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BENTONITE DRYER TEST

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MILLS, WYOMING

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1. INTRODUCTION

This report provides emission test data and process information for the dryer and emission control equipment used in the processing of bentonite at the Black Hills Bentonite Company in Mills, Wyoming. The report was prepared as part of the U.S. Environmental Protection Agency Industry Studies Program conducted by the Emission Standards and Engineering Division, Emission Measurement Branch (EMB). The purpose of the program is to develop new source performance standards for calciners and dryers in the mineral industries.

TRW Environmental Operations, Research Triangle Park, North Carolina, was contracted to do the field sampling and provide analytical results. The field sampling was conducted September 20-22, 1983. The data obtained during the emission tests consisted of: (a) particulate matter (PM) concentrations, (b) PM mass emission rates, (c) particle size distributions (PS) for the PM, (d) visible emission (VE) measurements, and (e) feed and product size and moisture content. The New Source Performance Standards (NSPS) contractor responsible for regulatory and engineering analysis of the emissions data is Midwest Research Institute (MRI).

The processing of bentonite commences with the transportation of bentonite by truck to the facility and stockpiling in designated open areas. Bentonite is transferred into a hopper from which it is conveyed into a slicer. The resultant particles (fines - 1.0 in) of bentonite are fed to a direct-fired rotary dryer at about thirty tons per hour (TPH). The dryer, which uses natural gas for initial start-up, was fired with a low sulfur coal at 37 pounds of coal per ton of product to provide proper process heating during the tests. The presence of montmorillonite ($Al_2Si_4O_{10}(OH)_2 \cdot XH_2O$) gives bentonite water-absorptive properties which necessitate drying the bentonite prior to pulverization, air-classification, and storage in hoppers.

During the pre-test survey it was determined that the proximity of the product cyclone to the baghouse required the inlet testing location for determination of emission control to be the inlet duct to the cyclone rather than at the baghouse inlet. This inlet data is required for emission control modeling purposes. The control device outlet test location was an eight-foot extension installed on the baghouse exhaust stack. In addition to modeling purposes, this outlet data will be used to determine the mass emission rate and the particulate sized 10 microns or less (PM_{10}) mass emission rate to the environment. The results of these tests revealed an average of 7732 pounds per hour (lbs/hr) going to the cyclone of which 461 lbs/hr (6 percent) were 10 micron or less in size. The outlet averaged 2.69 lbs/hr of which 2.00 lbs/hr (74 percent) were 10 microns or less. This indicates a removal efficiency for the cyclone and baghouse of 99.96 percent for all particles and 99.56 percent removal for particles 10 microns and less.

The average mass concentration at the inlet location was 113.08 grains per dry standard cubic foot and 0.0204 grains per dry standard cubic foot at the outlet. The gas stream is diluted in the baghouse by a bag heating system which heats ambient air, taken from inside the plant, and blows the heated air around the bags. This is done to prevent condensation of moisture in the bags. This heated plant air is not filtered. The heated air input volume is about 7378 dscfm. This value is estimated using the inlet location flue gas flow rate which averaged 7979 dscfm and the outlet location flow rate which averaged 15357 dscfm.

Visible emissions data taken at the baghouse exhaust stack during the tests averaged 2.2 percent opacity for the three tests. Visible emissions were also taken at the feed discharge point where no visible emissions were observed.

The results of ASTM D422 analysis of bentonite process samples by Law Engineering Testing Company are summarized. Feed (before the dryer) and product (after the dryer) samples showed the feed to average 0.0209 mm in size and 20.1 percent moisture, while the product averages 0.0207 mm in size and 9.2 percent moisture. The specific gravity of both feed and product was 2.75.

The firebox temperature and stack temperatures were monitored throughout the testing as was the feed system. The process operated at a constant rate and was in its normal operation mode throughout the emission tests.

2. SUMMARY AND DISCUSSION OF RESULTS

2.1 SUMMARY OF RESULTS

The data reported for each of the three test runs include: raw material feed rates, mass concentrations, mass emission rates, mass removal efficiency, and visible emissions. Table 2-1 presents a summary of results for each test run and average values for the entire test series. The Andersen impactor values were obtained through use of the PADRE program to determine the particle size distribution for each impactor run. The Method 5 tests were used to determine mass emission rates and concentrations. The PADRE value of percentage by weight for particles less than 10 microns when multiplied by the Method 5 mass emission rate yields the mass emission rate by weight of particles less than 10 microns in size. A summary of visible emissions during each test period is reported in Table 2-2 for each of the two sampling locations.

In Table 2-3, SASS and Andersen emission rates are compared to the emission rates as determined by Method 5 testing. The SASS and Andersen values are reported in pounds per hour and also as a percentage of the Method 5 mass rate value. The percent isokinetic rate is also reported for each test.

Andersen impactor data and the values as calculated by the PADRE program are shown in Tables 2-4 and 2-5. Andersen size distributions are calculated by PADRE based on Mercer's definition of aerodynamic impaction. Data relating SASS test data to Andersen impactor test data are found in Table 2-6. Table 2-6 relates the four size categories, as calculated by weight, for each of the SASS tests to the values as calculated by PADRE for the comparable Andersen runs.

A detailed summary of the test parameters for each of the three tests is given in Tables 2-7 through 2-9. Parameters for test #1 are found in Table 2-7; parameters for test #2 in Table 2-8, and for test #3, parameters are found in Table 2-9.

Table 2-1. SUMMARY OF TEST RESULTS

	Test #1	Test #2	Test #3	Average for test series
Date	9-20-83	9-21-83	9-22-83	
Time	1250-1710	1545-1915	1030-1345	
Feed Rate				
Wet feed rate (tons/hr)	29.3	29.6	30.1	29.7
Mass Concentrations				
Inlet (gr/dscf)	110.849	117.316	111.079	113.081
Inlet (mg/dscm)	253,666	268,466	254,192	258,775
Outlet (gr/dscf)	0.0134	0.0198	0.0280	0.0204
Outlet (mg/dscm)	30.75	45.25	64.18	46.73
Mass Emission Rate				
Inlet mass (lb/hr)	8192	7821	7183	7732
Inlet mass less than 10 microns (lb/hr)	471[b]	414[b]	497[b]	461[b]
Outlet mass (lb/hr)	1.74	2.68	3.65	2.69
Outlet mass less than 10 microns (lb/hr)	1.28[b]	2.05[b]	2.66[b]	2.00[b]
Cyclone Baghouse Mass Removal Efficiency				
Total mass (%)	99.98[b]	99.96[b]	99.95[b]	99.96[b]
10 microns and less (%)	99.73[b]	99.50[b]	99.46[b]	99.56[b]
Visible Emissions				
Opacity exhaust stack (%)	1.09[a]	3.09	2.54	2.24
Opacity feed belt discharge (%)	0	0	0	0
Visible emissions from feed belt discharge	None observed	None observed	None observed	None observed

[a]There were periods of time during the overall test when readings were not taken.

[b]Based on PADRE values.

Table 2-2. SUMMARY OF VISIBLE EMISSIONS

Location	Time	Opacity (%)
Test #1 (9-20-83)		
Baghouse Exhaust Stack	1300-1353	1.40
	1527-1556	0.54
	1600-1629	1.10
Average[a] Test #1		1.09
Feed Belt Discharge	1250-1410	0.00
	1425-1455	0.00
	1520-1600	0.00
	1600-1620	0.00
Test #2 (9-21-83)		
Baghouse Exhaust Stack	1545-1915	3.09
Feed Belt Discharge	1545-1630	0.00
	1640-1725	0.00
	1735-1825	0.00
	1835-1915	0.00
Test #3 (9-22-83)		
Baghouse Exhaust Stack	1030-1355	2.54
Feed Belt Discharge	1030-1115	0.00
	1125-1210	0.00
	1220-1305	0.00
	1320-1345	0.00

[a]Time weighted.

Table 2-3. SUMMARY COMPARISON OF METHOD 5, ANDERSEN, AND SASS TEST RESULTS

	Mass emissions total catch (lb/hr)	Mass emissions 10 microns and less (lb/hr)	Mass emissions greater than 10 microns (lb/hr)	Total mass measured compared to Method 5 (%)	Percentage of mass: 10 microns and less (%)	Percentage of mass: Greater than 10 microns (%)	Percent isokinetic
Inlet Test #1							
Method 5 test	8192[c]	471[a]	7662[a]	100	5.75[a]	94.25[a]	103.6[c]
SASS test	4604[c]	645[d]	3959[d]	56.2	14.01[d]	85.99[d]	120.4[c]
Andersen average of 4 runs	10,261[c]	505.8[a,c]	9755[a,c]	125.2	5.75[b]	94.25[b]	118.4[b]
Outlet Test #1							
Method 5 test	1.74[c]	1.28[a]	0.46[a]	100	73.62[a]	26.38[a]	102.6[c]
Andersen test	1.56[a]	1.15[a,c]	0.41[a,c]	89.6	73.62[b]	26.38[b]	97.4[b]
Inlet Test #2							
Method 5 test	7821[c]	413.7[a]	7407[a]	100	5.29[a]	94.71[a]	101.7[c]
SASS test	7531[c]	909.3[d]	6622[d]	96.3	12.0[d]	87.93[d]	73.4[c]
Andersen average of 4 runs	6475[c]	345.3[a,c]	6130[a,c]	82.8	5.29[b]	94.71[b]	120.6[b]
Outlet Test #2							
Method 5 test	2.68[c]	2.05[a]	0.63[a]	100	76.52[a]	23.48[a]	104.5[a]
Andersen test	1.74[c]	1.33[a,c]	0.41[a,c]	64.9	76.52[b]	23.48[b]	95.3[b]
Inlet Test #3							
Method 5 test	7183[a]	497.1[a]	6685[a]	100	6.92[a]	93.08[a]	103.4[c]
SASS test	7366[c]	843.6[d]	6522[d]	102.5	11.45[d]	88.55[d]	78.7[c]
Andersen average of 4 runs	5143[c]	350.1[a,c]	4793[a,c]	71.6	6.92[b]	93.08[b]	122.8[b]
Outlet Test #3							
Method 5 test	3.65[c]	2.66[a]	.99[a]	100	72.76[a]	27.24[a]	104.6[c]
Andersen test	2.07[c]	1.51[a,c]	.56[a,c]	56.7	72.76[b]	27.24[b]	101.0[b]

[a]Based on Andersen/PADRE results.

[b]Based on PADRE results.

[c]Calculated as a Method 5.

[d]Based on weight of the SASS size fractions calculated as a Method 5.

