PUBL 4365-83 0732290 0042154 0

Characterization Of Particulate Emissions From Refinery Process Heaters And Boilers

API PUBLICATION NO. 4365
JUNE 1983

American Petroleum Institute
2101 L Street, Northwest
Washington, D.C. 20037

PUBL 4365-83 0732290 0042155 2

CHARACTERIZATION OF PARTICULATE EMISSIONS FROM REFINERY PROCESS HEATERS AND BOILERS

Prepared by:

ROY F. WESTON, INC.
WESTON WAY
WEST CHESTER, PENNSYLVANIA 19380

Prepared for:

AMERICAN PETROLEUM INSTITUTE
2101 L Street, Northwest
Washington, DC 20037

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

WESTON DESIGNERS CONSULTANTS

LIST OF TABLES

LIST OF TABLES
(continued)

WESTON DESIGNERS CONSULTANTS

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

This report presents the results of a field testing effort to characterize particulate emissions from refinery combustion sources. The effort included 155 tests on two process heaters and three boilers over a one year period. The units are described in Table 1-1 along with process conditions and number of tests by category.

The major objective of this program was to determine emission factors, size distribution, and chemical composition of particulates from refinery combustion sources. This was accomplished by measuring and analyzing source emissions from several types of units under a variety of fuel firing and excess air conditions. The tests were run under steady load conditions.

Key study findings and data interpretation are presented in Section 4. A brief discussion of major study findings is given below.

1.1 Particulate Emission Rates

Particulate emission rates for heaters and boilers on 100 percent gas or 100 percent oil were less than those predicted by EPA emission factors (AP-42).[1] Emission rates for 100 percent gas or 100 percent oil firing ranged from 7 to 87 percent of the values predicted by AP-42. EPA particulate emission factors are shown on pages 8 and 12 in the report and compared to our test data. Emission rates for the two units firing 100 percent gas ranged from 7 to 65 percent of the lower range predicted by AP-42 estimates. Emission rates for the two units firing 100 percent oil ranged from 52 to 87 percent of the AP-42 estimates. Fuel oil emission test results are compared with AP-42 data in Figure 4-1 of the text. Although survey data are lower than the

[1]The U.S. Environmental Protection Agency developed emission factors from tests conducted on industrial process boilers firing either 100 percent gas or 100 percent fuel oil. These factors were published in AP-42, "Compilation of Air Pollution Emission Factors," Third Edition, with Supplements 1 through 13. During this project, tests were conducted under both single- and mixed-fuel-firing conditions. Results from tests completed under single fuel conditions are compared directly herein with the AP-42 factors. For those tests performed under mixed-fuel-firing conditions, comparison emission factors were calculated by prorating the AP-42 emission factors for oil and gas based on the heat rate of each fuel.

Table 1-1

UNIT DESCRIPTIONS AND DATA BASE

Refinery	Source	Type of Unit	Max. Design Rating 10^6 BTU/hr	Description of Conditions: Condition No.	Fuel Firing Ratio % Gas : % Oil	% O_2 at Test Site (Boiler)	No. of Tests by Type: Particulate[1]	PSD[2]	NO_x[3]
A	1	Process Heater	315	1	97:3	2.3	3	1	3
				2	93:7	4.3	3	1	3
				3	51:49	4.0	3	1	3
				4	54:46	5.4	3	1	3
B	1	Process Heater	60.1	1	100:0	4.1	3	-	3
				2	100:0	6.0	3	-	3
A	2	Boiler	215	1	100:0	6.8 (2.9)	3	1	3
				2	100:0	8.6 (4.7)	3	-	3
				3	69:31	8.9 (5.2)	2	2	2
				4	75:25	9.7 (6.5)	2	2	2
				5	40:60	8.7 (5.5)	3	3	3
				6	40:60	10.0 (6.8)	3	3	3
B	2	Boiler	576	1	31:69	5.0	3	3	3
				2	29:71	6.7	3	3	3
				3	0:100	4.9	3	3	3
				4	0:100	6.6	3	3	3
C	1	Boiler	200	1	43:57	9.1 (5.4)	3	3	3
				2	37:63	10.1 (6.5)	3	3	3
				3	0:100	7.3 (3.7)	3	3	3
				4	0:100	9.6 (5.4)	3	3	3
						TOTALS	58	39	58

[1] EPA Method 5 as specified in Code of Federal Regulations, Title 40, Part 60, Appendix A, "Standards of Performance for New Stationary Sources," August 18, 1977.

[2] PSD = particle size distribution. Testing was performed according to Operating Manual for Andersen 2000, Inc., "Mark III Particle Sizing Stack Samplers," Andersen 2000 Inc., P. O. Box 20769, Atlanta, GA.

[3] EPA Method 7. Code of Federal Regulations, Title 40, Part 60, Appendix A, "Standards of Performance for New Stationary Sources," August 18, 1977.

AP-42 predicted values, the data are within the range of data used to develop the AP-42 correlation.

Emission rates for mixed-fuel-firing ranged from 9 percent of the AP-42 lower limit to 125 percent of the AP-42 upper limit. Emissions from three of the four units were below those predicted by AP-42.

The effect of excess air on mass emissions was examined. Over the range of excess air conditions tested, no significant effects were observed.

1.2 Particle Size Distribution

The particle size distribution (PSD) test results indicate that relatively small particles are produced during both gas and oil firing. The data show that ~ 50 weight (wt) percent of the particles for most tests were submicron (< 1 um). An average of about 75 percent of the particles by weight were < 10 um effective aerodynamic diameter. Excess air showed no effect on size distributions. The data show that a greater weight percentage of small particles is formed during gas firing than for oil- and mixed-fuel-fired conditions.

1.3 Chemical Composition

Particles were analyzed for heavy metals, extractable organics, sulfates, nitrates, and elemental carbon, hydrogen, and nitrogen. The particles generally contained small quantities of metals (< 2 wt percent) and no nitrates (< 0.1 wt percent). Organics content varied widely from less than 1 percent to over 50 percent. Sulfate content ranged from 25 to 85 wt percent. The remaining chemical consituents were not identified in this study.

1.4 Nitrogen Oxides

Results of limited oxides of nitrogen testing indicated that NO_x emissions increased with rising excess air levels and also with the proportion of oil fired in those sources.

2.0 INTRODUCTION

2.1 Background

The importance of airborne particulate size and chemical composition is being examined by EPA as the Agency considers revising the National Ambient Air Quality Standard for particulate matter. The impact of discrete size fractions and fine or respirable particles is being considered rather than the currently controlled total suspended particulate (TSP) matter.

As mandated by the Federal Clean Air Act, the promulgation of a revised particulate standard could have impact on control strategies and revisions to the existing State Implementation Plans. This would affect many source types, including refinery combustion sources (i.e., steam generators and process heaters) and non-fired sources (e.g., FCC stacks and cokers). The purpose of this test program is to provide a preliminary data base of particulate emission rates, size distributions, and chemical compositions.

2.2 The Study Objectives

The objectives of this program were:

1. To determine particulate emission factors.
2. To obtain particle size distribution data.
3. To determine the chemical composition of the particulate.

2.3 The Project Organization

The test program determined the particulate mass emission rates, particle size distribution, and chemical composition (i.e., sulfates, heavy metals, nitrates, and elemental analyses) from process heaters and steam-generating boilers. These data were related to fuel composition and to predicted AP-42 emission rates. Nitrogen oxides emission rates were measured and compared to predicted AP-42 values to demonstrate the relationship between particulates generation and nitrous oxide formation. The effects of excess air levels were examined for each test unit. Testing on the first unit started 14 July 1981, and on 19 May 1982 all testing was completed. A total of 155 tests on two heaters and three boilers were conducted.

2.4 Field Test Methods

Standard test methods were employed in the program as follows:

1. Mass emissions - EPA Method 5.
2. Particle size distribution - Andersen impactor.
3. NO_x - EPA Method 7.

3.0 DESCRIPTIONS OF UNITS TESTED

Five sources (two heaters and three boilers) were surveyed under this contract. A brief description of each unit is presented below. Additional information on each unit is provided in Appendix B.

3.1 Process Heaters

3.1.1 Refinery A - Source 1

This source is a 1978 Foster Wheeler side-fired horizontal radiant-tube crude process heater. It has a maximum gross fired duty of 315 x 10^6 Btu/hr; fuel ratios can be varied from 0 to 100 percent gas or oil.

3.1.2 Refinery B - Source 1

This source is a 1978 G.C. Broach Company vertical-fired process heater on a hydrotreating unit used for desulfurization of diesel distillate. Unit processing capacity is 25,000 barrels per operating day (bpod). Its maximum fired duty is 60.1 x 10^6 Btu/hr and it is typically operated at 25 percent of maximum duty. It is designed to only fire 100 percent plant fuel gas.

3.2 Boilers

3.2.1 Refinery A - Source 2

This source is a Riley Stoker boiler constructed in 1948. It is a balanced draft, end-horizontal-fired boiler with radiant tubes and horizontal section convection tubes. It has a maximum gross fired duty of 215 x 10^6 Btu/hr; fuel ratios can be varied from 0 to 100 percent refinery fuel gas or oil.

3.2.2 Refinery B - Source 2

This horizontal-fired steam generator, built in 1978 by Riley Stoker, is of a natural circulation, water tube-type design. Its steam production capacity is 440 x 10^3 lb/hr at a maximum heat rating of 576 x 10^6 Btu/hr. Its fuel-firing ratio is infinitely adjustable but is currently limited to about 30 percent gas based on the availability of process fuel gas.

3.2.3 Refinery C - Source 1

This boiler was designed by Babcock and Wilcox and constructed in 1942. It is a balanced draft, horizontal-fired unit with a maximum steam rating of 125,000 lb/hr at 750°F and 700 psig. The boiler has a design efficiency of 86 percent and is rated at 200 x 10^6 Btu/hr. It can be fired on gas or oil or any combination thereof.

4.0 RESULTS OF MEASUREMENTS

4.1 Mass Emissions

4.1.1 Process Heaters

Process heater emission factors based on the front-half catch[1] are compared to those from AP-42 in Table 4-1. Key particulate data and results are listed, by run, in Tables 4-2 and 4-3 for Refinery A Source 1 and Refinery B Source 1, respectively. Detailed data are included in Appendix A.

Data for Refinery A process heater were obtained while the source fired a combination of process gas and a No. 4 fuel oil (0.09 wt percent S, <0.01 wt percent ash) ranging from 51 to 97 percent gas on a Btu basis. The measured particulate emission factors were all less than the lower limits of the prorated EPA emission factor ranges for all combinations of fuel-firing and excess air. The average measured particulate emission factor was 0.0024 ± 0.0006 lb/10^6 Btu. The lower limits of the prorated EPA emission factor ranges varied from 0.0055 to 0.027 lb/10^6 Btu.

Refinery B process heater operated on 100 percent fuel gas at its typical firing rate during the survey. The measured particulate emissions factors were an order of magnitude less than the lower limit of the AP-42 predicted range. As expected, the average measure particulate emission factor, 0.0004 lb/10^6 Btu, was significantly less than the value obtained for the mixed-oil-gas-firing of Refinery A process heater.

Particulate emissions were measured at two excess air levels for each source. Excess air levels were monitored by stack percent O_2. The stack O_2 level varied from 2.0 to 5.5 percent for Refinery A Source 1 and from 4.1 to 6.0 percent for Refinery B Source 1. Two of the three tests indicated insignificant effects of excess air on particulate emissions. One test on the Refinery A heater, at very low excess air, showed increased emission rates.

Front-half and total (front-half plus back-half) particulate were measured.[1] For Refinery A heater (mixed-fuel-fired), the front-half catch averaged 62 percent of the total particulate. For Refinery B heater (gas-fired), the front-half particulate averaged 17 percent of the total catch.

---

[1] Terms are defined in Appendix C.

AMERICAN PETROLEUM INSTITUTE

Table 4-1

Summary of Particulate Emission Factors from Process Heaters

Refinery	Source	Test Run Numbers[4]	Fuel Firing Ratio % Gas : % Oil	Percent O_2 at Test Location	Heat Input Rate 10^6 BTU/hr	Fuel Firing Rate 10^6 Gas ft^3/hr	Fuel Firing Rate 10^3 Oil gph	Particulate Emission Factors[1] Measured lb/10^6 BTU	EPA[2] lb/10^6 BTU	Measured lb/10^6 SCF gas	EPA[3] lb/10^6SCF gas: lb/10^3 gal oil
A	1	1,2,3	97:3	2.0	262	0.212	0.054	0.0031	0.0055-0.014	---	5-15:7
		4,5,6	93:7	4.0	257	0.200	0.125	0.0017	0.0073-0.015	---	5-15:7
		7,9,11	51:49	4.0	270	0.115	0.914	0.0023	0.027-0.031	---	5-15:7
		8,12,13	54:46	5.5	252	0.113	0.802	0.0023	0.025-0.029	---	5-15:7
B	1	4,5,6	100:0	4.1	15	0.015	---	0.0004	0.0049-0.015	0.39	5-15:---
		1,2,3	100:0	6.0	16	0.016	---	0.0003	0.0049-0.015	0.35	5-15:---

[1]Particulate is defined in this section as that material collected by EPA Method 5 (front-half catch).

[2]Values shown for single fuel firing conditions were calculated using AP-42 Emission Factors and actual fuel firing rates and fuel sample analysis results. Those shown for mixed fuel firing were calculated by prorating the AP-42 Emission Factors for gas and oil based on the heat rate of each fuel using the following equation:

$$\frac{\text{lb Particulate}}{10^6\ \text{BTU}} = \frac{(\text{Gas Fired Duty})(\text{AP-42 Gas Emission Factor}) + (\text{Oil Fired Duty})(\text{AP-42 Oil Emission Factor})}{\text{TOTAL FIRED DUTY}}$$

[3]Values obtained from AP-42 Third Edition. Grade 4 oil was fired in Refinery A process heater.

[4]Run 10 was discounted because of process swings during test.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE NO. 1

Table 4-2

SUMMARY OF TEST RESULTS

Test Run Number[1]	One	Two	Three	Four	Five	Six	Seven	Nine	Eleven	Eight	Twelve	Thirteen
Fuel Firing Ratio % Gas : % Oil	100:0	100:0	91:9	94:6	91:9	94:6	46:54	46:54	61:39	48:52	57:43	58:42
Percent O_2 at Test Location	2.3	2.3	2.3	4.4	4.3	4.3	3.8	4.1	4.1	5.2	5.5	5.4
Particulate Results												
Front-Half												
Concentration, grains/dscf, $x10^{-3}$	3.0	1.6	2.2	0.7	1.3	1.3	1.9	1.3	1.1	1.6	1.5	0.8
Mass Emission Rate, pounds/hour	1.1	0.56	0.78	0.26	0.50	0.57	0.80	0.54	0.52	0.70	0.64	0.38
Series Average Mass Emission Rate, lbs/hr		0.81			0.44			0.62			0.57	
Total												
Concentration, grains/dscf, $x10^{-3}$	4.0	2.5	3.3	1.3	2.1	2.3	2.5	3.0	2.1	2.2	2.3	1.6
Mass Emission Rate, pounds/hour	1.4	0.91	1.2	0.50	0.81	0.99	1.1	1.3	0.97	0.95	1.0	0.75
Series Average Mass Emission Rate, lbs/hr		1.2			0.77			1.1			0.90	
NO_x Emissions, as NO_2[2]												
Concentration, ppm by Volume, dry basis	30.	51.	42.	64.	59.	77.	112.	142.	138.	126.	162.	136.
Concentration, lbs/dscf, x 10-6	3.6	6.1	5.0	7.6	7.0	9.2	13.	17.	17.	15.	19.	16.
Mass Emission Rate, pounds/hour	8.8	15.	12.	21.	19.	28.	40.	51.	53.	45.	60.	52.
Series Average Mass Emission Rate, lbs/hr		12.			23.			48.			52.	

[1]Run 10 was discounted because of process swings during test.

[2]Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 1

TABLE 4-3

SUMMARY OF TEST RESULTS

Test Run Number	Four	Five	Six	One	Two	Three
Fuel Firing Ratio, %Gas:%Oil	100:0	100:0	100:0	100:0	100:0	100:0
Percent O_2 at test location	4.0	4.0	4.4	6.3	5.8	5.9
Particulate Results						
Front-Half						
Concentration, grains/dscf, x 10^{-5}	11.8	2.23	21.5	5.68	18.6	10.1
Mass Emission Rate, lbs/hr, x 10^{-3}	5.76	1.04	10.2	2.74	9.06	4.99
Series Average Mass Emission Rate, lbs/hr, x 10^{-3}		5.67			5.60	
Total						
Concentration, grains/dscf, x 10^{-5}	64.6	62.7	77.6	54.7	84.0	58.8
Mass Emission Rate, lbs/hr, x 10^{-3}	31.5	29.3	36.6	26.4	41.0	29.0
Series Average Mass Emission Rate, lbs/hr, x 10^{-3}		32.5			32.1	
NO_x Emissions, as NO_2[1]						
Concentration, ppm by volume, dry basis	48.5	50.6	68.4	64.8	55.1	58.2
Concentration, lbs/dscf, x 10^{-6}	5.79	6.05	8.16	7.74	6.58	6.95
Mass Emission Rate, lbs/hr	1.97	1.98	2.69	2.62	2.25	2.40
Series Average Mass Emission Rate, lbs/hr		2.21			2.42	

[1]Results shown are averages of three (3) grab samples.

4.1.2 Boilers

Boiler particulate emissions factors, based on the front-half catch, are compared with AP-42 emission factors in Table 4-4. Summarized data can be found in Tables 4-5, 4-6, and 4-7 for Refinery A, B, and C boilers, respectively. Detailed data are included in Appendix A.

During 100 percent gas-firing conditions for Refinery A boiler, the average emission rate, 0.0022 $\pm$ .0012 lb/10^6 Btu, was less than the lower limit of the predicted EPA emission factor (0.0045 lb/10^6 Btu). During 100 percent oil-firing conditions for Refinery B and C boilers, the average measured emission rates were also less than the EPA-predicted rates:

Refinery	Average Emission Factor, lb/10^6 Btu	Predicted EPA AP-42 Value*, lb/10^6 Btu
B	0.035 $\pm$ .003	0.069
C	0.071 $\pm$ .022	0.10

*Based on fuel composition and firing rates

Although the survey data are lower than the AP-42 predicted values, the data are within the range of data used to develop the AP-42 correlation (see Figure 4-1).

Particulate emission factors were estimated for mixed-fuel-firing on Refinery boilers A, B, and C by prorating AP-42 values based on fuel heat contents and firing rates. These prorated AP-42 values are compared to average measured emission rates below:

Refinery	Average Emission Factor, lb/10^6 Btu	Range of Prorated EPA AP-42 Values, lb/10^6 Btu
A	0.012 $\pm$ .004	0.012 - 0.027
B	0.030 $\pm$ .005	0.049 - 0.053
C	0.078 $\pm$ .009	0.059 - 0.068

The test data, shown in Table 4-4, generally indicated that mass emissions increased with the proportion of oil fired but showed no correlation with excess air over the range of excess air conditions studied.

AMERICAN PETROLEUM INSTITUTE

TABLE 4-4

Summary of Particulate Emission Factors from Boilers

Refinery	Source	Test Run Numbers	Fuel Firing Ratio % Gas : % Oil	Percent O_2 at Test Location (Boiler)	Heat Input Rate 10^6 BTU/hr	Fuel Firing Rate: Gas $10^6 ft^3$/hr	Fuel Firing Rate: Oil 10^3gph	Particulate Emission Factors[1]: Measured lb/10^6 BTU	Particulate Emission Factors[1]: EPA[2] lb/10^6 BTU	Particulate Emission Factors[1]: Measured lb/$10^6 ft^3$ gas (lb/10^3 gal oil)	Particulate Emission Factors[1]: EPA[3,4] lb/10^6SCF gas: lb/10^3 gal oil
A	2	7,8,9	100:0	6.8 (2.9)	199	0.181	---	0.0030	0.0045-0.014	3.3	5-15:----
		10,11,12	100:0	8.6 (4.7)	204	0.185	---	0.0013	0.0045-0.014	1.5	5-15:----
		13,14	69:31	8.9 (5.2)	196	0.123	0.411	0.0066	0.014-0.020	---	5-15:5.2
		15,16	75:25	9.7 (6.5)	194	0.132	0.328	0.0072	0.012-0.019	---	5-15:5.2
		1,2,3	40:60	8.7 (5.5)	182	0.066	0.737	0.016	0.023-0.027	---	5-15:5.2
		4,5,6	40:60	10.0 (6.8)	187	0.068	0.758	0.014	0.023-0.027	---	5-15:5.2
B	2	1,2,3	31:69	5.0	549	0.114	2.53	0.028	0.049-0.052	---	5-15:10
		4,5,6	29:71	6.7	541	0.103	2.59	0.032	0.050-0.053	---	5-15:10
		10,11,12	0:100	4.9	560	---	3.75	0.035	0.069	(5.2)	----:10
		7,8,9	0:100	6.6	567	---	3.80	0.035	0.069	(5.2)	----:10
C	1	7,8,9	43:57	9.1 (5.4)	172	0.072	0.653	0.079	0.059-0.063	---	5-15:15
		10,11,12	37:63	10.1 (6.5)	160	0.057	0.674	0.076	0.065-0.068	---	5-15:15
		1,2,3	0:100	7.3 (3.7)	203	---	1.36	0.054	0.10	(8.0)	----:15
		4,5,6	0:100	9.6 (5.4)	155	---	1.04	0.088	0.10	(13)	----:15

[1] Particulate is defined in this section as that material collected by EPA Method 5 (front-half catch).

[2] Values shown for single fuel firing conditions were calculated using AP-42 Emission factors and actual fuel firing rates and fuel sample analysis results. Those shown for mixed fuel firing were calculated by prorating the AP-42 Emission Factors for gas and oil based on the heat rate of each fuel using the following equation:

$$\frac{\text{lb Particulate}}{10^6 \text{ BTU}} = \frac{(\text{Gas Fired Duty})(\text{AP-42 Gas Emission Factor}) + (\text{Oil Fired Duty})(\text{AP-42 Oil Emission Factor})}{\text{TOTAL FIRED DUTY}}$$

[3] The AP-42 Particulate Emission Factors for residual oil combustion are best described, on the average, as a function of fuel oil grade and sulfur content, as shown below: Grade 6 oil: lb/10^3 gal = 10 (S) + 3, where S is the percentage, by weight, of sulfur in the oil.
Grade 5 oil: 10 lb/10^3 gal.
Grade 4 oil: 7 lb/10^3 gal.

[4] Grade 6 oil was fired in all boiler sources. For Refinery A, wt. % S in the oil = 0.22
For Refinery B, wt. % S in the oil = 0.73
For Refinery C, wt. % S in the oil = 1.19

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
TABLE 4-5
SUMMARY OF TEST RESULTS

Test Run Number	Seven	Eight	Nine	Ten	Eleven	Twelve	Thirteen	Fourteen	Fifteen	Sixteen	One	Two	Three	Four	Five	Six
Fuel Firing Ratio, % Gas : % Oil	100:0	100:0	100:0	100:0	100:0	100:0	68:32	70:30	75:25	74:26	40:60	40:60	40:60	41:59	40:60	39:61
Percent O_2 Exiting Boiler	2.9	3.0	2.9	4.8	4.6	4.6	5.3	5.1	6.5	6.4	5.5	5.3	5.5	6.8	6.8	6.8
Percent O_2 at Test Location	7.0	7.0	6.6	8.6	8.7	8.5	8.8	9.0	9.6	9.8	8.7	8.6	8.9	10.0	10.0	10.0
Particulate Results																
Front-half																
Concentration, grains/dscf, x 10^{-3}	1.9	1.3	2.7	0.7	0.5	1.2	3.5	3.9	3.3	4.3	8.3	8.0	8.5	6.5	7.2	7.1
Mass Emission Rate, pounds/hour	0.57	0.39	0.80	0.24	0.19	0.39	1.2	1.4	1.2	1.5	2.9	2.7	3.0	2.3	2.8	2.9
Series Average Mass Emission Rate, lbs/hr		0.59			0.27		1.3		1.4			2.9			2.7	
Total																
Concentrations, grains/dscf, x 10^{-3}	3.8	3.9	7.7	1.8	2.0	3.3	5.5	8.5	7.0	10.3	15.9	13.6	15.5	11.4	14.9	13.7
Mass Emission Rate, pounds/hour	1.1	1.2	2.3	0.65	0.70	1.1	1.9	2.9	2.4	3.6	5.5	4.6	5.4	4.0	5.9	5.5
Series Average Mass Emission Rate, lbs/hr		1.5			0.82		2.4		3.0			5.2			5.1	
NO_x Emissions as NO_2[1]																
Concentration, ppm by volume, dry basis	76.	102.	69.	131.	125.	117.	215.	203.	189.	202.	200.	211.	211.	194.	212.	206.
Concentration, lbs/dscf, x 10^{-6}	9.0	12.2	8.2	15.7	14.9	14.0	25.6	24.2	22.5	24.2	23.8	25.2	25.2	23.2	25.3	24.6
Mass Emission Rate, lbs/hr	19.	26.	17.	39.	37.	32.	61.	59.	55.	59.	58.	60.	61.	57.	70.	69.
Series Average Mass Emission Rate, lbs/hr		21.			36.		60.		57.			60.			65.	

[1]Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY B
SOURCE 2
TABLE 4-6

SUMMARY OF TEST RESULTS

Test Run Number	One	Two	Three	Four	Five	Six	Ten	Eleven	Twelve	Seven	Eight	Nine
Fuel Firing Ratio, % Gas : % Oil	27:73	33:67	33:67	31:69	27:73	27:73	0:100	0:100	0:100	0:100	0:100	0:100
Percent O_2 at Test Location	4.8	5.0	5.1	6.7	6.7	6.6	4.9	5.0	4.7	6.5	6.7	6.6
Particulate Results												
Front-Half												
Concentration, grains/dscf	0.017	0.013	0.011	0.013	0.015	0.014	0.019	0.019	0.015	0.017	0.017	0.016
Mass Emission Rate, pounds/hour	18.2	14.7	12.3	16.2	18.8	17.5	20.4	21.3	16.6	19.9	20.7	19.1
Series Average Mass Emission Rate,lbs/hr		15.1			17.5			19.4			19.9	
Total												
Concentration, grains/dscf	0.019	0.014	0.014	0.013	0.016	0.015	0.019	0.020	0.019	0.018	0.018	0.016
Mass Emission Rate, pounds/hour	20.3	15.0	15.0	16.3	19.3	18.9	20.9	21.9	20.3	21.2	21.3	19.9
Series Average Mass Emission Rate,lbs/hr		16.8			18.2			21.0			20.8	
NO_X Emissions, as NO_2[1]												
Concentration, ppm by volume, dry basis	110.	106.	127.	125.	79.8	115.	131.	133.	140.	130.	132.	127.
Concentration, lbs/dscf, x 10^{-6}	13.2	12.7	15.2	14.9	9.53	13.8	15.6	15.9	16.8	15.5	15.8	15.2
Mass Emission Rate, lbs/hr	98.0	98.1	117.	131.	81.2	118.	121.	123.	129.	130.	135.	129.
Series Average Mass Emission Rate,lbs/hr		104.			110.			124.			131.	

[1]Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1

TABLE 4-7

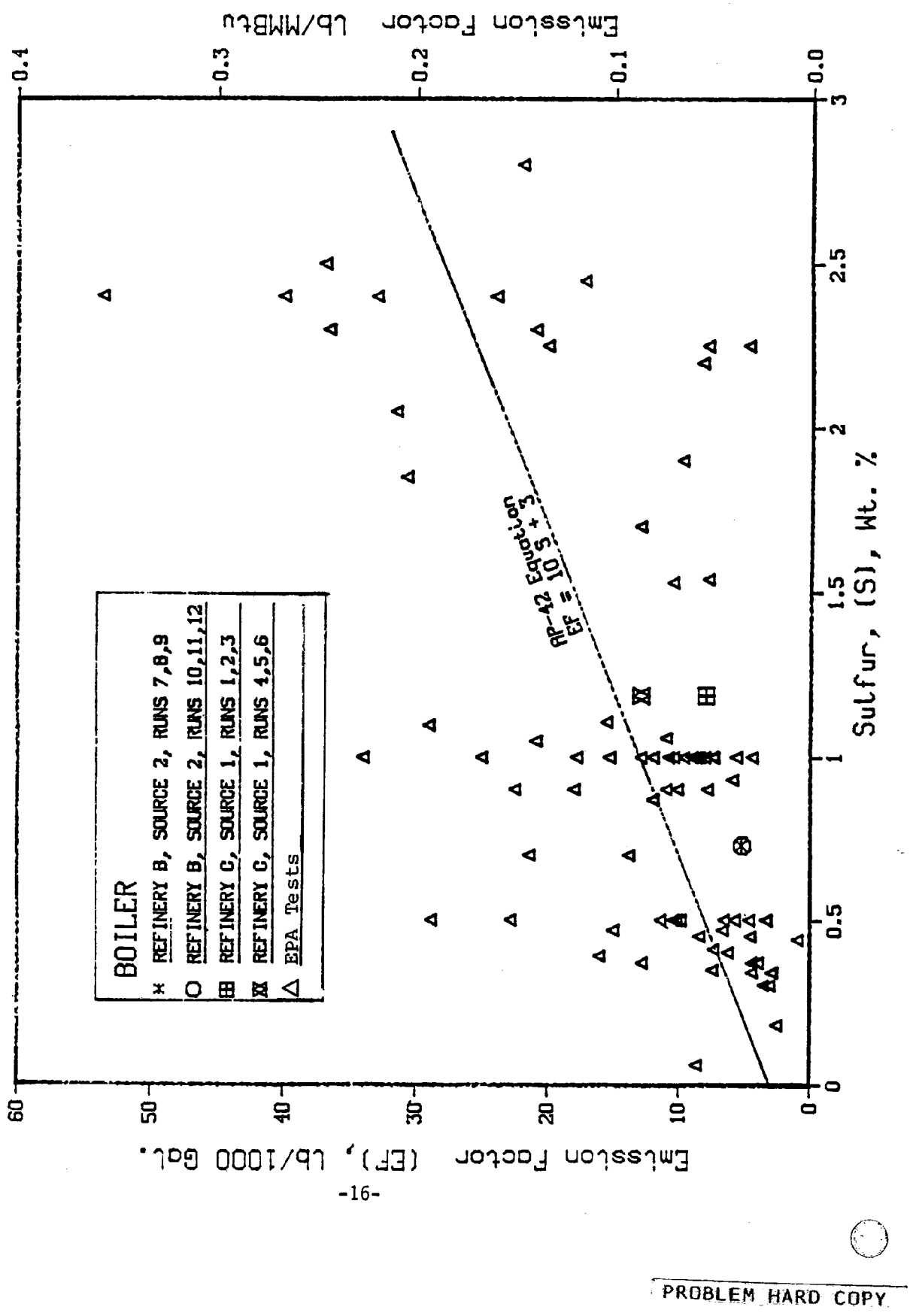
SUMMARY OF TEST RESULTS

Test Run Number	Seven	Eight	Nine	Ten	Eleven	Twelve	One	Two	Three	Four	Five	Six
Fuel Firing Ratio, % Gas : % Oil	47:53	36:64	48:52	43:57	33:67	35:65	0:100	0:100	0:100	0:100	0:100	0:100
Percent O_2 at Test Location	9.2	9.1	9.1	10.5	10.2	9.7	7.5	7.5	7.2	9.7	9.5	9.6
Percent O_2 Exiting Boiler	5.5	5.4	5.4	6.4	6.6	6.5	3.5	4.0	3.5	5.4	5.4	5.5
Particulate Results												
Front-Half												
Concentration, grains/dscf	0.030	0.037	0.035	0.034	0.027	0.029	0.021	0.030	0.027	0.038	0.039	0.031
Mass Emission Rate, pounds/hour	12.2	14.9	13.8	13.2	11.1	12.0	8.29	12.9	11.4	14.6	14.8	11.8
Series Average Mass Emission Rate, lbs/hr		13.6			12.1			10.9			13.7	
Total												
Concentration, grains/dscf	0.031	0.042	0.040	0.035	0.028	0.031	0.027	0.032	0.038	0.041	0.049	0.034
Mass Emission Rate, pounds/hour	12.5	16.8	15.5	13.3	11.3	13.0	10.9	13.5	16.0	15.7	18.5	13.1
Series Average Mass Emission Rate, lbs/hr		14.9			12.5			13.5			15.8	
NO_x Emissions, as NO_2[1]												
Concentration, ppm by volume, dry basis	134.	121.	118.	130.	127.	109.	157.	123.	191.	170.	162.	158.
Concentration, lbs/dscf, x 10^{-6}	16.0	14.4	14.1	15.5	15.1	13.0	18.8	14.7	22.8	20.3	19.3	18.9
Mass Emission Rate, lbs/hr	45.1	40.1	38.6	41.9	43.3	37.9	52.7	43.8	67.4	54.9	51.1	51.0
Series Average Mass Emission Rate, lbs/hr		41.3			41.0			54.6			52.3	

[1]Results shown are averages of the three (3) grab samples.

FIGURE 4-1

COMPARISON OF MEASURED PARTICULATE EMISSIONS TO EPA'S AP-42 CORRELATION FOR NO. 6 OIL-FIRED FURNACES



The impact of fuel mixture on front-half/back-half particulate catches was examined. The percentage front-half to total particulate catch was inversely related to the proportion of gas fired in the boilers:

Refinery	Average % Gas Fired	Front Half:Total Particulate Catch,%
B	15	94
C	20	89
A	71	47

4.2 Size Distribution

4.2.1 Process Heaters

Particle size distribution (PSD) data were obtained only for Refinery A heater (see Table 4-8 below for results summary). Single tests were performed at 70 percent gas : 30-percent oil-firing condition at two different oxygen levels. No PSD data were obtained for Refinery B heater because the extremely low particulate loading (average of 1.2×10^{-4} gr/dscf) prevented the attainment of sufficient mass with the impactor over a reasonable sampling period.

Additional PSD data are included in Appendix A.

TABLE 4-8

REFINERY A SOURCE 1

PARTICLE SIZE DISTRIBUTION DATA

Fuel-Firing Ratio % Gas: % Oil	Percent O_2 at Test Location	Mass Percent Less Than Stated Size			
		0.3 um	1.0 um	3.0 um	10.0 um
70:30	3.9	84	86	87	88
70:30	5.5	70	72	73	76

The above data are presented graphically in Figure 4-2.

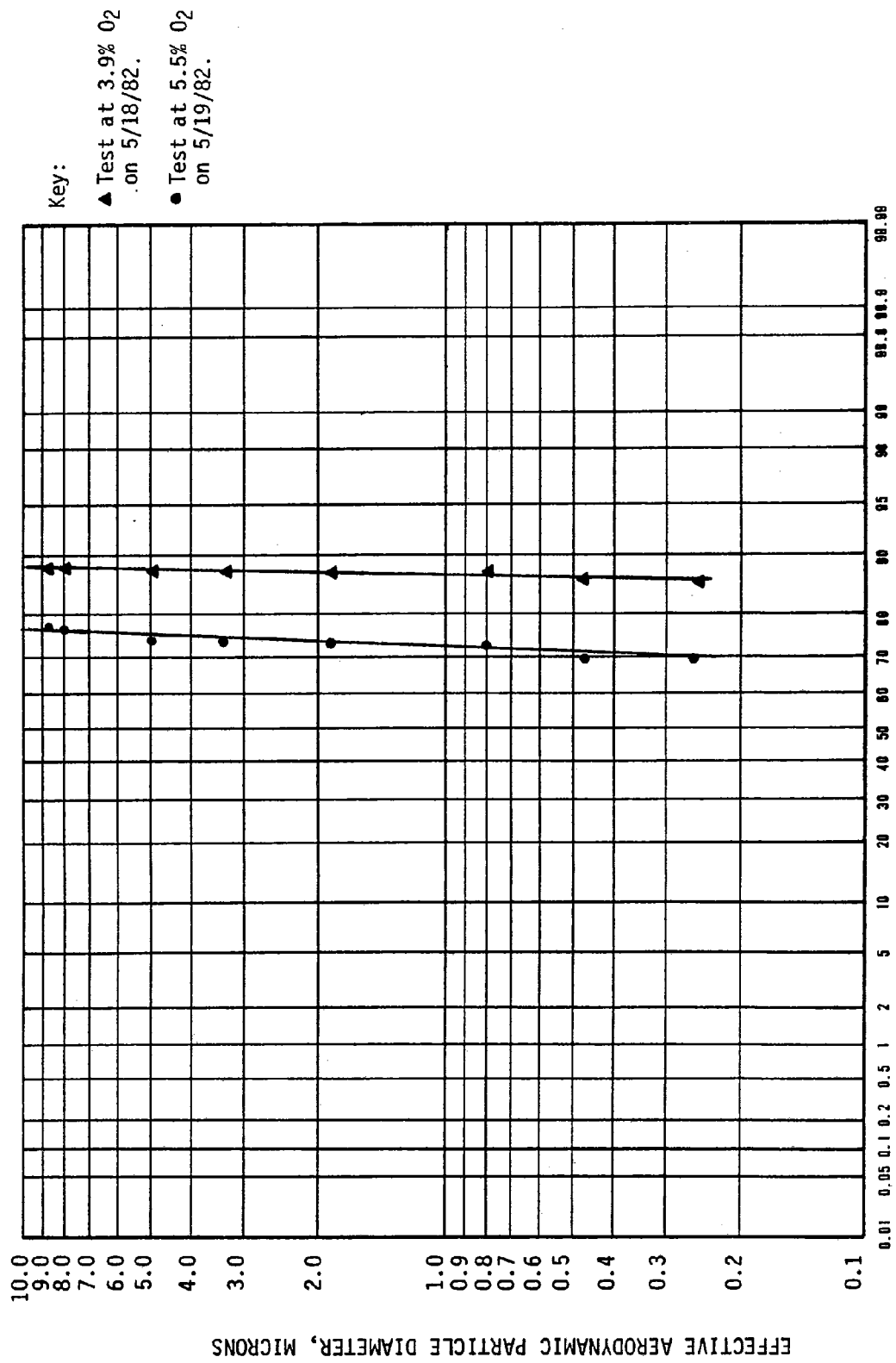


FIGURE 4-2

4.2.2 Boilers

Average PSD data for the three boilers are presented in Table 4-9. Mean mass percent less than 0.3, 1.0, 3.0, and 10 um data are shown for tests performed at each process condition. Detailed information for all PSD tests is contained in Appendix A.

