Background Report Reference

AP-42 Section Number: 9.9.1

Background Report Section: 4

Reference Number: 43

Title: Particulate Emission Tests on Cyclone Exhaust at Pillsbury Operated Grain Elevator in Currin, Illinois

Industrial Testing Laboratories, Inc.

June 1972

June 1972

AP-42 Section 9.9.1
Reference
Report Sect. 4
Reference 43

PARTICULATE EMISSION TESTS ON CYCLONE EXHAUST AT PILLSBURY OPERATED GRAIN ELEVATOR in Curran, Illinois

Report No. 25-6-171

Prepared by:

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Report No. 26-6-171

TABLE OF CONTENTS

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Report No. 26-6-171

Part I SUMMARY OF TEST RESULTS

A. Mass Emission Rates (Std. Cond.), Pounds Per Hour:

(1) Primary-Upper Cyclone

Test No. 1	8.5
Test No. 2	7.7

(2) Primary-Lower Cyclone

Test No. 3	4.2
Test No. 4	5.4

(3) Small Cyclone (rail-loading) ✓

Test No. 5	0.06
Test No. 6	0.06

NOTE ←

B. Volumetric Flow Rates, s.c.f.m.

(1) Primary-Upper Cyclone	11,000 (± 100)
(2) Primary-Lower Cyclone	9,600 (± 100)
(3) Small Cyclone	1,760 (± 20)

C. Maximum Allowable Emission (Ill. P.C.B. Newsletter #46, Table 2.1 for NEW PROCESS; $E = 2.54 \times (P)^{.534}$)

(1) Combined Primary Cyclones @ 294 ton/hr.	52.5
(2) Small Cyclone @ 29.6 ton/hr.	15.5 ← NOTE

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Report No. 26-6-171 June 25, 1972

Particulate emission tests on cyclones at Pillsbury Grain Elevator in Curran, Illinois.

The Pillsbury Company
608 Second Avenue South
Minneapolis, Minnesota 55402

P.O.: Letter May 24, 1972
Attn: Mr. D. E. Fiscus

TEST REPORT

Part II BACKGROUND

On June 23, 1972, a series of emission tests were conducted on the cyclones of the Pillsbury operated grain elevator in Curran, Illinois.

Duplicate particulate emission tests were performed on the exhaust gases of three Carter-Day cyclones, shown in Photographs Nos. 1 and 2. The tests were conducted in accordance with the applicable procedures of ASME Power Test Code 27-1957. Reder Hi Volume sampling systems were used in accordance with their operating manuals. Minor changes from their instructions (i.e., the use of a 0-1" magnehelic gage and the "Velocity Tables", etc.) were incorporated when they added to the precision or accuracy of the tests.

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The tests were conducted by Messers, M. Fuller and D. Dickus of Industrial Testing Laboratories, Inc., with the assistance of elevator personnel.

PHOTOGRAPHS

PHOTO NO. 1

Primary Cyclones, Upper & Lower (before addition of exhaust ducts) Day 45 H

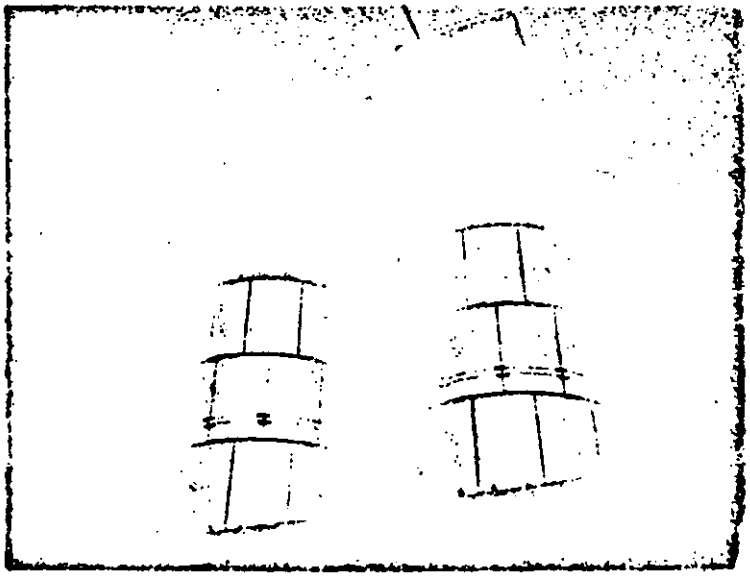

PHOTO NO. 2

Small Cyclone (before addition of exhaust duct) Day 20 H

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Report No. 26-6-171

Part IV SAMPLING EQUIPMENT & PROCEDURES:

Extensions were added to the cyclone exhaust orifices to provide a sampling location approximately 10 diameters and 2 diameters upstream from obstructions and bends. This was accomplished by the addition of 24" ID galvanized dust and 12" ID galvanized duct onto the Day 45H and 20 H cyclones, respectively. Access to samples points was achieved through two 4" ID entry ports placed 90° apart and two diameters from the discharge end of the extension ducts.