Table 2-4. SUMMARY OF CUMULATIVE MASS LESS THAN THE STATED SIZE AT THE INLET AND OUTLET LOCATIONS WITH COLLECTION EFFICIENCIES[a]

Andersen standard diameters (microns)	Average of the test series: Average of 3 outlets (D <50) (%)	Average of the test series: Average of 12 inlets (D <50) (%)	Average of the test series: Removal[a] efficiency (%)	Average test #1: Outlet (D <50) (%)	Average test #1: Average of 4 inlets (D <50) (%)	Average test #1: Removal[a] efficiency (%)	Average test #2: Outlet (D <50) (%)	Average test #2: Average of 4 inlets (D <50) (%)	Average test #2: Removal[a] efficiency (%)	Average test #3: Outlet (D <50) (%)	Average test #3: Average of 4 inlets (D <50) (%)	Average test #3: Removal[a] efficiency (%)
.63	1.21		99.906	2.25	0.16	99.899	0.56	0.20	99.925	0.81		99.904
1.00	2.15	0.22	99.897	3.40	0.24	99.901	1.47	0.28	99.874	1.58	0.15	99.907
1.25	2.99	0.31	99.834	3.98	0.31	99.935	2.49	0.35	99.671	2.49	0.27	99.789
2.50	12.46	0.95	99.835	10.94	0.90	99.918	14.92	0.94	99.767	11.51	0.99	99.774
3.00		1.24			1.14			1.26			1.31	
6.00	43.69	2.58	99.815	42.06	2.16	99.887	47.11	2.59	99.743	41.90	2.99	99.753
10.00	74.30	5.99	99.929	73.62	5.75	99.958	76.52	5.29	99.898	72.76	6.92	99.902
15.00	91.98	11.24	99.989	92.27	11.00	99.993	93.53	9.76	99.986	90.15	12.96	99.981
20.00	97.67	22.17	99.997	98.06	21.97	99.999	98.52	20.45	99.997	96.42	24.07	99.994

[a]Calculated by the PADRE program and based on Mercer's definition of aerodynamic impaction.

Table 2-5. ANDERSEN WEIGHTS PER STAGE AND CUMULATIVE PERCENT MASS LESS THAN D50 AT STANDARD DIAMETERS

	Weights per stage														
Test #	Outlet 1	Inlet 1-A	Inlet 1-B	Inlet 1-C	Inlet 1-D	Outlet 2	Inlet 2-A	Inlet 2-B	Inlet 2-C	Inlet 2-D	Outlet 3	Inlet 3-A	Inlet 3-B	Inlet 3-C	Inlet 3-D
PADRE #	3	4	5	6	7	2	8	9	10	11	1	12	13	14	15
Weight gains (mg)															
Pre-cutter	9.51	130.62	557.90	208.37	279.12	14.51	200.96	327.66	289.28	332.64	25.55	198.77	232.57	244.72	263.76
Stage 1	4.25	7.42	13.21	7.91	8.95	6.03	10.19	4.82	5.64	6.58	6.06	17.49	0.93	10.64	4.95
Stage 2	3.46	2.49	3.63	0.55	1.95	5.69	2.06	2.51	2.36	1.87	7.80	4.15	0.79	8.52	2.22
Stage 3	8.93	3.37	3.28	1.88	4.14	13.52	3.28	2.51	3.09	5.40	15.89	5.25	1.06	4.55	4.02
Stage 4	6.30	2.21	2.35	1.52	2.16	9.43	2.46	1.81	2.63	3.30	11.55	3.55	0.97	4.12	3.18
Stage 5	4.72	.99	2.66	1.78	3.39	11.29	3.73	1.73	2.06	4.92	10.63	2.83	1.93	3.65	3.38
Stage 6	2.05	1.53	1.51	0.96	1.48	5.56	1.87	1.20	1.02	2.03	5.40	2.15	1.39	1.75	1.53
Stage 7	0.48	0.40	.21	0.01	0.30	0.66	0.67	0.00	0.19	0.43	0.70	0.77	0.21	0.42	0.42
Stage 8	0.50	0.41	.22	0.03	0.12	0.09	0.20	0.30	0.00	0.07	0.00	0.23	0.00	0.07	0.01
Filter	0.49	0.41	.15	0.16	0.32	0.30	0.35	0.37	0.22	1.26	0.68	0.24	0.00	0.00	0.03

	Cumulative percent mass less than D50 at standard diameters[a]														
Test #	Outlet 1	Inlet 1-A	Inlet 1-B	Inlet 1-C	Inlet 1-D	Outlet 2	Inlet 2-A	Inlet 2-B	Inlet 2-C	Inlet 2-D	Outlet 3	Inlet 3-A	Inlet 3-B	Inlet 3-C	Inlet 3-D
PADRE #	3	4	5	6	7	2	8	9	10	11	1	12	13	14	15
Standard diameters (microns)															
.63	2.25					0.56					0.81				
1.00	3.40	.64	0.07	0.09	0.18	1.47	0.40	0.20	0.09	0.42	1.58	0.39	0.03	0.08	0.09
1.25	3.98	.81	0.10	0.10	0.25	2.49	0.56	0.21	0.13	0.49	2.49	0.59	0.12	0.18	0.17
2.50	10.94	1.83	0.37	0.58	0.82	14.92	1.53	0.58	0.47	1.18	11.51	1.53	0.78	0.85	0.82
3.00	N/A	2.04	0.50	0.81	1.19	N/A	2.07	0.71	0.62	1.62	N/A	1.84	1.05	1.17	1.17
6.00	42.06	3.36	1.05	1.85	2.39	47.11	3.92	1.48	1.74	3.21	41.90	4.00	1.85	3.18	2.93
10.00	73.62	8.44	3.44	5.21	5.93	76.52	7.42	3.50	4.24	6.00	72.76	11.46	2.70	7.74	5.79
15.00	92.27	16.12	7.13	10.10	10.67	93.53	14.20	6.97	7.59	10.28	90.15	20.63	5.94	15.05	10.23
20.00	98.06	27.03	17.87	21.35	21.64	98.52	25.02	17.73	17.87	21.19	96.42	32.15	17.07	25.77	21.29

[a] From PADRE program and based on Mercer's definition of aerodynamic impaction.

Table 2-6. SASS COMPARED TO ANDERSEN FOR CUMULATIVE MASS AS PERCENT LESS THAN STATED SIZE[a]

SASS as compared to Andersen/PADRE by percent weight less than standard size	Average for test series			Average for test #1			Average for test #2			Average for test #3		
	SASS inlet (%)	Andersen inlet (%)	SASS/Andersen (%)	SASS inlet (%)	Andersen inlet (%)	SASS/Andersen (%)	SASS inlet (%)	Andersen inlet (%)	SASS/Andersen (%)	SASS inlet (%)	Andersen inlet (%)	SASS/Andersen (%)
1.0 micron	0.20	0.22	90.9	0.18	0.24	75.0	0.22	0.28	78.6	0.21	0.15	140.0
3.0 micron	2.49	1.25	199.2	2.15	1.19	180.7	2.35	1.26	186.5	2.96	1.31	225.9
10.0 micron	12.51	5.99	208.8	14.01	5.75	243.6	12.07	5.29	228.2	11.45	6.92	165.5
Greater than 10 microns	87.49	94.01	93.1	85.99	94.25	91.2	87.93	94.71	92.8	88.55	93.08	95.1

[a]Andersen values based on Mercer's definition of aerodynamic impaction.

Table 2-7. SUMMARY OF TEST PARAMETERS FOR TEST #1: 9/20/83

Sample Train Run #	Method 5 #1 Inlet	SASS[d] #1 Inlet	Andersen[e] 1-A	Andersen[e] 1-B	Andersen[e] 1-C	Andersen[e] 1-D	Andersen Inlet average[b]	Method 5 #1 Outlet	Andersen[f] #1 Outlet
Sample location	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Outlet	Outlet
Start time (MST)	1330-1702	1830-1855	1250	1400	1500	1637	NA	1252-1633	1842-2044
Sampling point	Trav.	Trav.	B-2	B-5	A-2	A-5	NA	Trav.	Trav.
Sampling time (min)	60	20	0.083	0.083	0.083	0.083	NA	108	120
Meter volume (DSCF)	28.974	73.246	0.030	0.033	0.024	0.036	NA	69.415	55.290
Nozzle flow (ACFM)	----	6.15	0.482	0.506	0.535	0.526	NA	----	0.703
SASS cyclone flow (ACFM)	----	8.56	----	----	----	----	----	----	----
Stack flow (ACFM)	15701	15912	12841	14354	14385	13890	13868	23395	24746
Stack flow (DSCFM)	8620	9001	7074	7917	7907	7585	7621	15094	15984
Stack temperature (F)	176	158	177	177	180	177	NA	148	148
% isokinetic	103.6	120.4	120.2	112.8	119.2	121.4	NA	102.6	97.4
% opacity	1.09	NA	1.5	1.0	NA	1.9	----	1.09	NA
% moisture[i]	22.5	22.5	22.5	22.5	22.5	22.5	22.5	13.2	13.2
% CO_2[g]	3.39	3.39	3.39	3.39	3.39	3.39	3.39	1.68	1.68
% O_2[g]	18.3	18.3	18.3	18.3	18.3	18.3	18.3	19.8	19.8
% N_2[g]	78.31	78.31	78.31	78.31	78.31	78.31	78.31	78.52	78.52
Concentration (gr/DSCF)	110.849	59.647	77.29	271.60	142.09	127.40	----	0.0134	0.0114
Total particulate emissions (lb/hr)	8192	4604	4688	18438	9633	8286	10261	1.74	1.56

(continued)

Table 2-7. Concluded

Sample Train	Method 5	SASS[d]	Andersen[e]	Andersen[e]	Andersen[e]	Andersen[e]	Andersen	Method 5	Andersen[f]
Run #	#1 Inlet	#1 Inlet	1-A	1-B	1-C	1-D	Inlet average[b]	#1 Outlet	#1 Outlet
Emissions above 10 microns (lb/hr)	7662[a]	3959	4292	17804	9131	7795	9755	0.46[c]	0.41
% above 10 microns	94.25[a]	85.99	91.56	96.56	94.79	94.07	94.24	26.38[c]	26.38
Emissions below 10 microns (lb/hr)	471.0[a]	645	395.7	634.3	501.9	491.4	505.8	1.28[c]	1.15
% less than 10 microns	5.75[a]	14.01	8.44	3.44	5.21	5.93	5.75	73.62[c]	73.62
Emissions below 3 microns (lb/hr)	93.38[a]	99.03	95.64	92.19	78.03	98.60	91.11	----	----
% less than 3 microns	1.14[a]	2.15	2.04	0.50	0.81	1.19	1.14	----	----
Emissions below 1 micron (lb/hr)	19.66[a]	8.20	30.00	12.91	8.67	14.91	16.62	0.06[c]	0.04
% less than 1 micron	.24[a]	0.18	0.64	0.07	0.09	0.18	0.24	3.40[c]	3.40

[a]Based on PADRE/ANDERSEN values for the four Andersen inlet samples.