Data from the single PSD test conducted under 100 percent gas-firing conditions are plotted in Figure 4-3. The range, mean, standard deviation, and quartile groups of the PSD data for all mixed fuel and for all 100 percent oil-firing conditions are shown graphically in Figures 4-4 and 4-5, respectively.

The size distributions are combined by fuel fired as shown in Table 4-10:

TABLE 4-10

CUMULATIVE WEIGHT PERCENTAGE LESS THAN DIAMETER BY FUEL CONDITION

Particle Size Range, um	100% Gas	100% Oil	Mixed
≤0.3	73	44 ± 11	44 ± 14
≤1.0	78	55 ± 9	53 ± 13
≤3.0	82	68 ± 7	63 ± 11
≤10.0	85	79 ± 6	72 ± 9

For submicron particles, the data show that a greater weight percentage of smaller particles is formed during gas-firing than for oil- and mixed-fuel-fired conditions. For particles greater than 1 um, no significant differences between fuel types were observed.

Under 100 percent gas-firing conditions, ~ 73 percent of the particles by weight were ≤0.3 um effective aerodynamic diameter (EAD). For oil, 40 to 50 percent of the particles by weight were ≤0.3 um effective aerodynamic diameter. No consistent effects of excess air on PSD were found.

AMERICAN PETROLEUM INSTITUTE

TABLE 4-9

AVERAGE PARTICLE SIZE DISTRIBUTION DATA SUMMARY FOR BOILER SOURCES

Refinery/ Source	Fuel Firing Ratio % Gas : % Oil	Percent O_2 at Boiler	Mass Percent Less than Stated Size and Standard Deviation			
			0.3 um	1.0 um	3.0 um	10.0 um
A/2	100:0	2.9	73	78	82	85
	69:31	5.2	49 ± 9	57 ± 11	63 ± 13	70 ± 12
	75:25	6.5	43 ± 4	55 ± 6	66 ± 8	76 ± 9
	40:60	5.4	38 ± 7	48 ± 6	58 ± 5	70 ± 3
	40:60	6.8	50 ± 3	57 ± 8	66 ± 5	73 ± 2
B/2	31:69	5.0	65 ± 7	61 ± 10	77 ± 11	82 ± 13
	28:72	6.7	28 ± 11	39 ± 11	51 ± 10	64 ± 7
	0:100	4.9	44 ± 17	54 ± 14	64 ± 11	75 ± 8
	0:100	6.6	42 ± 5	55 ± 8	67 ± 9	77 ± 9
C/1	44:56	5.4	29 ± 6	41 ± 8	53 ± 10	66 ± 9
	37:63	6.5	47 ± 4	59 ± 5	68 ± 7	78 ± 8
	0:100	3.7	40 ± 13	55 ± 9	70 ± 4	82 ± 1
	0:100	5.4	50 ± 11	62 ± 9	72 ± 6	82 ± 4

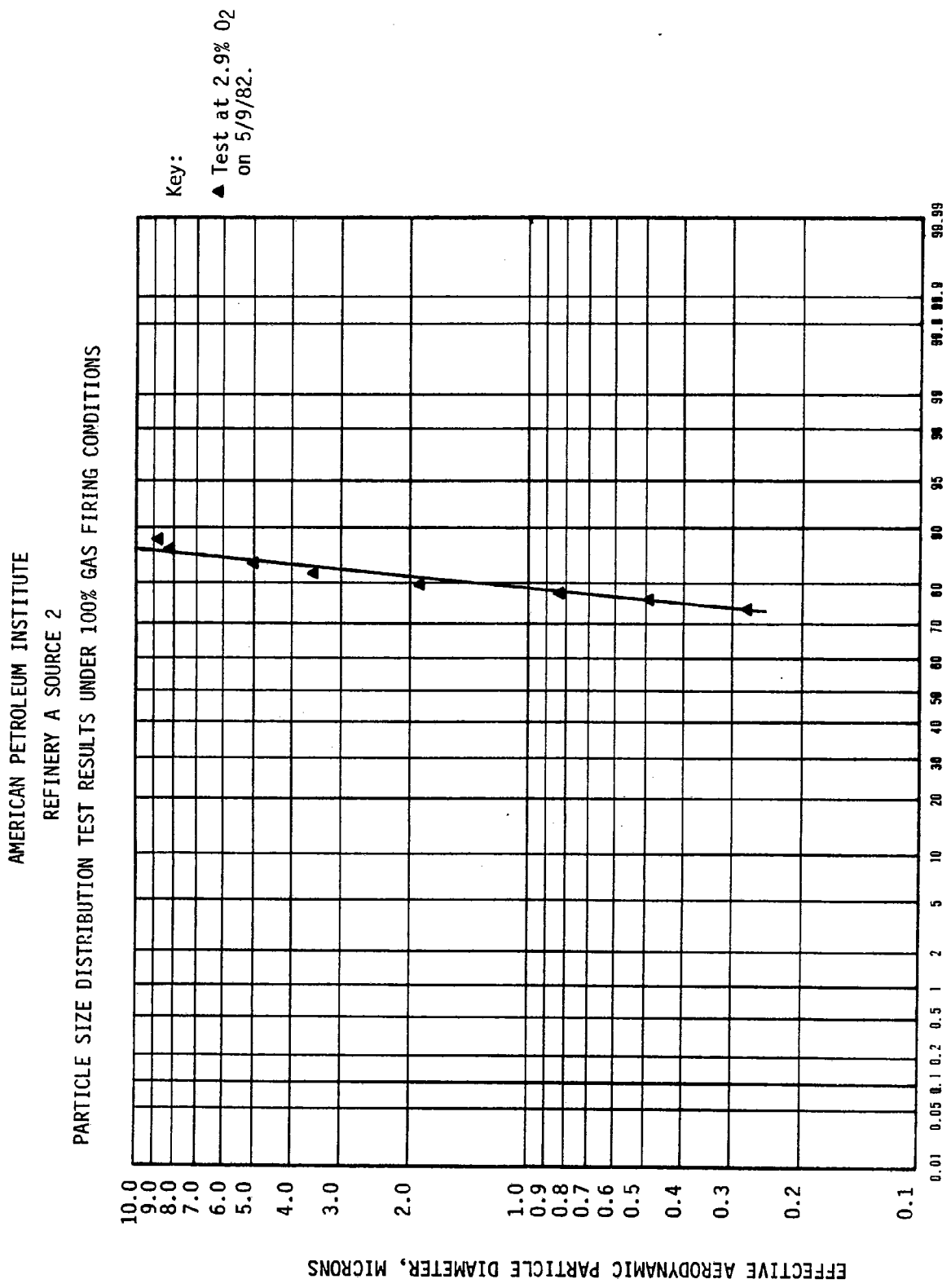


FIGURE 4-3

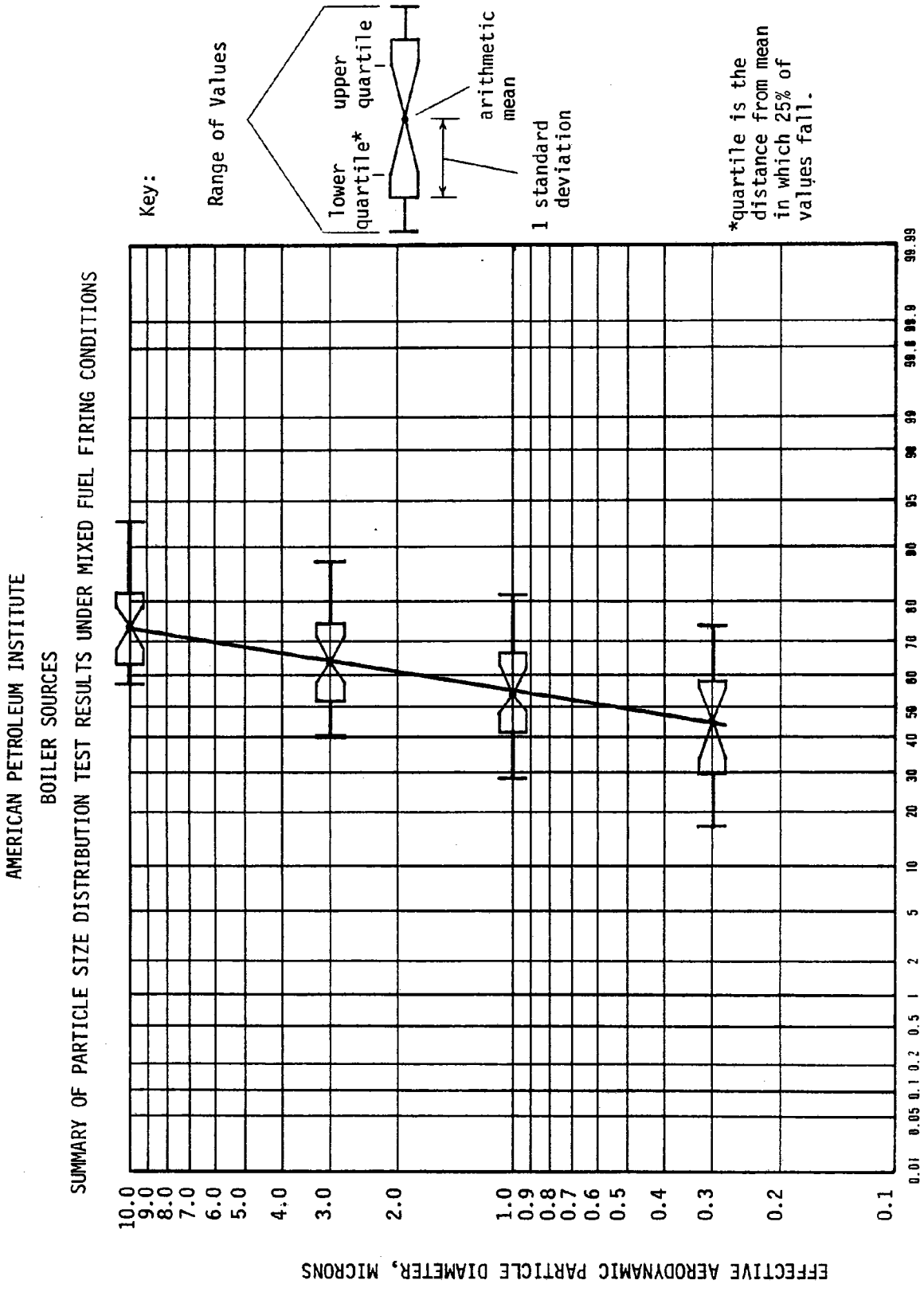


FIGURE 4-4

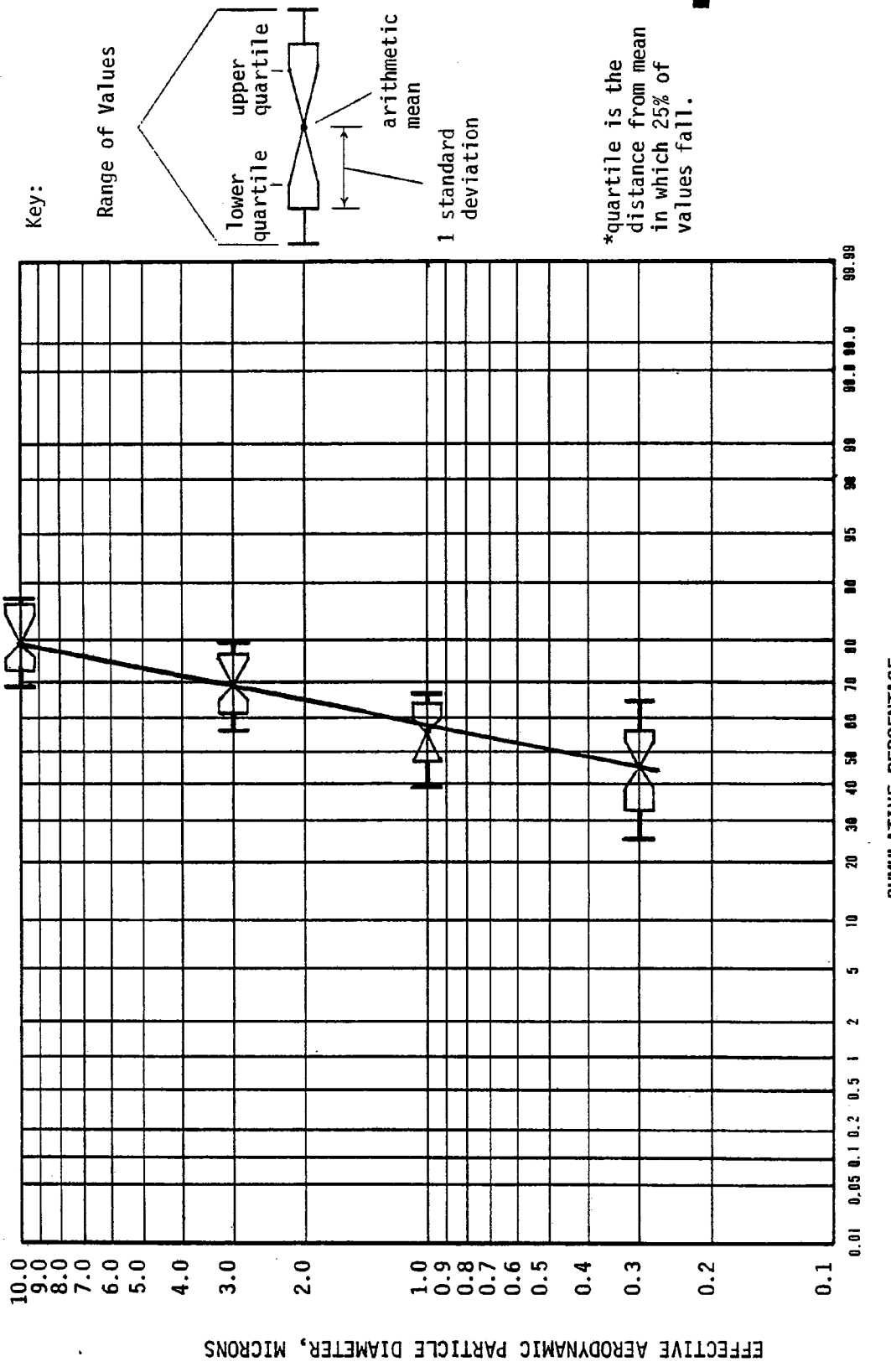


FIGURE 4-5

4.3 Chemical Composition of Particulates

Particulates were analyzed for metal content, sulfates, nitrates and carbon, hydrogen, and nitrogen. The chemical composition of composite fuel oil samples was determined.

4.3.1 Process Heaters

The fuel oil analysis for Refinery A process heater tests is shown in Table 4-11. The fuel was a No. 4 fuel oil and had a relatively low sulfur and ash content. Detailed fuel analysis results are shown in Appendix A.

Particulate chemical analyses are presented for Refinery A heater in Tables 4-12 and 4-13. There was insufficient sample (<20 mg/test) at Refinery B heater (from the 6 to 9 hour-long tests) to conduct tests other than gravimetric analyses.

The total heavy metals content of the front-half particulate sample residues was <1.4 percent by weight for Refinery A heater. Small amounts (0.02 to 0.85 percent by weight) of chromium, copper, nickel, and zinc were detected in the front-half samples residues during some of the tests. It is believed that most of the chromium and nickel found in the Test Run No. 1 sample originated from the stainless steel nozzle of the sampling train since these values were out of line with those determined in the other tests. Essentially no heavy metals were captured in the back-half catch samples. Some arsenic and mercury (0.39 and 0.12 ppm by weight, respectively) were detected in the composite fuel oil sample but not in the source samples. Since arsenic, mercury, and selenium are relatively volatile metals, it is expected that those compounds would not have been effectively captured by an EPA Method 5 particulate train.

Elemental analysis was performed on front- and back-half catches. The results are presented in Table 4-13.

Sulfate was the major component of both front-half and back-half sample residues. The sulfate content of the front-half samples averaged 53 percent (by weight) while the back-half catches averaged 68 percent. The data indicate no effect of excess air or fuel sulfur content on particulate sulfur content. The sulfur content of particulate collected during 100 percent gas-fired conditions was higher than expected based on the typical sulfur content of fuel gas. This could possibly be attributed to the flaking-off of stack sulfur particulate from previous oil-firing

TABLE 4-11

REFINERY "A" FUEL OIL COMPOSITE SAMPLE ANALYSIS

Analyte	Result
Ash, %	<0.01
Carbon, %	86.9
Hydrogen, %	12.3
Nitrogen, %	0.16
Oxygen, %	0.52
Sulfur, %	0.09
Metals, ppm by weight	
Arsenic	0.39
Barium	0.18
Cadmium	<0.04
Chromium	<0.04
Copper	0.10
Lead	<0.04
Mercury	0.12
Nickel	0.08
Selenium	0.19
Vanadium	0.04
Zinc	5.5

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

TABLE 4-12

MISCELLANEOUS ANALYTICAL RESULTS - METALS[1,2]

TEST RUN NUMBER:	One		Four		Seven		Eight	
TEST DATE:	7/14/81		7/16/81		7/18/81		7/18/81	
FUEL FIRING RATIO, % GAS : % OIL:	100:0		94:6		46:54		48:52	
PERCENT O_2 AT TEST LOCATION:	2.3		4.4		3.8		5.2	
RESIDUE CATCH FRACTION ANALYSIS:	Front-half	Back-half	Front-half	Back-half	Front-half	Back-half	Front-half	Back-half
PARTICULATE CATCH RATIO, % FRONT-HALF: BACK-HALF:	74:26		51:49		73:27		74:26	
HEAVY METALS CONTENT, % BY WEIGHT								
Cr	0.85	0.02	0.14	ND	0.09	ND	0.07	ND
Cu	0.03	ND	0.03	ND	ND	ND	0.02	ND
Ni	0.35	ND	ND	ND	0.04	ND	ND	ND
Zn	0.14	ND	0.12	ND	0.15	ND	0.15	ND

[1]Note that barium, cadmium, lead and vanadium were not found in any of the samples.

[2]Key: ND = Not Detected (<0.01% by weight).

AMERICAN PETROLEUM INSTITUTE
REFINERY A SOURCE 1
STACK No. 1 (HEATER)
TABLE 4-13

SUMMARY OF ELEMENTAL AND ION CHROMATOGRAPHIC ANALYTICAL RESULTS

Test Run Number	Test Date	Fuel Firing Ratio % Gas : % Oil/ % O_2	Residue Catch Fraction Analysis	Particulate Catch Ratio % Front-half: % Back-half	Parameter, % by Weight				
					Elemental Analysis[1]			Ion Chromatographic Analysis	
					C	H	N	Sulfate	Nitrate
Two	7/15/81	100:0/2.3	Front-half	61:39	<1	1.4	2.3	44	< 2
			Back-half		20	4.1	3.2	62	< 2
Five	7/16/81	91:9/4.3	Front-half	62:38	<1	2.7	1.4	60	< 2
			Back-half		10	3.1	1.4	73	< 2
Eleven	7/20/81	61:39/4.1	Front-half	54:46	<1	2.7	1.8	49	< 2
			Back-half		7.5	2.8	3.9	76	< 2
Thirteen	7/21/81	58:42/5.4	Front-half	51:49	4.6	3.3	3.1	57	< 2
			Back-half		1.8	3.1	4.4	61	< 2

[1] Elemental analysis results shown are questionable. Large errors due to working with small amounts of residue are probable.

operations. On the other hand, it might be attributed to artifact formation and weighing errors associated with small quantities of material analyzed. No nitrate particulate (<2 pecent) was detected in any samples. The remaining chemical constituents of the particulate were not identified in this study.

4.3.2 Boilers

Metals content, sulfates, nitrates, extractable organics, and elemental analyses were determined. For comparison purposes, the chemical composition of test fuels is shown in Table 4-14. Detailed fuel analyses are presented in Appendix A.

No cadmium, silver, aluminum, calcium, magnesium, tin, or silica was detected in particulate samples from these test boilers (see Table 4-15). Small amounts (<1 percent) of barium, chromium, copper, lead, zinc, and potassium were found in some particulate residues. Greater amounts (up to 2 to 5 percent) of nickel, vanadium, sodium, and iron were measured in some particulate residues. Data from 100 percent oil tests were examined for a metals balance. Metals in the particulate residues were traceable to the fuel burned although a balance was not obtained in all cases. The metals contents of the process fuel gases were less than that of the fuel oils on a comparable Btu basis. As can be seen from Table 4-15, the front-half (filterable particulate) samples contained a greater percentage of metals than did the back-half (condensible particulate) catches in most instances.

The elemental analyses indicate that the carbon, hydrogen, and nitrogen content of the front-half samples is affected by excess air. As excess air was increased, the carbon, hydrogen, and nitrogen content was found to decrease. No such trend was evident for the back-half elemental analysis data. The back-half elemental analysis results for Refineries B and C are believed to contain large ($\pm$ 50 percent) errors. These errors are introduced from accumulative weighing errors on samples in the 1 to 10 mg range in large (100 to 150 mg) containers and from analyzer errors from working at or below the normal limit of quantitation of the instrument. See Table 4-16 for results.

Sulfate particulate was a significant (25 to 83 percent by weight) constituent of front- and back-half catch residues for both gas and oil firing. Excess air levels and the fuel composition had no effect on the wt percent sulfate in the particulate when firing fuel oil (see Table 4-17).

Nitrate was not detected in any sample (<0.1 percent by weight). Chloride analyses were performed on Refinery A particulate catch residues but none was found (<0.1 percent by weight). The remaining chemical constituents of the particulates were not identified.

TABLE 4-14

FUEL OIL COMPOSITE SAMPLES ANALYSIS FOR BOILER SOURCES

Analyte	Results		
	Refinery A	Refinery B	Refinery C
Ash, %	0.02	0.03	0.02
Carbon, %	87.0	86.8	86.8
Hydrogen, %	12.2	11.3	11.2
Nitrogen, %	0.30	0.22	0.18
Oxygen, %	0.26	0.87	0.61
Sulfur,%	0.22	0.73	1.19
Metals, ppm by weight			
Arsenic	<0.2	<0.2	<0.2
Barium	1.9	0.7	0.75
Cadmium	<0.5	<0.5	<0.5
Chromium	<0.5	0.7	<0.5
Copper	3.0	1.5	<0.5
Lead	<0.5	5.4	<0.5
Mercury	0.03	0.05	0.07
Nickel	21	11	11
Selenium	0.26	<0.1	0.49
Vanadium	<0.5	2.1	31
Zinc	10	6.7	1.7

AMERICAN PETROLEUM INSTITUTE

BOILER SOURCES

TABLE 4-15

MISCELLANEOUS ANALYTICAL RESULTS - METALS[1,2]

Refinery/ Source	Test Run Number	Test Date	Fuel Firing Ratio % Gas : % Oil	Boiler % O_2	Particulate Catch Fraction	Particulate Catch Ratio % FH : % BH	METALS CONTENT, % BY WEIGHT									
							Ba	Cr	Cu	Ni	Pb	V	Zn	K	Na	Fe
A/2	Seven	5/8/82	100:0	2.9	Front-half	52:48	ND	0.02	0.01	0.12	ND	0.07	0.16	ND	ND	1.1
	Ten	5/10/82	100:0	4.8	Front-half	35:65	0.48	ND	0.02	0.29	ND	0.18	0.34	ND	ND	0.88
	Thirteen	5/12/82	68:32	5.3	Front-half	63:37	0.53	0.02	0.09	3.1	ND	0.63	0.75	0.14	1.5	4.2
	Fifteen	5/13/82	75:25	6.5	Front-half	50:50	0.54	0.02	0.06	2.9	ND	0.61	0.69	0.34	2.3	4.7
	One	5/4/82	40:60	5.5	Front-half	53:47	0.27	0.05	0.06	3.2	ND	0.66	0.51	0.17	1.4	4.7
	Four	5/6/82	41:59	6.8	Front-half	58:42	0.36	0.02	0.05	3.6	ND	0.75	0.53	0.12	1.4	4.1
B/2	One	12/11/81	27:73	4.8	Front-half	90:10	0.29	0.04	0.07	0.86	0.51	0.96	0.39	---	---	---
					Back-half		0.01	ND	0.14	ND	ND	ND	0.16	---	---	---
	Four	12/13/81	31:69	6.7	Front-half	99:01	0.38	0.05	0.08	1.3	0.58	1.4	0.46	---	---	---
					Back-half		0.06	ND	0.36	ND	ND	ND	0.32	---	---	---
	Ten	12/17/81	0:100	4.9	Front-half	98:02	0.44	0.05	0.06	1.4	0.49	1.3	0.49	---	---	---
					Back-half		0.04	ND	0.24	ND	ND	ND	0.33	---	---	---
	Seven	12/15/81	0:100	6.5	Front-half	94:06	0.34	0.05	0.07	0.14	0.50	1.3	0.48	---	---	---
					Back-half		0.02	ND	0.14	ND	ND	ND	0.24	---	---	---
C/1	Seven	3/3/82	47:53	5.5	Front-half	98:02	0.02	0.02	0.01	0.63	0.02	1.4	0.06	---	---	---
					Back-half		ND	ND	0.07	ND	ND	ND	0.11	---	---	---
	Ten	3/22/82	43:57	6.4	Front-half	99:01	0.03	0.02	0.01	0.16	ND	0.84	0.03	---	---	---
					Back-half		ND	ND	0.16	0.22	ND	0.16	0.24	---	---	---
	One	2/17/82	0:100	3.5	Front-half	76:24	0.05	0.09	0.02	0.23	0.05	1.1	0.09	---	---	---
					Back-half		ND	ND	0.01	ND	ND	0.01	0.04	---	---	---
	Four	2/22/82	0:100	5.4	Front-half	93:07	0.03	0.02	0.01	0.42	ND	1.7	0.04	---	---	---
					Back-half		ND	ND	0.03	ND	ND	ND	0.06	---	---	---

[1]Note that cadmium, silver, aluminum, calcium, magnesium, tin and silica were not found in any samples analyzed.

[2]Key: ND = Not Detected (<0.01% by weight).
--- = Means parameter not run.

AMERICAN PETROLEUM INSTITUTE
BOILER SOURCES
TABLE 4-16

SUMMARY OF ELEMENTAL AND ION CHROMATOGRAPHIC ANALYTICAL RESULTS

Refinery	Test Run Number	Test Date	Fuel Firing Ratio % Gas : % Oil	Percent O_2 Exiting Boiler (at test point)	Residue Catch Fraction Analysis	Particulate Catch Ratio % Front-half: % Back-half	PARAMETER, % BY WEIGHT					
							Analysis			Ion Chromatographic Analysis[1]		
							C	H	N	Sulfate	Nitrate	Chloride
A	Eight	5/8/82	100:0	3.0	Front-half	32:68	24	6.9	0.9	41	ND	ND
				(7.0)	Back-half		13	4.2	1.8	49	ND	ND
	Eleven	5/10/82	100:0	4.6	Front-half	27:73	23	7.2	6.9	42	ND	ND
				(8.7)	Back-half		12	4.0	1.2	32	ND	ND
	Fourteen	5/12/82	70:30	5.1	Front-half	46:54	13	3.8	0.8	39	ND	ND
				(9.0)	Back-half		5.1	4.5	0.6	28	ND	ND
	Sixteen	5/13/82	74:26	6.4	Front-half	42:58	8.5	2.4	0.1	32	ND	ND
				(9.8)	Back-half		3.3	3.8	1.0	43	ND	ND
	Two	5/5/82	40:60	5.3	Front-half	59:41	6.9	2.0	0.4	31	ND	ND
				(8.6)	Back-half		3.1	4.1	0.9	46	ND	ND
	Five	5/7/82	40:60	6.8	Front-half	48:52	5.9	2.3	0.3	30	ND	ND
				(10.0)	Back-half		2.4	4.2	0.8	46	ND	ND
B	Two	12/12/81	33:67	---	Front-half	98:02	13	3.1	0.4	45	ND	ND
				(5.0)	Back-half		42	6.6	2.7	36	ND	ND
	Five	12/14/81	27:73	---	Front-half	97:03	8.7	1.3	0.2	32	ND	ND
				(6.7)	Back-half		22	4.3	2.5	71	ND	ND
	Eleven	12/17/81	0:100	---	Front-half	97:03	4.3	1.3	0.2	25	ND	ND
				(5.0)	Back-half		21	5.2	2.7	70	ND	ND
	Eight	12/16/81	0:100	---	Front-half	97:03	3.1	2.1	0.3	41	ND	ND
				(6.7)	Back-half		43	6.5	2.8	62	ND	ND
C	Eight	3/4/82	36:54	9.1	Front-half	88:12	25	2.3	0.4	35	ND	ND
				(5.4)	Back-half		4.2	3.6	0.1	75	ND	ND
	Eleven	3/23/82	33:67	10.2	Front-half	98:02	6.9	2.4	0.2	26	ND	ND
				(6.6)	Back-half		27	5.4	7.1	49	ND	ND
	Two	2/18/82	0:100	7.5	Front-half	95:05	15	2.0	0.2	60	ND	ND
				(4.0)	Back-half		21	3.4	2.6	40	ND	ND
	Five	2/22/82	0:100	9.5	Front-half	80:20	5.0	2.6	0.1	60	ND	ND
				(5.4)	Back-half		0.8	1.2	0.1	83	ND	ND

[1] ND = Not Detected (<0.1% by weight).

TABLE 4-17

PERCENT FUEL SULFUR CONVERTED TO PARTICULATE

Refinery/ Source	Fuel Oil Sulfur Content, %	% Oil Fired in Boiler	% O_2 Exiting Boiler	Sulfate Particulate Emission Rate , as S, lb/hr	Fuel Sulfur Input to Boiler, lb/hr	% Fuel Sulfur Converted to Particulate
A/2	0.22	30	5.1	0.32	7.0	4.6
		26	6.4	0.46	5.6	8.2
		60	5.3	0.57	13	4.5
		60	6.8	0.76	13	5.9
B/2	0.73	67	5.0	2.2	148	1.5
		73	6.7	2.1	151	1.4
		100	5.0	1.9	218	0.9
		100	6.7	3.0	221	1.3
C/1	1.19	54	5.4	2.2	62	3.6
		67	6.6	1.0	64	1.6
		100	4.0	2.7	130	2.0
		100	5.4	4.0	99	4.0

Analytical results (Table 4-18) showed that a greater percentage of solvent extractable material was produced under gas-firing conditions than for oil. Back-half catches contained a higher proportion of solvent extractables than did the front-half samples. Excess air levels had no effect on the solvent extractable content of the particulate.

4.4 NO_x Emissions

The NO_x emission test results are presented in this section. The data are compared to EPA AP-42 emission factors in Tables 4-19 and 4-20. More detailed NO_x information is contained in Appendix A.

4.4.1 Heaters and Boilers

Survey findings for all sources are compared to AP-42 emission factors in Tables 4-19 and 4-20.

TABLE 4-19

COMPARISON OF MEASURED VS. AP-42 NO_x EMISSION FACTORS

Refinery/ Source	Fuel Firing Condition % Gas : % Oil	Percent of Predicted AP-42 Emission Factor[1]
A/1 (Heater)	95:5	16
	53:47	35
B/1 (Heater)	100:0	100
A/2 (Boiler)	100:0	23
	72:28	63
	40:60	80
B/2 (Boiler)	30:70	31
	0:100	32
C/1 (Boiler)	40:60	76
	0:100	129

[1]For mixed-fuel-firing conditions, measured values are compared to prorated AP-42 factors.

AMERICAN PETROLEUM INSTITUTE
BOILER SOURCES
TABLE 4-18
SOLVENT EXTRACTABLES RESULTS

Refinery	Test Run Number	Test Date	Fuel Firing Ratio % Gas : % Oil	Percent O_2 Exiting Boiler (at test point)	Particulate Catch Ratio % Front-half:% Back-half	Residue Catch Fraction Analysis	Solvent Extractables, % by Weight[1]
A	Nine	5/9/82	100:0	2.9 (6.6)	35:65	Front-half	13
						Back-half	32
	Twelve	5/11/82	100:0	4.6 (8.5)	36:64	Front-half	53
						Back-half	88
	Three	5/5/82	59:41	5.5 (8.9)	55:45	Front-half	15
						Back-half	56
	Six	5/7/82	58:42	6.8 (10.0)	52:48	Front-half	12
						Back-half	31
B	Three	12/12/81	33:67	--- (5.1)	82:18	Front-half	0.8
						Back-half	7.1
	Six	12/14/81	27:73	--- (6.6)	93:07	Front-half	0.2
						Back-half	73
	Twelve	12/18/81	0:100	--- (4.7)	82:18	Front-half	0.8
						Back-half	77
	Nine	12/16/81	0:100	--- (6.6)	96:04	Front-half	0.8
						Back-half	61
C	Nine	3/4/82	48:52	5.4 (9.1)	89:11	Front-half	2.3
						Back-half	79
	Twelve	3/23/82	37:63	6.5 (9.7)	92:08	Front-half	0.9
						Back-half	73
	Three	2/19/82	0:100	3.5 (7.2)	71:29	Front-half	0.05
						Back-half	6.4
	Six	2/23/82	0:100	5.5 (9.6)	90:10	Front-half	0.09
						Back-half	17

[1]Large weighing errors (±50%) may be present in results for those samples containing <10 mg of particulate.

The above data indicate that measured NO_x emissions are usually lower than predicted by AP-42. Data in Table 4-20 show that NO_x emissions increase with rising excess air levels and quantity of oil fired.

The reader is referred to AP-42 for a discussion of emissions dependency on the grade and composition of fuel, the type and size of boiler, the firing and loading practices used, and the level of equipment maintenance. Some of the differences between measured and predicted NO_x emissions shown in the above table are due to the way AP-42 categorizes heaters and boilers. This is especially true for Refinery/Source A/1 and A/2 when firing gas.

AMERICAN PETROLEUM INSTITUTE

TABLE 4-20

SUMMARY OF NO_x EMISSION FACTORS FROM PROCESS HEATERS AND BOILERS

Refinery	Source	Test Run Numbers	Fuel Firing Ratio % Gas : % Oil	Percent O_2 at Test Location (at Boiler)	Heat Input Rate 10^6 BTU/hr	Fuel Firing Rate: Gas $10^6 ft^3/hr$	Fuel Firing Rate: Oil $10^3 gph$	NO_x Emission Factors, as NO_2: Measured lb/10^6BTU	EPA[1] lb/10^6BTU	Measured lb/10^6 SCF gas (lb/10^3 gal oil)	EPA[2] lb/10^6 SCF gas: lb/10^3 gal oil
A	1 (Heater)	1,2,3	97:3	2.0	262	0.212	0.054	0.048	0.42	---	490:105
		4,5,6	93:7	4.0	257	0.200	0.125	0.088	0.42	---	476:105
		7,9,11[5]	51:49	4.0	270	0.115	0.914	0.18	0.58	---	532:105
		8,12,13	54:46	5.5	252	0.113	0.802	0.21	0.55	---	473:105
B	1 (Heater)	4,5,6	100:0	4.1	15	0.015	---	0.148	0.117-0.225	151	120-230:---
		1,2,3	100:0	6.0	16	0.016	---	0.149	0.117-0.225	152	120-230:---
A	2 (Boiler)	7,8,9	100:0	6.8 (2.9)	199	0.181	---	0.11	0.55	110	602:---
		10,11,12	100:0	8.6 (4.7)	204	0.185	---	0.18	0.57	180	630:---
		13,14	69:31	8.9 (5.2)	196	0.123	0.411	0.31	0.48	---	576:58[3]
		15,16	75:25	9.7 (6.5)	194	0.132	0.328	0.29	0.48	---	567:58
		1,2,3	40:60	8.7 (5.5)	182	0.066	0.737	0.33	0.42	---	518:58
		4,5,6	40:60	10.0 (6.8)	187	0.068	0.758	0.35	0.43	---	532:58
B	2 (Boiler)	1,2,3	31:69	5.0	549	0.114	2.53	0.19	0.62	---	630:105
		4,5,6	29:71	6.7	541	0.103	2.59	0.20	0.62	---	609:105
		10,11,12	0:100	4.9	560	---	3.75	0.22	0.70	(33)	---:105
		7,8,9	0:100	6.6	567	---	3.80	0.23	0.70	(35)	---:105
C	1 (Boiler)	7,8,9	43:57	9.1 (5.4)	172	0.072	0.653	0.24	0.35	---	525:35[4]
		10,11,12	37:63	10.1 (6.5)	160	0.057	0.674	0.26	0.31	---	469:35
		1,2,3	0:100	7.3 (3.7)	203	---	1.36	0.27	0.23	(40)	---:35
		4,5,6	0:100	9.6 (5.4)	155	---	1.04	0.34	0.23	(50)	---:35

[1]Calculated using the following equation:

$$\frac{\text{lb } NO_x}{10^6 \text{ BTU}} = \frac{(\text{Gas Fired Duty})(\text{AP-42 Gas Emission Factor}) + (\text{Oil Fired Duty})(\text{AP-42 Oil Emission Factor})}{\text{TOTAL FIRED DUTY}}$$

[2]Values obtained from AP-42 Third Edition, April 1981, assuming all units to be non-tangentially fired. Gas emission factors were calculated by correcting the maximum gross load boiler emission factor for units >100 x 10^6 BTU/hr (= 700 lb $NO_2/10^6$ BTU) with a load reduction coefficient determined from actual load conditions.

