulate	1300	1515	120	
	"	4	Outlet	NO_x	1404	1407	Leak	
	9/17	2	Inlet	SO_2	1027	1157	30	
		3	Inlet	SO_2	1153	1223	30	
		2	Outlet	SO_2	1026	1056	30	
		3	Outlet	SO_2	1152	1122	30	
		4	Outlet	NO_x	1024	1124	Leak	

APPENDIX M

PROJECT PARTICIPANTS

Project Participants

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Emission Standards and Engineering Division

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