Velocity Pressure and duct static pressure were measured with standard pitot tubes and magnehelic gages (0-1" H_2O). Gas temperature was measured with mercury thermometers. Barometric pressure was determined at the test site with a portable barometer. Orsat analysis was not required. Time was measured on a watch with a sweep-second hand. From these data gas velocities and isokinetic sampling rates were calculated from the calibration curves supplied with the sampler. The values were checked against those given in the Research-Cottrell, Inc., "Velocity Tables".

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Part IV

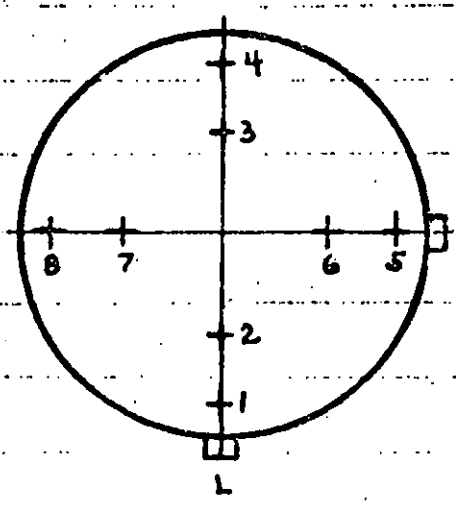
A total of eight sample points were used in each duct as shown in the traverse point layout (Figure 1). Sample was collected for one minute per point in the 24" ID duct from the 45 H cyclones and for 0.5 minutes per point in the 12" ID duct on the 20 H cyclone. A blank filter determination was run for each duplicate test on a cyclone. A Rader Hi-Volume Sampler, as shown in Figure 2, was used for particulate collection. Type A glass fiber filter pads were weighed immediately prior to and immediately after sample collection, using a Christian-Becker chain-o-matic balance.