[3]Oil emission factor based on Refinery A, Source 2 fuel composition of N content = 0.30 wt % and lb $NO_x/10^3$ gal oil = $22 + 400N^2 = 58$

[4]Oil emission factor based on Refinery C, Source 1 fuel composition of N content = 0.18 wt % and lb $NO_x/10^3$ gal oil = $22 + 400N^2 = 35$

[5]Run 10 was discounted because of process swings during test.

APPENDIX A

DETAILED TEST DATA AND TEST RESULT SUMMARIES

APPENDIX A

TABLE OF CONTENTS

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

APPENDIX A

TABLE OF CONTENTS
(continued)

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1

Table A-1

SUMMARY OF PARTICULATE TEST DATA

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	7/14/81	7/15/81	7/15/81
Test Period	1328-1818	0855-1325	1433-1950
Sampling Data			
Sampling Duration, minutes	240.0	240.0	240.0
Nozzle Diameter, inches	0.562	0.562	0.555
Barometric Pressure, inches mercury	29.70	29.77	29.77
Average Orifice Pressure Differential, inches water	1.68	1.65	1.65
Average Dry Gas Temperature at Meter, °F	96.	97.	95.
Total Water Collected by Train, ml	585.5	648.4	625.0
Standard Volume of Water Vapor Collected, cubic feet	27.6	30.5	27.7
Dry Gas Meter Calibration Factor, dimensionless	0.994	0.994	0.994
Sample Volume at Meter Conditions, cubic feet	167.6	164.7	164.7
Sample Volume at Standard Conditions, cubic feet[1]	157.8	155.0	155.7
Gas Stream Composition			
CO_2, percent by volume	8.8	8.7	8.8
O_2, percent by volume	2.3	2.3	2.3
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	88.9	89.0	88.9
Moisture in Gas Stream, percent by volume	14.9	16.5	15.9
Mole Fraction of Dry Gas	0.851	0.836	0.841
Molecular Weight of Dry Gas	29.5	29.5	29.5
Molecular Weight of Wet Gas	27.8	27.6	27.7
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.43	- 0.41	- 0.41
Absolute Pressure, inches mercury	29.7	29.7	29.7
Average Temperature, °F	324.	329.	327.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	24.0	24.0	24.0
Velocity at Actual Conditions, feet/second	10.6	11.0	10.9
Stack/duct Cross-Sectional Area, square feet	113.1	113.1	113.1
Volumetric Flow, Wet Actual cubic feet/minute	71,900.	74,600.	74,100.
Volumetric Flow, Dry Standard cubic feet/minute	40,900.	41,500.	41,600.
Percent Isokinetic	105.6	102.2	105.0
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % oil	100:0	100:0	91:9
Percent O_2 at test location	2.3	2.3	2.3

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-2

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	7/14/81	7/15/81	7/15/81
Test Time	1328-1818	0855-1325	1433-1950
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute (1)	40,900.	41,500.	41,600.
Wet Actual Cubic Feet/Minute	71,900.	74,600.	74,100.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0264	0.0095	0.0102
Front-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0063
Filter Catch Wt., grams	0.0042	0.0062	0.0055
Front-Half Catch Wt. Sub-total, grams	0.0306	0.0157	0.0220
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	---	0.0002
Impinger Contents/Wash Residue Wt., grams	0.0070	0.0061	0.0071
Back-Half Acetone Wash Residue Wt., grams	0.0035	0.0038	0.0015
Back-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0027
Back Half Catch Wt. Sub-total, grams	0.0105	0.0099	0.0115
Total Catch Weight, grams	0.0411	0.0256	0.0335
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	3.0	1.6	2.2
Mass Emission Rate, pounds/hour	1.1	0.56	0.78
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	4.0	2.5	3.3
Mass Emission Rate, pounds/hour	1.4	0.91	1.2
NO_X Emissions, as NO_2 (2)			
Concentration, Parts/million by Volume, dry basis	30.	51.	42.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	3.6	6.1	5.0
Mass Emission Rate, Pounds/Hour	8.8	15.	12.

(1) Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
(2) Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1

Table A-3

SUMMARY OF PARTICULATE TEST DATA

	4	5	6
Test Data			
Test Run Number	4	5	6
Test Date	7/16/81	7/16/81	7/17/81
Test Period	0843-1321	1402-1825	0925-1405
Sampling Data			
Sampling Duration, minutes	240.0	240.0	240.0
Nozzle Diameter, inches	0.562	0.555	0.562
Barometric Pressure, inches mercury	29.75	29.75	29.88
Average Orifice Pressure Differential, inches water	1.99	1.99	2.39
Average Dry Gas Temperature at Meter, °F	92.	89.	93.
Total Water Collected by Train, ml	660.0	655.0	715.0
Standard Volume of Water Vapor Collected, cubic feet	31.1	30.8	33.7
Dry Gas Meter Calibration Factor, dimensionless	0.994	0.994	0.994
Sample Volume at Meter Conditions, cubic feet	181.9	181.0	196.6
Sample Volume at Standard Conditions, cubic feet[1]	172.7	172.9	187.5
Gas Stream Composition			
CO_2, percent by volume	7.8	7.9	8.1
O_2, percent by volume	4.4	4.3	4.3
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	87.8	87.8	87.6
Moisture in Gas Stream, percent by volume	15.2	15.1	15.2
Mole Fraction of Dry Gas	0.848	0.849	0.848
Molecular Weight of Dry Gas	29.4	29.4	29.5
Molecular Weight of Wet Gas	27.7	27.7	27.7
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.42	- 0.42	- 0.43
Absolute Pressure, inches mercury	29.7	29.7	29.9
Average Temperature, °F	338.	339.	336.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	24.0	24.0	24.0
Velocity at Actual Conditions, feet/second	12.2	12.1	13.1
Stack/duct Cross-Sectional Area, square feet	113.1	113.1	113.1
Volumetric Flow, Wet Actual cubic feet/minute	82,700.	82,400.	89,500.
Volumetric Flow, Dry Standard cubic feet/minute	46,000.	45,900.	50,200.
Percent Isokinetic	102.6	105.7	102.2
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % oil	94:6	91:9	94:6
Percent O_2 at test location	4.4	4.3	4.3

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-4

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	4	5	6
Test Date	7/16/81	7/16/81	7/17/81
Test Time	0843-1321	1402-1825	0952-1406
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	46,000.	45,900.	50,200.
Wet Actual Cubic Feet/Minute	82,700.	82,400.	89,500.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0044	0.0077	0.0072
Front-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0014
Filter Catch Wt., grams	0.0029	0.0066	0.0075
Front-Half Catch Wt. Sub-total, grams	0.0073	0.0143	0.0161
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	---	0.0003
Impinger Contents/Wash Residue Wt., grams	0.0033	0.0068	0.0066
Back-Half Acetone Wash Residue Wt., grams	0.0036	0.0021	0.0013
Back-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0039
Back Half Catch Wt. Sub-total, grams	0.0069	0.0089	0.0121
Total Catch Weight, grams	0.0142	0.0232	0.0282
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	0.7	1.3	1.3
Mass Emission Rate, pounds/hour	0.26	0.50	0.57
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	1.3	2.1	2.3
Mass Emission Rate, pounds/hour	0.50	0.81	0.99
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	64.	59.	77.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	7.6	7.0	9.2
Mass Emission Rate, Pounds/Hour	21.	19.	28.

[1] Standard Conditions = 68°F (20°C) and 29.92 Inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-5

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	7	9	11
Test Date	7/18/81	7/19/81	7/20/81
Test Period	1100-1524	0838-1254	1001-1421
Sampling Data			
Sampling Duration, minutes	240.0	240.0	240.0
Nozzle Diameter, inches	0.555	0.555	0.562
Barometric Pressure, inches mercury	29.84	29.86	29.86
Average Orifice Pressure Differential, inches water	2.53	2.41	2.66
Average Dry Gas Temperature at Meter, °F	96.	98.	98.
Total Water Collected by Train, ml	751.0	745.5	797.5
Standard Volume of Water Vapor Collected, cubic feet	35.4	35.1	37.5
Dry Gas Meter Calibration Factor, dimensionless	0.994	0.994	0.994
Sample Volume at Meter Conditions, cubic feet	202.9	200.1	209.9
Sample Volume at Standard Conditions, cubic feet[1]	191.7	188.8	198.5
Gas Stream Composition			
CO_2, percent by volume	10.9	10.5	10.3
O_2, percent by volume	3.8	4.1	4.1
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	85.3	85.4	85.6
Moisture in Gas Stream, percent by volume	15.6	15.7	15.9
Mole Fraction of Dry Gas	0.844	0.843	0.841
Molecular Weight of Dry Gas	29.9	29.8	29.8
Molecular Weight of Wet Gas	28.0	28.0	27.9
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.43	- 0.44	- 0.44
Absolute Pressure, inches mercury	29.8	29.8	29.8
Average Temperature, °F	333.	339.	338.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	24.0	24.0	24.0
Velocity at Actual Conditions, feet/second	13.1	13.4	14.1
Stack/duct Cross-Sectional Area, square feet	113.1	113.1	113.1
Volumetric Flow, Wet Actual cubic feet/minute	89,100.	90,900.	95,800.
Volumetric Flow, Dry Standard cubic feet/minute	49,900.	50,500.	53,100.
Percent Isokinetic	107.8	104.9	102.2
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % Oil	46:54	46:54	61:39
Percent O_2 at test location	3.8	4.1	4.1

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-6

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	7	9	11
Test Date	7/18/81	7/19/81	7/20/81
Test Time	1100-1524	0838-1254	1001-1421
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	49,900.	50,500.	53,100.
Wet Actual Cubic Feet/Minute	89,100.	90,900.	95,800.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0099	0.0063	0.0095
Front-Half Methylene Chloride Wash Residue Wt., grams	---	0.0013	---
Filter Catch Wt., grams	0.0132	0.0077	0.0052
Front-Half Catch Wt. Sub-total, grams	0.0231	0.0153	0.0147
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	0.0004	---
Impinger Contents/Wash Residue Wt., grams	0.0070	0.0170	0.0084
Back-Half Acetone Wash Residue Wt., grams	0.0015	0.0009	0.0042
Back-Half Methylene Chloride Wash Residue Wt., grams	---	0.0026	---
Back Half Catch Wt. Sub-total, grams	0.0085	0.0209	0.0126
Total Catch Weight, grams	0.0316	0.0362	0.0273
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	1.9	1.3	1.1
Mass Emission Rate, pounds/hour	0.80	0.54	0.52
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	2.5	3.0	2.1
Mass Emission Rate, pounds/hour	1.1	1.3	0.97
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	112.	142.	138.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	13.	17.	17.
Mass Emission Rate, Pounds/Hour	40.	51.	53.

[1] Standard Conditions = 68°F (20°C) and 29.92 Inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-7

SUMMARY OF PARTICULATE TEST DATA

	8	12	13
Test Data			
Test Run Number	8	12	13
Test Date	7/18/81	7/21/81	7/21/81
Test Period	1616-1852	0824-1239	1317-1728
Sampling Data			
Sampling Duration, minutes	144.0	240.0	240.0
Nozzle Diameter, inches	0.562	0.562	0.555
Barometric Pressure, inches mercury	29.84	29.84	29.84
Average Orifice Pressure Differential, inches water	2.48	2.51	2.70
Average Dry Gas Temperature at Meter, °F	91.	96.	96.
Total Water Collected by Train, ml	439.5	677.0	752.0
Standard Volume of Water Vapor Collected, cubic feet	20.7	31.9	35.4
Dry Gas Meter Calibration Factor, dimensionless	0.994	0.994	0.994
Sample Volume at Meter Conditions, cubic feet	121.4	203.0	211.3
Sample Volume at Standard Conditions, cubic feet[1]	116.0	192.4	200.2
Gas Stream Composition			
CO_2, percent by volume	10.4	9.7	9.9
O_2, percent by volume	5.2	5.5	5.4
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	84.4	84.8	84.7
Moisture in Gas Stream, percent by volume	15.1	14.2	15.0
Mole Fraction of Dry Gas	0.849	0.858	0.850
Molecular Weight of Dry Gas	29.9	29.8	29.8
Molecular Weight of Wet Gas	28.1	28.1	28.0
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.43	- 0.45	- 0.44
Absolute Pressure, inches mercury	29.8	29.8	29.8
Average Temperature, °F	338.	349.	345.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	24.0	24.0	24.0
Velocity at Actual Conditions, feet/second	13.2	13.6	14.1
Stack/duct Cross-Sectional Area, square feet	113.1	113.1	113.1
Volumetric Flow, Wet Actual cubic feet/minute	89,700.	92,100.	95,900.
Volumetric Flow, Dry Standard cubic feet/minute	50,200.	51,400.	53,200.
Percent Isokinetic	105.4	102.4	105.5
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % Oil	48:52	57:43	58:42
Percent O_2 at test location	5.2	5.5	5.4

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE NO. 1
STACK NO. 1
Table A-8

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

Test Data			
Test Run Number	8	12	13
Test Date	7/18/81	7/21/81	7/21/81
Test Time	1616-1852	0824-1239	1317-1728
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	50,200.	51,400.	53,200.
Wet Actual Cubic Feet/Minute	89,700.	92,100.	95,900.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0059	0.0114	0.0077
Front-Half Methylene Chloride Wash Residue Wt., grams	---	0.0017	---
Filter Catch Wt., grams	0.0064	0.0051	0.0032
Front-Half Catch Wt. Sub-total, grams	0.0123	0.0182	0.0109
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	0.0002	---
Impinger Contents/Wash Residue Wt., grams	0.0026	0.0076	0.0070
Back-Half Acetone Wash Residue Wt., grams	0.0017	0.0009	0.0034
Back-Half Methylene Chloride Wash Residue Wt., grams	---	0.0016	---
Back Half Catch Wt. Sub-total, grams	0.0043	0.0103	0.0104
Total Catch Weight, grams	0.0166	0.0285	0.0213
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	1.6	1.5	0.8
Mass Emission Rate, pounds/hour	0.70	0.64	0.38
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	2.2	2.3	1.6
Mass Emission Rate, pounds/hour	0.95	1.0	0.75
NO_X Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	126.	162.	136.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	15.	19.	16.
Mass Emission Rate, Pounds/Hour	45.	60.	52.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY A SOURCE 1

Table A-9

PARTICLE SIZE DISTRIBUTION DATA[1]

Date	Fuel Firing Ratio %Gas:%Oil	Percent O_2 at Test Location	Mass Percent Less than Stated Size			
			0.3 um	1.0 um	3.0 um	10. um
7/15/81	96:4[2]	2.3	13	18	28	37
7/16/81	93:7	4.4	3.8	18	44	78
7/18/81	46:54	3.8	12	29	50	71
7/21/81	58:42	5.5	10	29	54	80

[1]This data is questionable since no impactor preseparator was used during these tests. Some large particle bounce-off and reintrainment may have occurred.

[2]Results from this test are suspect since several large particulate flakes, apparently originating from process equipment surfaces, were collected on the top stage of the impactor.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-10

PARTICLE SIZE DISTRIBUTION*

Run: One

Date: 5/18/82

Traverse Point No. Sampled: B-3 A-4

Fuel Firing Ratio, %Gas:%Oil 70:30

Percent O_2 (at test location) 3.9

Dry Standard Cubic Feet/Minute 48,800.

Wet Actual Cubic Feet/Minute 90,700.

Sample Flow Rate (at stack conditions): 1.13 cfm

Barometric Pressure(in. Hg)	29.99
Stack Temperature(^{o}F)	357.
Sample Time(min.)	600.
Sample Volume(cf)	371.2
Moisture(%H_2O)	16.8
Meter Temperature(^{o}F)	81.
Flow Setting,ΔH(in. H_2O)	1.3
Nozzle Diameter(in.)	0.490
Static Pressure(in. H_2O)	-0.40
Meter γ	0.998
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	5.1	12.5	87.5	8.5
2	0.0	0.0	87.5	7.9
3	0.2	0.5	87.0	4.9
4	0.1	0.2	86.8	3.3
5	0.3	0.7	86.1	1.8
6	0.0	0.0	86.1	0.79
7	0.3	0.7	85.4	0.47
8	0.4	1.0	84.4	0.24
Backup Filter	34.6	84.4	0.0	----
TOTAL	41.0	----	----	----

*Data plotted in Figure 4-2.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-11

PARTICLE SIZE DISTRIBUTION *

Run: Two

Date: 5/19/82

Traverse Point No. Sampled: B-2 C-3

Fuel Firing Ratio, %Gas:%Oil 70:30

Percent O_2 (at test location) 5.5

Dry Standard cubic Feet/Minute 54,000.

Wet Actual Cubic Feet/Minute 98,600.

Sample Flow Rate (at stack conditions): 1.10 cfm

Barometric Pressure(in. Hg)	29.95
Stack Temperature(^{o}F)	814.
Sample Time(min.)	382.
Sample Volume(cf)	234.6
Moisture(%H_2O)	15.5
Meter Temperature(^{o}F)	79.
Flow Setting,ΔH(in. H_2O)	1.3
Nozzle Diameter(in.)	0.490
Static Pressure(in. H_2O)	-0.42
Meter γ	0.998
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	6.3	22.9	77.1	8.6
2	0.5	1.8	75.3	8.0
3	0.5	1.8	73.5	5.0
4	0.2	0.7	72.8	3.3
5	0.2	0.7	72.1	1.8
6	0.1	0.4	71.7	0.80
7	0.6	2.2	69.5	0.47
8	0.0	0.0	69.5	0.25
Backup Filter	19.1	69.5	0.0	----
TOTAL	27.5	----	----	----

*Data plotted in Figure 4-2.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-12

PARTICLE SIZE DISTRIBUTION

Run: Performed during particulate tests four and five.

Date: 7/16/81

Traverse Point No. Sampled: D5-C6

Fuel Firing Ratio, %Gas:%Oil 93:7

Percent O_2 (at test location) 4.4

Sample Flow Rate (at stack conditions): 0.83 cfm

Barometric Pressure(in. Hg)	29.75
Stack Temperature(^oF)	338.
Sample Time(min.)	420.
Sample Volume(cf)	203.2
Moisture(%H_2O)	15.2
Meter Temperature(^oF)	91.
Flow Setting,ΔH(in. H_2O)	0.74
Nozzle Diameter(in.)	0.433
Static Pressure(in. H_2O)	-0.42
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	4.5	16.6	83.4	9.8
2	2.4	8 9	74.5	9.1
3	4.1	15.1	59.4	5.7
4	2.1	7.8	51.6	3.8
5	4.1	15.1	36.5	2.0
6	4.0	14.8	21.7	0.94
7	3.2	11.8	9.9	0.59
8	1.7	6.3	3.6	0.30
Backup Filter	1.0	3.6	0.0	----
TOTAL	27.1	----	----	----

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-13

PARTICLE SIZE DISTRIBUTION

Run: Performed during particulate tests two and three
Date: 7/15/81

Traverse Point No. Sampled: D5-C4

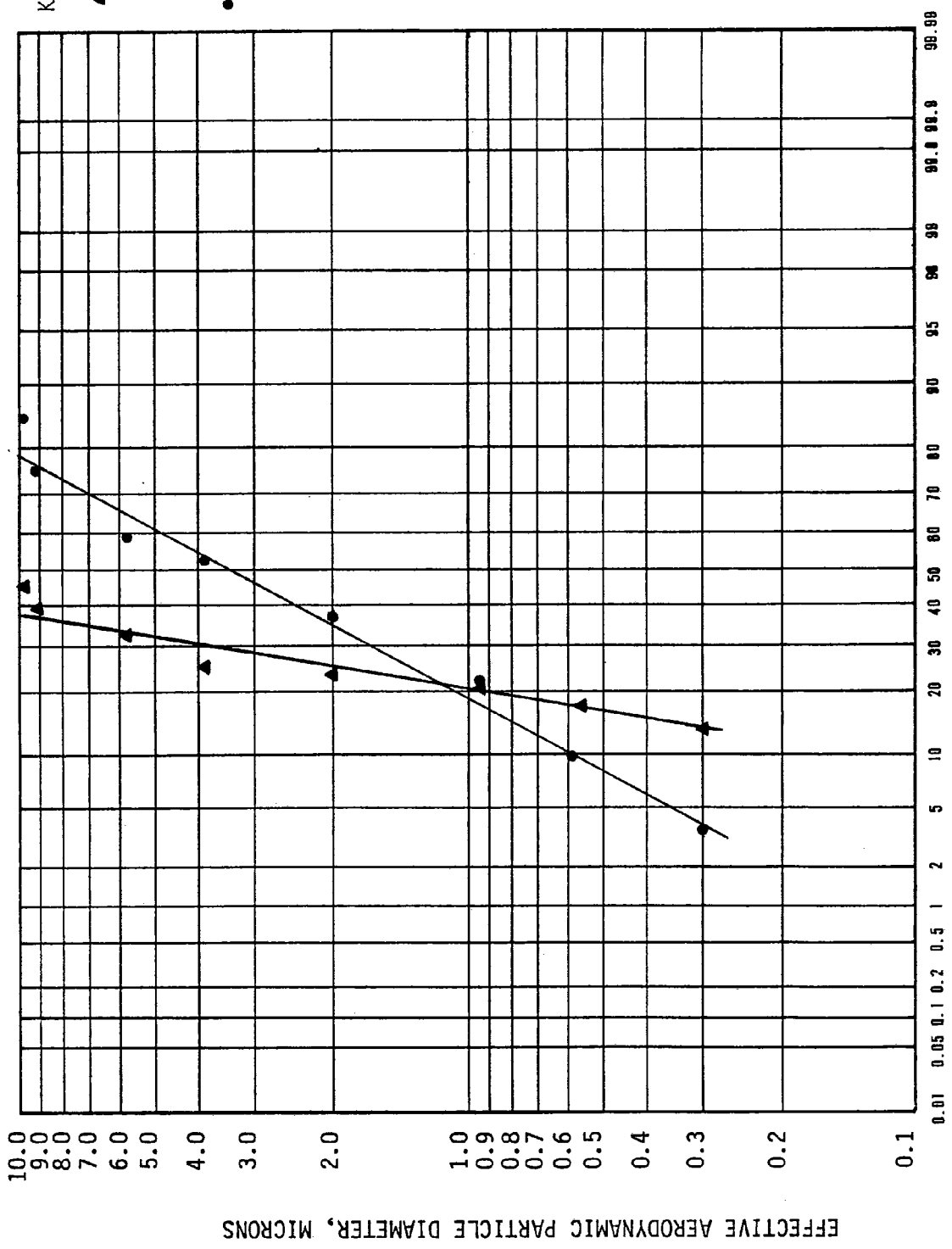
Fuel Firing Ratio, %Gas:%Oil 96:4

Percent O_2 (at test location) 2.3

Sample Flow Rate (at stack conditions): 0.84 cfm

Barometric Pressure(in. Hg)	29.88
Stack Temperature(^oF)	327.
Sample Time(min.)	420.
Sample Volume(cf)	206.8
Moisture(%H_2O)	16.2
Meter Temperature(^oF)	95.
Flow Setting,ΔH(in. H_2O)	0.74
Nozzle Diameter(in.)	0.433
Static Pressure(in. H_2O)	-0.40
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	5.2	55.3	44.7	9.8
2	0.5	5.3	39.4	9.0
3	0.7	7.5	31.9	5.6
4	0.6	6.4	25.5	3.8
5	0.3	3.2	22.3	2.0
6	0.2	2.1	20.2	0.93
7	0.3	3.2	17.0	0.55
8	0.4	4.3	12.7	0.30
Backup Filter	1.2	12.7	0.0	----
TOTAL	9.4	----	----	----



AMERICAN PETROLEUM INSTITUTE
REFINERY A SOURCE 1
PARTICLE SIZE DISTRIBUTION TEST RESULTS

FIGURE A-1

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-14

PARTICLE SIZE DISTRIBUTION

Run: Performed during particulate test seven.

Date: 7/18/81

Traverse Point No. Sampled: C4-D5

Fuel Firing Ratio, %Gas:%Oil 46:54

Percent O_2 (at test location) 3.8

Sample Flow Rate (at stack conditions): 0.84 cfm

Barometric Pressure(in. Hg)	29.84
Stack Temperature(^{o}F)	333.
Sample Time(min.)	240.
Sample Volume(cf)	117.3
Moisture(%H_2O)	15.6
Meter Temperature(^{o}F)	91.
Flow Setting,ΔH(in. H_2O)	0.76
Nozzle Diameter(in.)	0.433
Static Pressure(in. H_2O)	-0.43
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	6.6	15.8	84.2	9.8
2	4.5	10.8	73.4	9.1
3	5.7	13.7	59.7	5.6
4	4.6	11.0	48.7	3.8
5	4.1	9.8	38.9	2.0
6	4.4	10.6	28.3	0.93
7	4.3	10.3	18.0	0.55
8	2.5	6.0	12.0	0.29
Backup Filter	5.0	12.0	0.0	----
TOTAL	41.7	----	----	----

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-15

PARTICLE SIZE DISTRIBUTION

Run: Performed during particulate tests twelve and thirteen

Date: 7/21/81

Traverse Point No. Sampled: C5-D4

Fuel Firing Ratio, %Gas:%Oil 58:42

Percent O_2 (at test location) 5.5

Sample Flow Rate (at stack conditions): 0.85 cfm

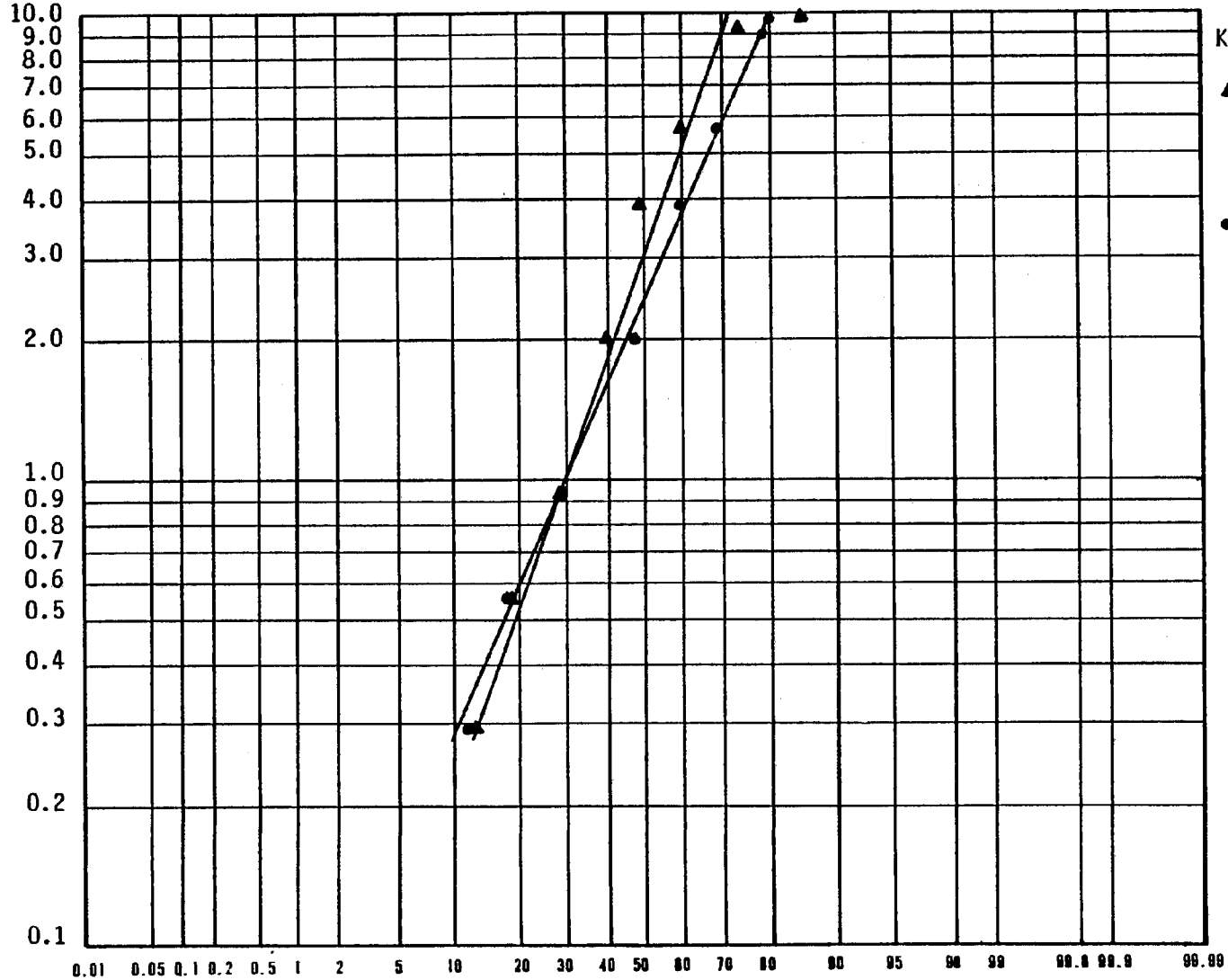
Barometric Pressure(in. Hg)	29.84
Stack Temperature(^oF)	345.
Sample Time(min.)	480.
Sample Volume(cf)	238.3
Moisture(%H_2O)	14.6
Meter Temperature(^oF)	92.
Flow Setting,ΔH(in. H_2O)	0.76
Nozzle Diameter(in.)	0.433
Static Pressure(in. H_2O)	-0.44
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	0.7	20.0	80.0	9.7
2	0.1	2.9	77.1	9.0
3	0.3	8.6	68.5	5.6
4	0.3	8.6	59.9	3.8
5	0.5	14.3	45.6	2.0
6	0.6	17.1	28.5	0.93
7	0.4	11.4	17.1	0.55
8	0.2	5.7	11.4	0.29
Backup Filter	0.4	11.4	0.0	----
TOTAL	3.5	----	----	----

AMERICAN PETROLEUM INSTITUTE

REFINERY A SOURCE 1

PARTICLE SIZE DISTRIBUTION TEST RESULTS



Key:

▲ Test at 46% Gas : 54% Oil and 3.8% O_2 on 7/18/81.

● Test at 58% Gas : 42% Oil and 5.5% O_2 on 7/21/81.

FIGURE A-2

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 1

Table A-16

ANALYSIS OF RESULTS OF FUEL OIL COMPOSITE SAMPLES

	Tests 7,8,9, 11, 12 & 13 7/18-21/81	PSD Tests 1 and 2 5/18-19/82
Ash, %	< 0.01	< 0.01
Carbon, %	86.9	86.9
Hydrogen, %	12.3	12.5
Nitrogen, %	0.16	0.20
Oxygen, %	0.52	0.17
Sulfur, %	0.09	0.27
Density, lbs/gal.	7.509	7.651
Heating Value, BTU/lb.	19,245.	19,170.
Heating Value, BTU/gal.	144,511	146,660.
Viscosity, SUS @ 100°F.	89.2	292.
Viscosity, SUS @ 122°F.	67.0	154.
Viscosity, SUS @ 210°F.	37.6	48.7
Gravity, °API	25.4	--
Metals, ppm by weight		
Arsenic	0.39	< 0.17
Barium	0.18	0.20
Cadmium	< 0.04	< 0.50
Chromium	< 0.04	< 0.50
Copper	0.10	3.0
Lead	< 0.04	< 0.50
Mercury	0.12	0.02
Nickel	0.08	2.0
Selenium	< 0.19	1.8
Vanadium	< 0.04	< 0.50
Zinc	5.5	18.