[b]Average for the four Andersen inlet samples.

[c]Based on PADRE/ANDERSEN value for the Andersen outlet sample.

[d]The SASS Train was run after the Method 5 run using the Method 5 pitote readings, moisture and gas composition. The SASS Train sample was taken for five minutes at each of the four points from which the Andersen samples were taken.

[e]The mass emission rate is calculated as a Method 5 test while the flow through the impactor is based on the meter box orifice value.

[f]The mass emission rate is calculated as a Method 5 test as are the other values which were imputed to the PADRE program.

[g]Bag sample was taken during the Method 5 test.

[h]Suspiciously large precutter catch.

[i]Moisture from Method 5 test.

Table 2-8. SUMMARY OF TEST PARAMETERS FOR TEST #2: 9/21/83

Sample Train	Method 5	SASS[d]	Andersen[e]	Andersen[e]	Andersen[e]	Andersen[e]	Andersen	Method 5	Andersen[f]
Run #	#2 Inlet	#2 Inlet	2-A	2-B	2-C	2-D	Inlet Average[b]	#2 Outlet	#2 Outlet
Sample location	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Outlet	Outlet
Start time (MST)	1558-1910	2100-2129	1545	1625	1706	1845	NA	1545-1915	1545-1915
Sampling point	Trav.	Trav.	A-2	A-5	B-2	B-5	NA	Trav.	Trav.
Sampling time (min)	60	20	0.167	0.167	0.167	0.167	NA	180	180
Meter volume (DSCF)	25.653	57.298	0.032	0.051	0.046	0.063	NA	123.784	83.004
Nozzle flow (ACFM)	----	4.96	0.526	0.520	0.485	0.533	NA	----	0.717
SASS cyclone flow (ACFM)	----	6.70	----	----	----	----	----	----	----
Stack flow (ACFM)	14287	15131	14235	13765	12845	13939	13696	24860	25690
Stack flow (DSCFM)	7775	8265	7880	7604	6987	7514	7496	15794	16279
Stack temperature (F)	171	172	160	161	171	177	NA	153	156
% isokinetic	101.7	73.4	118.3	121.0	120.7	122.4	NA	104.5	95.3
% opacity	3.09	NA	5.0	2.7	5.0	1.0	NA	3.09	3.09
% moisture[f]	23.9	23.9	23.9	23.9	23.9	23.9	23.9	13.8	13.8
% CO[g]	2.76	2.76	2.76	2.76	2.76	2.76	2.76	1.33	1.33
% O_2[g]	18.33	18.33	18.33	18.33	18.33	18.33	18.33	19.85	19.85
% N_2[g]	78.91	78.91	78.91	78.91	78.91	78.91	78.91	78.82	78.82
Concentration (gr/DSCF)	117.316	106.279	108.47	103.01	103.30	87.98	----	0.0198	0.0124
Total particulate emissions (lb/hr)	7821	7531	7329	6716	6188	5668	6475	2.68	1.74

(continued)

Table 2-8. Concluded

Sample Train Run #	Method 5 #2 Inlet	SASS[d] #2 Inlet	Andersen[e] 2-A	Andersen[e] 2-B	Andersen[e] 2-C	Andersen[e] 2-D	Andersen Inlet Average[b]	Method 5 #2 Outlet	Andersen[f] #2 Outlet
Emissions above 10 microns (lb/hr)	7407[a]	6622	6785	6481	5925	5328	6130	0.63[c]	0.41
% greater than 10 microns	94.71[a]	87.93	92.58	96.50	95.76	94.0	94.71	23.48[c]	23.48
Emissions below 10 microns (lb/hr)	413.73[a]	909.30	543.81	235.06	262.37	340.08	345.3	2.05[c]	1.33
% less than 10 microns	5.29[a]	12.07	7.42	3.50	4.24	6.00	5.29	76.52[c]	76.52
Emissions below 3 microns (lb/hr)	98.54[a]	177.12	151.71	47.68	38.36	91.82	82.42	NA	NA
% less than 3 microns	1.26[a]	2.35	2.07	0.71	0.62	1.62	1.26	NA	NA
Emissions below 1 microns (lb/hr)	21.90[a]	17.29	29.32	13.43	5.57	23.80	18.03	0.04[c]	0.03
% less than 1 micron	0.28[a]	0.22	0.40	0.20	0.09	0.42	0.28	1.47[c]	1.47

[a] Based on PADRE/ANDERSEN values for the four Andersen inlet samples.

[b] Average for the four Andersen inlet samples.

[c] Based on PADRE/ANDERSEN value for the Andersen outlet sample.

[d] The SASS Train was run after the Method 5 run using the Method 5 pitote readings, mositure and gas composition. The SASS Train sample was taken for five minutes at each of the four points from which the Andersen samples were taken.

[e] The mass emission rate is calculated as a Method 5 test while the flow through the impactor is based on the meter box orifice value.

[f] The mass emission rate is calculated as a Method 5 test as are the other values which were imputed to the PADRE program.

[g] Bag sample was taken during the Method 5 test.

[h] Suspiciously large pre-cutter catch.

[i] Moisture from Method 5 test.

Table 2-9. SUMMARY OF TEST PARAMETERS FOR TEST #3: 9/22/83

Sample Train Run #	Method 5 #3 Inlet	SASS[d] #3 Inlet	Andersen[e] 3-A	Andersen[e] 3-B	Andersen[e] 3-C	Andersen[e] 3-D	Andersen Inlet Average[b]	Method 5 #3 Outlet	Andersen[f] #3 Outlet
Sample location	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Inlet	Outlet	Outlet
Start time (MST)	1037-1343	1704-1730	1030	1058	1200	1314	NA	1030-1355	1031-1345
Sampling point	Trav.	Trav.	A-2	A-5	B-2	B-5	NA	Trav.	Trav.
Sampling time (min)	60	20	0.167	0.167	0.167	0.167	NA	180	180
Meter volume (DSCF)	25.296	56.664	0.056	0.056	0.051	0.040	NA	118.694	84.707
Nozzle flow (ACFM)	----	5.08	0.538	0.536	0.500	0.542	NA	----	0.736
SASS cyclone flow (ACFM)	----	6.87	----	----	----	----	----	----	----
Stack flow (ACFM)	14397	14769	14310	13894	12983	13980	13792	24254	25063
Stack flow (DSCFM)	7542	7618	7647	7322	6700	7255	7231	15184	15732
Stack temperature (F)	168	176	161	166	177	173	NA	154	156
% isokinetic	103.4	78.7	120.5	123.5	123.4	124.0	NA	104.6	101.0
% opacity	2.54	NA	3.1	3.1	5.2	0.0	NA	2.54	2.54
% moisture[i]	27.1	27.1	27.1	27.1	27.1	27.1	27.1	14.9	14.9
% CO^g	3.12	3.12	3.12	3.12	3.12	3.12	3.12	1.50	1.50
% $O_2{}^g$	17.99	17.99	17.99	17.99	17.99	17.99	17.99	20.07	20.07
% $N_2{}^g$	78.89	78.89	78.89	78.89	78.89	78.89	78.89	78.43	78.43
Concentration (gr/DSCF)	111.079	112.767	65.45	66.15	83.94	117.46	----	0.0280	0.0153
Total particulate emissions (lb/hr)	7183	7366	4292	4153	4822	7306	5143	3.65	2.07

(continued)

Table 2-9. Concluded

Sample Train Run #	Method 5 #3 Inlet	SASS[d] #3 Inlet	Andersen[e] 3-A	Andersen[e] 3-B	Andersen[e] 3-C	Andersen[e] 3-D	Andersen Inlet Average[b]	Method 5 #3 Outlet	Andersen[f] #3 Outlet
Emissions above 10 microns (lb/hr)	6685[a]	6522	3800	4041	4449	6883	4793	0.99[c]	0.56
% greater than 10 microns	93.08[a]	88.55	88.54	97.30	92.26	94.21	93.08	27.24[c]	27.24
Emissions below 10 microns (lb/hr)	497.06[a]	843.64	491.86	112.13	373.22	423.02	350.06	2.66[c]	1.51
% less than 10 microns	6.92[a]	11.45	11.46	2.70	7.74	5.79	6.92	72.76[c]	72.76
Emissions below 3 microns (lb/hr)	94.10[a]	217.89	78.97	43.61	56.42	85.48	66.12	NA	NA
% less than 3 microns	1.31[a]	2.96	1.84	1.05	1.17	1.17	1.31	NA	NA
Emissions below 1 microns (lb/hr)	10.77[a]	15.82	16.74	1.24	3.86	6.58	7.10	0.06[c]	0.03
% less than 1 micron	0.15[a]	0.21	0.39	0.03	0.08	0.09	0.15	1.58[c]	1.58

[a]Based on PADRE/ANDERSEN values for the four Andersen inlet samples.

[b]Average for the four Andersen inlet samples.

[c]Based on PADRE/ANDERSEN value for the Andersen outlet sample.

[d]The SASS Train was run after the Method 5 run using the Method 5 pitote readings, moisture and gas composition. The SASS Train sample was taken for five minutes at each of the four points from which the Andersen samples were taken.

[e]The mass emission rate is calculated as a Method 5 test while the flow through the impactor is based on the meter box orifice value.

[f]The mass emission rate is calculated as a Method 5 test as are the other values which were imputed to the PADRE program.

[g]Bag sample was taken during the Method 5 test.

[h]Suspiciously large precutter catch.

[i]Moisture taken from the Method 5 test.

2.2 DISCUSSION OF RESULTS

The data presented in Table 2-1 indicate that the mass rates and concentrations were relatively consistent at the inlet location with the concentration averaging 113.081 gr/dscf with a range of 110.849 gr/dscf to 117.316 gr/dscf. The inlet mass rate averaged 7732 lbs/hr with a range of 7183 lbs/hr to 8192 lbs/hr. The inlet mass rate for particulate matter less than 10 microns in size averaged 461 lbs/hr with a range of 414 lbs/hr to 497 lbs/hr.