Report No. 26-6-171

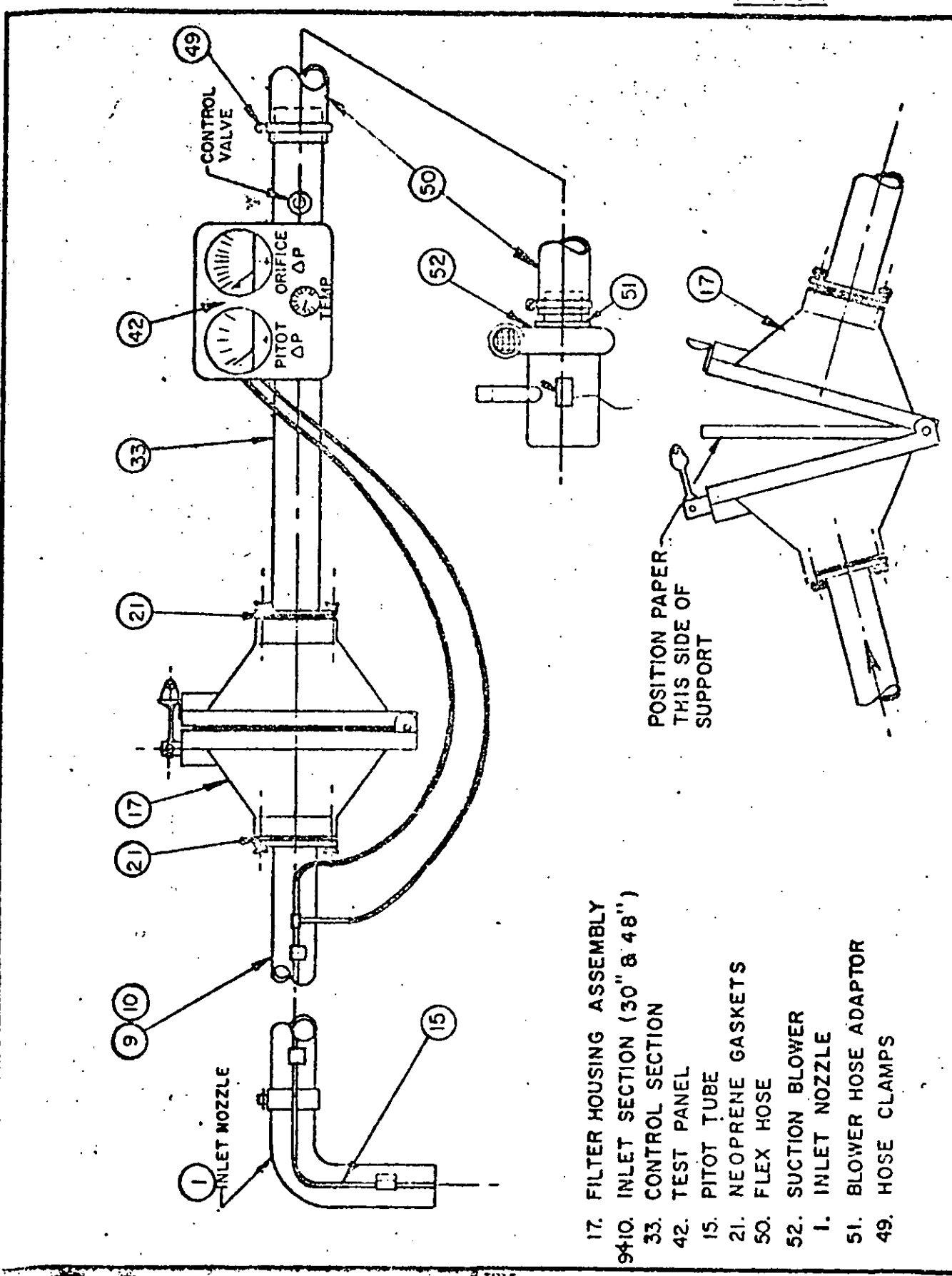
Part V

TRAVERSE POINT LAYOUT

Figure 1



Percent of Diameter From Circumference	Point Nos.
6.7	1, 5
25.0	2, 6
75.0	3, 7
99.3	4, 8



REV. A 10-21-71 MINOR WORDING CHANGES

TITLE RADER HI-VOLUME SAMPLER

SCALE —— DRWN. J.V. HIRSCH

DATE 7-30-71 CKD.

A-100332A

Report No. 26-6-171

Part VI SPECIFIC TEST DATA

Date:	6/23/72	6/23/72	6/23/72	6/23/72	6/23/72	6/23/72
Test No:	1	2	3	4	5	6
Location (Cyclone Exhaust):	Upper 45H	Upper 45H	Lower 45H	Lower 45H	20H	20H
Time:	1:39-1:51	2:01-2:12	2:35-2:45	2:52-3:06	4:00-4:05	4:10-4:17
Duration, min:	8	8	8	8	4	4
Ambient Conditions:						
Temperature, °F.	73	73	73	73	73	73
Barometric Pressure, in. Hg	29.41	29.41	29.41	29.41	29.40	29.40
Relative Humidity	80-75	80-75	80-75	80-75	75	75
Collection Equipment Data:						
Nozzle I.D. inches	15/16	15/16	15/16	15/16	1-7/8	1-7/8
Glass Pad Type	A	A	A	A	A	A
Particulate Collected, gms. (- blank)	0.775	0.707	0.390	0.500	0.0462	0.0420
Particulate Output: *						
Concentration, grains/s.c.f.	0.0309	0.0820	0.0510	0.0654	0.00397	0.00377
Mass Loading, pounds/hour	8.5	7.7	4.2	5.4	0.058	0.057

Part VI

Test No.	1	2	3	4	5	6
Stack Data:						
Traverse Points	8	8	8	8	8	8
Diameter, ins.	24	24	24	24	12	12
Area, sq. ft.	3.142	3.142	3.142	3.142	0.7854	0.7854
Temperature °F	74	74	74	74	70	70
" °R	534	534	534	534	530	530
Absolute Pressure, in. Hg	29.42	29.42	29.42	29.42	29.40	29.40
Gas Density (A = 1)	.99	.99	.99	.99	.99	.99
Volumetric Flow Rate, c.f.m.						
Stack conditions	11,285	11,285	9,857	9,857	1,786	1,786
Standard conditions	11,013	11,013	9,620	9,620	1,755	1,755
Sampler Data:						
Temperature °F	74	74	74	74	70	70
" °R	534	534	534	534	530	530
Orifice ΔP Avg, in. Hg	- .01	- .01	- .01	- .01	- .06	- .06
Total Sample Time, min.	8	8	8	8	4	4
Average Sample Rate, c.f.m.	17.0	17.0	15.1	15.1	43.8	43.8
Sample Volume, c.f.						
Sampler Conditions	136	136	121	121	175	175
Standard Conditions	133	133	118	118	172	172