AMERICAN PETROLEUM INSTITUTE
REFINERY B
SOURCE 1
TABLE A-17
SUMMARY OF PARTICULATE TEST DATA

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	12/30/81	12/31/81	1/1/82
Test Period	1023-1643	0958-1610	0828-1800
Sampling Data			
Sampling Duration, minutes	360.0	360.0	540.0
Nozzle Diameter, inches	0.618	0.776	0.776
Barometric Pressure, inches mercury	30.25	30.14	30.03
Average Orifice Pressure Differential, inches water	1.22	3.09	3.20
Average Dry Gas Temperature at Meter, °F	72.	94.	91.
Total Water Collected by Train, ml	758.0	1,268.0	1,918.0
Standard Volume of Water Vapor Collected, cubic feet	35.7	59.7	90.3
Dry Gas Meter Calibration Factor, dimensionless	0.991	0.991	0.991
Sample Volume at Meter Conditions, cubic feet	218.1	346.8	524.3
Sample Volume at Standard Conditions, cubic feet[1]	217.4	332.4	503.9
Gas Stream Composition			
CO_2, percent by volume	7.9	8.1	8.2
O_2, percent by volume	6.3	5.8	5.9
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	85.8	86.1	85.9
Moisture in Gas Stream, percent by volume	14.1	15.2	15.2
Mole Fraction of Dry Gas	0.859	0.848	0.848
Molecular Weight of Dry Gas	29.5	29.5	29.6
Molecular Weight of Wet Gas	27.9	27.8	27.8
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.06	- 0.04	- 0.05
Absolute Pressure, inches mercury	30.3	30.1	30.0
Average Temperature, °F	587.	579.	587.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	12.0	12.0	12.0
Velocity at Actual Conditions, feet/second	10.9	11.1	11.4
Stack/duct Cross-Sectional Area, square feet	19.6	19.6	19.6
Volumetric Flow, Wet Actual cubic feet/minute	12,900.	13,100.	13,400.
Volumetric Flow, Dry Standard cubic feet/minute	5,630.	5,690.	5,760.
Percent Isokinetic	101.1	97.0	96.9
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas:% Oil	100:0	100:0	100:0
Percent O_2 at test location	6.3	5.8	5.9
Unit Charge Rate, BPH	1200.	1200.	1200.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 1

TABLE A-18

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	1	2	3
Test Date	12/30/81	12/31/81	1/1/82
Test Time	1023-1643	0958-1610	0828-1800
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	5,630.	5,690.	5,760.
Wet Actual Cubic Feet/Minute	12,900.	13,100.	13,400.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0005	0.0033	0.0028
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	0.0002	-----
Filter Catch Wt., grams	0.0003	0.0005	0.0005
Front-Half Catch Wt. Sub-total, grams	0.0008	0.0040	0.0033
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	0.0006	-----
Impinger Contents/Wash Residue Wt., grams	0.0062	0.0052	0.0074
Back-Half Acetone Wash Residue Wt., grams	0.0007	0.0025	0.0085
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	0.0058	-----
Back Half Catch Wt. Sub-total, grams	0.0069	0.0141	0.0159
Total Catch Weight, grams	0.0077	0.0181	0.0192
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-5}	5.68	18.6	10.1
Mass Emission Rate, pounds/hour, x 10^{-3}	2.74	9.06	4.99
Total			
Concentration, grains/dry standard cubic foot x 10^{-5}	54.7	84.0	58.8
Mass Emission Rate, pounds/hour, x 10^{-3}	26.4	41.0	29.0
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	64.8	55.1	58.2
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	7.74	6.58	6.95
Mass Emission Rate, Pounds/Hour	2.62	2.25	2.40

[1] Standard Conditions = 68°F (20°C) and 29.92 Inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 1

TABLE A-19

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	4	5	6
Test Date	1/2/82	1/3/82	1/4/82
Test Period	0839-1457	0829-1754	1026-1635
Sampling Data			
Sampling Duration, minutes	360.0	540.0	360.0
Nozzle Diameter, inches	0.776	0.776	0.776
Barometric Pressure, inches mercury	29.93	29.85	30.29
Average Orifice Pressure Differential, inches water	3.23	2.97	2.91
Average Dry Gas Temperature at Meter, °F	85.	88.	92.
Total Water Collected by Train, ml	1,487.0	2,095.0	1,188.0
Standard Volume of Water Vapor Collected, cubic feet	70.0	98.6	55.9
Dry Gas Meter Calibration Factor, dimensionless	0.991	0.991	0.991
Sample Volume at Meter Conditions, cubic feet	350.5	505.4	333.1
Sample Volume at Standard Conditions, cubic feet[1]	339.4	485.1	322.3
Gas Stream Composition			
CO_2, percent by volume	9.3	9.3	8.9
O_2, percent by volume	4.0	4.0	4.4
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	86.7	86.7	86.7
Moisture in Gas Stream, percent by volume	17.1	16.9	14.8
Mole Fraction of Dry Gas	0.829	0.831	0.852
Molecular Weight of Dry Gas	29.7	29.6	29.6
Molecular Weight of Wet Gas	27.7	27.7	27.9
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.06	- 0.05	- 0.04
Absolute Pressure, inches mercury	29.9	29.9	30.3
Average Temperature, °F	572.	569.	576.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	12.0	12.0	12.0
Velocity at Actual Conditions, feet/second	11.4	10.9	10.6
Stack/duct Cross-Sectional Area, square feet	19.6	19.6	19.6
Volumetric Flow, Wet Actual cubic feet/minute	13,400.	12,800.	12,500.
Volumetric Flow, Dry Standard cubic feet/minute	5,690.	5,460.	5,500.
Percent Isokinetic	99.2	98.3	97.2
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas:% Oil	100:0	100:0	100:0
Percent O_2 at test location	4.0	4.0	4.4
Unit Charge Rate, BPH	1200.	1200.	1028.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 1

TABLE A-20

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

Test Data			
Test Run Number	4	5	6
Test Date	1/2/82	1/3/82	1/4/82
Test Time	0839-1457	0829-1754	1026-1635
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	5,690.	5,460.	5,500.
Wet Actual Cubic Feet/Minute	13,400.	12,800.	12,500.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0012	0.0002	0.0035
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0006
Filter Catch Wt., grams	0.0014	0.0005	0.0004
Front-Half Catch Wt. Sub-total, grams	0.0026	0.0007	0.0045
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0004
Impinger Contents/Wash Residue Wt., grams	0.0056	0.0143	0.0049
Back-Half Acetone Wash Residue Wt., grams	0.0060	0.0047	0.0019
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0045
Back Half Catch Wt. Sub-total, grams	0.0116	0.0190	0.0117
Total Catch Weight, grams	0.0142	0.0197	0.0162
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-5}	11.8	2.23	21.5
Mass Emission Rate, pounds/hour, x 10^{-3}	5.76	1.04	10.2
Total			
Concentration, grains/dry standard cubic foot, x 10^{-5}	64.6	62.7	77.6
Mass Emission Rate, pounds/hour, x 10^{-3}	31.5	29.3	36.6
NO_X Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	48.5	50.6	68.4
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	5.79	6.05	8.16
Mass Emission Rate, Pounds/Hour	1.97	1.98	2.69

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-21
SUMMARY OF PARTICULATE TEST DATA

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	5/4/82	5/5/82	5/5/82
Test Period	0832-1300	0755-1130	1224-1558
Sampling Data			
Samoling Duration, minutes	240.0	192.0	192.0
Nozzle Diameter, inches	0.253	0.253	0.250
Barometric Pressure, inches mercury	29.96	30.07	30.07
Average Orifice Pressure Differential, inches water	1.59	1.53	1.61
Average Dry Gas Temperature at Meter, ^{o}F	79.	76.	82.
Total Water Collected by Train, ml	385.0	320.5	312.0
Standard Volume of Water Vapor Collected, cubic feet	18.1	15.1	14.7
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	156.5	123.6	126.6
Sample Volume at Standard Conditions, cubic feet[1]	153.8	122.6	124.2
Gas Stream Composition			
CO_2, percent by volume	8.7	8.9	8.9
O_2, percent by volume	8.7	8.6	8.9
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	82.6	82.5	82.2
Moisture in Gas Stream, percent by volume	10.5	11.0	10.6
Mole Fraction of Dry Gas	0.895	0.890	0.894
Molecular Weight of Dry Gas	29.7	29.8	29.8
Molecular Weight of Wet Gas	28.5	28.5	28.5
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.74	- 0.69.	- 0.59
Absolute Pressure, inches mercury	30.0	30.0	30.0
Average Temperature, ^{o}F	315.	314.	317.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.85	0.84
Total Number of Traverse Points	48.0	48.0	48.0
Velocity at Actual Conditions, feet/second	48.7	47.5	48.7
Stack/duct Cross-Sectional Area, square feet	22.7	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	66,300.	64,600.	66,400.
Volumetric Flow, Dry Standard cubic feet/minute	40,600.	39,400.	40,500.
Percent Isokinetic	102.7	105.3	106.4
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:% Oil	40:60	40:60	40:60
Percent O_2 Exiting Boiler	5.5	5.3	5.5
Percent O_2 at Test Location	8.7	8.6	8.9
Steam Load, 10^3 lbs/hr	126.	127.	128.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2

Table A-22

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	5/4/82	5/5/82	5/5/82
Test Time	0832-1300	0755-1130	1224-1558
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	40,600.	39,400.	40,500.
Wet Actual Cubic Feet/Minute	66,300.	64,600.	66,400.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0193	0.0190	0.0186
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0091
Filter Catch Wt., grams	0.0639	0.0445	0.0411
Front-Half Catch Wt. Sub-total, grams	0.0832	0.0635	0.0688
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------	0.0013
Impinger Contents/Wash Residue Wt., grams	0.0740	0.0422	0.0249
Back-Half Acetone Wash Residue Wt., grams	0.0014	0.0020	0.0040
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0260
Back Half Catch Wt. Sub-total, grams	0.0754	0.0442	0.0562
Total Catch Weight, grams	0.1586	0.1077	0.1250
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	8.3	8.0	8.5
Mass Emission Rate, pounds/hour	2.9	2.7	3.0
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	15.9	13.6	15.5
Mass Emission Rate, pounds/hour	5.5	4.6	5.4
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	200.	211.	211.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	23.8	25.2	25.2
Mass Emission Rate, Pounds/Hour	58.	60.	61.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-23

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	4	5	6
Test Date	5/6/82	5/7/82	5/7/82
Test Period	0924-1530	0836-1305	1348-1720
Sampling Data			
Sampling Duration, minutes	240.0	240.0	192.0
Nozzle Diameter, inches	0.253	0.250	0.253
Barometric Pressure, inches mercury	30.04	29.93	29.93
Average Orifice Pressure Differential, inches water	1.64	2.06	2.12
Average Dry Gas Temperature at Meter, °F	81.	81.	80.
Total Water Collected by Train, ml	385.5	394.0	317.0
Standard Volume of Water Vapor Collected, cubic feet	18.1	18.5	14.9
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	160.2	178.5	145.1
Sample Volume at Standard Conditions, cubic feet[1]	157.2	174.8	142.4
Gas Stream Composition			
CO_2, percent by volume	7.8	7.7	7.7
O_2, percent by volume	10.0	10.0	10.0
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	82.2	82.3	82.3
Moisture in Gas Stream, percent by volume	10.4	9.6	9.5
Mole Fraction of Dry Gas	0.896	0.904	0.905
Molecular Weight of Dry Gas	29.6	29.6	29.6
Molecular Weight of Wet Gas	28.4	28.5	28.5
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.69	- 0.71	- 0.66
Absolute Pressure, inches mercury	30.0	29.9	29.9
Average Temperature, °F	318.	314.	318.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	48.0	48.0	48.0
Velocity at Actual Conditions, feet/second	49.3	55.0	56.0
Stack/duct Cross-Sectional Area, square feet	22.7	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	67,100.	74,900.	76,300.
Volumetric Flow, Dry Standard cubic feet/minute	40,900.	46,100.	46,800.
Percent Isokinetic	104.0	105.1	103.1
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:% Oil	41:59	40:60	39:61
Percent O_2 Exiting Boiler	6.8	6.8	6.8
Percent O_2 at Test Location	10.0	10.0	10.0
Steam Load 10^3 lbs/hr	129.	130.	133.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2

Table A-24

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	4	5	6
Test Date	5/6/82	5/7/82	5/7/82
Test Time	0924-1530	0836-1305	1348-1720
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	40,900.	46,100.	46,800.
Wet Actual Cubic Feet/Minute	67,100.	74,900.	76,300.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0165	0.0275	0.0121
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0070
Filter Catch Wt., grams	0.0497	0.0540	0.0468
Front-Half Catch Wt. Sub-total, grams	0.0662	0.0815	0.0659
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------	0.0007
Impinger Contents/Wash Residue Wt., grams	0.0460	0.0841	0.0416
Back-Half Acetone Wash Residue Wt., grams	0.0042	0.0034	0.0007
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0175
Back Half Catch Wt. Sub-total, grams	0.0502	0.0875	0.0605
Total Catch Weight, grams	0.1164	0.1690	0.1264
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	6.5	7.2	7.1
Mass Emission Rate, pounds/hour	2.3	2.8	2.9
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	11.4	14.9	13.7
Mass Emission Rate, pounds/hour	4.0	5.9	5.5
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	194.	212.	206.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	23.2	25.3	24.6
Mass Emission Rate, Pounds/Hour	57.	70.	69.

[1] Standard Conditions = 68°F (20°C) and 29.92 Inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-25
SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	7	8	9
Test Date	5/8/82	5/8/82	5/9/82
Test Period	0753-1217	1301-1721	0818-1824
Sampling Data			
Sampling Duration, minutes	240.0	240.0	576.0
Nozzle Diameter, inches	0.253	0.250	0.253
Barometric Pressure, inches mercury	29.91	29.91	29.95
Average Orifice Pressure Differential, inches water	1.34	1.29	1.17
Average Dry Gas Temperature at Meter, °F	75.	79.	78.
Total Water Collected by Train, ml	518.5	489.0	1,171.5
Standard Volume of Water Vapor Collected, cubic feet	24.4	23.0	55.1
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	138.9	138.8	318.8
Sample Volume at Standard Conditions, cubic feet[1]	137.0	135.9	313.3
Gas Stream Composition			
CO_2, percent by volume	8.2	8.4	8.2
O_2, percent by volume	7.0	7.0	6.6
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	84.8	84.6	85.2
Moisture in Gas Stream, percent by volume	15.1	14.5	15.0
Mole Fraction of Dry Gas	0.849	0.855	0.850
Molecular Weight of Dry Gas	29.6	29.7	29.6
Molecular Weight of Wet Gas	27.8	28.0	27.8
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.60	- 0.61	- 0.63
Absolute Pressure, inches mercury	29.9	29.9	29.9
Average Temperature, °F	302.	305.	302.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	48.0	48.0	48.0
Velocity at Actual Conditions, feet/second	44.3	44.6	42.6
Stack/duct Cross-Sectional Area, square feet	22.7	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	60,400.	60,700.	58,000.
Volumetric Flow, Dry Standard cubic feet/minute	35,400.	35,800.	34,100.
Percent Isokinetic	104.8	105.4	103.5
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:%Oil	100:0	100:0	100:0
Percent O_2 Exiting Boiler	2.9	3.0	2.9
Percent O_2 at Test Location	7.0	7.0	6.6
Steam Load 10^3 lbs/hr	138.	141.	138.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-26

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

	7	8	9
Test Data			
Test Run Number	7	8	9
Test Date	5/8/82	5/8/82	5/9/82
Test Time	0753-1217	1301-1721	0818-1824
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute (1)	35,400.	35,800.	34,100.
Wet Actual Cubic Feet/Minute	60,400.	60,700.	58,000.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0131	0.0076	0.0074
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0049
Filter Catch Wt., grams	0.0037	0.0035	0.0429
Front-Half Catch Wt. Sub-total, grams	0.0168	0.0111	0.0552
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------	0.0009
Impinger Contents/Wash Residue Wt., grams	0.0138	0.0201	0.0699
Back-Half Acetone Wash Residue Wt., grams	0.0027	0.0031	0.0067
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0256
Back Half Catch Wt. Sub-total, grams	0.0165	0.0232	0.1031
Total Catch Weight, grams	0.0333	0.0343	0.1583
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	1.9	1.3	2.7
Mass Emission Rate, pounds/hour	0.67	0.39	0.80
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	3.8	3.9	7.7
Mass Emission Rate, pounds/hour	1.1	1.2	2.3
NO_x Emissions, as NO_2 (2)			
Concentration, Parts/million by Volume, dry basis	76.	102.	69.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	9.0	12.2	8.2
Mass Emission Rate, Pounds/Hour	19.	26.	17.

(1) Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

(2) Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-27
SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	10	11	12
Test Date	5/10/82	5/10/82	5/11/82
Test Period	0850-1315	1410-1825	0813-1228
Sampling Data			
Sampling Duration, minutes	240.0	240.0	240.0
Nozzle Diameter, inches	0.250	0.250	0.250
Barometric Pressure, inches mercury	30.01	30.01	29.99
Average Orifice Pressure Differential, inches water	1.60	1.57	1.37
Average Dry Gas Temperature at Meter, ^{o}F	76.	77.	76.
Total Water Collected by Train, ml	505.5	519.8	485.5
Standard Volume of Water Vapor Collected, cubic feet	23.8	24.5	22.9
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	159.3	157.6	146.9
Sample Volume at Standard Conditions, cubic feet[1]	157.7	155.7	145.1
Gas Stream Composition			
CO_2, percent by volume	6.6	6.9	6.7
O_2, percent by volume	8.6	8.7	8.5
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	84.8	84.4	84.8
Moisture in Gas Stream, percent by volume	13.1	13.6	13.6
Mole Fraction of Dry Gas	0.869	0.864	0.864
Molecular Weight of Dry Gas	29.4	29.4	29.4
Molecular Weight of Wet Gas	27.9	27.9	27.9
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.64	- 0.61	- 0.67
Absolute Pressure, inches mercury	30.0	30.0	29.9
Average Temperature, ^{o}F	315.	315.	312.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	48.0	48.0	48.0
Velocity at Actual Conditions, feet/second	51.8	50.9	47.5
Stack/duct Cross-Sectional Area, square feet	22.7	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	70,600.	69,300.	64,700.
Volumetric Flow, Dry Standard cubic feet/minute	41,800.	40,900.	38,300.
Percent Isokinetic	104.5	105.7	105.2
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:%Oil	100:0	100:0	100:0
Percent O_2 Exiting Boiler	4.8	4.6	4.6
Percent O_2 at Test Location	8.6	8.7	8.5
Steam Load 10^3 lbs/hr	146.	142.	138.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2

Table A-28

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

Test Data			
Test Run Number	10	11	12
Test Date	5/10/82	5/10/82	5/11/82
Test Time	0850-1315	1410-1825	0813-1228
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute (1)	41,800.	40,900.	38,300.
Wet Actual Cubic Feet/Minute	70,600.	69,300.	64,700.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0020	0.0037	0.0023
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0054
Filter Catch Wt., grams	0.0047	0.0018	0.0034
Front-Half Catch Wt. Sub-total, grams	0.0067	0.0055	0.0111
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------	0.0006
Impinger Contents/Wash Residue Wt., grams	0.0116	0.0147	0.0023
Back-Half Acetone Wash Residue Wt., grams	0.0001	0.0000	0.0002
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------	0.0169
Back Half Catch Wt. Sub-total, grams	0.0117	0.0147	0.0200
Total Catch Weight, grams	0.0184	0.0202	0.0311
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot, x 10^{-3}	0.7	0.5	1.2
Mass Emission Rate, pounds/hour	0.24	0.19	0.39
Total			
Concentration, grains/dry standard cubic foot, x 10^{-3}	1.8	2.0	3.3
Mass Emission Rate, pounds/hour	0.65	0.70	1.1
NO_X Emissions, as NO_2 (2)			
Concentration, Parts/million by Volume, dry basis	131.	125.	117.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	15.7	14.9	14.0
Mass Emission Rate, Pounds/Hour	39.	37.	32.

(1) Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
(2) Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-29
SUMMARY OF PARTICULATE TEST DATA

Test Data		
Test Run Number	13	14
Test Date	5/12/82	5/12/82
Test Period	0817-1230	1311-1723
Sampling Data		
Sampling Duration, minutes	240.0	240.0
Nozzle Diameter, inches	0.250	0.250
Barometric Pressure, inches mercury	29.95	29.95
Average Orifice Pressure Differential, inches water	1.43	1.48
Average Dry Gas Temperature at Meter, ^{o}F	81.	79.
Total Water Collected by Train, ml	430.0	443.0
Standard Volume of Water Vapor Collected, cubic feet	20.2	20.9
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	151.4	154.8
Sample Volume at Standard Conditions, cubic feet[1]	148.0	152.1
Gas Stream Composition		
CO_2, percent by volume	8.0	7.6
O_2, percent by volume	8.8	9.0
CO, percent by volume	0.0	0.0
N_2, percent by volume	83.2	83.4
Moisture in Gas Stream, percent by volume	12.0	12.1
Mole Fraction of Dry Gas	0.880	0.879
Molecular Weight of Dry Gas	29.6	29.6
Molecular Weight of Wet Gas	28.2	28.2
Gas Stream Velocity and Volumetric Flow		
Static Pressure, inches water	- 0.62	- 0.61
Absolute Pressure, inches mercury	29.9	29.9
Average Temperature, ^{o}F	316.	317.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84
Total Number of Traverse Points	48.0	48.0
Velocity at Actual Conditions, feet/second	48.8	49.9
Stack/duct Cross-Sectional Area, square feet	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	66,400.	67,900.
Volumetric Flow, Dry Standard cubic feet/minute	39,700.	40,600.
Percent Isokinetic	103.3	104.0
Unit/Process Operations Data		
Fuel Firing Ratio, %Gas:%Oil	68:32	70:30
Percent O_2 Exiting Boiler	5.3	5.1
Percent O_2 at Test Location	8.8	9.0
Steam Load 10^3 lbs/hr	137.	137.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2

Table A-30

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data		
Test Run Number	13	14
Test Date	5/12/82	5/12/82
Test Time	0817-1230	1311-1723
Gas Flow Volumes		
Dry Standard Cubic Feet/Minute[1]	39,700.	40,600.
Wet Actual Cubic Feet/Minute	66,400.	67,900.
Particulate Analysis Report		
Front-Half Acetone Wash Residue Wt., grams	0.0055	0.0085
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------
Filter Catch Wt., grams	0.0285	0.0300
Front-Half Catch Wt. Sub-total, grams	0.0340	0.0385
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------
Impinger Contents/Wash Residue Wt., grams	0.0130	0.0422
Back-Half Acetone Wash Residue Wt., grams	0.0057	0.0028
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------
Back Half Catch Wt. Sub-total, grams	0.0187	0.0450
Total Catch Weight, grams	0.0527	0.0835
Particulate Results		
Front-Half		
Concentration, grains/dry standard cubic foot, x 10^{-3}	3.5	3.9
Mass Emission Rate, pounds/hour	1.2	1.4
Total		
Concentration, grains/dry standard cubic foot, x 10^{-3}	5.6	8.6
Mass Emission Rate, pounds/hour	1.9	2.9
NO_x Emissions, as NO_2[2]		
Concentration, Parts/million by Volume, dry basis	215.	203.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	25.6	24.2
Mass Emission Rate, Pounds/Hour	61.	59.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2
Table A-31
SUMMARY OF PARTICULATE TEST DATA

Test Data		
Test Run Number	15	16
Test Date	5/13/82	5/13/81
Test Period	0832-1246	1401-1832
Sampling Data		
Sampling Duration, minutes	240.0	240.0
Nozzle Diameter, inches	0.250	0.253
Barometric Pressure, inches mercury	29.98	29.98
Average Orifice Pressure Differential, inches water	1.42	1.44
Average Dry Gas Temperature at Meter, °F	78.	79.
Total Water Collected by Train, ml	414.0	429.0
Standard Volume of Water Vapor Collected, cubic feet	19.5	20.2
Dry Gas Meter Calibration Factor, dimensionless	0.998	0.998
Sample Volume at Meter Conditions, cubic feet	150.3	152.4
Sample Volume at Standard Conditions, cubic feet[1]	147.9	149.8
Gas Stream Composition		
CO_2, percent by volume	7.2	7.4
O_2, percent by volume	9.6	9.8
CO, percent by volume	0.0	0.0
N_2, percent by volume	83.2	82.8
Moisture in Gas Stream, percent by volume	11.6	11.9
Mole Fraction of Dry Gas	0.884	0.881
Molecular Weight of Dry Gas	29.5	29.6
Molecular Weight of Wet Gas	28.2	28.2
Gas Stream Velocity and Volumetric Flow		
Static Pressure, inches water	- 0.62	- 0.67
Absolute Pressure, inches mercury	29.9	29.9
Average Temperature, °F	312.	312.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84
Total Number of Traverse Points	48.0	48.0
Velocity at Actual Conditions, feet/second	48.9	49.3
Stack/duct Cross-Sectional Area, square feet	22.7	22.7
Volumetric Flow, Wet Actual cubic feet/minute	66,500.	67,100.
Volumetric Flow, Dry Standard cubic feet/minute	40,200.	40,400.
Percent Isokinetic	102.0	100.3
Unit/Process Operations Data		
Fuel Firing Ratio, %Gas:%Oil	75:25	74:26
Percent O_2 Exiting Boiler	6.5	6.4
Percent O_2 at Test Location	9.6	9.8
Steam Load 10^3 lbs/hr	135.	136.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-32

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data		
Test Run Number	15	16
Test Date	5/13/82	5/13/82
Test Time	0823-1246	1401-1832
Gas Flow Volumes		
Dry Standard Cubic Feet/Minute[1]	40,200.	40,400.
Wet Actual Cubic Feet/Minute	66,500.	67,100.
Particulate Analysis Report		
Front-Half Acetone Wash Residue Wt., grams	0.0047	0.0135
Front-Half Methylene Chloride Wash Residue Wt., grams	------	------
Filter Catch Wt., grams	0.0273	0.0283
Front-Half Catch Wt. Sub-total, grams	0.0320	0.0418
Methylene Chloride Extraction of Impinger Contents/Wash Residue Wt., grams	------	------
Impinger Contents/Wash Residue Wt., grams	0.0310	0.0557
Back-Half Acetone Wash Residue Wt., grams	0.0042	0.0024
Back-Half Methylene Chloride Wash Residue Wt., grams	------	------
Back Half Catch Wt. Sub-total, grams	0.0352	0.0581
Total Catch Weight, grams	0.0672	0.0999
Particulate Results		
Front-Half		
Concentration, grains/dry standard cubic foot, x 10^{-3}	3.3	4.3
Mass Emission Rate, pounds/hour	1.2	1.5
Total		
Concentration, grains/dry standard cubic foot, x 10^{-3}	7.0	10.3
Mass Emission Rate, pounds/hour	2.4	3.6
NO_x Emissions, as NO_2[2]		
Concentration, Parts/million by Volume, dry basis	189.	202.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	22.5	24.2
Mass Emission Rate, Pounds/Hour	54.	59.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-33

PARTICLE SIZE DISTRIBUTION *

Run: Nine

Date: 5/9/82

Traverse Point No. Sampled: C-3

Fuel Firing Ratio, %Gas:%Oil 100:0

Percent O_2 (exiting boiler) 2.9

Percent O_2 (at test location) 6.6

Sample Flow Rate (at stack conditions): 1.02 cfm

Barometric Pressure(in. Hg)	29.95
Stack Temperature(^oF)	302.
Sample Time(min.)	570.
Sample Volume(cf)	346.1
Moisture(%H_2O)	15.0
Meter Temperature(^oF)	73.
Flow Setting,ΔH(in. H_2O)	1.35
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.63
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	4.6	13.3	86.7	8.7
2	0.6	1.7	85.	8.1
3	0.6	1.7	83.3	5.0
4	0.6	1.7	81.6	3.4
5	0.7	2.1	79.5	1.8
6	0.9	2.6	76.9	0.83
7	0.8	2.4	74.5	0.49
8	0.6	1.7	72.8	0.26
Backup Filter	25.2	72.8	0.0	---
TOTAL	34.6	---	---	---

*Data plotted in Figure 4-3.

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-34

PARTICLE SIZE DISTRIBUTION

Run: Thirteen

Date: 5/12/82

Traverse Point No. Sampled: D-6

Fuel Firing Ratio, %Gas:%Oil 68:32

Percent O_2 (exiting boiler) 5.3

Percent O_2 (at test location) 8.8

Sample Flow Rate (at stack conditions): 1.03 cfm

Barometric Pressure(in. Hg)	29.95
Stack Temperature(^{o}F)	316.
Sample Time(min.)	240.
Sample Volume(cf)	151.
Moisture(%H_2O)	12.0
Meter Temperature(^{o}F)	77.
Flow Setting,ΔH(in. H_2O)	1.45
Nozzle Diameter(in.)	0.250
Static Pressure(in. H_2O)	-0.62
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	6.9	20.7	79.3	8.7
2	0.5	1.5	77.8	8.1
3	0.7	2.1	75.7	5.0
4	0.9	2.7	73.	3.4
5	2.1	6.3	66.7	1.8
6	1.6	4.8	61.9	0.82
7	1.1	3.3	58.6	0.49
8	1.3	3.9	54.7	0.26
Backup Filter	18.2	54.7	0.0	---
TOTAL	33.3	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-35

PARTICLE SIZE DISTRIBUTION

Run: Fourteen

Date: 5/12/82

Traverse Point No. Sampled: D-6

Fuel Firing Ratio, %Gas:%Oil 70:30

Percent O_2 (exiting boiler) 5.1

Percent O_2 (at test location) 9.0

Sample Flow Rate (at stack conditions): 1.08 cfm

Barometric Pressure(in. Hg)	29.95
Stack Temperature(^oF)	317.
Sample Time(min.)	240.
Sample Volume(cf)	156.2
Moisture(%H_2O)	12.1
Meter Temperature(^oF)	73.
Flow Setting,ΔH(in. H_2O)	1.45
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.61
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.2	31.5	68.5	8.5
2	2.5	9.6	58.9	7.9
3	0.6	2.3	56.6	4.9
4	0.5	1.9	54.7	3.3
5	0.7	2.7	52.	1.8
6	1.9	7.3	44.7	0.80
7	0.6	2.3	42.7	0.47
8	0.1	0.5	41.9	0.25
Backup Filter	10.9	41.9	0.0	---
TOTAL	26.0	---	---	---

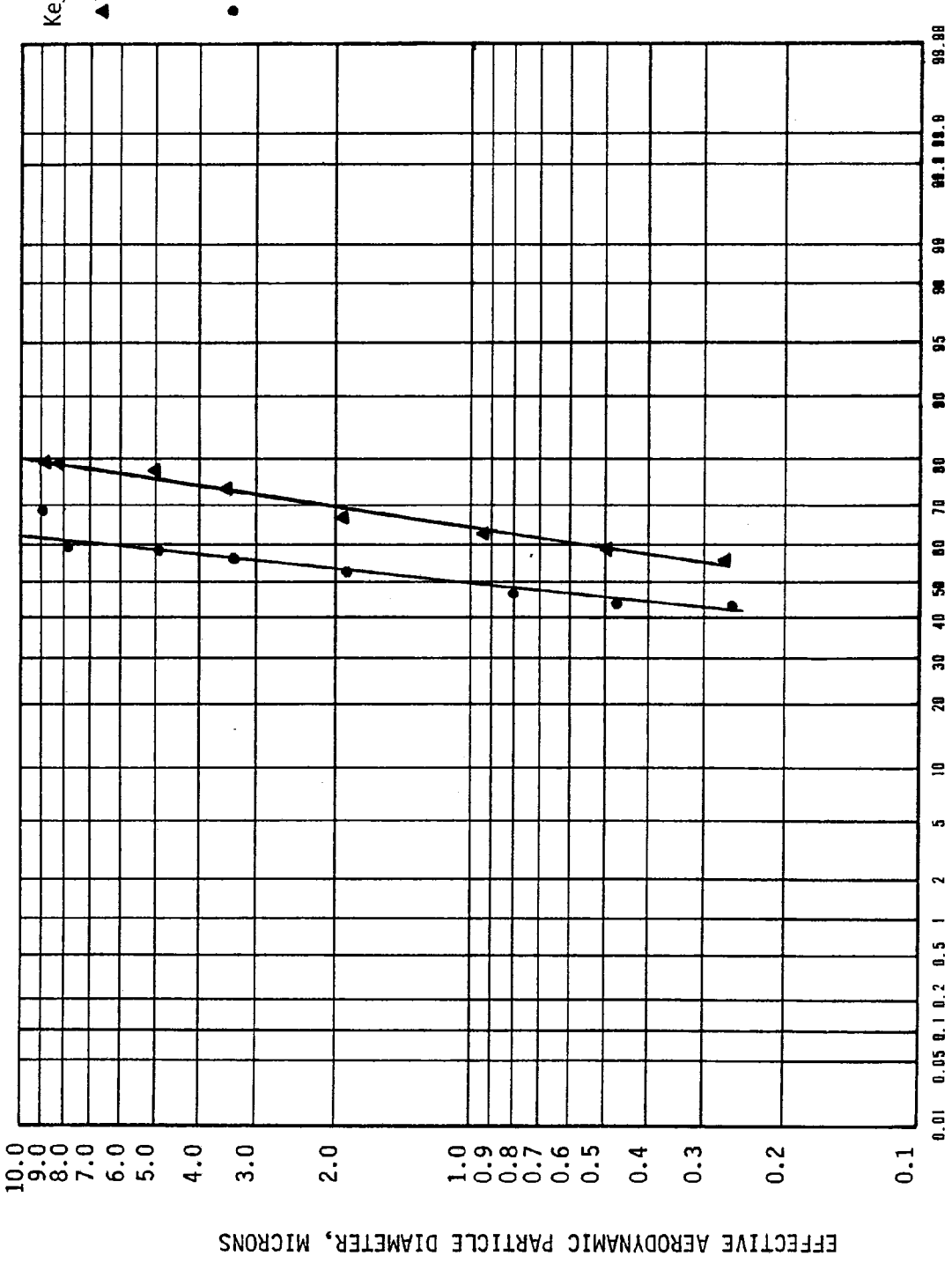


FIGURE A-3

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-36

PARTICLE SIZE DISTRIBUTION

Run: Fifteen

Date: 5/13/82

Traverse Point No. Sampled: C-4

Fuel Firing Ratio, %Gas:%Oil 75:25

Percent O_2 (exiting boiler) 6.5

Percent O_2 (at test location) 9.6

Sample Flow Rate (at stack conditions): 1.07 cfm

Barometric Pressure(in. Hg)	29.98
Stack Temperature(^oF)	312.
Sample Time(min.)	240.
Sample Volume(cf)	160.5
Moisture(%H_2O)	11.6
Meter Temperature(^oF)	76.
Flow Setting,ΔH(in. H_2O)	1.55
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.62
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	6.1	17.6	82.4	8.6
2	0.9	2.6	79.8	7.9
3	1.8	5.2	74.6	4.9
4	1.3	3.8	70.8	3.3
5	2.7	7.8	63.	1.8
6	2.4	6.9	56.1	0.81
7	1.6	4.6	51.5	0.48
8	1.2	3.5	48.0	0.25
Backup Filter	16.7	48.1	0.0	---
TOTAL	34.7	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-37

PARTICLE SIZE DISTRIBUTION

Run: Sixteen

Date: 5/13/82

Traverse Point No. Sampled: C-5

Fuel Firing Ratio, %Gas:%Oil 74:26

Percent O_2 (exiting boiler) 6.4

Percent O_2 (at test location) 9.8

Sample Flow Rate (at stack conditions): 1.02 cfm

Barometric Pressure(in. Hg)	29.98
Stack Temperature(^oF)	312.
Sample Time(min.)	240.
Sample Volume(cf)	149.8
Moisture(%H_2O)	11.9
Meter Temperature(^oF)	74.
Flow Setting,ΔH(in. H_2O)	1.45
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.67
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	13.7	30.3	69.7	8.8
2	1.1	2.4	67.3	8.1
3	1.4	3.1	64.2	5.0
4	2.0	4.4	59.8	3.4
5	2.6	5.8	54.	1.8
6	2.7	6.0	48.	0.83
7	2.3	5.1	42.9	0.49
8	2.0	4.4	38.5	0.26
Backup Filter	17.4	38.5	0.0	---
TOTAL	45.2	---	---	---

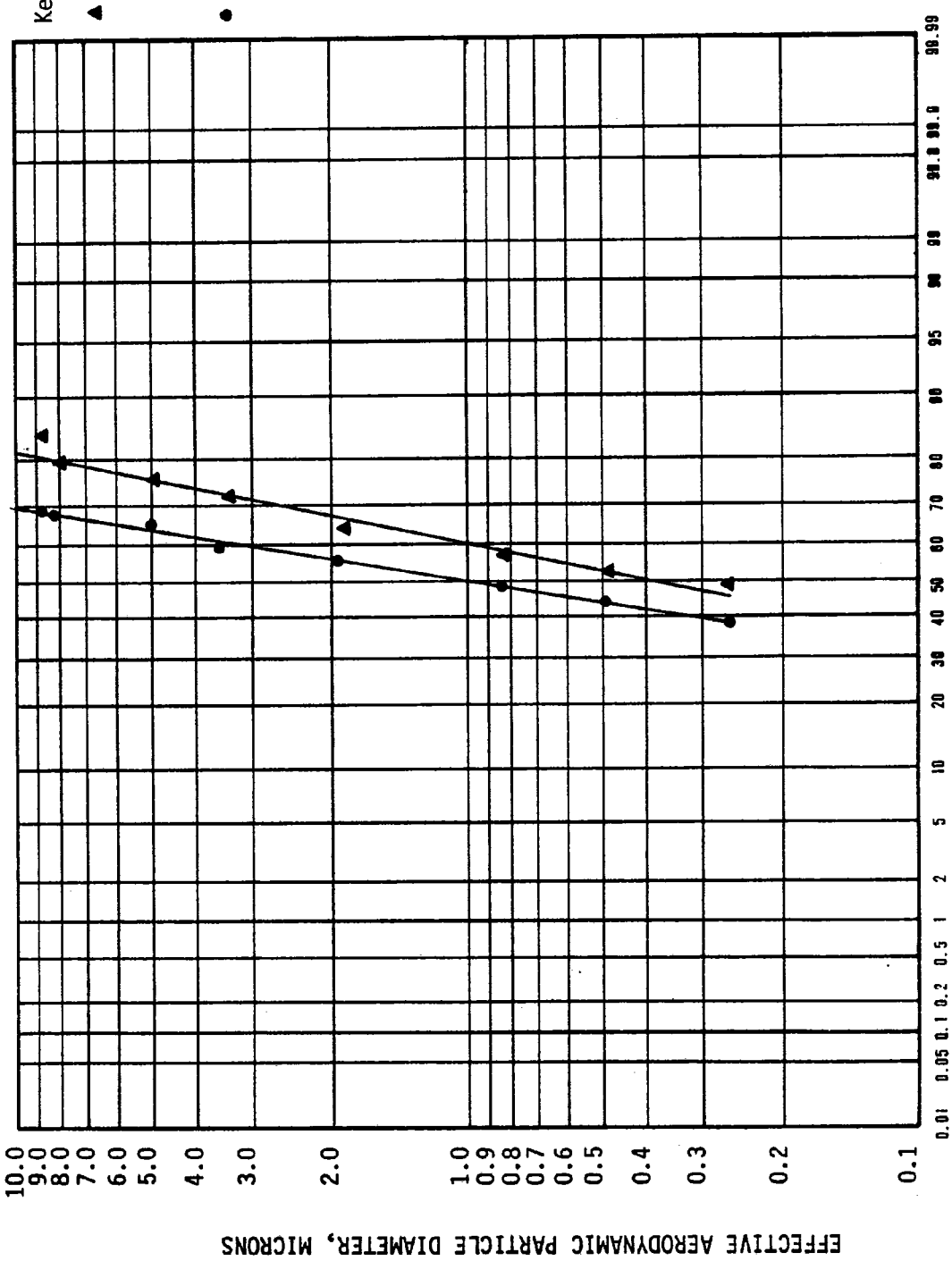


FIGURE A-4

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-38

PARTICLE SIZE DISTRIBUTION

Run: One

Date: 5/4/82

Traverse Point No. Sampled: D-5

Fuel Firing Ratio, %Gas:%Oil 40:60

Percent O_2 (exiting boiler) 5.5

Percent O_2 (at test location) 8.7

Sample Flow Rate (at stack conditions): 1.03 cfm

Barometric Pressure(in. Hg)	29.96
Stack Temperature(^oF)	315.
Sample Time(min.)	180.
Sample Volume(cf)	114.4
Moisture(%H_2O)	10.5
Meter Temperature(^oF)	74.
Flow Setting,ΔH(in. H_2O)	1.50
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.74
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	14.6	25.5	74.5	8.7
2	1.4	2.4	72.1	8.1
3	1.9	3.3	68.8	5.0
4	2.6	4.5	64.3	4.0
5	2.8	4.9	59.4	1.8
6	2.9	5.1	54.3	0.83
7	2.6	4.5	49.8	0.49
8	2.5	4.4	45.4	0.26
Backup Filter	26.0	45.4	0.0	---
TOTAL	57.3	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-39

PARTICLE SIZE DISTRIBUTION

Run: Two

Date: 5/5/82

Traverse Point No. Sampled: C5

Fuel Firing Ratio, %Gas:%Oil 40:60

Percent O_2 (exiting boiler) 5.3

Percent O_2 (at test location) 8.6

Sample Flow Rate (at stack conditions): 1.05 cfm

Barometric Pressure(in. Hg)	30.07
Stack Temperature(^oF)	314.
Sample Time(min.)	180.
Sample Volume(cf)	115.9
Moisture(%H_2O)	11.0
Meter Temperature(^oF)	70.
Flow Setting,ΔH(in. H_2O)	1.50
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.69
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	11.1	28.8	71.2	8.6
2	2.2	5.7	65.5	8.0
3	1.2	3.1	62.4	5.0
4	2.2	5.7	56.7	3.3
5	2.2	5.7	51.	1.8
6	1.9	4.9	46.1	0.81
7	2.0	5.2	40.9	0.48
8	1.5	3.9	37.0	0.25
Backup Filter	14.3	37.0	0.0	---
TOTAL	38.6	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-40