The outlet location was more variable with a concentration averaging 0.0204 gr/dscf with a range of 0.0134 gr/dscf to 0.0280 gr/dscf. The mass emission rate averaged 2.69 lbs/hr with a range of 1.74 lbs/hr to 3.65 lbs/hr. The mass emission rate for particulate matter less than 10 microns in size averaged 2.00 lbs/hr with a range of 1.28 lbs/hr to 2.66 lbs/hr. The variability of the particulate matter at the outlet may have been caused by differences in the baghouse operation or differences in the unfiltered room air used to heat the bags. The (cyclone/baghouse) mass removal efficiencies were relatively consistent for each run, yielding averages of 99.96% total mass removal and 99.56% at 10 micron and less.

Tables 2-7, 2-8, and 2-9 show the flue gas flow rates to be fairly consistent between the tests for each location based on the Method 5 pitot tube traverses. The inlet location averaged 14795 acfm with a range of 14287 acfm to 15701 acfm, or in alternate units, an average of 7979 dscfm with a range of 7542 dscfm to 8620 dscfm. The outlet location averaged 24170 acfm with a range of 23395 acfm to 24860 acfm, or on a dry basis, an average of 15998 dscfm with a range of 15732 dscfm to 16279 dscfm.

The exhaust stack opacity during test #1 was considerably lower than during tests #2 and #3. During the first test, the visible emissions observer was required to assist elsewhere for a period of time. It is not expected that these periods affected the overall visible emissions results. The average for the three runs were 2.24 percent. No visible emissions were observed being emitted from the feed belt discharge.

Table 2-3 shows inlet Andersen values for the inlet tests, which because of the heavy grain loading, were run for only 5 or 10 seconds. The brief sampling period was a result of the low sample loading design of this impactor. A maximum of 10 milligrams per any one stage is best for valid sizing results. It is difficult to evaluate the representability of results covering such a short period, but results indicate that the values, when averaged, are reasonably consistent for the four runs which are consolidated as one test.

The particulate mass rate determinations at the inlet location for the SASS and the Method 5 test runs 2 and 3 are fairly comparable. At less than 1 micron and greater than 10 microns, the SASS and Andersen values are also reasonably comparable. It is possible that the Andersen data are biased towards indicating more particles in the larger size ranges because of the low impactor start-up flow rates and such a short run period. Mass emissions for SASS during test #1 were low (although the cut off points were satisfactory). The reason for this is not fully understood, but appears to be a function of the operation of the SASS train.

The isokinetic ranges reported in Table 2-3 reveal Andersen runs to range between 95.3 to 122.8 percent and the range for Method 5 tests to be between 101.7 and 104.6 percent of isokinetic. These isokinetic sampling rates are within the allowed limits, meaning that there are no major experimental measurement errors attributable to non-representative sampling in this respect.

2.3 PARTICULATE DATA REDUCTION SYSTEM (PADRE)

The PADRE program, which was used to calculate the Andersen impactor results, is described in "Particulate Data Reduction System (PADRE) Terminal Users Guide" by W. M. Yeager and C. E. Tatsch of the Research Triangle Institute for the Industrial Environmental Protection Agency (EPA). The abstract and introduction of this manual are duplicated below.

2.3.1 Abstract

The Particulate Data Reduction (PADRE) system is an interactive computer program which facilitates the entry, reduction, and analysis of cascade impactor data for particle size distributions. PADRE was developed to assure the quality of data included in the Fine Particle Emissions Information System (FPEIS), which is a component of the Environmental Assessment Data System (EADS). PADRE users control the logical flow through the system in response to prompts from the program. Data may be entered, stored, reviewed, edited, and analyzed. A variety of data checks is employed by PADRE to warn users about invalid or suspect data. Cut points of the impactor stages are calculated. Cumulative and differential mass concentrations are determined and interpolated to standard diameters. This document describes how to access and use PADRE. It includes a summary of the logic and capabilities of the system. It is intended as a reference for users who are at a computer terminal.

2.3.2 Introduction

The purpose of the Particulate Data Reduction (PADRE) system is to facilitate entry of qualified, field-observable cascade impactor data for particle-size distributions into the Fine Particle Emissions Information System (FPEIS). This data base is a major component of the Environmental Assessment Data Systems (EADS) and is described in the FPEIS User Guide. Reduction of the data to determine the cut diameters for each impactor stage, as well as the mass and number distributions at standard diameters, may be performed to facilitate rapid evaluation of these data. This reduction is based on the Cascade Impactor Data Reduction System (CIDRS) computer programs developed by Southern Research Institute under contract to EPA.

The data organization and terminology are consistent with EADS/FPEIS, insofar as possible. Thus, several impactor runs (samples) are logically connected to one test, with specification of the stream and operating levels embedded within the run data records. In particular, all runs for a given test share a common site and particle density and begin on or after the date of the test of which they are a part. PADRE uses the site and date to access all stored data as a means of minimizing user effort while providing multikey security for users' data. Three types of data may be entered by PADRE users:

- Weight data: Substrates description; number of weights, pre-weights, and post-weights.
- Test data: Site, starting date, particle density, and test comments.
- Run data: Comments, impactor identification and operating parameter, and pointer to the corresponding weight data.

In order to facilitate data entry and correction, data are entered and stored in the units in which they are commonly observed.

3. PROCESS DESCRIPTION AND CONDITION DURING TESTING

3.1 PROCESS DESCRIPTION

The process unit tested is a rotary dryer processing 24 Mg (27 tons) of high-swelling Wyoming bentonite clay per hour. This plant operates continuously, except for breakdowns, 24 hours per day and 6 or 7 days per week. Figures 3-1 and 3-2 present a simplified process schematic. Bentonite is received by trucks and stockpiled in the open. From the stockpile, the bentonite is loaded into a hopper from which it is conveyed to a slicer. The slicer produces fines to 2.5-cm (1-in.) chunks of bentonite which are fed to a direct-fired rotary dryer. The dried bentonite is elevated to a Raymond mill, pulverized, and air-classified before being conveyed to finished product bins. Product is shipped out in bulk by either rail or truck or is bagged (50- to 100-lb bags) for shipment.

The rotary dryer was manufactured by Stearn-Rogers. It is 20 m (65 ft) long and is 2.4 m (8 ft) in diameter. Bentonite is fed to the dryer by a conveyor belt. The dryer has a heat input rate of about 10 million Btu per hour (2.9×10^8 Joules per second). The dryer can be fired with either coal or natural gas. Usually, the dryer is fired with low sulfur (about 0.6 percent) coal. The exhaust gas temperature prior to the cyclone, as indicated by the control panel monitor, is 66° to 82°C (150° to 180°F). The dryer is insulated to reduce heat loss. The dryer has a retention time of 20 minutes and dries the bentonite from 15 to 18 percent moisture down to 6 to 8 percent. Table 3-1 presents the design and operating parameters for the dryer.

Particulate emissions from the dryer exhaust are controlled by a baghouse. Data for the baghouse are shown in Table 3-2. The baghouse was manufactured by W. W. Sly Manufacturing Company (Model No. JM 2698). It has only one compartment and is equipped with polyester bags which have a total cloth area of 1,277 m^2 (13,750 ft^2). The design air-to-cloth

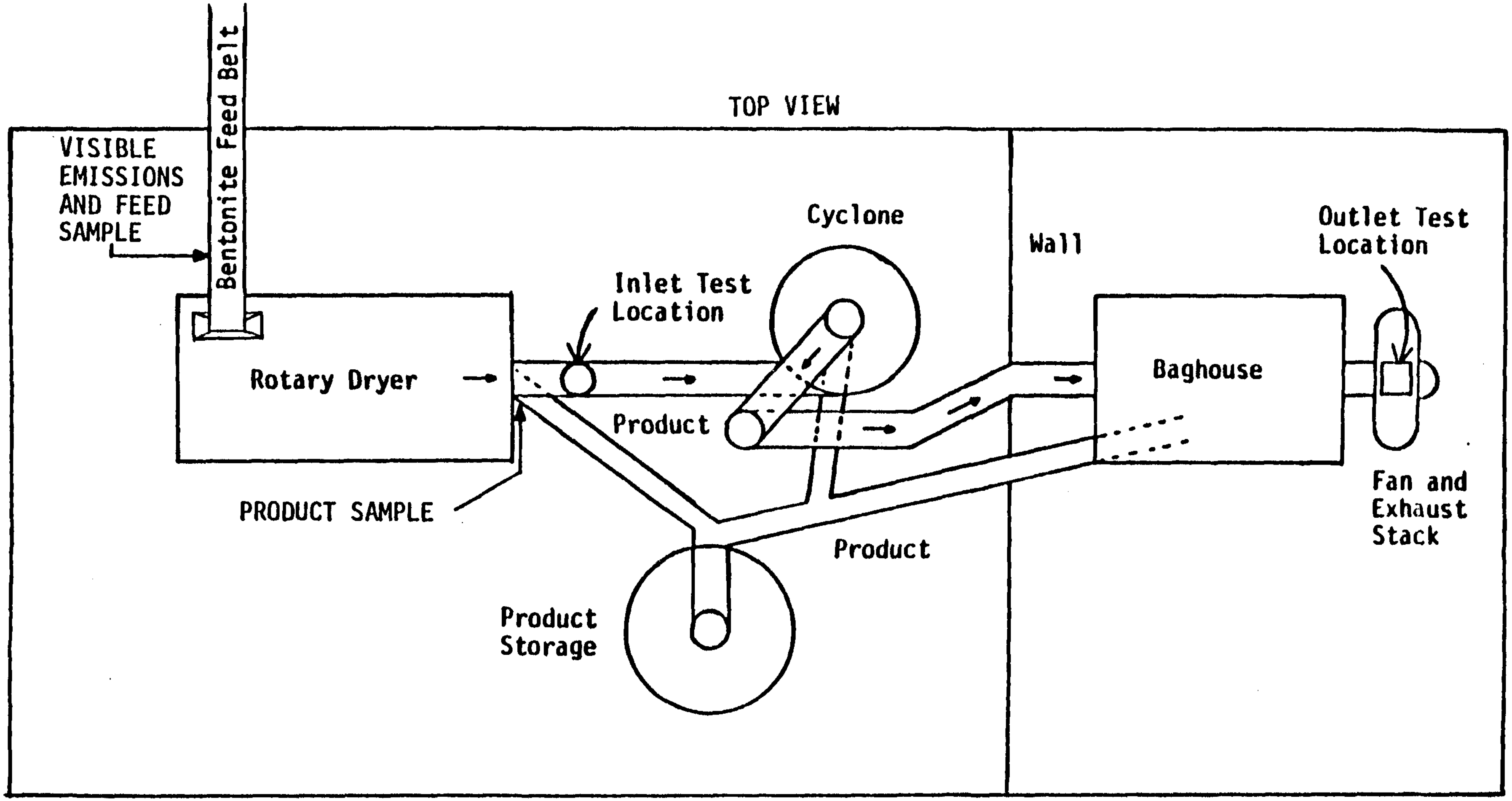

Figure 3-1. Process schematic - Black Hills Benonite Co., Mills, Wyoming.