Report No. 26-6-171

Part VII

Job: Pillsbury, Currao, Ill. Date: 6/23/22 Test No: 1, 2

Location: Upper Primary Cyclone Exhaust

Point No.	Duct Data					Sampler Data					Time		Time	
						Test (1)				Test (2)				
	T_s °F	ΔH H_2O"	Velc. F.P.S	Velc. F.P.M		T_M °F	ΔP H_2O"	Time sec.	Vol. c.f.		Start	Stop		
1	74	.76	58.7	3522		74	.10	60	17.0		1:39PM	1:40	2:01P	2:
2	74	.80	60.2	3612		74	.10	60	16.8		1:40	1:41	2:02	2:
3	74	.85	62.1	3726		74	.11	60	17.8		1:41	1:42	2:03	2:
4	74	.74	57.9	3474		74	.10	60	17.0		1:42	1:43	2:04	2:
5	74	.70	56.4	3384		74	.09	60	16.2		1:47	1:48	2:08	2:
6	74	.80	60.0	3600		74	.10	60	16.8		1:48	1:49	2:09	2:
7	74	.84	61.7	3702		74	.11	60	17.8		1:49	1:50	2:10	2:
8	74	.72	57.2	3432		74	.09	60	16.2		1:50	1:51	2:11	2:
Σ								480						
$\bar{X}$	74			3556		74			17.0					

Duct Dimensions: 24" I.D. Duct Area, sq. ft.: 3.142 Duct Static Press: .01" H / .14" H

Ambient Conditions: Temp: 73°F Barometric Pressure: 29.41 Relative Humidity: 80-75

Gas Composition: CO_2% = 0 ; O_2% = 21 ; CO% = 0 ; N_2% = 79 ; _____ ; _____

Gas Moisture, %: 2 Gas Density: 0.992

Collection ORIFICE: 0.9375" I.D.

Comments: P_B = 29.42 T_B = 534 P_M = 29.40 T_M = 534

Job: Pillsbury, Curran, Ill Date: 6/23/72 Test No: 3, 4

Location: Lower Primary Cyclone Exhaust

Point No.	Duct Data					Sampler Data					Test (3) Time		Test (4) Time	
	T_s °F	ΔH H_2O"	Velc. F.P.S	Velc. F.P.M		T_M °F	ΔP H_2O"	Time sec.	Vol. c.f.		Start	Stop		
1	74	.52	47.9	2877		74	.06	60	14.0		2:35P	2:36	2:52	2
2	74	.62	52.8	3168		74	.08	60	15.5		2:36	2:37	2:53	2
3	74	.66	54.4	3264		74	.09	60	16.0		2:37	2:38	2:54	2
4	74	.60	52.0	3120		74	.08	60	15.0		2:38	2:39	2:55	2
5	74	.55	49.7	2982		74	.07	60	14.5		2:41	2:42	3:02	3
6	74	.62	52.8	3163		74	.08	60	15.5		2:42	2:43	3:03	3
7	74	.68	55.2	3318		74	.09	60	16.0		2:43	2:44	3:04	3
8	74	.54	49.3	2958		74	.07	60	14.5		2:44	2:45	3:05	3
Σ								480						
$\bar{X}$	74			3106		74			15.1					

Duct Dimensions: 24" I.D. Duct Area, sq.ft.: 3.142 Duct Static Press: +.01 -.09

Ambient Conditions: Temp: 73°F Barometric Pressure: 29.41 Relative Humidity: 80-75

Gas Composition: CO_2%= 0 ; O_2%= 21 ; CO%= 0 ; N_2%= 79 ; ____ ; ____

Gas Moisture, %= 2% Gas Density: 0.992

Collection ORIFICE: 0.9375" I.D.

Comments: P_b = 29.42 T_s = 534 P_m = 29.40 T_M = 534

Part VII

Job. Pillsbury, Curran, Ill. Date: 6/23/72 Test No: 5, 6

Location: Small cyclone Exhaust (Low loading)

Point No.	Duct Data					Sampler Data					Time		Time	
											Test (5)		Test (6)	
	T_L °F	ΔH H_2O"	Vel. F.P.S	Vel. F.P.M		T_M °F	ΔP H_2O"	Time min	V.I. c.f		Start	Stop		
1	70	0.30	36.6	2196		70	.75	30	43		4:00.0	4:00.5	4:10.5	4:11
2	70	0.37	40.6	2436		70	.86	30	46		4:00.5	4:01.0	4:11.0	4:11.5
3	70	0.32	37.8	2268		70	.78	30	44		4:01.0	4:01.5	4:11.5	4:12
4	70	0.28	35.3	2118		70	.66	30	41		4:01.5	4:02.0	4:12.0	4:12.
5	70	0.30	36.6	2196		70	.75	30	43		4:03.5	4:04.0	4:15.0	4:15
6	70	0.28	41.2	2472		70	.95	30	48		4:04.0	4:04.5	4:15.5	4:16
7	70	0.35	41.2	2472		70	.95	30	48		4:04.5	4:05.0	4:16.0	4:16
8	70	0.21	31.3	1878		70	.60	30	37		4:05.0	4:05.5	4:16.5	4:17
Σ								240						
$\bar{X}$	70			2254		70			43.8					