PARTICLE SIZE DISTRIBUTION

Run: Three

Date: 5/5/82

Traverse Point No. Sampled: D-6

Fuel Firing Ratio, %Gas:%Oil 40:60

Percent O_2 (exiting boiler) 5.5

Percent O_2 (at test location) 8.9

Sample Flow Rate (at stack conditions): 1.06 cfm

Barometric Pressure(in. Hg)	30.07
Stack Temperature(^{o}F)	317.
Sample Time(min.)	200.
Sample Volume(cf)	131.3
Moisture(%H_2O)	10.6
Meter Temperature(^{o}F)	77.
Flow Setting,ΔH(in. H_2O)	1.5
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.59
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	14.9	34.7	65.3	8.6
2	1.0	2.3	63.	7.9
3	1.8	4.2	58.8	5.0
4	1.6	3.7	55.1	3.4
5	2.2	5.1	50.	1.8
6	3.2	7.6	42.4	0.81
7	2.2	5.1	37.3	0.48
8	2.9	6.8	30.5	0.25
Backup Filter	13.1	30.5	0.0	---
TOTAL	42.9	---	---	---

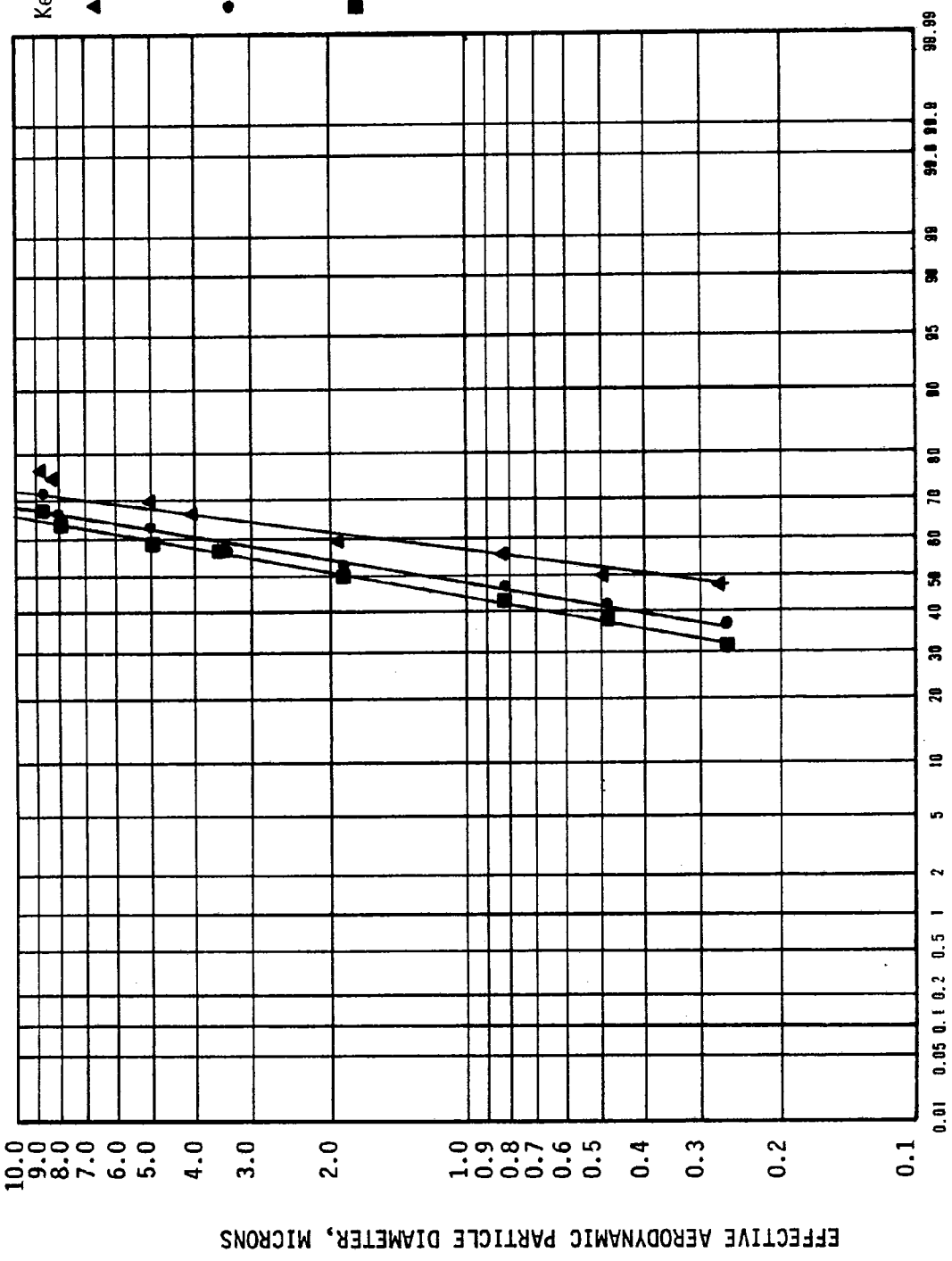


FIGURE A-5

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-41

PARTICLE SIZE DISTRIBUTION

Run: Four

Date: 5/6/82

Traverse Point No. Sampled: C4

Fuel Firing Ratio, %Gas:%Oil 41:59

Percent O_2 (exiting boiler) 6.8

Percent O_2 (at test location) 10.0

Sample Flow Rate (at stack conditions): 1.04 cfm

Barometric Pressure(in. Hg)	30.04
Stack Temperature(^oF)	318.
Sample Time(min.)	240.
Sample Volume(cf)	154.4
Moisture(%H_2O)	10.4
Meter Temperature(^oF)	77.
Flow Setting,ΔH(in. H_2O)	1.5
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.69
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	13.2	26.7	73.3	8.7
2	1.6	3.2	70.1	8.1
3	2.4	4.8	65.3	5.0
4	2.7	5.4	59.9	3.4
5	2.9	5.9	54.	1.8
6	3.3	6.7	47.3	0.82
7	2.9	5.9	41.4	0.49
8	2.5	5.0	36.4	0.26
Backup Filter	18.0	36.4	0.0	---
TOTAL	49.5	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-42

PARTICLE SIZE DISTRIBUTION

Run: Five

Date: 5/7/82

Traverse Point No. Sampled: D-4

Fuel Firing Ratio, %Gas:%Oil 40:60

Percent O_2 (exiting boiler) 6.8

Percent O_2 (at test location) 10.0

Sample Flow Rate (at stack conditions): 1.08 cfm

Barometric Pressure(in. Hg)	29.93
Stack Temperature(^oF)	314.
Sample Time(min.)	200.
Sample Volume(cf)	134.8
Moisture(%H_2O)	9.6
Meter Temperature(^oF)	76.
Flow Setting,ΔH(in. H_2O)	1.6
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.71
Meter δ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	13.3	25.2	74.8	8.5
2	1.0	1.9	72.9	7.9
3	0.7	1.3	71.6	4.9
4	0.9	1.7	69.9	3.3
5	2.4	4.5	65.4	1.8
6	2.8	5.3	60.1	0.80
7	2.1	4.0	56.1	0.47
8	1.3	2.5	53.6	0.25
Backup Filter	28.3	53.6	0.0	---
TOTAL	52.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-43

PARTICLE SIZE DISTRIBUTION

Run: Six

Date: 5/7/82

Traverse Point No. Sampled: D-5

Fuel Firing Ratio, %Gas:%Oil 39:61

Percent O_2 (exiting boiler) 6.8

Percent O_2 (at test location) 10.0

Sample Flow Rate (at stack conditions): 1.10 cfm

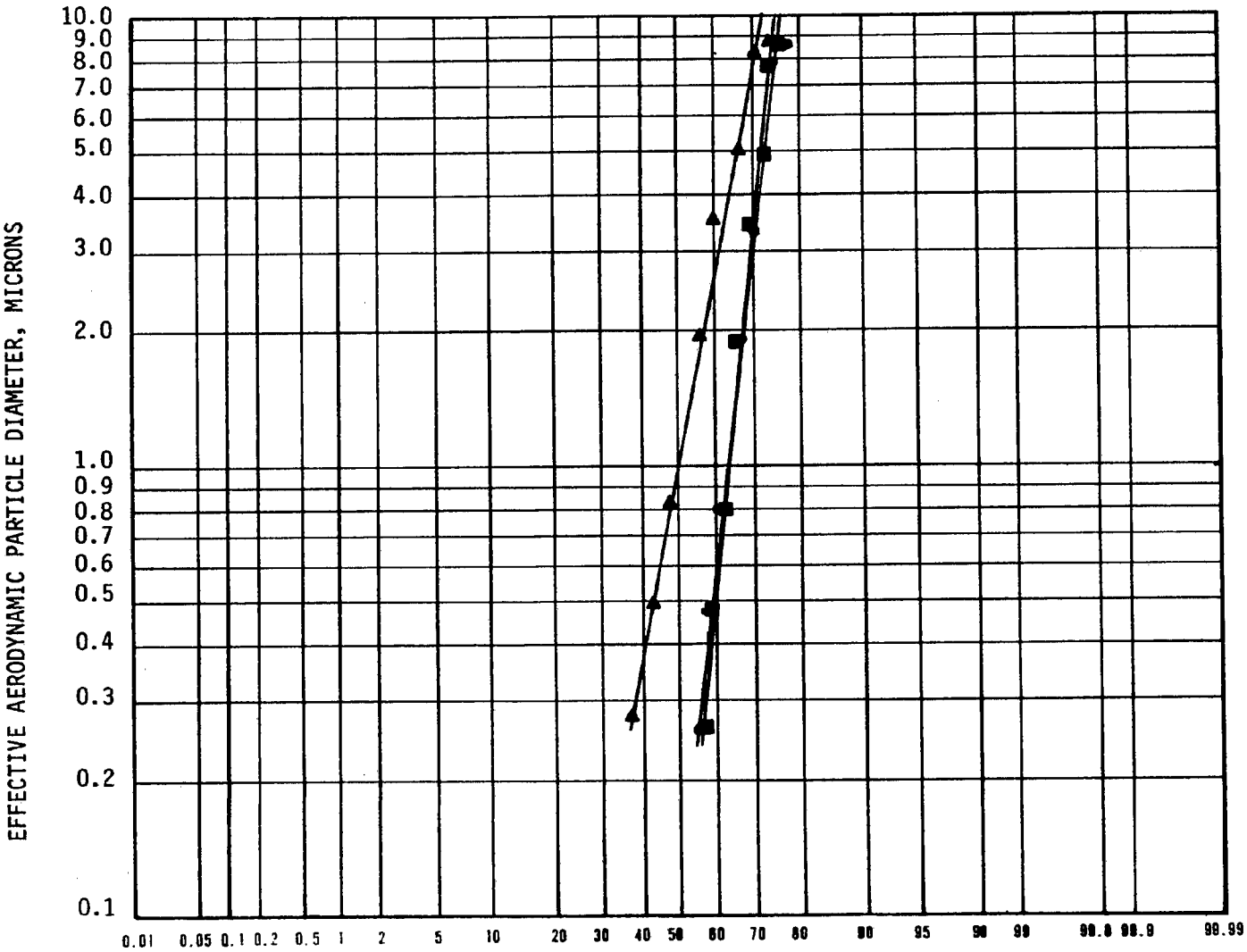
Barometric Pressure(in. Hg)	29.93
Stack Temperature(^oF)	319.
Sample Time(min.)	200.
Sample Volume(cf)	136.7
Moisture(%H_2O)	9.5
Meter Temperature(^oF)	75.
Flow Setting,ΔH(in. H_2O)	1.7
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.66
Meter γ	0.994
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	12.9	25.9	74.1	8.5
2	0.8	1.6	72.5	7.8
3	0.2	0.4	72.1	4.9
4	1.7	3.4	68.7	3.3
5	2.4	4.8	63.9	1.8
6	1.4	2.8	61.1	0.8
7	1.1	2.3	58.8	0.47
8	2.2	4.4	54.4	0.25
Backup Filter	27.1	54.4	0.0	---
TOTAL	49.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY A SOURCE 2

PARTICLE SIZE DISTRIBUTION TEST RESULTS



Key:

▲ Test at 41% Gas : 59% Oil and 6.8% O2 on 5/1/82.

● Test at 40% Gas : 60% Oil and 6.8% O_2 on 5/7/82.

■ Test at 39%Gas : 61% Oil and 6.8% O_2 on 5/7/82.

F-11 FIGURE A-6 F-12

AMERICAN PETROLEUM INSTITUTE

REFINERY A

SOURCE 2

Table A-44

RESULTS OF FUEL OIL COMPOSITE SAMPLE ANALYSIS
FOR TEST RUNS 1-6, 13-16; 5/4-13/82

Ash, %	0.02
Carbon, %	87.0
Hydrogen, %	12.2
Nitrogen, %	0.30
Oxygen, %	0.26
Sulfur, %	0.22
Density, lbs/gal.	7.752
Heating Value, BTU/lb.	19,120.
Heating Value, BTU/gal.	148,250.
Viscosity, SUS @ 100°F.	*
Viscosity, SUS @ 122°F.	*
Viscosity, SUS @ 210°F.	158.
Metals, ppm by weight	
Arsenic	< 0.2
Barium	1.9
Cadmium	< 0.5
Chromium	< 0.5
Copper	3.0
Lead	< 0.5
Mercury	0.03
Nickel	21.
Selenium	0.26
Vanadium	< 0.5
Zinc	10.

*The material was too viscous at this temperature to measure the Saybolt viscosity.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-45

SUMMARY OF PARTICULATE TEST DATA

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	12/11/81	12/12/81	12/12/81
Test Period	0904-1337	0756-1232	1324-1808
Sampling Data			
Sampling Duration, minutes	256.0	256.0	256.0
Nozzle Diameter, inches	0.180	0.180	0.180
Barometric Pressure, inches mercury	29.93	29.96	29.96
Average Orifice Pressure Differential, inches water	1.03	1.10	1.08
Average Dry Gas Temperature at Meter, °F	88.	75.	84.
Total Water Collected by Train, ml	425.0	442.0	404.0
Standard Volume of Water Vapor Collected, cubic feet	20.0	20.8	19.0
Dry Gas Meter Calibration Factor, dimensionless	1.000	1.000	1.000
Sample Volume at Meter Conditions, cubic feet	141.0	145.1	146.0
Sample Volume at Standard Conditions, cubic feet[1]	136.3	143.8	142.3
Gas Stream Composition			
CO_2, percent by volume	11.1	11.0	10.8
O_2, percent by volume	4.8	5.0	5.1
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	84.1	84.0	84.1
Moisture in Gas Stream, percent by volume	12.8	12.6	11.8
Mole Fraction of Dry Gas	0.872	0.874	0.882
Molecular Weight of Dry Gas	30.0	30.0	29.9
Molecular Weight of Wet Gas	28.4	28.4	28.5
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	-1.01	-0.93	- 0.89
Absolute Pressure, inches mercury	29.9	29.9	29.9
Average Temperature, °F	481.	489.	493.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	32.0	32.0	32.0
Velocity at Actual Conditions, feet/second	102.5	107.0	106.1
Stack/duct Cross-Sectional Area, square feet	41.3	41.3	41.3
Volumetric Flow, Wet Actual cubic feet/minute	254,000	265,000	263,000
Volumetric Flow, Dry Standard cubic feet/minute	124,000	129,000	128,000
Percent Isokinetic	100.4	101.9	101.2
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % Oil	27:73	33:67	33:67
% O_2 at test location	4.8	5.0	5.1
Boiler Steam Production Rate, 10^3 lb/hr	371.	370.	370.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY 8

SOURCE 2

Table A-46

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	12/11/81	12/12/81	12/12/81
Test Time	0904-1337	0756-1232	1324-1808
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	124,000.	129,000.	128,000.
Wet Actual Cubic Feet/Minute	254,000.	265,000.	263,000.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0546	0.0449	0.0342
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0001
Filter Catch Wt., grams	0.0965	0.0793	0.0691
Front-Half Catch Wt. Sub-total, grams	0.1511	0.1242	0.1034
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0005
Impinger Contents/Wash Residue Wt., grams	0.0144	0.0017	0.0063
Back-Half Acetone Wash Residue Wt., grams	0.0032	0.0003	0.0036
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0116
Back Half Catch Wt. Sub-total, grams	0.0176	0.0020	0.0220
Total Catch Weight, grams	0.1687	0.1262	0.1254
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.017	0.013	0.011
Mass Emission Rate, pounds/hour	18.2	14.7	12.3
Total			
Concentration, grains/dry standard cubic foot	0.019	0.014	0.014
Mass Emission Rate, pounds/hour	20.3	15.0	15.0
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	110.	106.	127.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	13.2	12.7	15.2
Mass Emission Rate, Pounds/Hour	98.0	98.1	117.

[1] Standard Conditions = 68°F (20°C) and 29.92 Inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-47

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	4	5	6
Test Date	12/13/81	12/14/81	12/14/81
Test Period	0824-1259	0801-1141	1323-1658
Sampling Data			
Sampling Duration, minutes	256.0	200.0	200.0
Nozzle Diameter, inches	0.180	0.180	0.180
Barometric Pressure, inches mercury	30.03	30.05	30.05
Average Orifice Pressure Differential, inches water	1.32	1.34	1.36
Average Dry Gas Temperature at Meter, °F	84.	80.	78.
Total Water Collected by Train, ml	399.	318.	318.
Standard Volume of Water Vapor Collected, cubic feet	18.8	15.0	15.0
Dry Gas Meter Calibration Factor, dimensionless	1.000	1.000	1.000
Sample Volume at Meter Conditions, cubic feet	161.4	126.1	126.0
Sample Volume at Standard Conditions, cubic feet[1]	157.8	124.3	124.5
Gas Stream Composition			
CO_2, percent by volume	9.7	9.8	9.8
O_2, percent by volume	6.7	6.7	6.6
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	83.6	83.5	83.6
Moisture in Gas Stream, percent by volume	10.6	10.8	10.7
Mole Fraction of Dry Gas	0.894	0.893	0.893
Molecular Weight of Dry Gas	29.8	29.8	29.8
Molecular Weight of Wet Gas	28.6	28.6	28.6
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 1.4	- 0.99	- 1.3
Absolute Pressure, inches mercury	29.9	30.0	30.0
Average Temperature, °F	517.	505.	505.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	32.0	40.0	40.0
Velocity at Actual Conditions, feet/second	121.6	117.4	117.6
Stack/duct Cross-Sectional Area, square feet	41.3	41.3	41.3
Volumetric Flow, Wet Actual cubic feet/minute	301,000.	291,000.	291,000.
Volumetric Flow, Dry Standard cubic feet/minute	146,000.	142,000.	142,000.
Percent Isokinetic	98.9	102.1	102.2
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas; % Oil	31:69	27:73	27:73
Percent O_2 at test location	6.7	6.7	6.6
Boiler Steam Production Rate, 10^3 lb/hr	370.	370.	368.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2
Table A-48

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

Test Data			
Test Run Number	4	5	6
Test Date	12/13/81	12/14/81	12/14/81
Test Time	0824-1259	0801-1141	1323-1658
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	146,000.	142,000.	142,000.
Wet Actual Cubic Feet/Minute	301,000.	291,000.	291,000.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0593	0.0553	0.0498
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0002
Filter Catch Wt., grams	0.0735	0.0687	0.0660
Front-Half Catch Wt. Sub-total, grams	0.1328	0.1240	0.1160
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0006
Impinger Contents/Wash Residue Wt., grams	0.0003	0.0014	0.0024
Back-Half Acetone Wash Residue Wt., grams	0.0007	0.0018	0.0017
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0043
Back Half Catch Wt. Sub-total, grams	0.0010	0.0032	0.0090
Total Catch Weight, grams	0.1338	0.1272	0.1250
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.013	0.015	0.014
Mass Emission Rate, pounds/hour	16.2	18.8	17.5
Total			
Concentration, grains/dry standard cubic foot	0.013	0.016	0.015
Mass Emission Rate, pounds/hour	16.3	19.3	18.9
NO_X Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	125.	79.8	115.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	14.9	9.53	13.8
Mass Emission Rate, Pounds/Hour	131.	81.2	118.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-49

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	7	8	9
Test Date	12/15/81	12/16/81	12/16/81
Test Period	1051-1426	0811-1148	1340-1713
Sampling Data			
Sampling Duration, minutes	200.0	200.0	200.0
Nozzle Diameter, inches	0.180	0.180	0.180
Barometric Pressure, inches mercury	30.14	30.08	30.08
Average Orifice Pressure Differential, inches water	1.28	1.36	1.36
Average Dry Gas Temperature at Meter, °F	96.	96.	86.
Total Water Collected by Train, ml	260.	287.	290.
Standard Volume of Water Vapor Collected, cubic feet	12.2	13.5	13.6
Dry Gas Meter Calibration Factor, dimensionless	1.000	1.000	1.000
Sample Volume at Meter Conditions, cubic feet	123.0	127.3	127.0
Sample Volume at Standard Conditions, cubic feet[1]	118.1	122.1	124.0
Gas Stream Composition			
CO_2, percent by volume	10.5	10.2	10.5
O_2, percent by volume	6.5	6.7	6.6
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	83.0	83.1	82.9
Moisture in Gas Stream, percent by volume	9.4	10.0	9.9
Mole Fraction of Dry Gas	0.906	0.900	0.901
Molecular Weight of Dry Gas	29.9	29.9	30.0
Molecular Weight of Wet Gas	28.8	28.7	28.8
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 1.35	- 1.33	- 1.15
Absolute Pressure, inches mercury	30.0	30.0	30.0
Average Temperature, °F	498.	501.	499.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	112.2	115.6	115.2
Stack/duct Cross-Sectional Area, square feet	41.3	41.3	41.3
Volumetric Flow, Wet Actual cubic feet/minute	278,000.	286,000.	285,000.
Volumetric Flow, Dry Standard cubic feet/minute	139,000.	142,000.	142,000.
Percent Isokinetic	99.0	100.5	102.1
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas: % Oil	0:100	0:100	0:100
Percent O_2 at test location	6.5	6.7	6.6
Boiler Steam Production Rate, 10^3 lb/hr	370.	364.	362.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-50

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	7	8	9
Test Date	12/15/81	12/16/81	12/16/81
Test Time	1051-1426	0811-1148	1340-1713
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute(1)	139,000.	142,000.	142,000.
Wet Actual Cubic Feet/Minute	278,000.	286,000.	285,000.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0542	0.0628	0.0541
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0010
Filter Catch Wt., grams	0.0732	0.0716	0.0712
Front-Half Catch Wt. Sub-total, grams	0.1274	0.1344	0.1263
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0004
Impinger Contents/Wash Residue Wt., grams	0.0056	0.0017	0.0021
Back-Half Acetone Wash Residue Wt., grams	0.0025	0.0024	0.0000
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0029
Back Half Catch Wt. Sub-total, grams	0.0081	0.0041	0.0054
Total Catch Weight, grams	0.1355	0.1385	0.1317
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.017	0.017	0.016
Mass Emission Rate, pounds/hour	19.9	20.7	19.1
Total			
Concentration, grains/dry standard cubic foot	0.018	0.018	0.016
Mass Emission Rate, pounds/hour	21.2	21.3	19.9
NO_x Emissions, as NO_2(2)			
Concentration, Parts/million by Volume, dry basis	130.	132.	127.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	15.5	15.8	15.2
Mass Emission Rate, Pounds/Hour	130.	135.	129.

(1) Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

(2) Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-51

SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	10	11	12
Test Date	12/17/81	12/17/81	12/18/81
Test Period	0802-1148	1332-1704	0805-1224
Sampling Data			
Sampling Duration, minutes	200.0	200.0	200.0
Nozzle Diameter, inches	0.180	0.180	0.180
Barometric Pressure, inches mercury	30.19	30.19	30.29
Average Orifice Pressure Differential, inches water	1.05	1.05	1.03
Average Dry Gas Temperature at Meter, °F	78.	83.	77.
Total Water Collected by Train, ml	275.	259.	259.
Standard Volume of Water Vapor Collected, cubic feet	12.9	12.2	12.2
Dry Gas Meter Calibration Factor, dimensionless	1.000	1.000	1.000
Sample Volume at Meter Conditions, cubic feet	111.3	111.5	108.1
Sample Volume at Standard Conditions, cubic feet[1]	110.5	109.8	107.9
Gas Stream Composition			
CO_2, percent by volume	11.9	11.8	11.9
O_2, percent by volume	4.9	5.0	4.7
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	83.2	83.2	83.4
Moisture in Gas Stream, percent by volume	10.5	10.0	10.2
Mole Fraction of Dry Gas	0.895	0.900	0.898
Molecular Weight of Dry Gas	30.1	30.1	30.1
Molecular Weight of Wet Gas	28.8	28.9	28.9
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 1.0	- 1.01	- 1.23
Absolute Pressure, inches mercury	30.1	30.1	30.2
Average Temperature, °F	485.	488.	486.
Pitot Tube Calibration Coefficient, dimensionless	0.840	0.840	0.840
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	102.9	103.4	102.0
Stack/duct Cross-Sectional Area, square feet	41.3	41.3	41.3
Volumetric Flow, Wet Actual cubic feet/minute	255,000.	256,000.	253,000.
Volumetric Flow, Dry Standard cubic feet/minute	128,000.	129,000.	128,000.
Percent Isokinetic	100.5	99.2	98.5
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas:% Oil	0:100	0:100	0:100
Percent O_2 at test location	4.9	5.0	4.7
Boiler Steam Production Rate, 10^3 lb/hr.	370.	370.	370.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-52

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

Test Data			
Test Run Number	10	11	12
Test Date	12/17/81	12/17/81	12/18/81
Test Time	0802-1148	1332-1704	0850-1224
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	128,000.	129,000.	128,000.
Wet Actual Cubic Feet/Minute	255,000.	256,000.	253,000.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0582	0.0582	0.0292
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0078
Filter Catch Wt., grams	0.0746	0.0784	0.0691
Front-Half Catch Wt. Sub-total, grams	0.1328	0.1366	0.1061
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0009
Impinger Contents/Wash Residue Wt., grams	0.0020	0.0011	0.0053
Back-Half Acetone Wash Residue Wt., grams	0.0013	0.0032	0.0000
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0171
Back Half Catch Wt. Sub-total, grams	0.0033	0.0043	0.0233
Total Catch Weight, grams	0.1361	0.1409	0.1294
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.019	0.019	0.015
Mass Emission Rate, pounds/hour	20.4	21.3	16.6
Total			
Concentration, grains/dry standard cubic foot	0.019	0.020	0.019
Mass Emission Rate, pounds/hour	20.9	21.9	20.3
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	131.	133.	140.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	15.6	15.9	16.8
Mass Emission Rate, Pounds/Hour	121.	123.	129.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-53

PARTICLE SIZE DISTRIBUTION

Run:	One	Barometric Pressure(in. Hg)	29.93
Date:	12/11/81	Stack Temperature(^{o}F)	481.
Traverse Point No. Sampled:	B-3	Sample Time(min.)	256
Fuel Firing Ratio, %Gas:%Oil	27:73	Sample Volume(cf)	141.3
Percent O_2 (at test location)	4.8	Moisture(%H_2O)	12.8
		Meter Temperature(^{o}F)	97.
		Flow Setting,ΔH(in. H_2O)	1.10
		Nozzle Diameter(in.)	0.185
		Static Pressure(in. H_2O)	-1.01
		Meter γ	0.990
Sample Flow Rate (at stack conditions):	1.07 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.8	8.2	91.8	9.2
2	1.1	1.0	90.8	8.5
3	3.6	3.3	87.5	5.3
4	1.9	1.8	85.7	3.6
5	2.2	2.0	83.7	1.9
6	4.1	3.8	79.9	0.85
7	3.5	3.2	76.7	0.50
8	4.6	4.3	72.4	0.25
Backup Filter	78.2	72.4	0.0	---
TOTAL	108.0	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-54

PARTICLE SIZE DISTRIBUTION

Run: Two

Date: 12/12/81

Traverse Point No. Sampled: B-3; D-3

Fuel Firing Ratio, %Gas:%Oil 33:67

Percent O_2 (at test location) 5.0

Sample Flow Rate (at stack conditions): 1.08 cfm

Barometric Pressure(in. Hg)	29.96
Stack Temperature(^{o}F)	488.
Sample Time(min.)	210.
Sample Volume(cf)	114.9
Moisture(%H_2O)	12.6
Meter Temperature(^{o}F)	85.
Flow Setting,ΔH(in. H_2O)	1.10
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-0.93
Meter γ	0.990
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	17.9	32.3	67.7	9.1
2	0.4	0.7	67.0	8.4
3	0.6	1.1	65.9	5.2
4	0.5	0.9	65.0	3.5
5	0.6	1.1	63.9	1.9
6	0.4	0.7	63.2	0.84
7	1.8	3.3	59.9	0.49
8	2.0	3.6	56.3	0.25
Backup Filter	31.2	56.3	0.0	---
TOTAL	55.4	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-55

PARTICLE SIZE DISTRIBUTION

Run:	Three	Barometric Pressure(in. Hg)	29.96
Date:	12/12/81	Stack Temperature(^{o}F)	493.
		Sample Time(min.)	210.
Traverse Point No. Sampled:	B-3;D-3	Sample Volume(cf)	113.6
Fuel Firing Ratio, %Gas:%Oil	33:67	Moisture(%H_2O)	11.8
Percent O_2 (at test location)	5.1	Meter Temperature(^{o}F)	70.
		Flow Setting,ΔH(in. H_2O)	1.10
		Nozzle Diameter(in.)	0.180
		Static Pressure(in. H_2O)	-0.89
		Meter γ	0.990
Sample Flow Rate (at stack conditions):	1.10 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	5.6	11.9	88.1	9.1
2	1.0	2.1	86.0	8.4
3	1.0	2.1	83.9	5.2
4	2.3	4.9	79.0	3.5
5	2.1	4.5	74.5	1.9
6	2.4	5.1	69.4	0.84
7	2.9	6.1	63.3	0.49
8	0.7	1.5	61.8	0.25
Backup Filter	29.1	61.8	0.0	---
TOTAL	47.1	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B SOURCE 2

PARTICLE SIZE DISTRIBUTION TEST RESULTS

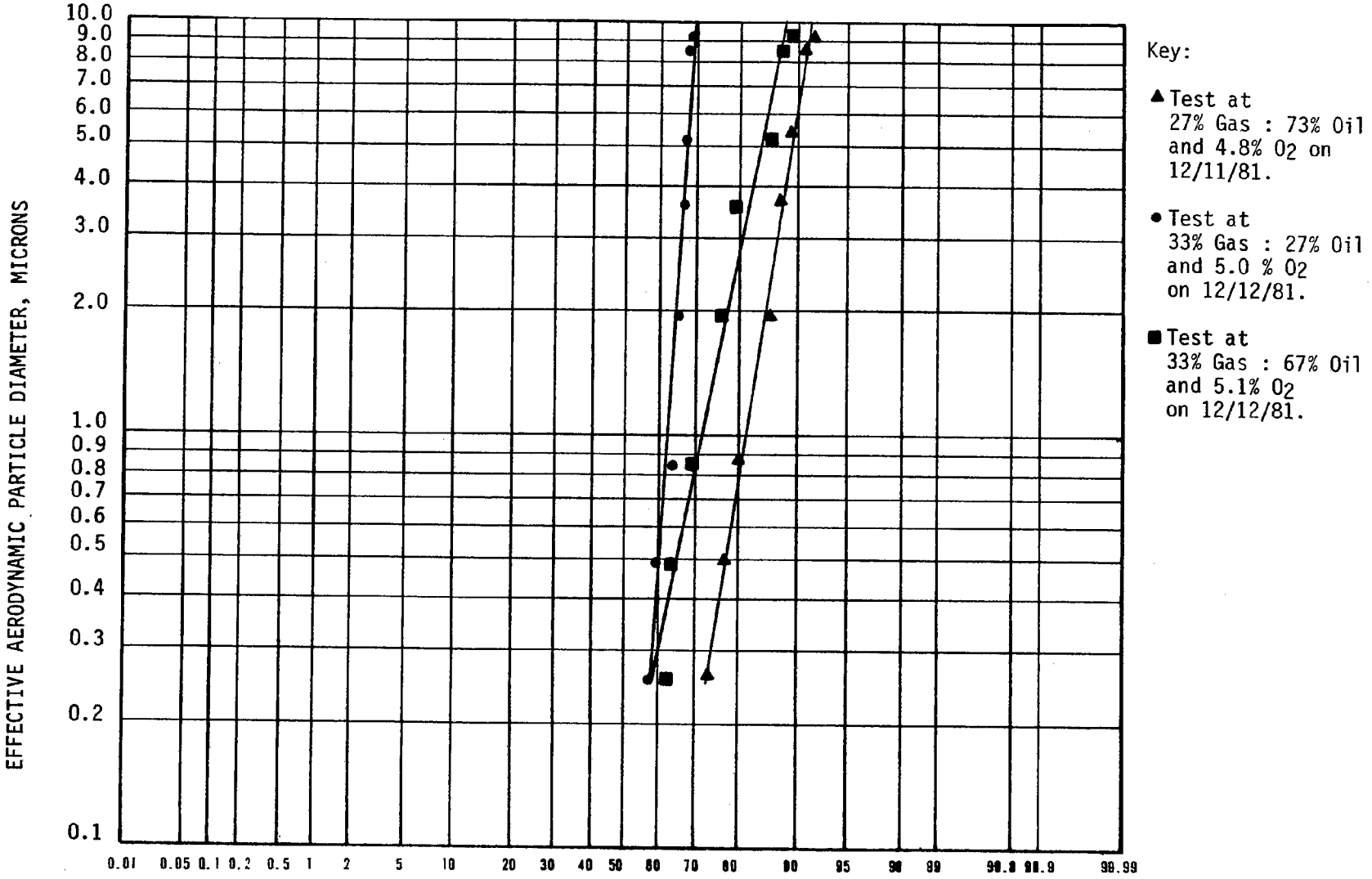


FIGURE A-7

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-56

PARTICLE SIZE DISTRIBUTION

Run: Four

Date: 12/13/81

Traverse Point No. Sampled: B-3; D-3

Fuel Firing Ratio, %Gas:%Oil 31:69

Percent O_2 (at test location) 6.7

Sample Flow Rate (at stack conditions): 1.17 cfm

Barometric Pressure(in. Hg)	30.03
Stack Temperature(^oF)	517.
Sample Time(min.)	210.
Sample Volume(cf)	120.5
Moisture(%H_2O)	10.6
Meter Temperature(^oF)	76.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-1.38
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	23.2	26.4	73.6	8.9
2	2.7	3.1	70.5	8.2
3	5.1	5.8	64.7	5.1
4	4.8	5.5	59.2	3.4
5	5.5	6.3	52.9	1.8
6	5.7	6.5	46.4	0.81
7	6.1	6.9	39.5	0.47
8	5.9	6.7	32.8	0.24
Backup Filter	28.8	32.8	0.0	---
TOTAL	87.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-57

PARTICLE SIZE DISTRIBUTION

Run: Five

Date: 12/14/81

Traverse Point No. Sampled: B-3; D-3

Fuel Firing Ratio, %Gas:%Oil 27:73

Percent O_2 (at test location) 6.7

Sample Flow Rate (at stack conditions): 1.20 cfm

Barometric Pressure(in. Hg)	30.05
Stack Temperature(^oF)	505.
Sample Time(min.)	210.
Sample Volume(cf)	121.4
Moisture(%H_2O)	10.7
Meter Temperature(^oF)	60.
Flow Setting,ΔH(in. H_2O)	1.30
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-0.99
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	30.9	36.1	63.9	8.7
2	2.0	2.3	61.6	8.1
3	3.5	4.1	57.5	5.0
4	4.1	4.8	52.7	3.4
5	4.4	5.2	47.5	1.8
6	4.8	5.6	41.9	0.79
7	4.5	5.3	36.6	0.46
8	3.0	3.5	33.1	0.23
Backup Filter	28.3	33.1	0.0	---
TOTAL	85.5	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-58

PARTICLE SIZE DISTRIBUTION

Run: Six

Date: 12/14/81

Traverse Point No. Sampled: B-3; D-3

Fuel Firing Ratio, %Gas:%Oil 27:73

Percent O_2 (at test location) 6.6

Sample Flow Rate (at stack conditions): 1.19 cfm

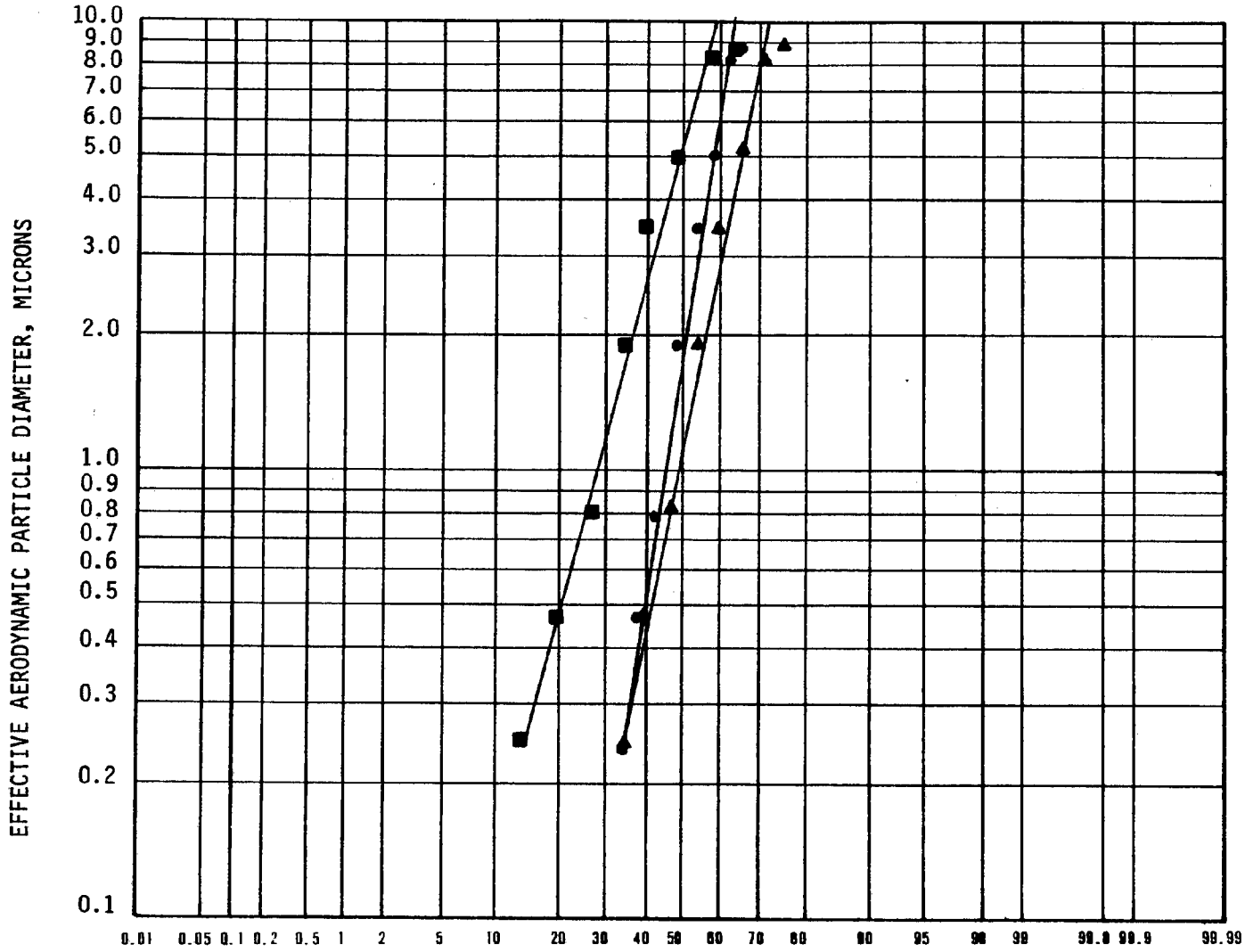
Barometric Pressure(in. Hg)	30.05
Stack Temperature(^oF)	505.
Sample Time(min.)	150.
Sample Volume(cf)	86.1
Moisture(%H_2O)	10.7
Meter Temperature(^oF)	59.
Flow Setting,ΔH(in. H_2O)	1.3
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-1.30
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	22.1	37.7	62.3	8.7
2	3.3	5.6	56.7	8.1
3	5.0	8.5	48.2	5.0
4	4.8	8.2	40.0	3.4
5	4.0	6.8	33.2	1.8
6	4.4	7.5	25.7	0.80
7	3.8	6.5	19.2	0.46
8	3.5	6.0	13.2	0.24
Backup Filter	7.7	13.2	0.0	---
TOTAL	58.6	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B SOURCE 2

PARTICLE SIZE DISTRIBUTION TEST RESULTS



Key:

▲Test at 31% Gas : 69% Oil and 6.7% O_2 on 12/13/81.