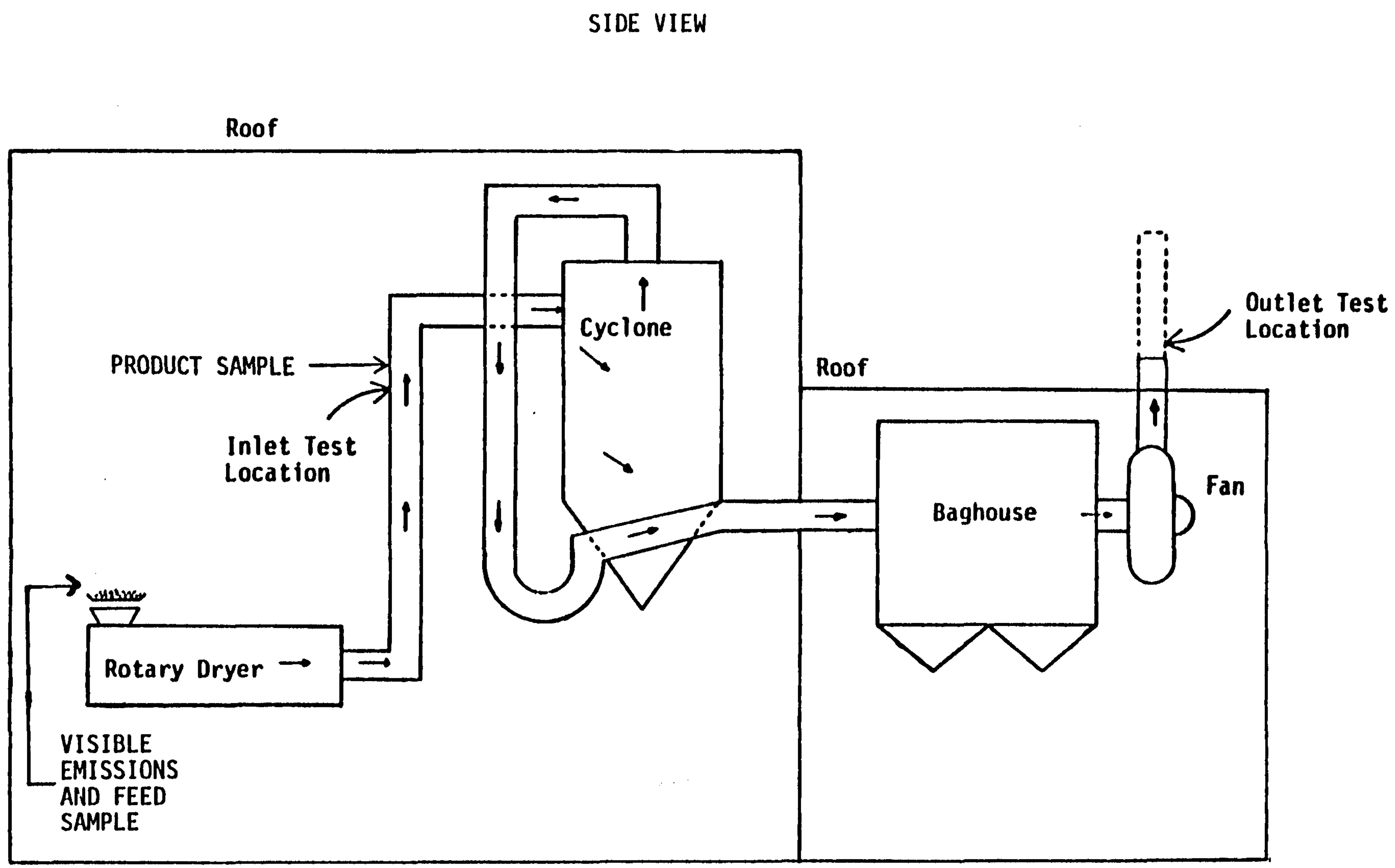

Figure 3-2. Process schematic - Black Hills Bentonite Co., Mills, Wyoming.

Table 3-1. DATA FOR ROTARY DRYER AT BLACK HILLS BENTONITE COMPANY PLANT AT MILLS, WYOMING

	Rotary dryer
Manufacturer	Stearn-Rogers
Date of installation	1964
Design of production rate, tph	31.0
Actual production rate, tph	27.0
Hours of operation	
hours/day	24
days/week	6-7
Retention time, min.	20
Maximum drying temperature (gas), °F	1800
Fuel used	Coal; natural gas (alternate)
Feed moisture content, %	15-18
Feed particle size, in.	≤1.5
Feed density, lb/ft^3	60
Product moisture content, %	6-8
Product density, lb/ft^3	60

Table 3-2. DATA FOR BAGHOUSE CONTROL EQUIPMENT FOR ROTARY DRYER AT BLACK HILLS BENTONITE COMPANY PLANT AT MILLS, WYOMING

Manufacturer	W.W. Sly Mfg. Co.
Model no.	JM 2698
Design gas flow rate, acfm	20,000
Bag material	Polyester
Bag life, months	~12
Total cloth area, ft^2	13,750
Design air/cloth ratio, ft./min.	1.45:1
Cleaning mechanism	Reverse air
Frequency of cleaning, per hour	40
Pressure drop, in. w.c.	Unknown
No. of compartments	1

ratio is 0.0074:1 m/s (1.45:1 ft/min). The temperature of the inlet gas is 66° to 82°C (150° to 180°F). The collected material from the baghouse is returned to the process. The baghouse is equipped with a natural-gas-fired heater to prevent condensation. Plant air is drawn into the heater and is used as reverse cleaning air for the baghouse. The heated air is exhausted through the baghouse stack.

3.2 PROCESS CONDITIONS DURING TESTING

All processes were operated normally during the emission testing. The dryer operation is monitored from a control panel that contains gauges for both the fire box temperature and the stack temperature and a television monitor of the feed conveyor belt. All process units in the plant operate at a constant fixed rate of 24 Mg (27 tons) per hour (dry product rate). The design capacity of the dryer is 27 Mg (30 tons) per hour. Based on the inlet and outlet moisture contents of the clay and the dryer product rate of 24 Mg (27 tons) per hour, the dryer had a wet feed rate of 26.6, 26.8, and 27.3 Mg (29.3, 29.6, and 30.1 tons) per hour during the tests. Because the operational speed of the dryer feed system (slicer and conveyor) is fixed, the feed and production rates are constant. The dryer rotational speed is also fixed; therefore, retention time is constant at approximately 20 minutes. The rheostat for the coal feed system is set manually to keep the dryer fire box temperature between 820° and 980°C (1500° and 1800°F). Once the rheostat is set, the coal feed rate is constant. Tables 3-3, 3-4, and 3-5 present the fire box and stack temperatures monitored during the test and show that the feed system was operating normally throughout testing. No feed or product weight scales for the dryer exist at the facility. However, all process units operate at a constant fixed rate. Therefore, monitoring of fire box and stack temperatures and the operation of the feed system was sufficient to document normal operation.

During the testing, the dryer was fired on coal at an average rate of 18.5 kg/Mg (37 lbs/ton). The coal used during the test, as specified by the supplier, has a heating value of 26.7 Mj/kg (11,600 Btu/lb), a sulfur content of 0.62 percent, and a moisture and ash content of 10.5 and 5.6 percent, respectively.

Some fluctuation in the dryer fire box temperature was observed throughout testing of the dryer. The fluctuations are normal and are

Table 3-3. OPERATING CONDITIONS - RUN NO. 1 - 9/20/83

Time	Firebox temperature (°F)	Stack temperature (°F)	Feed system
12:50	1450	160	Normal
1:00	1500	160	Normal
1:10	1550	170	Normal
1:20	1575	170	Normal
1:30	1600	180	Normal
1:40	1650	175	Normal
1:50	1625	175	Normal
2:00	1625	170	Normal
2:10	1625	170	Normal
2:20	1650	175	Normal
2:30	1675	180	Normal
2:40	1650	175	Normal
2:50	1675	175	Normal
3:00	1700	180	Normal
3:10	1650	175	Normal
3:20	1650	170	Normal
3:30	1625	170	Normal
3:40	1650	185	Normal
3:50	1625	-[a]	Normal
4:00	1650	-[a]	Normal
4:10	1650	185	Normal
4:20	1650	180	Normal
4:30	1650	180	Normal
4:40	1625	-[a]	Normal
4:50	1650	-[a]	Normal
5:00	1650	-[a]	Normal

[a]Stack temperature gauge required reset.

Table 3-4. OPERATING CONDITIONS - RUN NO. 2 - 9/21/83

Time	Firebox temperature (°F)	Stack temperature (°F)	Feed system
3:40	1550	175	Normal
3:50	1450	185	Normal
4:00	1375	175	Normal
4:10	1400	165	Normal
4:20	1475	-[a]	Normal
4:30	1500	160	Normal
4:40	-[b]	-[b]	Normal
4:50	1550	175	Normal
5:00	1575	170	Normal
5:10	1625	175	Normal
5:20	1600	180	Normal
5:30	1600	-[a]	Normal
5:40	1625	-[a]	Normal
5:50	1650	-[a]	Normal
6:00	1625	170	Normal
6:10	1650	165	Normal
6:20	1675	170	Normal
6:30	1650	180	Normal
6:40	1625	180	Normal
6:50	1650	180	Normal
7:00	1675	180	Normal
7:10	1650	180	Normal
7:20	1650	175	Normal

[a]Stack temperature gauge required reset.

[b]No reading taken.

Table 3-5. OPERATING CONDITIONS - RUN NO. 3 - 9/22/83

Time	Firebox temperature (°F)	Stack temperature (°F)	Feed system
10:30	1775	-[a]	Normal
10:40	1700	170	Normal
10:50	1675	170	Normal
11:00	-[b]	-[b]	Normal
11:10	-[b]	-[b]	Normal
11:20	-[b]	-[b]	Normal
11:30	1700	180	Normal
11:40	1700	180	Normal
11:50	1700	180	Normal
12:00	1725	180	Normal
12:10	1750	180	Normal
12:20	1750	180	Normal
12:30	1750	180	Normal
12:40	1725	180	Normal
12:50	1725	180	Normal
1:00	1725	180	Normal
1:10	1725	185	Normal
1:20	1725	180	Normal
1:30	1725	180	Normal
1:40	1725	180	Normal

[a]Stack temperature gauge required reset.