<0.01

Duct Dimensions: 12" I.D Duct Area, sq. ft.: 0.7854 Duct Static Press: +.04

Ambient Conditions. Temp: 73 Barometric Pressure: 29.40 Relative Humidity: 75

Gas Composition: CO_2%= 0 ; O_2%= 21 ; CO%= 0 ; N_2%= 79 ; ____ ; ____

Gas Moisture, %= 2% Gas Density: 0.992

Collection ORIFICE: 1.875" I.D.

Comments: P_G = 29.40 T_G = 530 P_M = 29.37 T_A = 530

Report No. 26-6-171

Part VIII

Calculations I

Weather Data (at test site)

6-23-72

Time	Temperature	Barometric Pressure	Relative Humidity
10:00 AM	74	29.43	70
11:00 AM	74	29.42	70
12:00 AM	74	29.41	75 (74,69
1:00 PM	73	29.41	80
2:00 PM	73	29.41	80
3:00 PM	73	29.41	75
4:00 PM	73	29.40	75

from Dwyer Calculator

Velocity Correction Factor for RH = 75% = .991

Velocity Correction Factor for .32" CM = $\frac{2260}{2268}$ = .996 ≈ 0.4

Air Density (Ref) = .0729 #/ft³ [@ by Dwyer 70°F = 0.0808]

$$\%H_2O = \frac{\text{from Vel} = .50}{\frac{.8462 \times 75\%}{29.4}} \quad 2.1\%$$

H_2O = .022 × 18 = .40

Air = .978 × 28.95 = 28.31

.992 = $\frac{28.71}{28.95}$

$$V_c = \sqrt{\frac{29.43}{29.42} \times \frac{1}{.992}} = \sqrt{1.024} = 1.013$$

Calculations II

I Velocity Correction Factor (Average).

$$V_c = \sqrt{\frac{29.92}{29.71} \times \frac{1}{.992}} = \sqrt{1.02} = 1.01$$

II Volumetric Flow Rates

		c.f.m.	s.c.f.m.
Test no 1 & 2 =	$1.01 \times 3556 \times 3.142$ =	$11,285 \times \frac{29.42}{29.92} \times \frac{530}{534}$ =	11,013
Test no 3 & 4 =	$1.01 \times 3106 \times 3.142$ =	$9,857 \times \frac{29.42}{29.92} \times \frac{530}{534}$ =	9,620
Test no 5 & 6 =	$1.01 \times 2254 \times .7845$	$1,786 \times \frac{29.40}{29.92} \times \frac{530}{530}$ =	1,755

III Sample Volumes Converted to Std. Cond. (70°F & 29.92" Hg)

		c.f.	s.c.f.
Test no 1 & 2	8×17.0 =	$136 \times \frac{29.40}{29.92} \times \frac{530}{534}$ =	133
Test no 3 & 4	8×15.1 =	$121 \times \frac{29.40}{29.92} \times \frac{530}{534}$ =	118
Test no 5 & 6	4×43.8 =	$175 \times \frac{29.84}{29.92} \times \frac{530}{530}$ =	172

IV Particulate Concentration & Mass Emission Rate. (std. cond.)

Test no 1	$\frac{(.979 - .004) \times 15.43}{133}$ =	$(.0894) \times \frac{11,013}{7,000} \times 60$ =	8.5
Test no 2	$\frac{(.711 - .004) \times 15.43}{133}$ =	$(.0820) \times \frac{11,013}{7,000} \times 60$ =	7.7
Test no 3	$\frac{(.393 - .003) \times 15.43}{118}$ =	$(.0510) \times \frac{9,620}{7,000} \times 60$ =	4.2
Test no 4	$\frac{(.503 - .003) \times 15.43}{118}$ =	$(.0654) \times \frac{9620}{7,000} \times 60$ =	5.4
Test no 5	$\frac{(.0486 - .0044) \times 15.43}{172}$ =	$(.00397) \times \frac{1,755}{7,000} \times 60$ =	0.058
Test no 6	$\frac{(.0464 - .0044) \times 15.43}{172}$ =	$(.00377) \times \frac{1,755}{7,000} \times 60$ =	0.057