●Test at 27% Gas : 73% Oil and 6.7% O_2 on 12/14/81.

■Test at 27% Gas : 73% Oil and 6.6% O_2 on 12/14/81.

FIGURE A-8

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-59

PARTICLE SIZE DISTRIBUTION

Run:	Ten	Barometric Pressure(in. Hg)	30.19
Date:	12/17/81	Stack Temperature(^{o}F)	485.
Traverse Point No. Sampled:	B-3	Sample Time(min.)	120.
Fuel Firing Ratio, %Gas:%Oil	0:100	Sample Volume(cf)	66.0
Percent O_2 (at test location)	4.9	Moisture(%H_2O)	10.5
		Meter Temperature(^{o}F)	62.
		Flow Setting,ΔH(in. H_2O)	1.20
		Nozzle Diameter(in.)	0.180
		Static Pressure(in. H_2O)	-1.0
		Meter γ	0.99
Sample Flow Rate (at stack conditions):	1.11 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	24.2	18.7	81.3	9.0
2	11.0	8.5	72.8	8.3
3	12.7	9.8	63.0	5.2
4	11.5	8.9	54.1	3.5
5	11.5	8.9	45.2	1.8
6	10.7	8.2	37.0	0.83
7	10.9	8.4	28.6	0.49
8	9.6	7.4	21.2	0.25
Backup Filter	27.5	21.2	0.0	---
TOTAL	129.6	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-60

PARTICLE SIZE DISTRIBUTION

Run: Eleven

Date: 12/17/81

Traverse Point No. Sampled: D-3

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (at test location) 5.0

Sample Flow Rate (at stack conditions): 1.07 cfm

Barometric Pressure(in. Hg)	30.20
Stack Temperature(^oF)	488.
Sample Time(min.)	120.
Sample Volume(cf)	65.4
Moisture(%H_2O)	10.0
Meter Temperature(^oF)	72.
Flow Setting,ΔH(in. H_2O)	1.10
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-1.01
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.0	14.3	85.7	9.2
2	0.9	1.6	84.1	8.5
3	3.3	5.9	78.2	5.3
4	3.0	5.4	72.8	3.5
5	2.3	4.1	68.7	1.9
6	2.9	5.2	63.5	0.85
7	1.7	3.0	60.5	0.49
8	2.2	3.9	56.6	0.25
Backup Filter	31.7	56.6	---	---
TOTAL	56.0	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-61

PARTICLE SIZE DISTRIBUTION

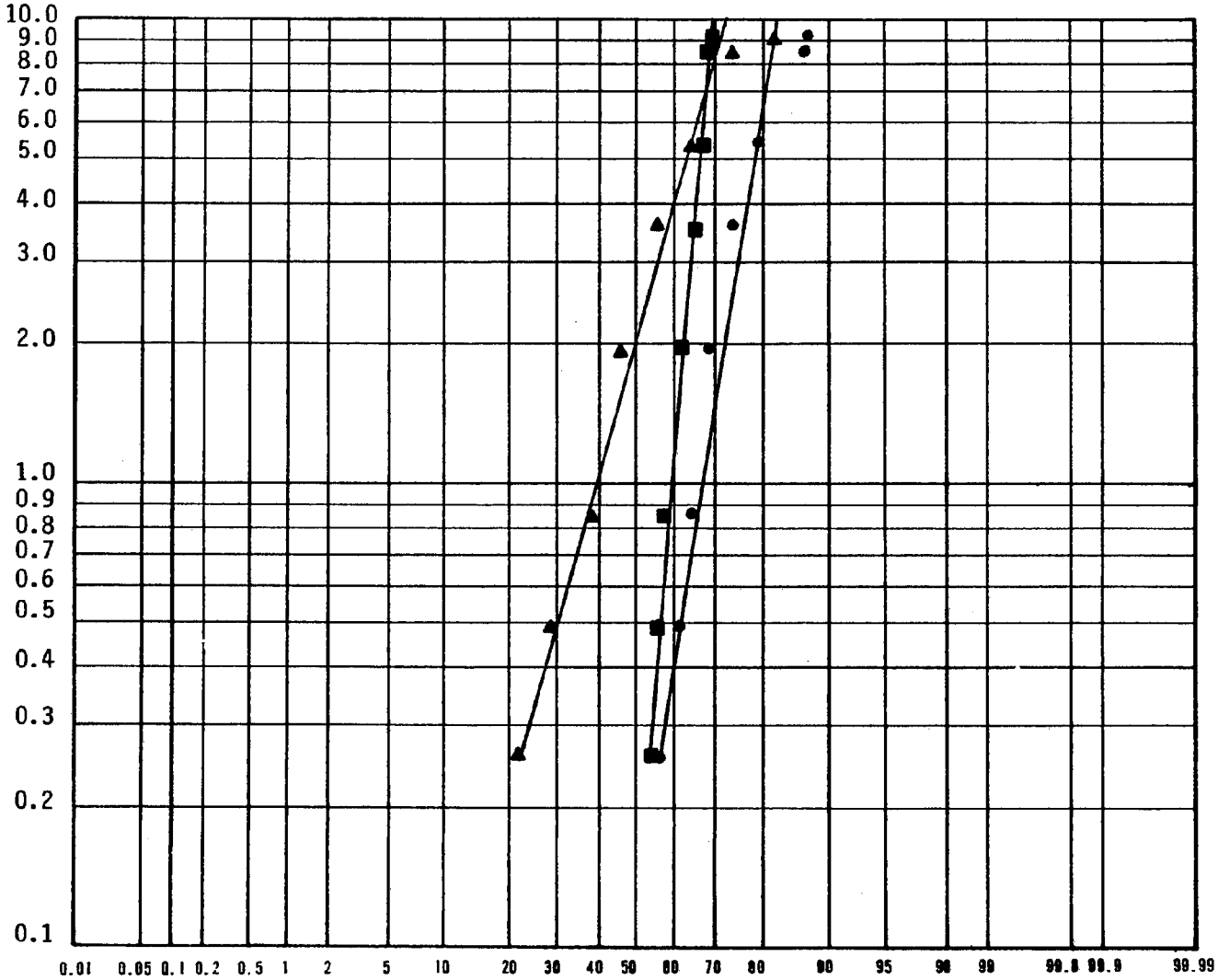
Run:	Twelve	Barometric Pressure(in. Hg)	30.29
Date:	12/18/81	Stack Temperature(^{o}F)	486.
Traverse Point No. Sampled:	B-3: D-3	Sample Time(min.)	120.
Fuel Firing Ratio, %Gas:%Oil	0:100	Sample Volume(cf)	64.6
Percent O_2 (at test location)	4.7	Moisture(%H_2O)	10.2
		Meter Temperature(^{o}F)	64.6
		Flow Setting,ΔH(in. H_2O)	1.10
		Nozzle Diameter(in.)	0.180
		Static Pressure(in. H_2O)	-1.23
		Meter γ	0.99
Sample Flow Rate (at stack conditions):	1.08 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	13.4	30.6	69.4	9.1
2	0.9	2.1	67.3	8.5
3	0.7	1.6	65.7	5.3
4	0.8	1.8	63.9	3.5
5	1.3	3.0	60.9	1.9
6	1.7	3.9	57.0	0.85
7	1.2	2.7	54.3	0.49
8	0.8	1.8	52.5	0.25
Backup Filter	23.0	52.5	0.0	---
TOTAL	43.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B SOURCE 2

PARTICLE SIZE DISTRIBUTION TEST RESULTS



Key:

▲Test at 0% Gas : 100% Oil and 4.9% O_2 on 12/17/81.

●Test at 0% Gas : 100% Oil and 5.0% O_2 on 12/17/81.

■Test at 0% Gas : 100% Oil and 4.7% O_2 on 12/18/81.

FIGURE A-9

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-62

PARTICLE SIZE DISTRIBUTION

Run:	Seven	Barometric Pressure(in. Hg)	30.14
Date:	12/15/81	Stack Temperature(^{o}F)	498.
Traverse Point No. Sampled:	D-3	Sample Time(min.)	120.
Fuel Firing Ratio, %Gas:%Oil	0:100	Sample Volume(cf)	68.9
Percent O_2 (at test location)	6.5	Moisture(%H_2O)	9.4
		Meter Temperature(^{o}F)	73.
		Flow Setting,ΔH(in. H_2O)	1.30
		Nozzle Diameter(in.)	0.180
		Static Pressure(in. H_2O)	-1.35
		Meter γ	0.99
Sample Flow Rate (at stack conditions):	1.20 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	15.3	22.3	77.7	8.7
2	1.5	2.2	75.5	8.0
3	3.8	5.5	70.0	5.0
4	2.7	3.9	66.1	3.4
5	3.0	4.4	61.7	1.8
6	5.2	7.6	54.1	0.80
7	6.3	9.2	44.9	0.46
8	4.6	6.7	38.2	0.23
Backup Filter	26.2	38.2	0.0	---
TOTAL	68.6	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-63

PARTICLE SIZE DISTRIBUTION

Run: Eight

Date: 12/16/81

Traverse Point No. Sampled: B-3

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (at test location) 6.7

Sample Flow Rate (at stack conditions): 1.14 cfm

Barometric Pressure(in. Hg)	30.08
Stack Temperature(^{o}F)	501.
Sample Time(min.)	120.
Sample Volume(cf)	71.1
Moisture(%H_2O)	10.0
Meter Temperature(^{o}F)	92.
Flow Setting,ΔH(in. H_2O)	1.35
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-1.33
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	27.4	31.4	68.6	8.9
2	2.0	2.3	66.3	8.2
3	4.1	4.7	61.6	5.1
4	3.2	3.7	57.9	3.4
5	3.5	4.0	53.9	1.8
6	3.6	4.1	49.8	0.82
7	7.9	9.0	40.8	0.48
8	4.2	4.8	36.0	0.24
Backup Filter	31.4	36.0	0.0	---
TOTAL	87.3	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-64

PARTICLE SIZE DISTRIBUTION

Run: Nine

Date: 12/16/81

Traverse Point No. Sampled: D-3

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (at test location) 6.6

Sample Flow Rate (at stack conditions): 1.15 cfm

Barometric Pressure(in. Hg)	30.08
Stack Temperature(^oF)	499.
Sample Time(min.)	120.
Sample Volume(cf)	72.2
Moisture(%H_2O)	9.9
Meter Temperature(^oF)	93.
Flow Setting,ΔH(in. H_2O)	1.35
Nozzle Diameter(in.)	0.180
Static Pressure(in. H_2O)	-1.15
Meter γ	0.99
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	7.9	14.0	86.0	8.9
2	0.8	1.4	84.6	8.2
3	2.1	3.7	80.9	5.1
4	3.7	6.6	74.3	3.4
5	3.3	5.9	68.4	1.8
6	3.7	6.6	61.8	0.81
7	3.7	6.6	55.2	0.47
8	5.5	9.8	45.4	0.24
Backup Filter	25.6	45.4	0.0	---
TOTAL	56.3	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY B SOURCE 2

PARTICLE SIZE DISTRIBUTION TEST RESULTS

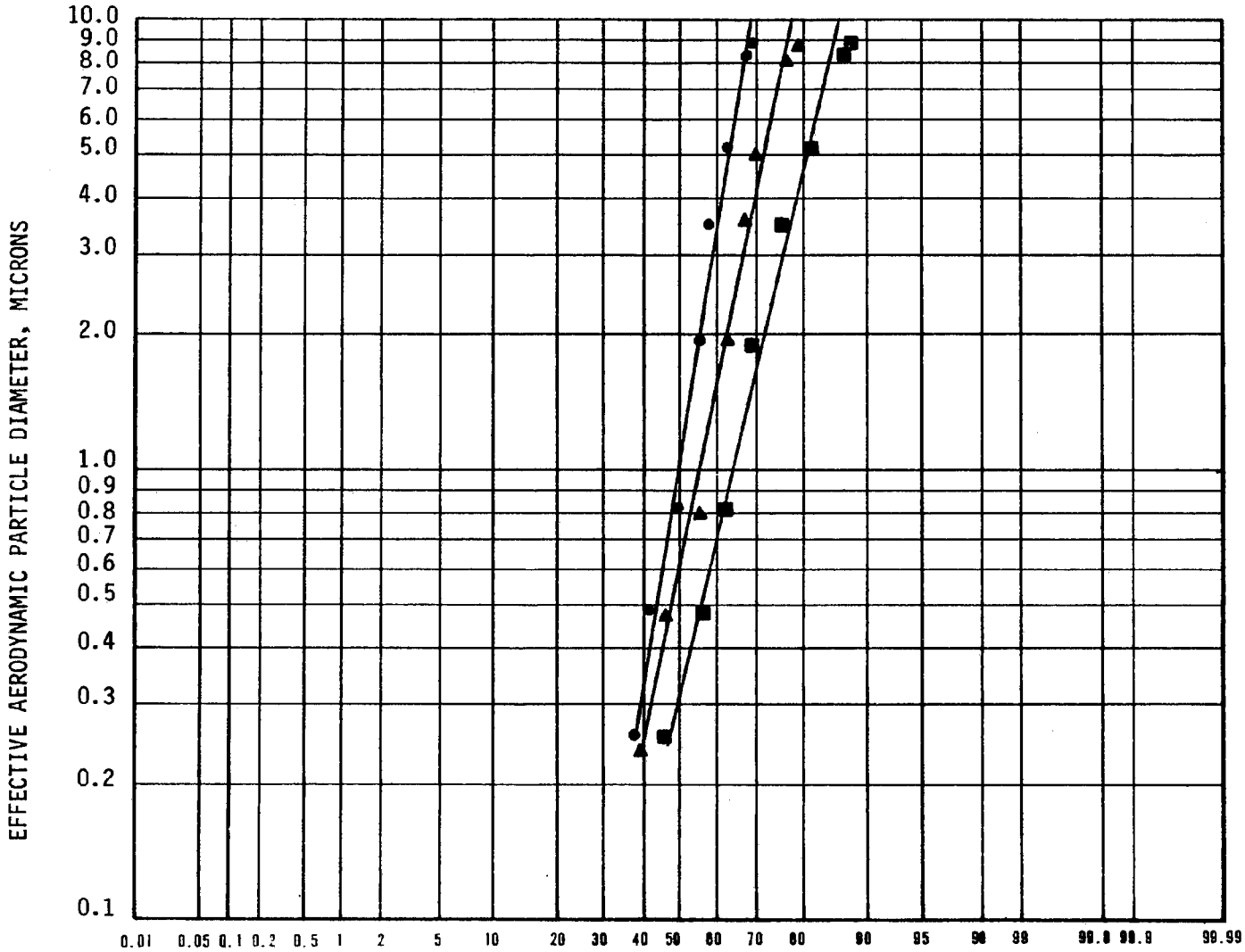


FIGURE A-10

AMERICAN PETROLEUM INSTITUTE

REFINERY B

SOURCE 2

Table A-65

RESULTS OF FUEL OIL COMPOSITE SAMPLE ANALYSES
FOR TEST RUNS 1-12, 12/11-18/81

Ash, %	0.03
Carbon, %	86.8
Hydrogen, %	11.3
Nitrogen, %	0.22
Oxygen, %	0.87
Sulfur, %	0.73
Density, lbs/gal	7.951
Heating Value, BTU/lb.	18,750.
Heating Value, BTU/gal.	149,100.
Viscosity, SFS at 122°F.	81.6
Metals, ppm by weight	
Arsenic	< 0.2
Barium	0.7
Cadmium	< 0.5
Chromium	0.7
Copper	1.5
Lead	5.4
Mercury	0.05
Nickel	11.0
Selenium	< 0.1
Vanadium	2.1
Zinc	6.7

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1
Table A-66
SUMMARY OF PARTICULATE TEST DATA

	1	2	3
Test Data			
Test Run Number			
Test Date	2/17/82	2/18/82	2/19/82
Test Period	1005-1421	0908-1458	0937-1400
Sampling Data			
Sampling Duration, minutes	240.0	200.0	200.0
Nozzle Diameter, inches	0.253	0.253	0.253
Barometric Pressure, inches mercury	30.12	30.28	29.95
Average Orifice Pressure Differential, inches water	1.55	1.62	1.61
Average Dry Gas Temperature at Meter, °F	61.	70.	75.
Total Water Collected by Train, ml	315.5	251.0	252.0
Standard Volume of Water Vapor Collected, cubic feet	14.9	11.8	11.9
Dry Gas Meter Calibration Factor, dimensionless	1.005	1.005	1.005
Sample Volume at Meter Conditions, cubic feet	136.3	120.8	122.2
Sample Volume at Standard Conditions, cubic feet[1]	140.2	122.9	121.8
Gas Stream Composition			
CO_2, percent by volume	9.8	9.4	10.0
O_2, percent by volume	7.2	7.5	7.2
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	83.0	83.1	82.8
Moisture in Gas Stream, percent by volume	9.6	8.8	8.9
Mole Fraction of Dry Gas	0.904	0.912	0.911
Molecular Weight of Dry Gas	29.9	29.8	29.9
Molecular Weight of Wet Gas	28.7	28.8	28.8
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.33	- 0.28	- 0.32
Absolute Pressure, inches mercury	30.1	30.3	29.9
Average Temperature, °F	349.	359.	364.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	46.6	49.1	49.8
Stack/duct Cross-Sectional Area, square feet	28.3	28.3	28.3
Volumetric Flow, Wet Actual cubic feet/minute	79,100.	83,400.	84,500.
Volumetric Flow, Dry Standard cubic feet/minute	46,900.	49,600.	49,300.
Percent Isokinetic	100.8	100.3	100.0
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:%Oil	0:100	0:100	0:100
Percent O_2 Exiting Boiler	3.5	4.0	3.5
Percent O_2 at Test Location	7.2	7.5	7.2
Boiler Steam Production Rate, 10^3 lb/hr.	103.	106.	103.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1
Table A-67

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

	1	2	3
Test Data			
Test Run Number	1	2	3
Test Date	2/17/82	2/18/82	2/19/82
Test Time	1005-1421	0908-1458	0937-1400
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	46,900.	49,600.	49,300.
Wet Actual Cubic Feet/Minute	79,100.	83,400.	84,500.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0709	0.1039	0.0889
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0001
Filter Catch Wt., grams	0.1163	0.1370	0.1241
Front-Half Catch Wt. Sub-total, grams	0.1872	0.2409	0.2131
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0000
Impinger Contents/Wash Residue Wt., grams	0.0566	0.0103	0.0799
Back-Half Acetone Wash Residue Wt., grams	0.0022	0.0012	0.0019
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0036
Back Half Catch Wt. Sub-total, grams	0.0588	0.0115	0.0854
Total Catch Weight, grams	0.2460	0.2524	0.2985
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.021	0.030	0.027
Mass Emission Rate, pounds/hour	8.29	12.9	11.4
Total			
Concentration, grains/dry standard cubic foot	0.027	0.032	0.038
Mass Emission Rate, pounds/hour	10.9	13.5	16.0
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	157.	123.	191.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	19.	15.	23.
Mass Emission Rate, Pounds/Hour	53.	44.	67.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.
[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1
Table A-68
SUMMARY OF PARTICULATE TEST DATA

	4	5	6
Test Data			
Test Run Number	4	5	6
Test Date	2/22/82	2/22/82	2/23/82
Test Period	0855-1246	1313-1640	0929-1311
Sampling Data			
Sampling Duration, minutes	200.0	200.0	200.0
Nozzle Diameter, inches	0.253	0.253	0.253
Barometric Pressure, inches mercury	29.80	29.80	30.07
Average Orifice Pressure Differential, inches water	1.15	1.13	1.22
Average Dry Gas Temperature at Meter, °F	59.	61.	73.
Total Water Collected by Train, ml	198.0	210.0	211.0
Standard Volume of Water Vapor Collected, cubic feet	9.3	9.9	9.9
Dry Gas Meter Calibration Factor, dimensionless	1.005	1.005	1.005
Sample Volume at Meter Conditions, cubic feet	110.4	108.8	112.8
Sample Volume at Standard Conditions, cubic feet[1]	112.6	110.8	113.3
Gas Stream Composition			
CO_2, percent by volume	8.1	8.5	8.3
O_2, percent by volume	9.7	9.5	9.6
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	82.2	82.0	82.1
Moisture in Gas Stream, percent by volume	7.6	8.2	8.1
Mole Fraction of Dry Gas	0.924	0.918	0.919
Molecular Weight of Dry Gas	29.7	29.7	29.7
Molecular Weight of Wet Gas	28.9	28.7	28.8
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.28	- 0.31	- 0.42
Absolute Pressure, inches mercury	29.8	29.8	30.0
Average Temperature, °F	372.	373.	377.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	45.5	45.0	45.5
Stack/duct Cross-Sectional Area, square feet	28.3	28.3	28.3
Volumetric Flow, Wet Actual cubic feet/minute	77,100.	76,300.	77,200.
Volumetric Flow, Dry Standard cubic feet/minute	45,000.	44,200.	45,000.
Percent Isokinetic	101.4	101.5	102.0
Unit/Process Operations Data			
Fuel Firing Ratio, %Gas:% Oil	0:100	0:100	0:100
Percent O_2 Exiting Boiler	5.4	5.4	5.5
Percent O_2 at Test Location	9.7	9.5	9.6
Boiler Steam Production Rate, 10^3 lb/hr.	100.	100.	95.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-69

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

	4	5	6
Test Data			
Test Run Number	4	5	6
Test Date	2/22/82	2/22/82	2/23/82
Test Time	0855-1246	1313-1640	0949-1311
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	45,000.	44,200.	45,000.
Wet Actual Cubic Feet/Minute	77,100.	76,300.	77,200.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.0704	0.1027	0.1040
Front-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0002
Filter Catch Wt., grams	0.2057	0.1782	0.1200
Front-Half Catch Wt. Sub-total, grams	0.2761	0.2809	0.2242
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	-----	-----	0.0000
Impinger Contents/Wash Residue Wt., grams	0.0190	0.0691	0.0210
Back-Half Acetone Wash Residue Wt., grams	0.0022	0.0013	0.0006
Back-Half Methylene Chloride Wash Residue Wt., grams	-----	-----	0.0038
Back Half Catch Wt. Sub-total, grams	0.0212	0.0704	0.0254
Total Catch Weight, grams	0.2973	0.3513	0.2496
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot	0.038	0.039	0.031
Mass Emission Rate, pounds/hour	14.6	14.8	11.8
Total			
Concentration, grains/dry standard cubic foot	0.041	0.049	0.034
Mass Emission Rate, pounds/hour	15.7	18.5	13.1
NO_X Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	170.	162.	158.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	20.	19.	19.
Mass Emission Rate, Pounds/Hour	55.	51.	51.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1
Table A-70
SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	7	8	9
Test Date	3/3/82	3/4/82	3/4/82
Test Period	0910-1556	0937-1315	1429-1718
Sampling Data			
Sampling Duration, minutes	400.0	200.0	160.0
Nozzle Diameter, inches	0.253	0.253	0.253
Barometric Pressure, inches mercury	30.14	30.24	30.24
Average Orifice Pressure Differential, inches water	1.46	1.45	1.38
Average Dry Gas Temperature at Meter, °F	61.	63.	72.
Total Water Collected by Train, ml	523.0	274.0	209.0
Standard Volume of Water Vapor Collected, cubic feet	24.6	12.9	9.8
Dry Gas Meter Calibration Factor, dimensionless	1.005	1.005	1.005
Sample Volume at Meter Conditions, cubic feet	232.3	115.7	91.7
Sample Volume at Standard Conditions, cubic feet[1]	239.0	119.0	92.8
Gas Stream Composition			
CO_2, percent by volume	7.4	7.5	7.4
O_2, percent by volume	9.2	9.1	9.1
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	83.4	83.4	83.5
Moisture in Gas Stream, percent by volume	9.3	9.8	9.6
Mole Fraction of Dry Gas	0.907	0.902	0.904
Molecular Weight of Dry Gas	29.6	29.6	29.6
Molecular Weight of Wet Gas	28.5	28.4	28.4
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.41	- 0.35	- 0.50
Absolute Pressure, inches mercury	30.1	30.2	30.2
Average Temperature, °F	366.	368.	369.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	47.4	47.0	46.2
Stack/duct Cross-Sectional Area, square feet	28.3	28.3	28.3
Volumetric Flow, Wet Actual cubic feet/minute	80,500.	79,700.	78,300.
Volumetric Flow, Dry Standard cubic feet/minute	46,900.	46,300.	45,500.
Percent Isokinetic	103.1	104.0	103.1
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas : % Oil	47:53	36:64	48:52
Percent O_2 Exiting Boiler	5.5	5.4	5.4
Percent O_2 at test location	9.2	9.1	9.1
Boiler Steam Production Rate, 10^3 lb/hr.	97.	100.	100.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-71

SUMMARY OF PARTICULATE AND NO_X TEST RESULTS

Test Data			
Test Run Number	7	8	9
Test Date	3/3/82	3/4/82	3/4/82
Test Time	0910-1556	0937-1315	1429-1718
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	46,900.	46,300.	45,500.
Wet Actual Cubic Feet/Minute	80,500.	79,700.	78,300.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.2267	0.1127	0.0832
Front-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0041
Filter Catch Wt., grams	0.2444	0.1759	0.1250
Front-Half Catch Wt. Sub-total, grams	0.4711	0.2886	0.2123
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	---	0.0131
Impinger Contents/Wash Residue Wt., grams	0.0087	0.0355	0.0056
Back-Half Acetone Wash Residue Wt., grams	0.0013	0.0026	0.0013
Back-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0071
Back Half Catch Wt. Sub-total, grams	0.0100	0.0381	0.0271
Total Catch Weight, grams	0.4811	0.3267	0.2394
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot,	0.030	0.037	0.035
Mass Emission Rate, pounds/hour	12.2	14.9	13.8
Total			
Concentration, grains/dry standard cubic foot,	0.031	0.042	0.040
Mass Emission Rate, pounds/hour	12.5	16.8	15.5
NO_X Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	134.	121.	118.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	16.	14.	14.
Mass Emission Rate, Pounds/Hour	45.	40.	39.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1
Table A-72
SUMMARY OF PARTICULATE TEST DATA

Test Data			
Test Run Number	10	11	12
Test Date	3/22/82	3/23/82	3/23/82
Test Period	1007-1340	0900-1230	1430-1757
Sampling Data			
Sampling Duration, minutes	200.0	200.0	200.0
Nozzle Diameter, inches	0.253	0.253	0.253
Barometric Pressure, inches mercury	30.10	30.03	30.03
Average Orifice Pressure Differential, inches water	1.18	1.39	1.40
Average Dry Gas Temperature at Meter, °F	72.	78.	88.
Total Water Collected by Train, ml	225.0	227.0	226.0
Standard Volume of Water Vapor Collected, cubic feet	10.6	10.7	10.6
Dry Gas Meter Calibration Factor, dimensionless	1.005	1.005	1.005
Sample Volume at Meter Conditions, cubic feet	114.3	120.2	121.4
Sample Volume at Standard Conditions, cubic feet[1]	115.1	119.4	118.5
Gas Stream Composition			
CO_2, percent by volume	7.4	7.4	7.8
O_2, percent by volume	10.5	10.2	9.7
CO, percent by volume	0.0	0.0	0.0
N_2, percent by volume	82.1	82.4	82.5
Moisture in Gas Stream, percent by volume	8.4	8.2	8.2
Mole Fraction of Dry Gas	0.916	0.918	0.918
Molecular Weight of Dry Gas	29.6	29.6	29.6
Molecular Weight of Wet Gas	28.6	28.6	28.7
Gas Stream Velocity and Volumetric Flow			
Static Pressure, inches water	- 0.25	- 0.32	- 0.27
Absolute Pressure, inches mercury	30.1	30.0	30.0
Average Temperature, °F	370.	363.	361.
Pitot Tube Calibration Coefficient, dimensionless	0.84	0.84	0.84
Total Number of Traverse Points	40.0	40.0	40.0
Velocity at Actual Conditions, feet/second	45.3	47.7	48.4
Stack/duct Cross-Sectional Area, square feet	28.3	28.3	28.3
Volumetric Flow, Wet Actual cubic feet/minute	76,900.	80,800.	82,100.
Volumetric Flow, Dry Standard cubic feet/minute	45,000.	47,800.	48,600.
Percent Isokinetic	103.5	101.2	98.8
Unit/Process Operations Data			
Fuel Firing Ratio, % Gas : % Oil	43:57	33:67	35:65
Percent O_2 Exiting Boiler	6.4	6.6	6.5
Percent O_2 at test location	10.5	10.2	9.7
Boiler Steam Production Rate, 10^3 lb/hr.	96.	95.	94.

[1]Standard Conditions = 68°F (20°C) and 29.92 inches (760 mm) mercury, dry basis.

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-73

SUMMARY OF PARTICULATE AND NO_x TEST RESULTS

	10	11	12
Test Data			
Test Run Number	10	11	12
Test Date	3/22/82	3/23/82	3/23/82
Test Time	1007-1341	0900-1230	1430-1757
Gas Flow Volumes			
Dry Standard Cubic Feet/Minute[1]	45,000.	47,800.	48,600.
Wet Actual Cubic Feet/Minute	76,900.	80,800.	82,100.
Particulate Analysis Report			
Front-Half Acetone Wash Residue Wt., grams	0.1121	0.0978	0.0927
Front-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0019
Filter Catch Wt., grams	0.1432	0.1123	0.1256
Front-Half Catch Wt. Sub-total, grams	0.2553	0.2101	0.2202
Methylene Chloride Extraction of Impinger Contents/Wash Residue wt., grams	---	---	0.0029
Impinger Contents/Wash Residue Wt., grams	0.0019	0.0035	0.0049
Back-Half Acetone Wash Residue Wt., grams	0.0006	0.0007	0.0011
Back-Half Methylene Chloride Wash Residue Wt., grams	---	---	0.0093
Back Half Catch Wt. Sub-total, grams	0.0025	0.0042	0.0182
Total Catch Weight, grams	0.2578	0.2143	0.2384
Particulate Results			
Front-Half			
Concentration, grains/dry standard cubic foot,	0.034	0.027	0.029
Mass Emission Rate, pounds/hour	13.2	11.1	12.0
Total			
Concentration, grains/dry standard cubic foot,	0.035	0.028	0.031
Mass Emission Rate, pounds/hour	13.3	11.3	13.0
NO_x Emissions, as NO_2[2]			
Concentration, Parts/million by Volume, dry basis	130.	127.	109.
Concentration, Pounds/Dry Standard Cubic Foot x 10^{-6}	16.	15.	13.
Mass Emission Rate, Pounds/Hour	42.	43.	38.

[1] Standard Conditions = 68°F (20°C) and 29.92 inches Hg.

[2] Results shown are averages of three (3) grab samples.