[b]No reading taken.

caused by variations in the coal and feed moisture content and amount of fines in the coal. Manual changes in the coal feed rate were made whenever the fire box temperature dropped below 820°C (1500°F). Because of the heat retained in the fire box brick, the stack gas temperature showed no significant corresponding temperature variation. Throughout the test, the stack gas temperature, as indicated by the control panel gauge, was between 71° and 85°C (160° and 185°F). Because of this limited stack gas temperature variation, stack gas flow rates would be expected to vary by no more than four percent during the test. Any impacts resulting from these variations can be assessed after the test results are analyzed.

The plant processes four grades (based on gelling qualities) of bentonite from 10 different pits. These clays are blended before drying. The blend is almost always constant except when a customer requests a specific high gel product. Any variations in dust loadings or particle size distributions among the four clays are unknown. Plant personnel indicated that there were no noticeable variations in dust levels or controllability of dust among the four grades. The normal blend was processed during the emission tests.

The test crew noted that standard condition gas volumes were higher at the exhaust stack outlet than at the cyclone inlet during the test. This increase in volume is due to the additional air added to the baghouse by the baghouse heating system. Plant personnel were unable to provide the gas flow rate for the heater; however, gas flow rates from the inlet and outlet tests should provide enough data to accurately estimate the incremental volume increase from the heater. It should be noted that this air bypasses the filtering sytem and enters the exhaust stack. As a result, process fugitive dust emissions inside the plant could have some impact on outlet particulate levels. Any impacts are expected to be insignificant except during extremely dusty periods resulting from process upsets in the plant.

4. SAMPLING LOCATIONS

The outlet sampling location is depicted in Figure 4-1. The sample ports were located eleven feet downstream of the blower and four feet below the top of the stack extension. The stack extension was a 29.25 x 32.75 inch rectangle, eight feet long, fitted over the stub stack which only slightly protruded from the roof. Thirty-six points on a six-by-six matrix were sampled for each Method 5 test. The Andersen sample was taken from four (4) points located at eight and twenty-four inches into the second and fifth port.

The inlet location is shown in Figure 4-2. The circular duct had an inside diameter of 34 inches with the ports located 165 inches after a 90 degree bend and 65 inches before a 90 degree bend. The SASS and Andersen samples were taken at the second and fifth point on each traverse. The Method 5 train was traversed over 12 points, six on each traverse, for each test.

The bentonite feed belt discharge point, where visible emissions were taken using Methods 22/9, is shown in Figure 4-3.

BAGHOUSE EXHAUST
LOCATION C

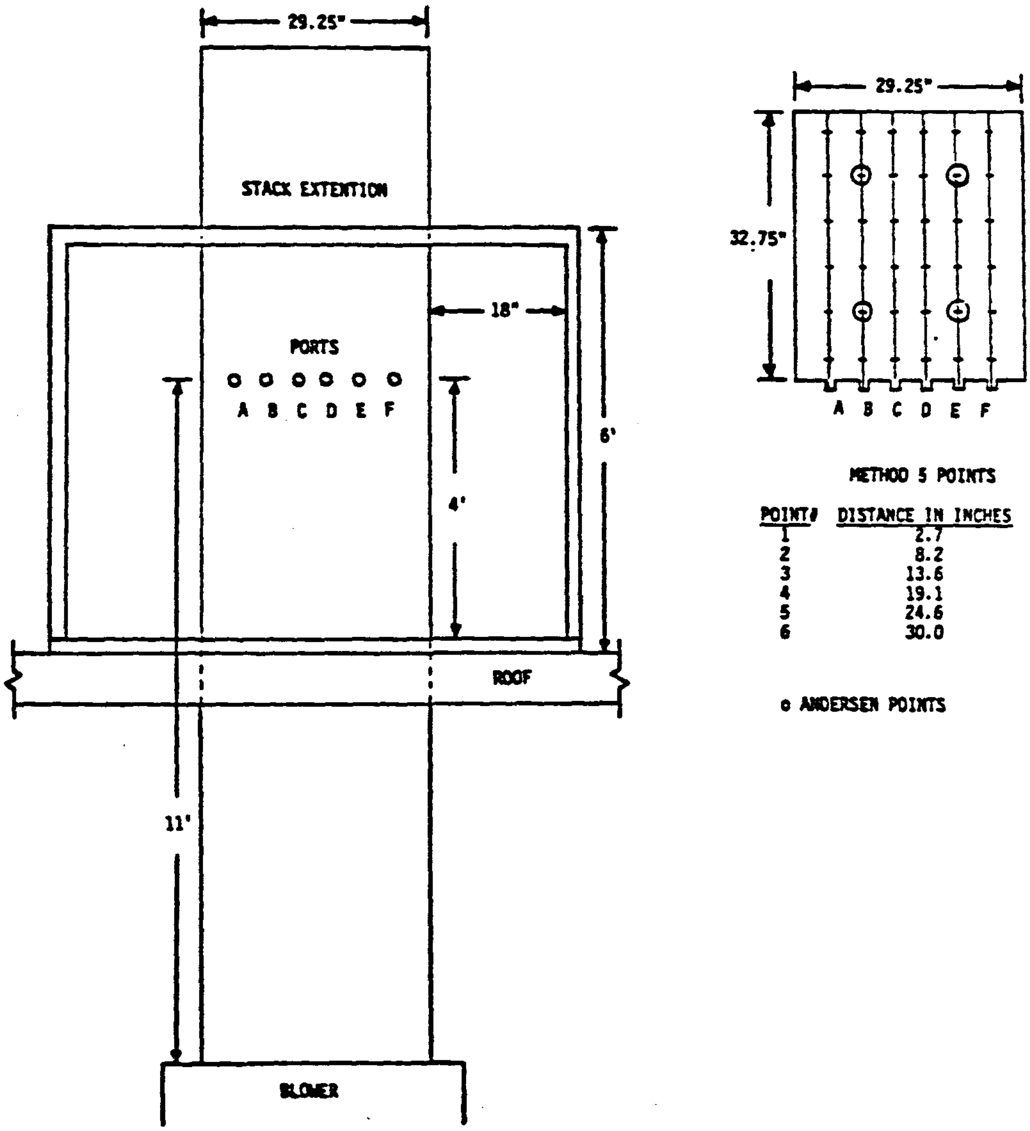

Figure 4-1. Outlet sampling site and traverse points - Black Hills Bentonite Co., Mills, Wyoming.

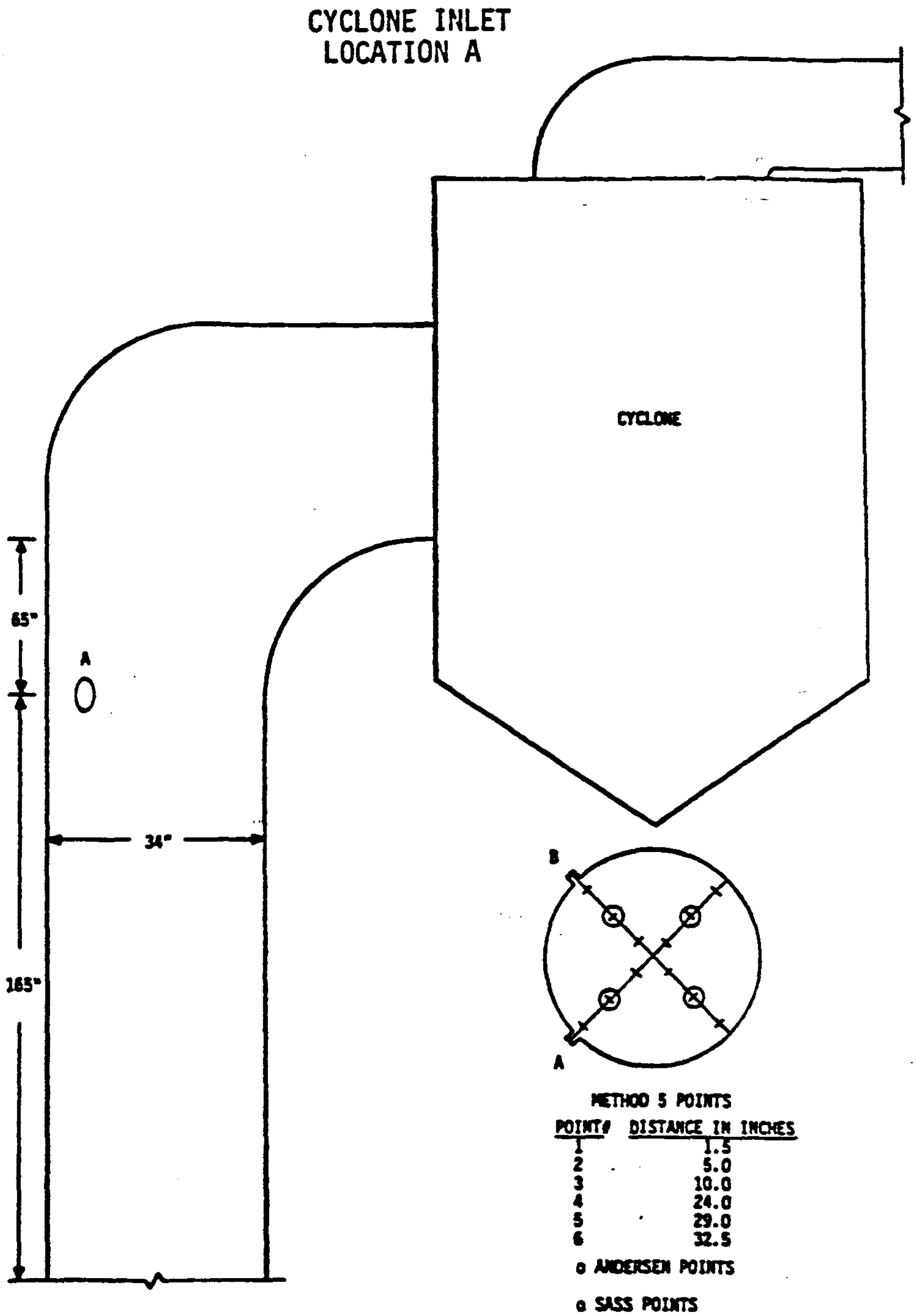

Figure 4-2. Inlet sampling site and traverse points - Black Hills Bentonite Co., Mills, Wyoming.