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-74

PARTICLE SIZE DISTRIBUTION

Run:	Seven	Barometric Pressure(in. Hg)	30.14
Date:	3/3/82	Stack Temperature(^{o}F)	366.
Traverse Point No. Sampled:	X-10: Y-8	Sample Time(min.)	200.
Fuel Firing Ratio, %Gas:%Oil	47:53	Sample Volume(cf)	117.1
Percent O_2 (exiting boiler)	5.5	Moisture(%H_2O)	9.3
Percent O_2 (at test location)	9.2	Meter Temperature(^{o}F)	62.
		Flow Setting,ΔH(in. H_2O)	1.25
		Nozzle Diameter(in.)	0.253
		Static Pressure(in. H_2O)	-0.41
		Meter γ	1.002
Sample Flow Rate (at stack conditions):	1.03 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	45.5	41.7	58.3	8.9
2	5.4	4.9	53.4	8.3
3	5.3	4.9	48.5	5.2
4	6.5	5.9	42.6	3.5
5	6.3	5.8	36.8	1.8
6	6.1	5.6	31.2	0.84
7	3.7	3.4	27.8	0.50
8	3.8	3.5	24.3	0.26
Backup Filter	26.5	24.3	0.0	---
TOTAL	109.1	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-75

PARTICLE SIZE DISTRIBUTION

Run: Eight

Date: 3/4/82

Traverse Point No. Sampled: X-10; Y-8

Fuel Firing Ratio, %Gas:%Oil 36:64

Percent O_2 (exiting boiler) 5.4

Percent O_2 (at test location) 9.1

Sample Flow Rate (at stack conditions): 1.02 cfm

Barometric Pressure(in. Hg)	30.24
Stack Temperature(^oF)	368.
Sample Time(min.)	200.
Sample Volume(cf)	116.4
Moisture(%H_2O)	9.8
Meter Temperature(^oF)	69.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.35
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	27.2	22.1	77.9	9.0
2	6.1	5.0	72.9	8.3
3	8.5	6.9	66.0	5.2
4	9.5	7.7	58.3	3.5
5	7.9	6.4	51.9	1.9
6	7.7	6.3	45.6	0.85
7	4.4	3.6	42.0	0.50
8	4.7	3.8	38.0	0.26
Backup Filter	46.9	38.2	0.0	---
TOTAL	122.9	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-76

PARTICLE SIZE DISTRIBUTION

Run:	Nine	Barometric Pressure(in. Hg)	30.24
Date:	3/4/82	Stack Temperature(^{o}F)	369.
Traverse Point No. Sampled:	X-10:Y-8	Sample Time(min.)	160.
Fuel Firing Ratio, %Gas:%Oil	48:52	Sample Volume(cf)	94.7
Percent O_2 (exiting boiler)	5.4	Moisture(%H_2O)	9.6
Percent O_2 (at test location)	9.1	Meter Temperature(^{o}F)	74.
		Flow Setting,ΔH(in. H_2O)	1.25
		Nozzle Diameter(in.)	0.252
		Static Pressure(in. H_2O)	-0.5
		Meter γ	1.002
Sample Flow Rate (at stack conditions):	1.02 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	18.2	24.7	75.3	9.0
2	5.0	6.8	68.5	8.3
3	4.6	6.2	62.3	5.2
4	5.2	7.1	55.2	3.5
5	6.2	8.4	46.8	1.9
6	5.7	7.7	39.1	0.84
7	4.7	6.4	32.7	0.50
8	3.9	5.3	27.4	0.26
Backup Filter	20.2	27.4	0.0	---
TOTAL	73.7	---	---	---

AMERICAN PETROLEUM INSTITUTE
REFINERY C SOURCE 1
PARTICLE SIZE DISTRIBUTION TEST RESULTS

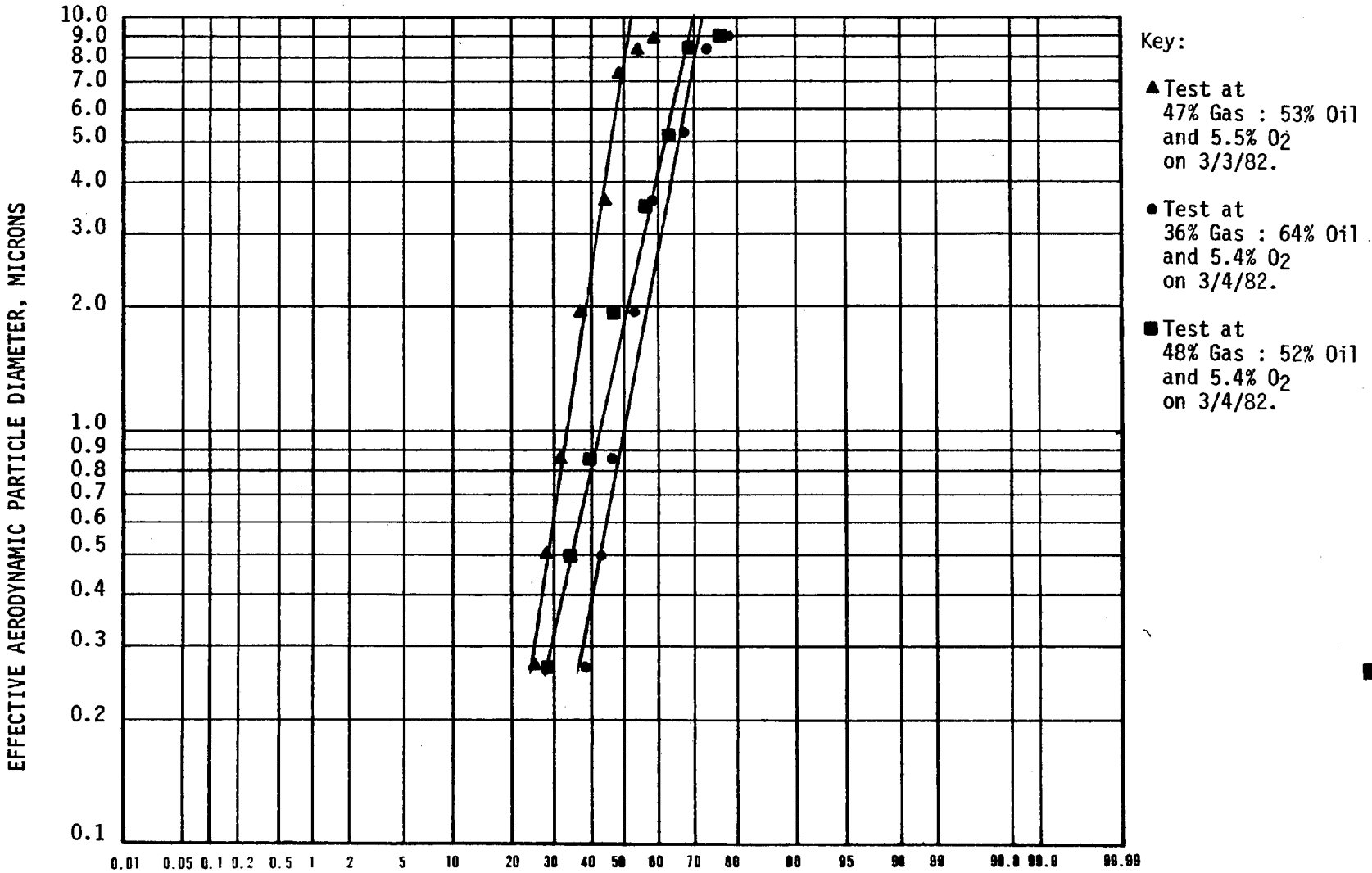


FIGURE A-11

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-77

PARTICLE SIZE DISTRIBUTION

Run: Ten

Date: 3/22/82

Traverse Point No. Sampled: X-10:Y-8

Fuel Firing Ratio, %Gas:%Oil 43:57

Percent O_2 (exiting boiler) 6.4

Percent O_2 (at test location) 10.5

Sample Flow Rate (at stack conditions): 1.02 cfm

Barometric Pressure(in. Hg)	30.10
Stack Temperature(^oF)	370.
Sample Time(min.)	200.
Sample Volume(cf)	120.6
Moisture(%H_2O)	8.5
Meter Temperature(^oF)	78.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.253
Static Pressure(in. H_2O)	-0.25
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	17.3	29.2	70.8	9.0
2	0.9	1.5	69.3	8.3
3	2.0	3.4	65.9	5.2
4	2.5	4.2	61.7	3.5
5	4.4	7.4	54.3	1.9
6	3.4	5.7	48.6	0.84
7	0.6	1.0	47.6	0.50
8	0.9	1.5	46.1	0.26
Backup Filter	27.3	46.1	0.0	---
TOTAL	59.3	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-78

PARTICLE SIZE DISTRIBUTION

Run: Eleven

Date: 3/23/82

Traverse Point No. Sampled: X-11; Y-10

Fuel Firing Ratio, %Gas:%Oil 33:67

Percent O_2 (exiting boiler) 6.6

Percent O_2 (at test location) 10.2

Sample Flow Rate (at stack conditions): 0.992 cfm

Barometric Pressure(in. Hg)	30.03
Stack Temperature(^oF)	363.
Sample Time(min.)	200.
Sample Volume(cf)	119.3
Moisture(%H_2O)	8.2
Meter Temperature(^oF)	82.
Flow Setting,ΔH(in. H_2O)	1.2
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.32
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	10.0	17.3	82.7	9.1
2	2.1	3.6	79.1	8.4
3	1.7	3.0	76.1	5.2
4	2.8	4.9	71.2	3.5
5	3.9	6.7	64.5	1.9
6	4.7	8.1	56.4	0.86
7	1.9	3.3	53.1	0.51
8	1.0	1.7	51.4	0.27
Backup Filter	29.7	51.4	0.0	---
TOTAL	57.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-79

PARTICLE SIZE DISTRIBUTION

Run: Twelve

Date: 3/23/82

Traverse Point No. Sampled: X-11;Y-12

Fuel Firing Ratio, %Gas:%Oil 35:65

Percent O_2 (exiting boiler) 6.5

Percent O_2 (at test location) 9.7

Sample Flow Rate (at stack conditions): 0.99 cfm

Barometric Pressure(in. Hg)	30.03
Stack Temperature(^oF)	361.
Sample Time(min.)	200.
Sample Volume(cf)	120.1
Moisture(%H_2O)	8.3
Meter Temperature(^oF)	87.
Flow Setting,ΔH(in. H_2O)	1.2
Nozzle Diameter(in.)	0.253
Static Pressure(in. H_2O)	-0.27
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.2	14.6	85.4	9.1
2	1.5	2.7	82.7	8.4
3	1.8	3.2	79.5	5.3
4	2.4	4.3	75.2	3.5
5	3.7	6.6	68.6	1.9
6	5.2	9.2	59.4	0.86
7	1.9	3.4	56.0	0.51
8	1.3	2.3	53.7	0.27
Backup Filter	30.3	53.7	0.0	---
TOTAL	56.3	---	---	---

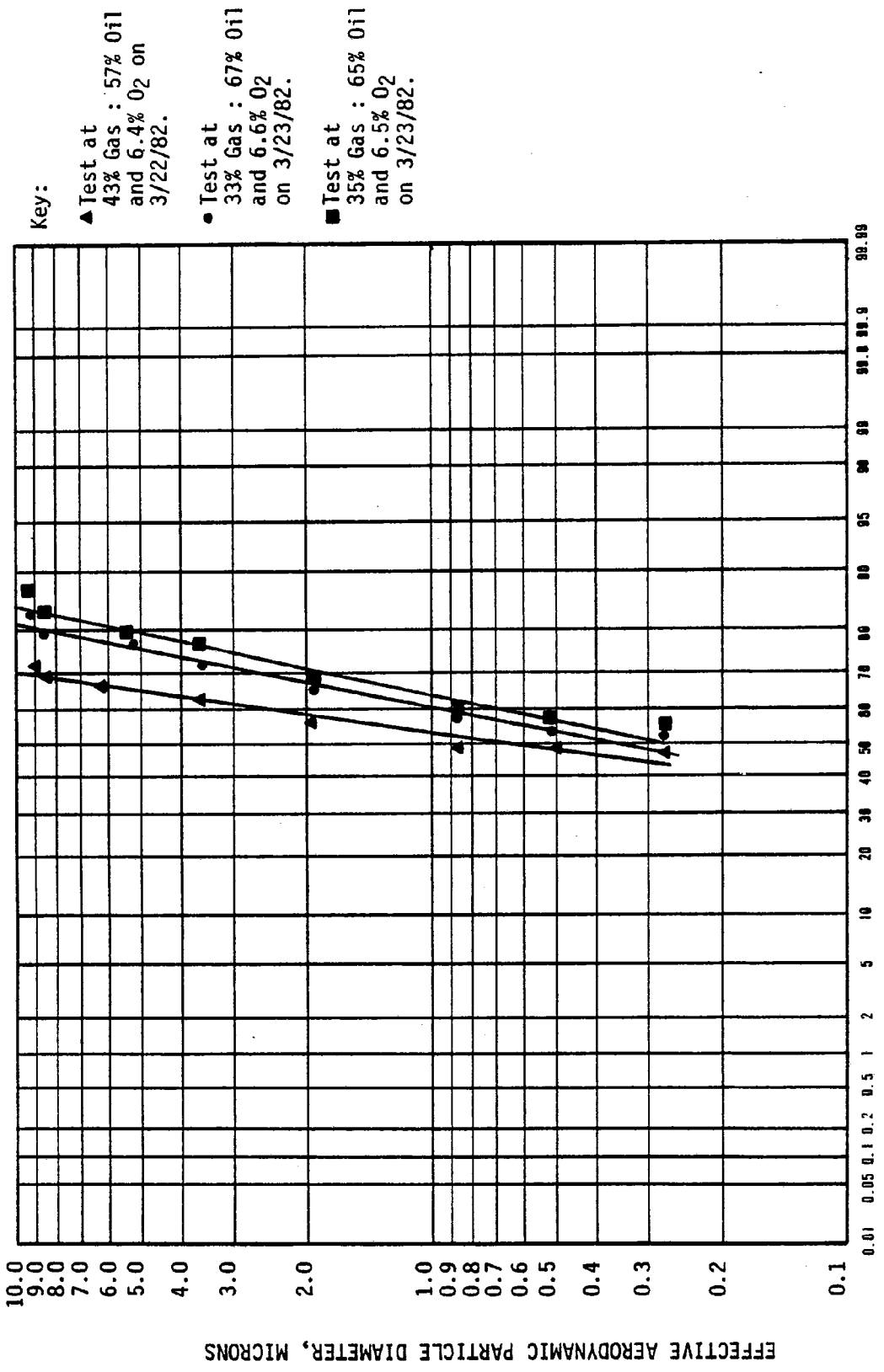


FIGURE A-12

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-80

PARTICLE SIZE DISTRIBUTION

Run:	One	Barometric Pressure(in. Hg)	30.12
Date:	2/17/82	Stack Temperature(^{o}F)	349.
Traverse Point No. Sampled:	Y-13/ X-11	Sample Time(min.)	240.
Fuel Firing Ratio, %Gas:%Oil	0:100	Sample Volume(cf)	146.0
Percent O_2 (exiting boiler)	3.5	Moisture(%H_2O)	9.6
Percent O_2 (at test location)	7.2	Meter Temperature(^{o}F)	48.
		Flow Setting,ΔH(in. H_2O)	1.40
		Nozzle Diameter(in.)	0.252
		Static Pressure(in. H_2O)	-0.33
		Meter γ	1.002
Sample Flow Rate (at stack conditions):	1.08 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	10.1	14.7	85.3	8.7
2	2.3	3.4	81.9	8.0
3	3.4	5.0	76.9	5.0
4	4.5	6.6	70.3	3.4
5	6.3	9.2	61.1	1.8
6	6.7	9.8	51.3	0.81
7	5.3	7.7	43.6	0.48
8	4.8	7.0	36.6	0.25
Backup Filter	25.1	36.6	0.0	---
TOTAL	68.5	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-81

PARTICLE SIZE DISTRIBUTION

Run: Two

Date: 2/18/82

Traverse Point No. Sampled: Y-11; X-11

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (exiting boiler) 4.0

Percent O_2 (at test location) 7.5

Sample Flow Rate (at stack conditions): 1.01 cfm

Barometric Pressure(in. Hg)	30.28
Stack Temperature(^oF)	359.
Sample Time(min.)	200.
Sample Volume(cf)	115.2
Moisture(%H_2O)	8.8
Meter Temperature(^oF)	55.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.28
Meter δ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.1	14.8	85.2	9.0
2	3.6	6.6	78.6	8.3
3	3.8	6.9	71.7	5.2
4	4.4	8.0	63.7	3.5
5	5.3	9.7	54.0	1.9
6	5.8	10.6	43.4	0.85
7	3.8	6.9	36.5	0.50
8	2.5	4.6	31.9	0.26
Backup Filter	17.5	31.9	0.0	---
TOTAL	54.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-82

PARTICLE SIZE DISTRIBUTION

Run: Three

Date: 2/19/82

Traverse Point No. Sampled: Y-11;X-11

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (exiting boiler) 3.5

Percent O_2 (at test location) 7.2

Sample Flow Rate (at stack conditions): 1.02 cfm

Barometric Pressure(in. Hg)	29.95
Stack Temperature(^oF)	364.
Sample Time(min.)	200.
Sample Volume(cf)	118.3
Moisture(%H_2O)	8.9
Meter Temperature(^oF)	6.7
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.32
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	10.5	16.7	83.3	9.0
2	2.6	4.1	79.2	8.3
3	2.8	4.5	74.7	5.2
4	1.6	2.5	72.2	3.5
5	2.1	3.3	68.9	1.9
6	3.0	4.8	64.1	0.84
7	3.1	4.9	59.2	0.50
8	1.9	3.0	56.2	0.26
Backup Filter	35.3	56.2	0.0	---
TOTAL	62.9	---	---	---

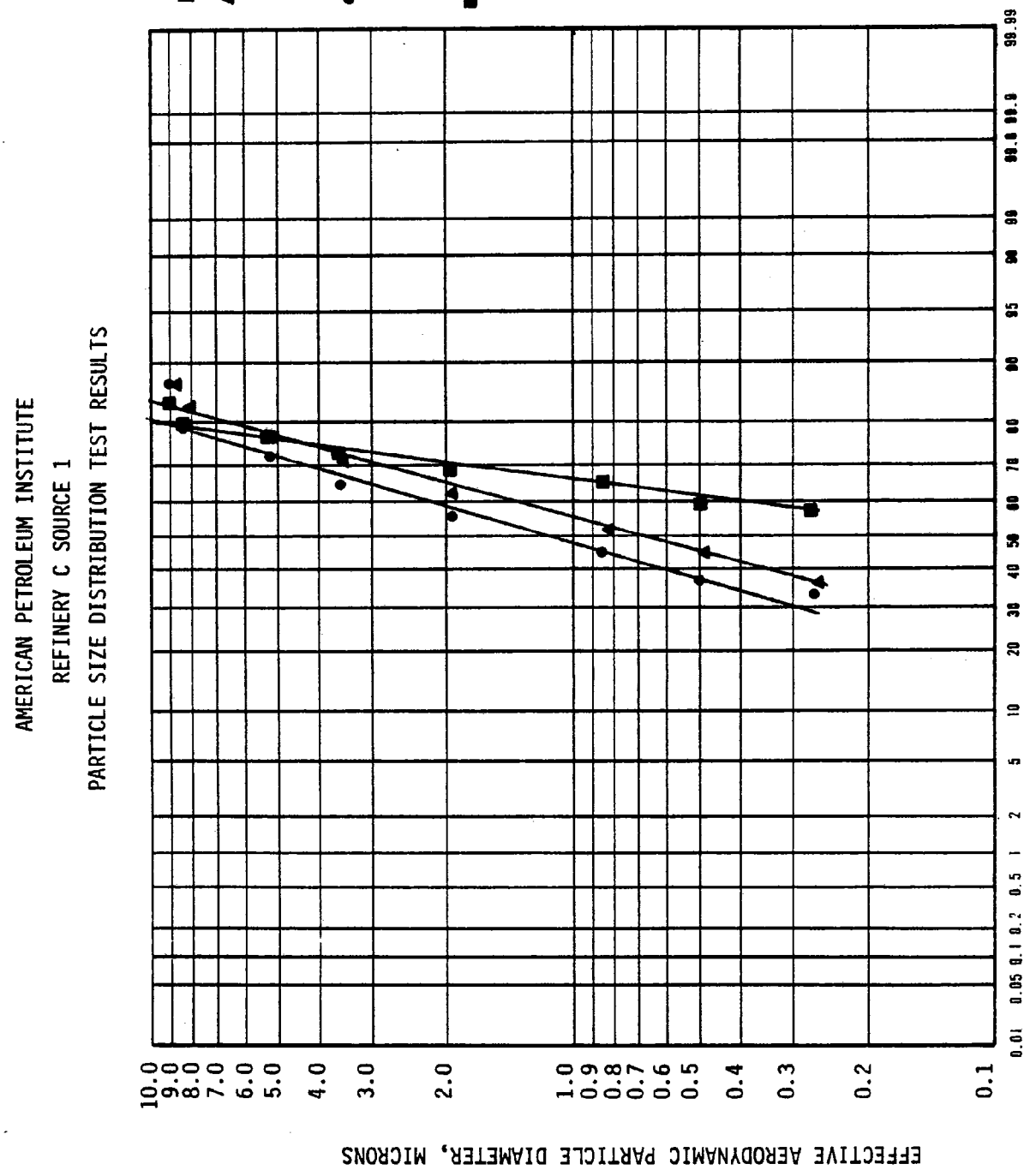


FIGURE A-13

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-83

PARTICLE SIZE DISTRIBUTION

Run: Four

Date: 2/22/82

Traverse Point No. Sampled: Y-11; X-11

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (exiting boiler) 5.4

Percent O_2 (at test location) 9.7

Sample Flow Rate (at stack conditions): 1.03 cfm

Barometric Pressure(in. Hg)	29.80
Stack Temperature(^oF)	372
Sample Time(min.)	200
Sample Volume(cf)	117.4
Moisture(%H_2O)	7.6
Meter Temperature(^oF)	55.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.252
Static Pressure(in. H_2O)	-0.28
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	9.2	13.4	86.6	8.9
2	1.5	2.2	84.4	8.3
3	2.0	2.9	81.5	5.2
4	2.0	2.9	78.6	3.5
5	2.7	3.9	74.7	1.8
6	3.6	5.2	69.5	0.84
7	3.4	4.9	64.6	0.49
8	2.2	3.2	61.4	0.26
Backup Filter	42.2	61.4	0.0	---
TOTAL	68.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-84

PARTICLE SIZE DISTRIBUTION

Run: Five

Date: 2/22/82

Traverse Point No. Sampled: X-10; Y-11

Fuel Firing Ratio, %Gas:%Oil 0:100

Percent O_2 (exiting boiler) 5.4

Percent O_2 (at test location) 9.5

Sample Flow Rate (at stack conditions): 1.03 cfm

Barometric Pressure(in. Hg)	29.80
Stack Temperature(^oF)	373.
Sample Time(min.)	200.
Sample Volume(cf)	116.9
Moisture(%H_2O)	8.2
Meter Temperature(^oF)	59.
Flow Setting,ΔH(in. H_2O)	1.25
Nozzle Diameter(in.)	0.255
Static Pressure(in. H_2O)	-0.31
Meter γ	1.002
Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	15.2	20.6	79.4	9.0
2	2.6	3.5	75.9	8.3
3	2.3	3.1	72.8	5.2
4	3.9	5.3	67.5	3.5
5	5.0	6.8	60.7	1.8
6	5.6	7.6	53.1	0.84
7	4.4	5.9	47.2	0.49
8	5.2	7.0	40.2	0.26
Backup Filter	29.7	40.2	0.0	---
TOTAL	73.9	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-85

PARTICLE SIZE DISTRIBUTION

Run:	Six	Barometric Pressure(in. Hg)	30.07
Date:	2/23/82	Stack Temperature(^{o}F)	377.
Traverse Point No. Sampled:	Y-10:X-11	Sample Time(min.)	200.
Fuel Firing Ratio, %Gas:%Oil	0:100	Sample Volume(cf)	112.8
Percent O_2 (exiting boiler)	5.5	Moisture(%H_2O)	8.1
Percent O_2 (at test location)	9.6	Meter Temperature(^{o}F)	76.
		Flow Setting,ΔH(in. H_2O)	1.25
		Nozzle Diameter(in.)	0.252
		Static Pressure(in. H_2O)	-0.42
		Meter γ	1.002
Sample Flow Rate (at stack conditions):	1.02 cfm	Sample Vac.(in. Hg)	1.0

Plate No.	Net Wt. (mg)	Percent in Size Range	Cumulative Percent Less Than Dia.	EAD (microns)
1	8.8	17.0	83.0	9.0
2	1.8	3.5	79.5	8.4
3	2.3	4.4	75.1	5.2
4	2.5	4.8	70.3	3.5
5	3.1	6.0	64.3	1.9
6	4.7	9.1	55.2	0.85
7	3.3	6.4	48.8	0.50
8	2.3	4.4	44.4	0.26
Backup Filter	23.0	44.4	0.0	---
TOTAL	51.8	---	---	---

AMERICAN PETROLEUM INSTITUTE

REFINERY C SOURCE 1

PARTICLE SIZE DISTRIBUTION TEST RESULTS

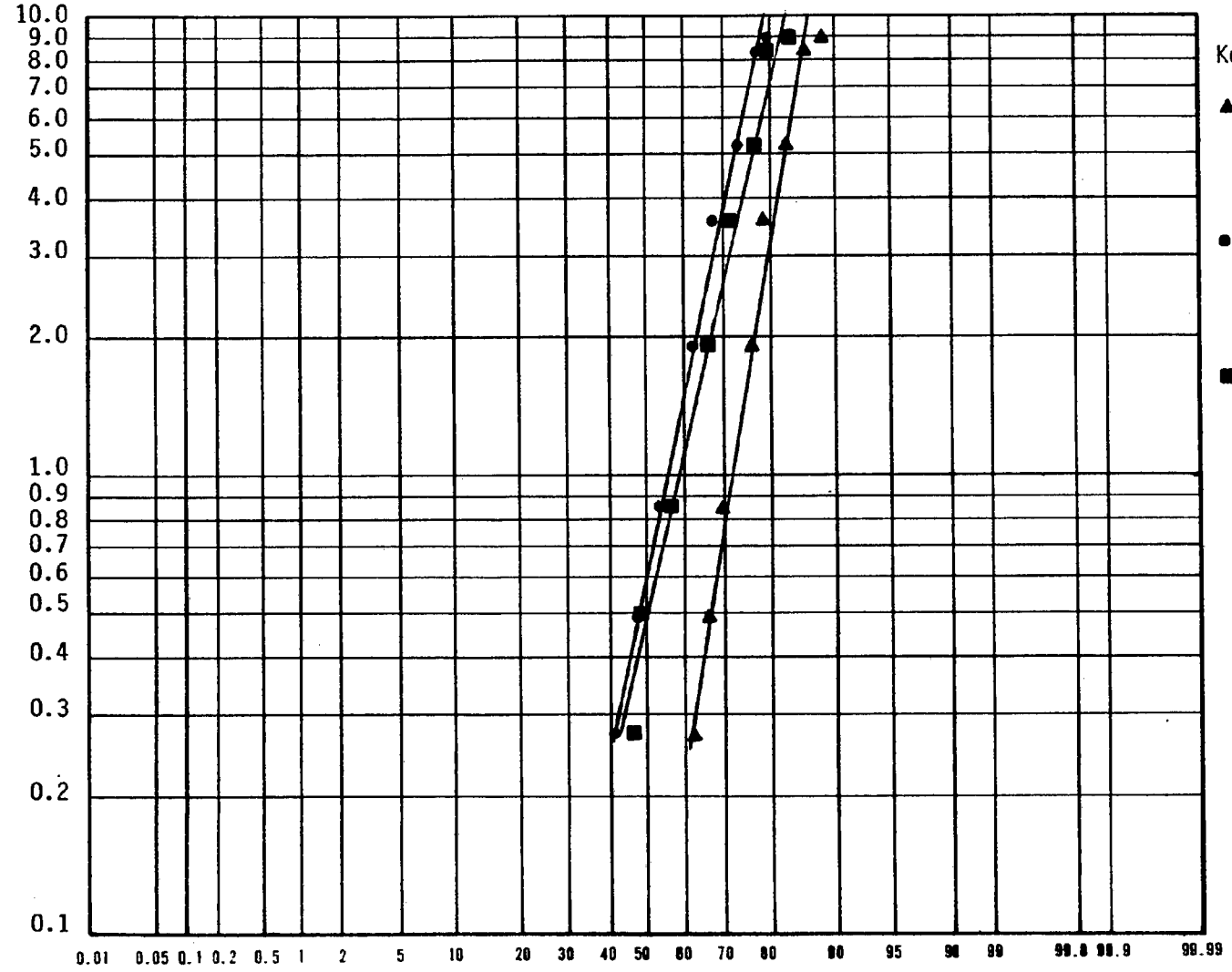


FIGURE A-14

AMERICAN PETROLEUM INSTITUTE

REFINERY C

SOURCE 1

Table A-86

RESULTS OF FUEL OIL COMPOSITE SAMPLE ANALYSES
FOR TEST RUNS 1-12, 2/17-23/1982

Ash, %	0.02
Carbon, %	86.8
Hydrogen, %	11.2
Nitrogen, %	0.18
Oxygen, %	0.61
Sulfur, %	1.19
Density, lbs/gal	8.027
Heating Value, BTU/lb.	18,610.
Heating Value, BTU/gal.	149,400.
Viscosity, SFS @ 122°F.	45.0
Metals, ppm by weight	
Arsenic	< 0.2
Barium	0.75
Cadmium	< 0.5
Chromium	< 0.5
Copper	< 0.5
Lead	< 0.5
Mercury	0.067
Nickel	11.0
Selenium	0.49
Vanadium	31.0
Zinc	1.7

APPENDIX B

DESCRIPTIONS OF UNITS TESTED

DESCRIPTIONS OF UNITS TESTED

Five sources (2 heaters and 3 boilers) were surveyed under this contract. Descriptions of the units and schematics of the test points are contained in this Appendix.

Process Heaters

Refinery A - Source 1

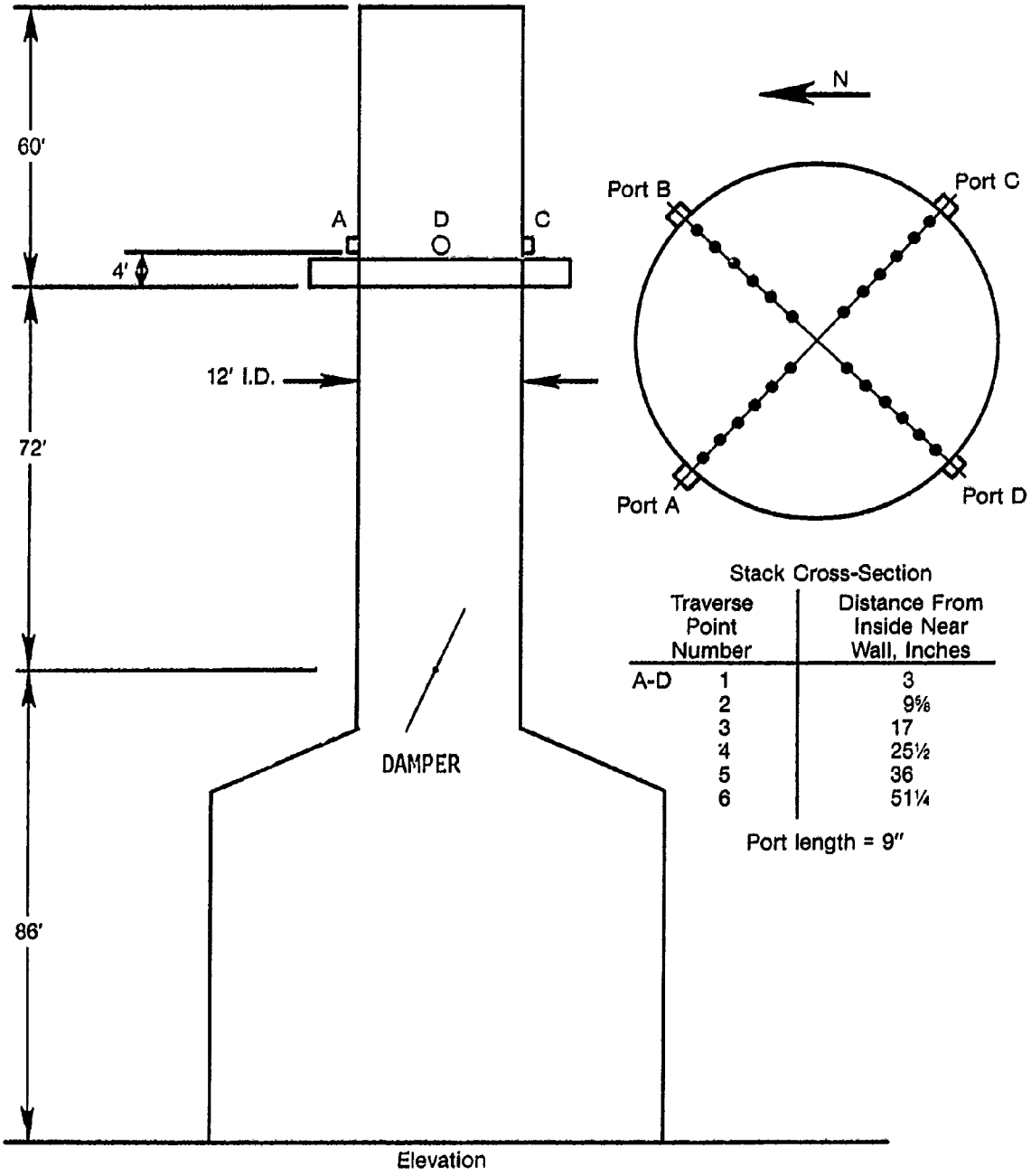
This source is an atmospheric crude heater installed in 1978 by Foster Wheeler. It is 1 of 2 furnaces used to supply heat to a crude unit before atomospheric distillation.

It has a maximum gross fired duty of 315 x 10^6 BTU/hr; fuel ratios can be varied from 0 to 100% gas or oil.

It is a side-fired horizontal radiant tube furnace. Low pressure steam is produced in the convection section.

A schematic of the test site showing traverse point locations is presented in Figure B-1.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 1 (FURNACE)



Stack Cross-Section

	Traverse Point Number	Distance From Inside Near Wall, Inches
A-D	1	3
	2	9⅝
	3	17
	4	25½
	5	36
	6	51¼

Port length = 9"

FIGURE B-1 TEST POINT SCHEMATIC

Refinery B - Source 1

This source, constructed in 1978, is a hydrotreating unit furnace normally used for desulfurization of diesel distillate. Unit processing capacity is 25,000 BPOD with a maximum fired duty of 60.1 x 10^6 BTU/hr. Heat is supplied by firing plant fuel gas only.

The unit may be divided into three sections, namely:

1. Make-up Hydrogen Section
2. Reactor Section
3. Fractionation Section

1. Make-up Hydrogen Section

Make-up hydrogen is supplied from existing high pressure and low pressure hydrogen systems to the unit. Two 100 percent capacity reciprocating machines are provided to compress the make-up gas from either hydrogen system to the suction pressure of a recycle compressor.

2. Reactor Section

The Reaction Section consists of the reactor, heat exchangers, fired heater, coolers, a high pressure separator and centrifugal recycle gas compressor.

Unit charge is supplied cold from offsite tankage. Charge is pumped through a feed solids separator, then through feed/effluent exchangers. The hot oil is then routed through a feed heater.

Recycle gas from the discharge of the recycle compressor exchanges heat with reactor effluent and then combines with the hot charge. Effluent flow leaving the reactor is split between the feed/effluent and gas/effluent exchangers. After exchange, the combined effluent flows to an effluent air cooler where condensate and corrosion inhibitors are injected into the inlet piping. Separation of hydrogen rich gas and rerun tower feed occurs in the HP Separator.

Bleed gas from the HP Separator is released to the high pressure hydrogen system and recycle gas enters the compressor KO drum for recompression by a recycle gas compressor.

Make up gas feed into the effluent air cooler inlet is obtained from either or both the plant high and low pressure hydrogen systems.

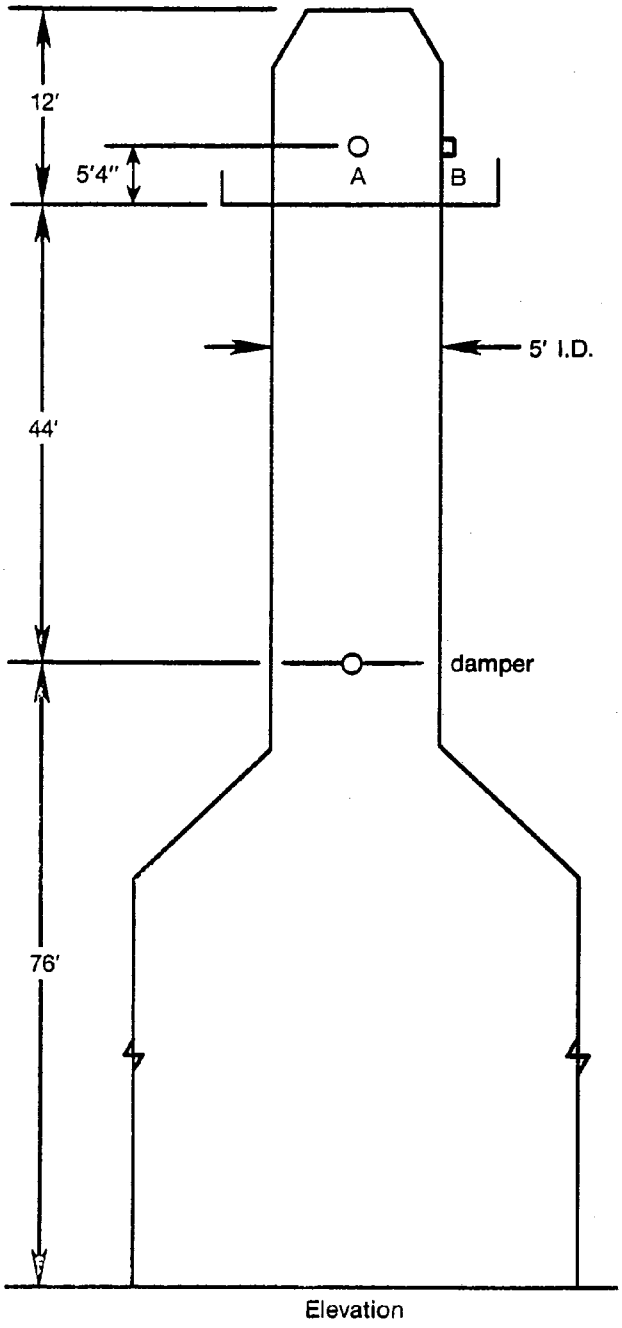
3. Fractionation Section

The stripping and fractionation of the reaction product liquid is accomplished in a routine manner in a rerun tower with a fired heater reboiler.

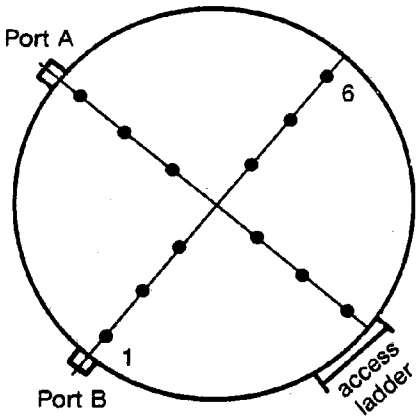
Off gas from the rerun tower is MEA-scrubbed for H_2S removal, compressed and routed offsite for further treating.

A schematic of the test point is presented in Figure B-2.