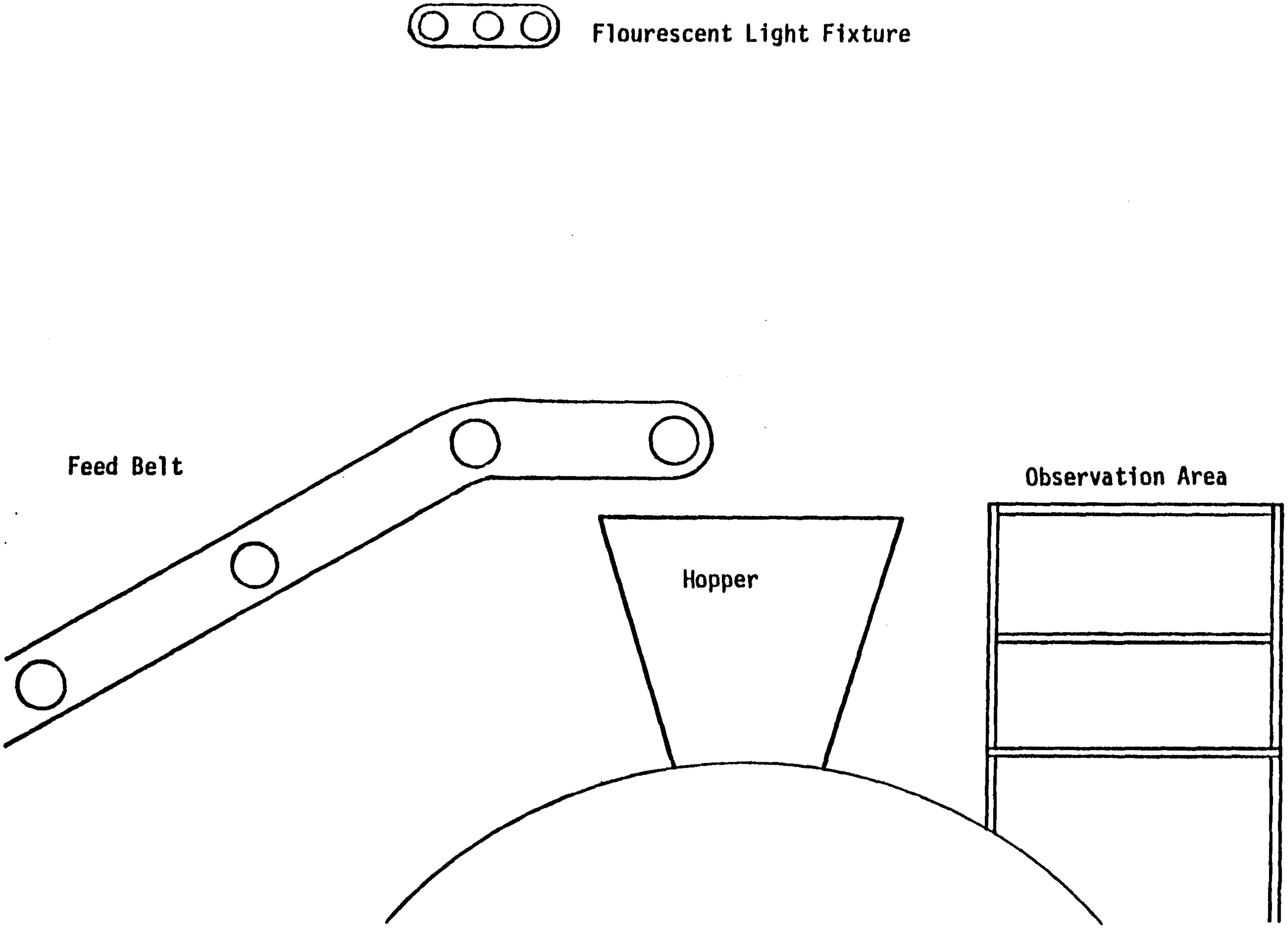

Figure 4-3. Method 22 observation location for the feed belt discharge point.

5. SAMPLING AND ANALYTICAL PROCEDURES

5.1 SAMPLING PROCEDURES

5.1.1 Reference Method 5 Sampling Procedures

Figure 5-1 depicts the Method 5 train which was used for these tests. Standard Method 5 procedures were used with the following exceptions.

1. The inlet was sampled at fewer than the normal points. Since it was actually a product stream rather than the inlet to the actual control device (baghouse) it was felt that twelve (12) points would be adequate and allow simultaneous sampling with the outlet.
2. A gas chromatograph, rather than an Orsat, was used to determine the carbon dioxide and oxygen composition of the stack gas. The volumetric percentage of nitrogen in the stack was determined by subtracting the above from 100 percent.

5.1.2 Andersen Sampling Procedures

Figure 5-2 is a diagram of the Andersen particle sizing train as used in this test series, including a right angle pre-impactor. The testing procedures used were based on the draft manual "Guidelines for Source Testing for Size Specific Particulate Emissions", Section 5. The testing procedure was as follows:

1. take a pitot reading at the point to be sampled;
2. determine and install the desired nozzle;
3. leak-check the sampling train;
4. put the impactor at the sampling point with the nozzle facing at 180 degrees from the flow;
5. wait until the impactor internal temperature is within 5°F of the stack temperature, or heat the impactor above the stack temperature to prevent condensation in the impactor;

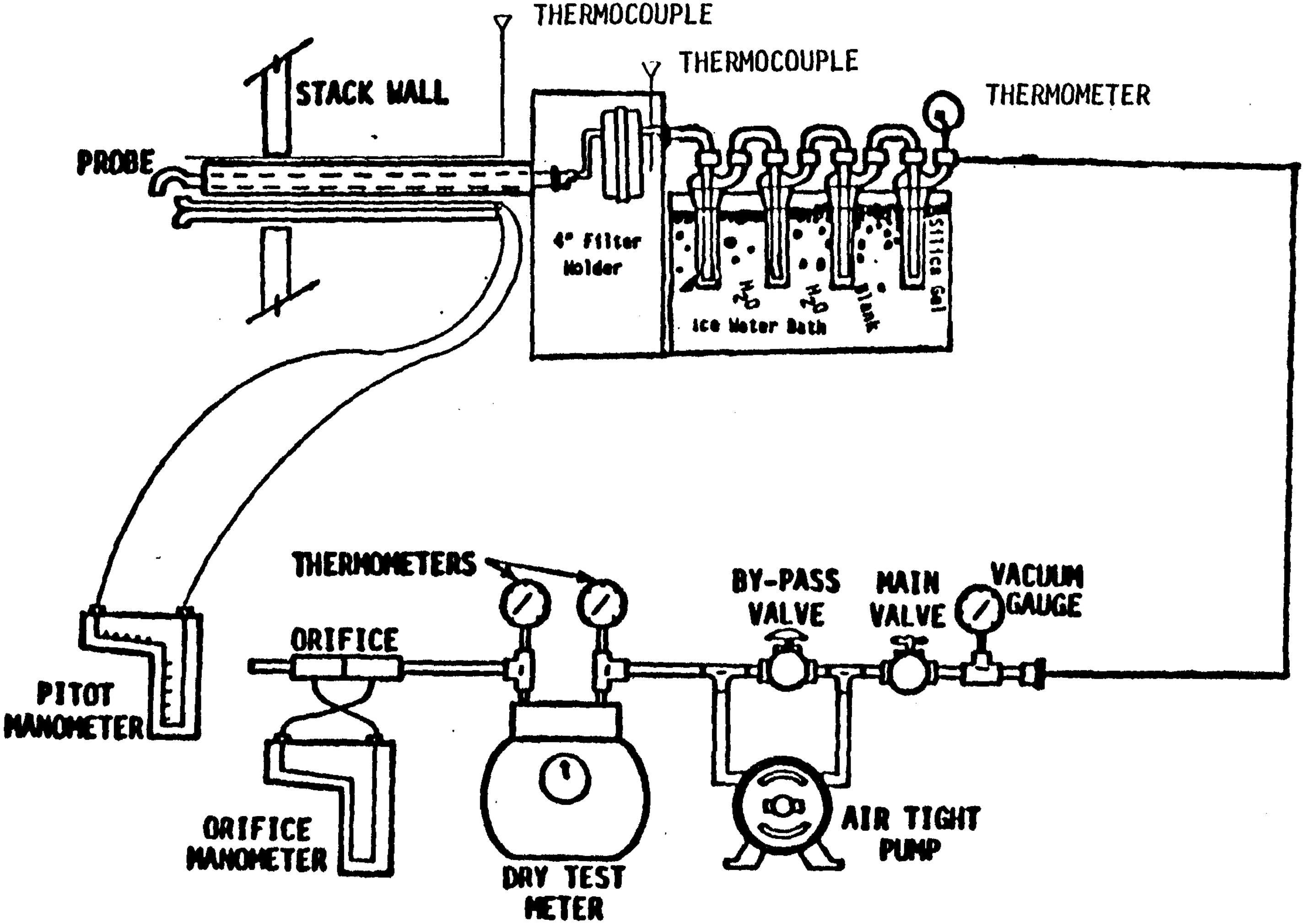

Figure 5-1. Method 5 - Sampling Train

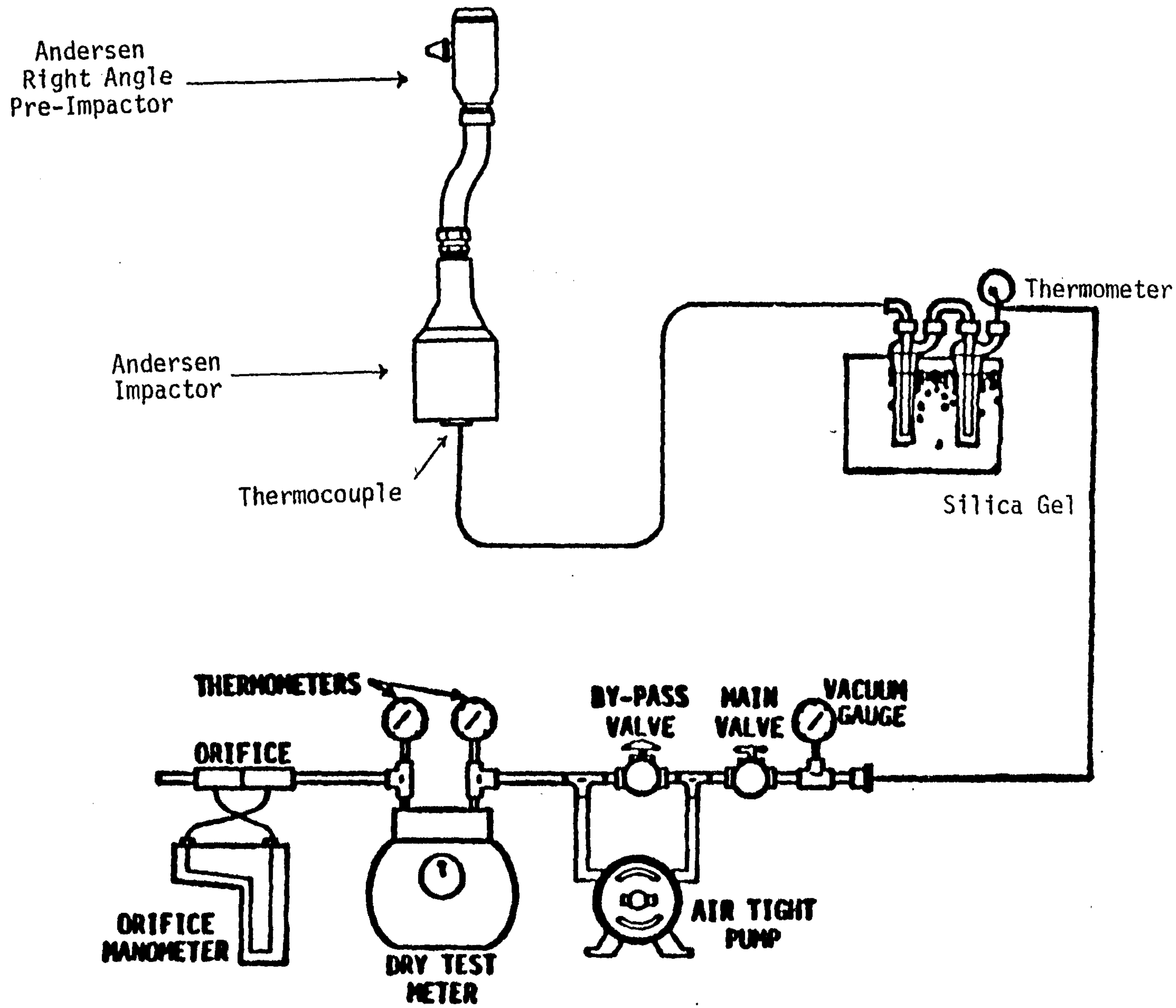

Figure 5-2. Andersen Sampling Train With Right Angle Pre-Impactor

6. turn the impactor's nozzle into the flow;
7. start sampling at the predetermined isokinetic sampling rate;
8. at the end of the predetermined sampling time, turn off the sampling train;
9. withdraw the impactor unit from the stack (being careful not to jar or shake it);
10. draw 0.5 cubic foot, at 0.1 actual cubic foot per minute, of clean ambient air through the train;
11. take the sampling head off the probe; and
12. keep the sampling head upright after removing from sampling probe until after sample recovery.

Andersen flow rates and the validity of a run were determined by visual inspection of the impactor substrates and inputting the test parameters to the PADRE program.

5.1.3 SASS Sampling Procedures

Figure 5-3 depicts the SASS train as it was used to determine particulate mass and size distribution. The conceptual approach was to use the SASS cyclones and filter in high grain-loading situations as approach to using the Andersen impactors with the required very short run duration. The SASS was operated at the Andersen sampling points while using the Method 5 moisture and pitot values for the calculations of the particulate mass emission rates. The SASS train was leak-checked and the probe and oven were heated to 400°F. The SASS was run as isokinetically as possible (restricted by the limited selection of nozzle sizes) as opposed to the optimal flow rate through the cyclones (as required to produce the exact calibrated cut points in each cyclone). This approach was taken to obtain the most representative measures of particulate msss rates, although sacrificing some of the accuracy of the SASS particle size measurements.

5.2 ANALYTICAL PROCEDURES

5.2.1 Method 5 Analytical Procedures

The analytical procedures used were per the method with one exception. The acetone washings were heated at 100°-120°F to facilitate overnight drying to allow next day weighings, as opposed to the standard method of allowing the acetone to evaporate at ambient conditions.

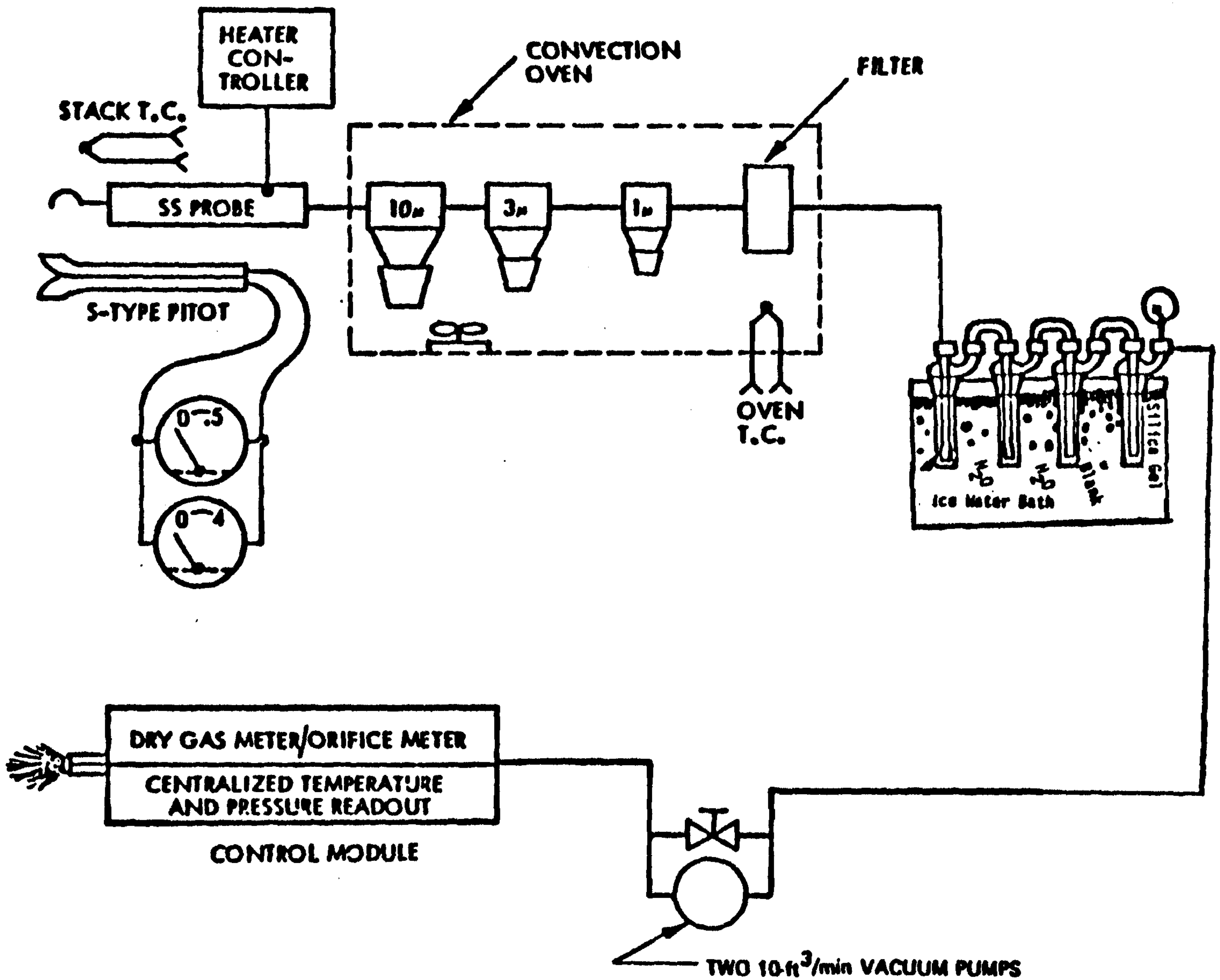

Figure 5-3. SASS - SAMPLING TRAIN FOR PARTICULATE SIZING AND MASS EMISSIONS DETERMINATION

5.2.2 Andersen Analytical Procedures

The Reeves Angel filters, Reeves Angel substrates, and foil packets were desiccated overnight. Each filter or substrate was then preweighed with its foil packet and placed in a petri dish. The petri dishes were placed in the correct order to load the Andersen impactor and taped together. After carefully loading the filter and substrates, the impactor was ready for sampling. At the completion of sampling, the impactor was allowed to cool, taken to a clean recovery area, disassembled, and the sample recovered. The various portions were placed in their assigned petri dishes and desiccated overnight. The samples were weighed the following day.

5.2.3 SASS Analytical Procedures

The SASS recovery procedure was to dry-brush the nozzle and probe into the 10-micron cyclone catch. The 3-micron cyclone catch, 1-micron cyclone catch, and filter catch were recovered as separate samples. The probe and nozzle were acetone-rinsed and the rinse dried overnight on a (100-120°F) hot plate. The samples were placed in a desiccator and subsequently weighed.

6. QUALITY ASSURANCE PROCEDURES AND RESULTS

The following list of procedures were used to assure the validity of the test program.

1. The pitots were leak-checked.
2. A leak check was made after each Method 5 test.
3. A leak check was conducted before each Andersen run.
4. Dry gas meter calibrations were performed before the test series.
5. Thermocouples and thermometers were checked to read ambient temperature each day.
6. Reeves Angel filters and substrates were used to prevent weight gain from SO_2.
7. Visual observation of the Andersen filters and substrates was performed during sample recovery.
8. The balance was checked each day against known weights.
9. PADRE results were compared to the other PADRE and Method 5 results.
10. Percent isokinetic was calculated as soon as possible following each test.
11. An impactor blank was run to check for SO_2-caused weight gain.
12. An impactor was sealed and put in the stack for 45 minutes to provide a check on handling and recovery procedures.
13. Acetone and filter blanks were taken and checked.
14. Impactor holes and nozzles were checked for size.

The balance checks as shown in Table 6-1 show the weighing method to be accurate and repeatable, while Table 6-2 shows the results of the handling and recovery blank procedure.

Tables 6-1 and 6-2 show that the weighing methods were reasonably accurate and repeatable, considering the motel room environment where the weighings were conducted.

Table 6-1. METTLER H20T BALANCE CHECKS

Date	Calibration weight	Balance weight shown (grams)
9-19-83	1 gram	0.99985
9-21-83	1 gram	0.99978
	100 mg	0.09995
	100 mg	0.1000
9-22-83	1 gram	0.99982
	100 mg	0.09994
	1 gram	1.00018
9-23-83	1 gram	0.99982
	100 mg	0.10000

Table 6-2. PLUGGED INSTACK IMPACTOR BLANK RESULTS

Tare	Weight gain after 3 hours in desiccator	Weight gain after overnight in desiccator
421.60 mg	0.03 mg	0.08 mg
639.54	0.00	0.09
665.70	0.07	0.06
648.29	0.04	0.03
557.81	0.04	0.06
598.32	0.16	0.14
611.77	0.00	0.04
624.84	0.15	0.21
652.95	0.01	0.11
681.63	0.01	0.02
Total	+ 0.51	+ 0.84