AMERICAN PETROLEUM INSTITUTE
REFINERY B
SOURCE 1 (HEATER - DIESEL CHARGE)



Elevation



Stack Cross-Section

Traverse Point Number	Distance From Inside Near Wall, Inches
1	2⅝
2	8¾
3	17¾
4	42¼
5	51¼
6	57⅜

Port length = 8"

FIGURE B-2 TEST POINT SCHEMATIC

Boilers

Refinery A - Source 2

This source is a Riley Stoker utility boiler constructed in 1948. The boiler generates high pressure steam for refinery use.

It has a maximum gross fired duty of 215 x 10^6 BTU/hr; fuel ratios can be varied from 0 to 100% refinery fuel gas or oil.

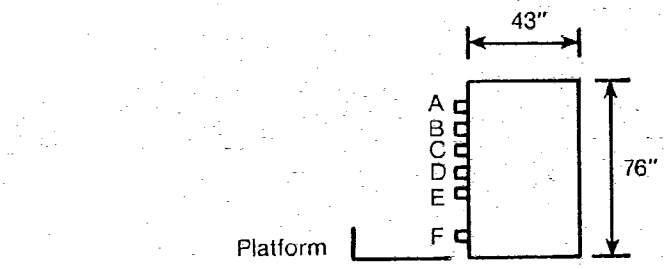
It is a balanced draft, end horizontal fired boiler with vertical section radient tubes and horizontal section convection tubes. It has a combustion air preheater.

A test point schematic is presented in Figure B-3.

AMERICAN PETROLEUM INSTITUTE
REFINERY A
SOURCE 2 (BOILER)

Traverse Point Number	Distance From Inside Near Wall, Inches
1	2⅝
2	8
3	13⅜
4	18¾
5	24⅛
6	29½
7	34⅞
8	40¼

Port Length = 6"



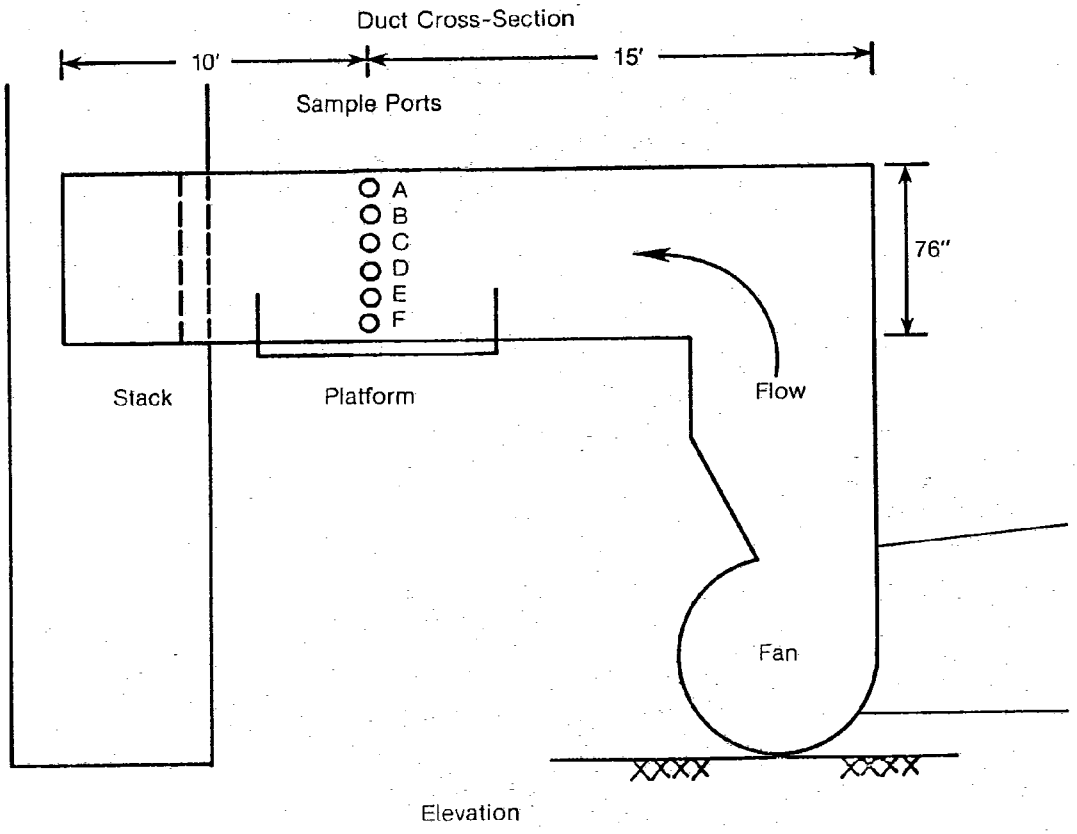


FIGURE B-3 TEST POINT SCHEMATIC

Refinery B - Source 2

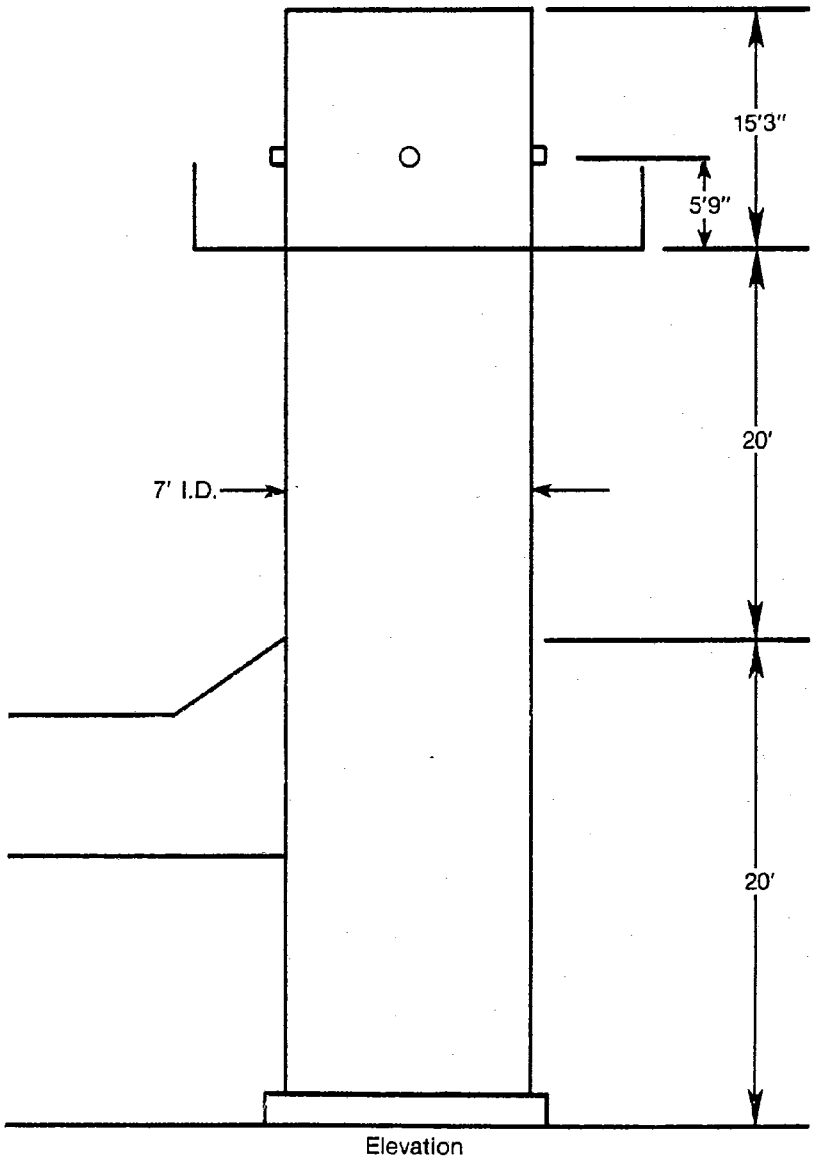
Basically, in this process, water is fed into a generator, and by application of heat, evaporated continuously into steam. The heat is supplied by firing No. 6 fuel oil and/or process fuel gas. The steam generator is of a natural circulation water tube type design built in 1978.

Its steam production capacity is 440. x 10^3 lbs/hr. at a maximum heat rating of 576.1 x 10^6 BTU/hr. Its fuel firing ratio is infinitely adjustable but is currently limited by the availability of process fuel gas to about 30% gas. The unit is normally operated on oil using gas as a float.

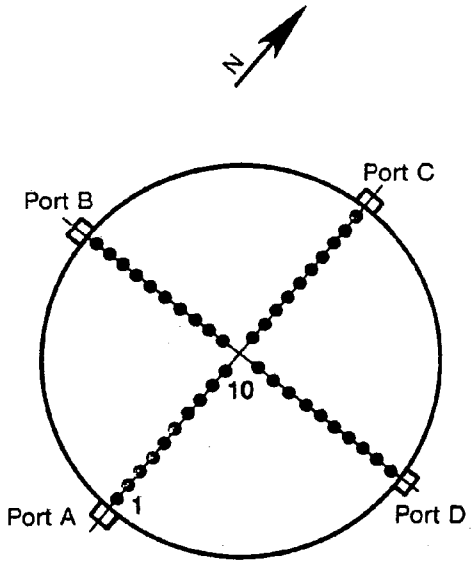
Water is initially introduced into the economizer section for preheat, then flows into the boiler section. The boiler section consists of a steam drum, mud drum, boiler tubes and water wall tubes. Water enters the boiler section via the steam drum, then, by natural circulation, the fluid flows from the steam drum through the boiler and water wall tubes to the mud drum and back to the steam drum. During this natural circulation period, the water is evaporated into steam. The saturated steam is collected in the top half of the steam drum, then flows to the superheater section of the steam generator. The superheater raises the temperature of the steam above its saturation point. In order to maintain adequate superheated steam temperature, a steam attemperation control is utilized. This control passes a portion of the superheated steam through a heat exchanger place in the mud drum of the boiler section where a portion of the steam is cooled close to saturation temperature and is then returned to the superheater outlet header. The cooled steam mixes with the superheated steam so that the temperature of the mixture reaches the design final steam temperature.

See Figure B-4 for a schematic of the test point.

AMERICAN PETROLEUM INSTITUTE
REFINERY B
SOURCE 2 (BOILER)



Elevation



Stack Cross-Section

Traverse Point Number		Distance From Inside Near Wall, Inches
A-D	1	1⅛
	2	3⅜
	3	5⅞
	4	8½
	5	11¼
	6	14⅜
	7	17¾
	8	21¾
	9	26⅝
	10	33¾

Port length = 15"

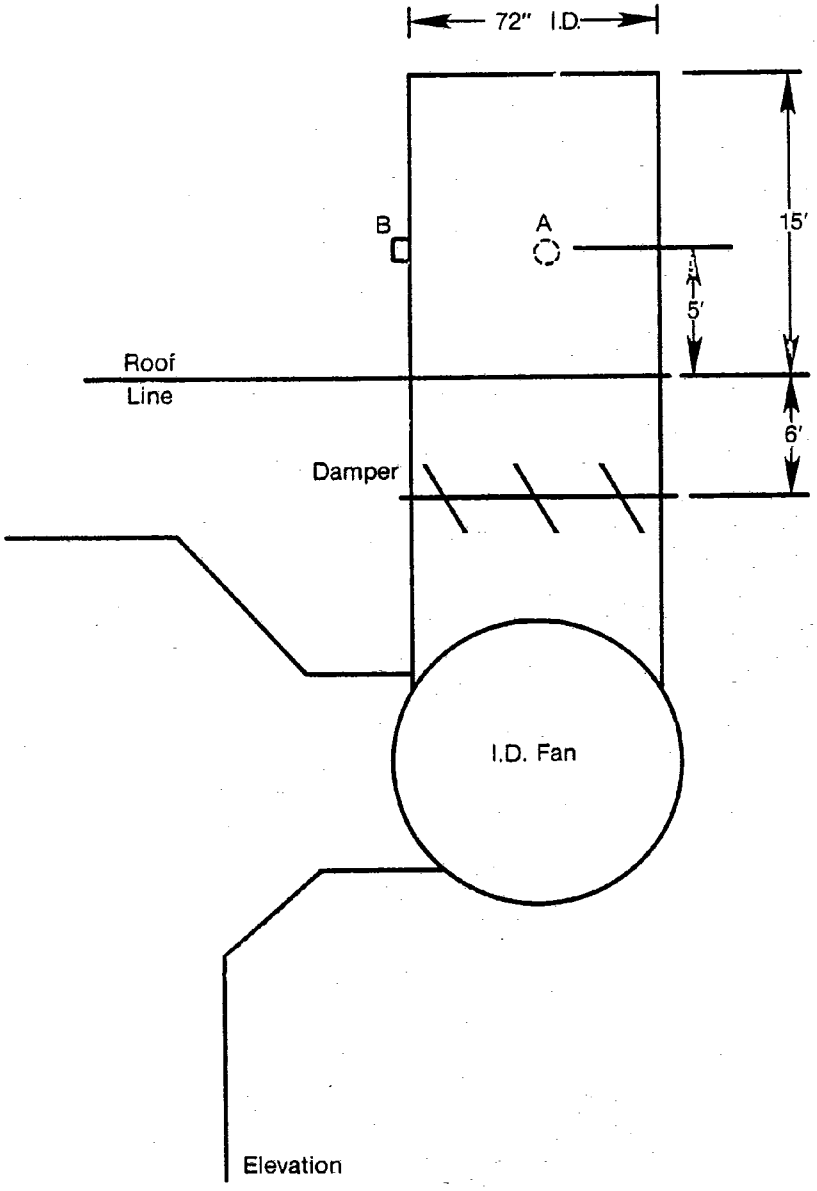
FIGURE B-4 TEST POINT SCHEMATIC

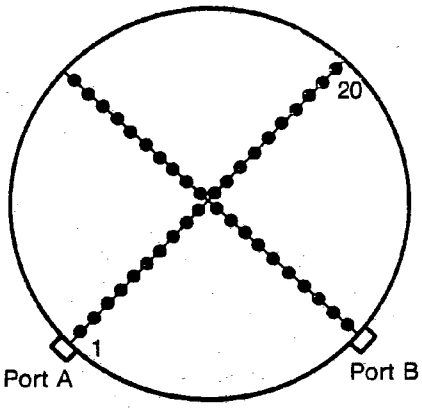
Refinery C - Source 1

This boiler was designed by Babcock and Wilcox and constructed in 1942. It is a balanced draft unit with a maximum steam rating of 125,000 lb/hr at 750°F and 700 psig. The boiler can be fired by either oil or gas using a series of four conventional tip burners for oil or four B and W ring type burners for gas. The fire box dimensions are 21' high by 16' wide and 21' deep. The boiler is equipped with a heat exchanger air heater. Its design efficiency is 86%. Maximum design rating is 200×10^6 Btu/hr.

A schematic of the test site showing port and traverse point locations is presented in Figure B-5.

AMERICAN PETROLEUM INSTITUTE
REFINERY C
SOURCE 1 (BOILER)





Stack Cross-Section

Traverse Point Number	Distance From Inside Near Wall, Inches
1	⅞
2	2¾
3	4⅞
4	7
5	9¼
6	11⅞
7	14¾
8	18
9	22
10	27⅛
11	44⅛
12	50
13	54
14	57¼
15	60⅛
16	62¾
17	65
18	67⅛
19	69¼
20	71⅛

Port length = 17"

FIGURE B-5. TEST POINT SCHEMATIC

APPENDIX C

TESTING AND ANALYSIS EQUIPMENT AND PROCEDURES

TESTING AND ANALYSIS EQUIPMENT AND PROCEDURES

Particulate Measurement and Procedures

Test Equipment

The test train utilized for particulate sampling at all boiler and heater sources was the standard EPA Method 5 train (see Figure C-1).

A stainless steel nozzle was attached to a heated ($\sim$ 250°F) borosilicate probe which was connected directly to a borosilicate filter holder containing a 9-cm Reeve Angel 934 AH glass fiber filter. The filter holder was maintained at approximately 250°F in a heated chamber, and was connected by a rigid borosilicate connector to the first of four Greenburg-Smith impingers. Each of the first two impingers contained 100 ml of distilled water, the third was dry, and the final impinger contained 200 gm of dry preweighed silica gel. The first, third, and fourth impingers were modified Greenburg-Smith types; the second was of the standard design. All impingers were maintained in a crushed ice bath. An RAC or Nutech control console with vacuum pump, dry gas meter, a calibrated orifice, and inclined manometers completed the sampling train. Flue gas temperature was measured by means of a Type K thermocouple connected to a calibrated direct readout pyrometer. The thermocouple sensor was positioned adjacent to the sampling nozzle.

Flue gas velocity was measured using a calibrated "S" type pitot tube (provided with extensions) fastened alongside the sampling probe. Gas stream composition (carbon dioxide, oxygen, and carbon monoxide content), was determined utilizing an Orsat apparatus to analyze grab samples of the flue gases. Orsat analyses were performed at each port in conjunction with each particulate test set.

Preliminary Test Procedures

Preliminary test data were obtained at each sampling location. Duct geometry measurements were recorded, and traverse point distances calculated. A preliminary velocity traverse was performed at each site utilizing a calibrated S-type pitot tube and a Dwyer inclined manometer to determine velocity profiles. A check for the presence or absence of cyclonic flow was conducted at each site prior to formal testing. Flue gas temperatures were observed with a calibrated direct readout pyrometer equipped with a chromel-alumel thermocouple. Water vapor content was estimated from previous experience or determined through an EPA Method 4 moisture test. Preliminary test data were used for nozzle sizing and nomagraph set-up for isokinetic sampling procedures.

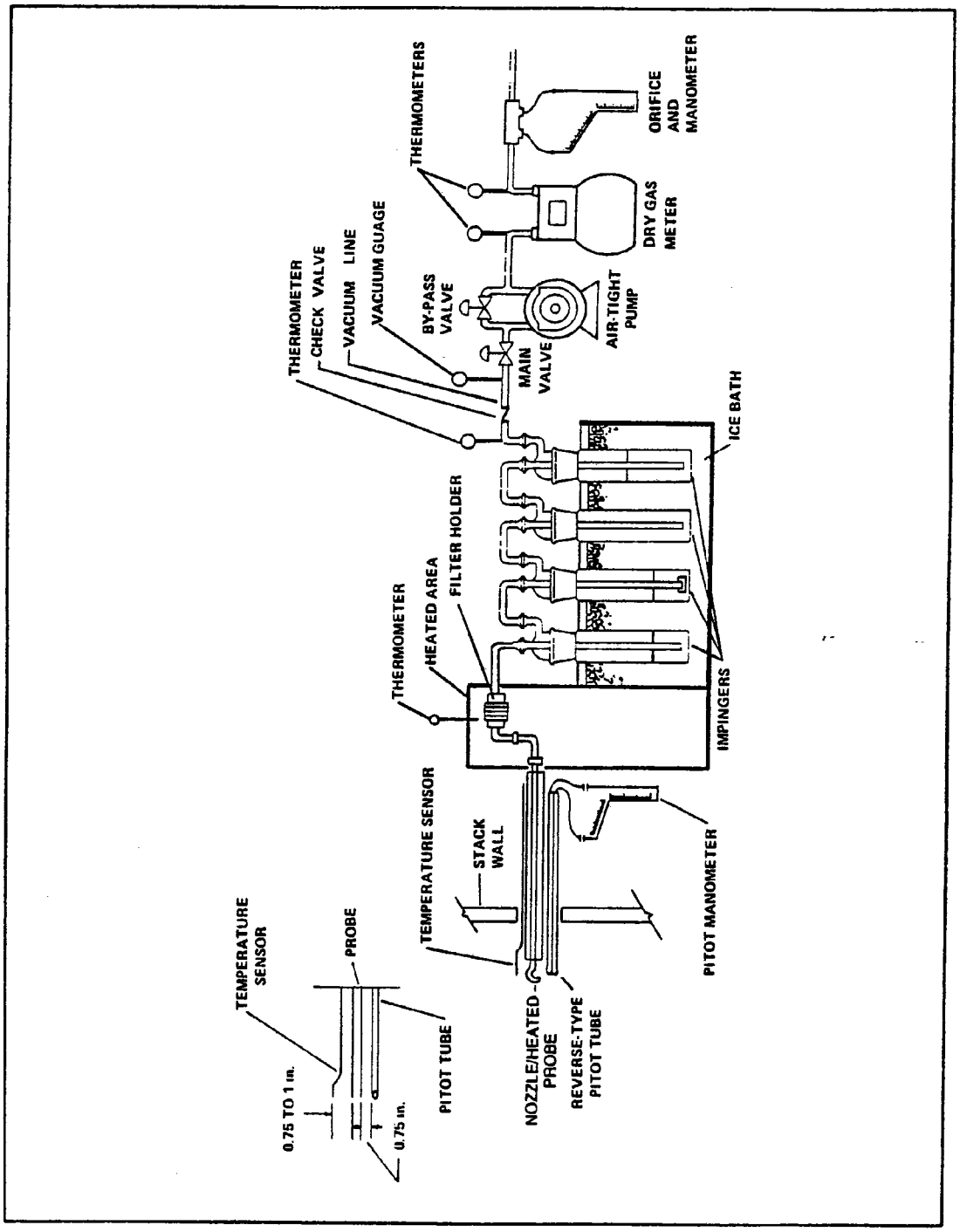


FIGURE C-1 PARTICULATE SAMPLING TRAIN-EPA METHOD 5

Calibration of sampling nozzles, pitot tubes, metering systems, thermocouples/ pyrometers, and temperature gauges was performed as specified in Section 5 of EPA Method 5 test procedures.

Prior to formal sampling, the oxygen content of the flue gas stream was determined using an Orsat apparatus. The Orsat O_2 readings were compared to those recorded by the continuous monitoring instrumentation. This cross check was conducted to determine the accuracy of the continuous O_2 monitors and to determine if any in-leakage of ambient air was occurring between the boiler or heater exit and the sampling location.

Particulate Test Procedures

During the sampling program triplicate EPA Method 5 particulate test runs were conducted at each unit operating condition. An exception occurred for Refinery A Source 2 where duplicate tests were run for 2 of the 6 operating conditions studied. The third test of these 2 sets could not be performed due to a boiler outage. The number of test sets performed on each unit (2 to 6) was dependent on the fuel firing capacilities of the source.

During particulate sampling, gas stream velocities were measured by inserting a calibrated S-type pitot tube into the gas stream adjacent to the sampling nozzle. The velocity pressure differential was observed immediately after positioning the nozzle at each point, and the sampling rate was adjusted to maintain isokineticity. Flue gas temperature was monitored at each point with a pyrometer and thermocouple. Temperature readings of the filter box, final impinger, and inlet and outlet of the dry test meter were also recorded. See Figure C-1 for a schematic of the EPA Method 5 particulate sampling train.

Leak checks were performed on the equipment according to EPA Method 5 instructions, prior to and after each run and/or component change.

Testing duration for particulate sampling was dependent on the units fuel firing ratio, oxygen level and particulate loading for each test set condition.

Control room operating data, plus fuel samples for each source, were collected during each test run.

Sample Recovery Procedures

One of two sample recovery procedures were employed depending upon the analysis required following the gravimetric step.

Particulate Sample Recovery for Analysis Types 1 and 2

During each test set (a total of 3 runs), particulate sample recovery procedures for sample analysis types one and two were identical and are described below.

At the conclusion of each test, the sampling trains were dismantled, openings sealed, and the components transported to the field laboratory.

A consistent procedure was employed for sample recovery:

1. The glass fiber filter(s) was removed from its holder with tweezers and placed in its original container (petri dish), along with any loose particulate and filter fragments (sample 1).

2. The probe and nozzle were separated and the internal particulate rinsed with acetone into a borosilicate container while brushing a minimum of three times. Particulate adhering to the brush was rinsed with acetone into the same container. The front-half of the filter holder, and connecting glassware were rinsed with acetone while brushing a minimum of three times. The rinses were added to the container, and the container was then sealed with a Teflon-lined cap (sample 2).

3. The total liquid contents of impingers 1, 2, and 3 was measured and placed in a borosilicate container fitted with a Teflon-lined closure (sample 3). Also included in this sample was a distilled water rinse of the impingers and connectors.

4. Components from the aforementioned step were acetone washed into a separate borosilicate container fitted with a Teflon-lined lid (sample 4).

5. The silica gel was removed from the last impinger, immediately weighed, and the weight gain recorded.

6. Samples of acetone and distilled water were retained for blank analysis.

Particulate Sample Recovery for Analysis Type 3

The third particulate test sample per set of 3, designated for Analysis Type 3, was recovered in the manner described below.

At the conclusion of each test, the sampling trains were dismantled, openings sealed, and the components transported to the field laboratory.

A consistent procedure was employed for sample recovery:

1. The glass fiber filter(s) was removed from its holder with tweezers and placed in its original container (petri dish), along with any loose particulate and filter fragments (sample 1).

2. The probe and nozzle were separated and the internal particulate rinsed with acetone into a borosilicate container while brushing a minimum of three times. Particulate adhering to the brush was rinsed with acetone into the same container. The front-half of the filter holder, and connecting glassware were rinsed with acetone while brushing a minimum of three times. The rinses were added to the container and the container was then sealed with a Teflon-lined cap (sample 2).

3. Sampling train components in the aforementioned step were rinsed with methylene chloride and brushed in like manner into another borosilicate container with a Teflon-lined lid (sample 3).

4. The total liquid contents of impingers 1, 2, and 3 was measured and placed in a borosilicate container fitted with a Teflon-lined closure (sample 4). Also included in this sample was a distilled water rinse of the impingers and connectors.

5. The impingers and connectors were acetone washed into a separate borosilicate container fitted with a Teflon-lined lid (sample 5).

6. Components from the aforementioned step were methylene chloride washed into a separate borosilicate container fitted with a Teflon-lined lid (sample 6).

7. The silica gel was removed from the last impinger, immediately weighed, and the weight gain recorded.

8. Samples of acetone, methylene chloride, and distilled water were retained for blank analysis.

Sample Analysis Procedures

Analysis Type 1 (filterable and total particulate plus heavy metals content).

The particulate analysis proceeded as shown in Figure C-2 and as described below.

1. The filters (sample 1) and any loose fragments were desiccated for 24 hours and weighed to the nearest 0.1 milligram to a constant weight.

2. The front-half acetone wash samples (sample 2) were evaporated at ambient temperature and pressure in tared beakers, and desiccated to constant weight to the nearest 0.1 mg.

3. The back-half water wash samples (sample 3) and a distilled water blank were evaporated to dryness at 105°C ± 5°C in tared beakers, cooled, then desiccated to constant 0.1 mg weight.

4. The back-half acetone wash samples (sample 4) and a blank were evaporated at ambient temperature and pressure in tared beakers, then desiccated to constant 0.1 mg weight.

After completion of the gravimetric particulate analysis the resultant "front-half" and "back-half" residues were combined then solubilized in acid/peroxide and analyzed for heavy metals content using inductively coupled plasma (ICP) spectrophotometry. (Perkin Elmer Model 5000).

Analysis Type 2 (filterable and total particulate plus nitrate, sulfate, and elemental analysis).

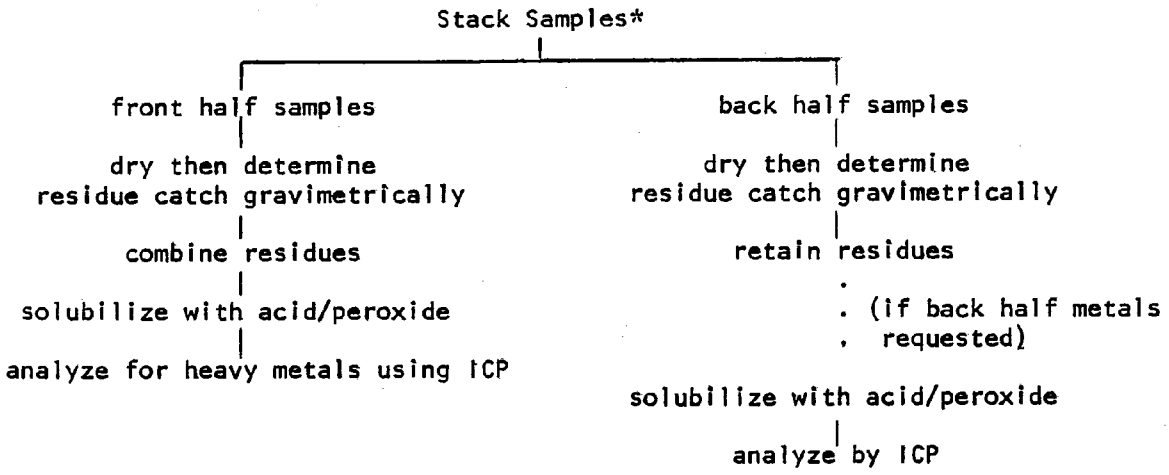
The sample analysis scheme is indicated in Figure C-3.

Since nitrate, sulfate, and elemental analysis of the particulate residues were planned, the particulate sample residues were split prior to gravimetric analysis. The procedures followed for gravimetric Analysis Type 2 samples are identical to those described under Analysis Type 1.

After completion of the gravimetric particulate analyses, one split sample was analyzed for nitrate and sulfate content using a Perkin-Elmer Series 2 High Performance Liquid Chromatograph equipped with a Vydac conductivity detector. The total carbon, hydrogen and nitrogen content of the remaining split sample was determined using a Perkin-Elmer Model 240-B Elemental analyzer.

Analysis Type 3 (filterable and total particulate plus extractable organics).

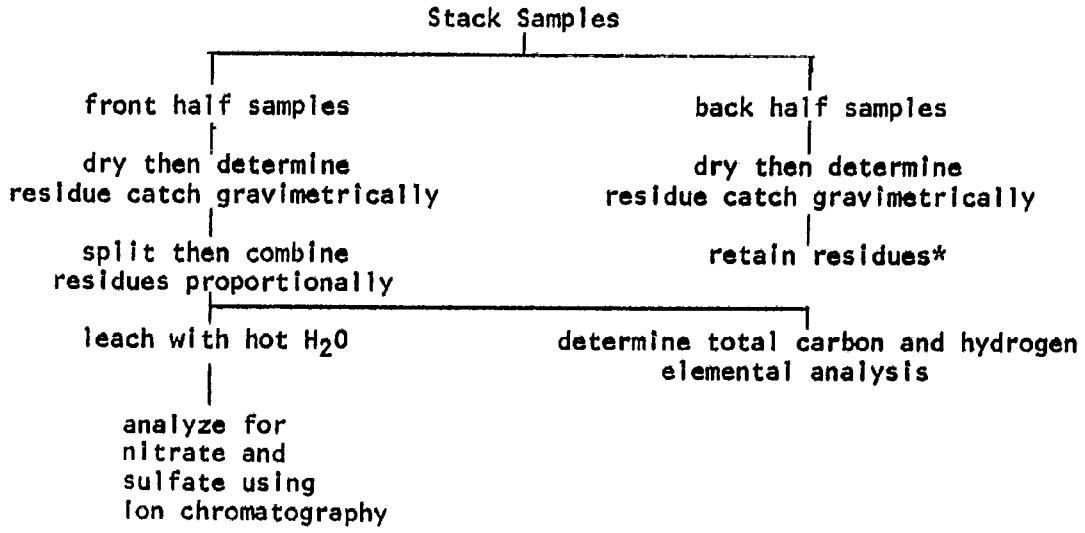
An analysis tree is shown in Figure C-4.



*Front half samples:
1. Acetone wash of nozzle, probe, and front half filter holder.
2. Filter catch.

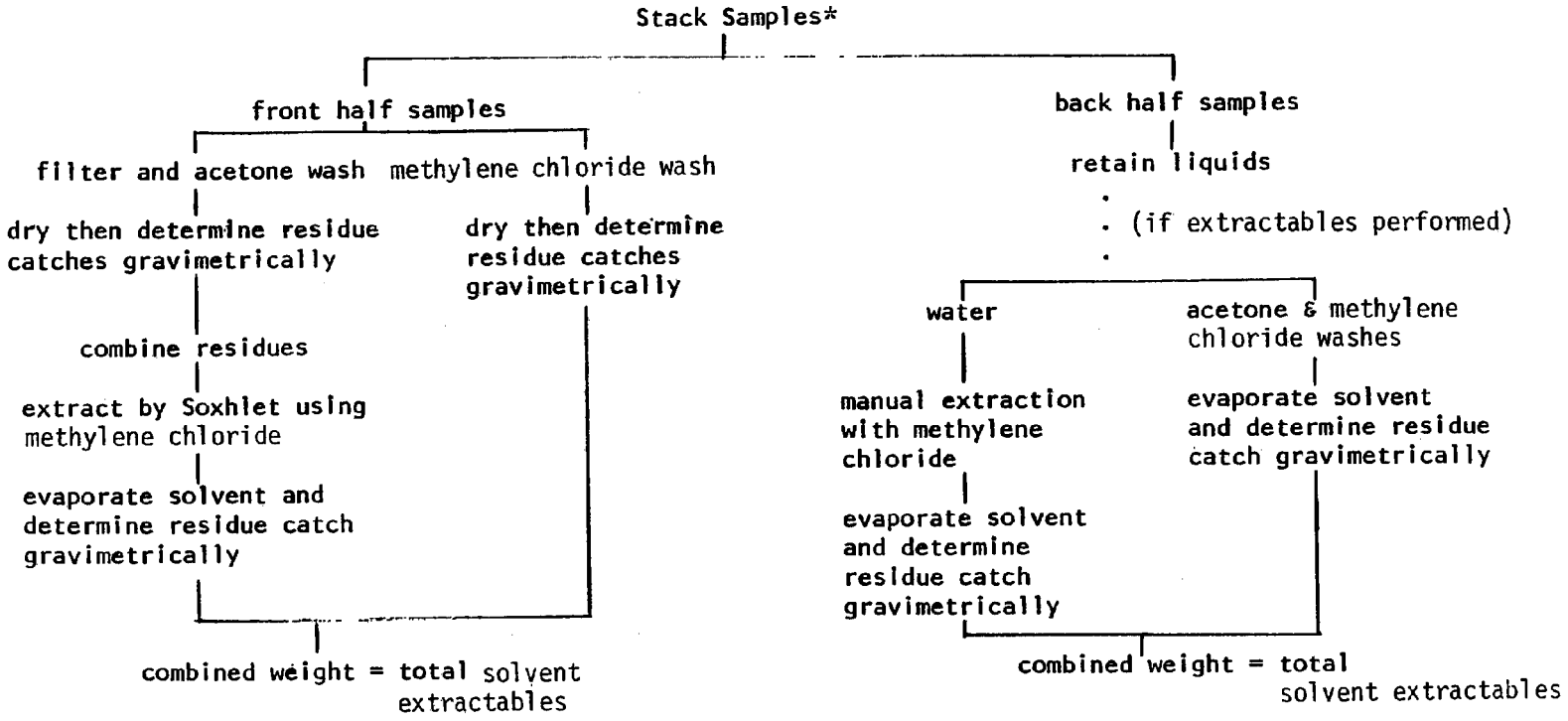
Back half samples:
1. Impinger contents and water wash.
2. Acetone wash of impingers and connectors.

FIGURE C-2. ANALYSIS TREE FOR ANALYSIS TYPE 1



*Back half analysis if requested would follow that described for front half starting at the splitting step.

FIGURE C-3. ANALYSIS TREE FOR ANALYSIS TYPE 2



*Separate methylene chloride washes of the front and back train components were performed following the acetone washes.

FIGURE C-4. ANALYSIS TREE FOR ANALYSIS TYPE 3

The particulate determination for Analysis Type 3 proceeded as follows.

1. The filters (sample 1) and any loose fragments were desiccated for 24 hours and weighed to the nearest 0.1 mg to a constant weight.

2. The front-half acetone and methylene chloride samples (samples 2 and 3) were evaporated at ambient temperature and pressure in tared beakers, and desiccated to constant weight to the nearest 0.1 mg.

3. The back-half impinger contents (sample 4) and wash were extracted with 75 mls of methylene chloride. The methylene chloride extract was then evaporated at ambient temperature and pressure in a tared beaker and desiccated to constant weight to the nearest 0.1 mg. The extracted impinger contents and wash were evaporated to dryness at 105°C in a tared beaker, cooled, then desiccated to constant 0.1 mg weight.

4. The back-half acetone and methylene chloride rinses (samples 5 and 6) plus blanks were evaporated at ambient temperature and pressure in tared beakers, and desiccated to constant weight to the nearest 0.1 mg.

After completion of the gravimetric particulate analyses, the "front-half" residues were combined, then methylene chloride extracted in a Soxhlet apparatus to determine solvent extractables.

Particle Size Distribution Measurement and Procedures

Test Equipment

The equipment utilized for particle size distribution measurements was an eight-stage Andersen Mark III Cascade Impactor. A stainless steel nozzle was connected directly to a preimpactor followed by an 8-stage Andersen Mark III Cascade Impactor which separated the particles according to their effective aerodynamic particle diameter. A solid Reeve Angel 934 AH glass fiber filter was used to capture any particles that passed through the impactor substrates to permit the measurement of total particulate. The filter holder was maintained at stack temperature, and was attached to a probe. Vacuum tubing joined the probe to the first of four Greenburg-Smith impingers which were included in the train to condense the moisture in the gas stream. All impingers were maintained in a crushed ice bath. An RAC or Nutech control console with vacuum pump, dry gas meter, a calibrated orifice, and inclined manometers completed the sampling train. See Figure C-5 for a schematic of the particle sizing apparatus.

WESTON

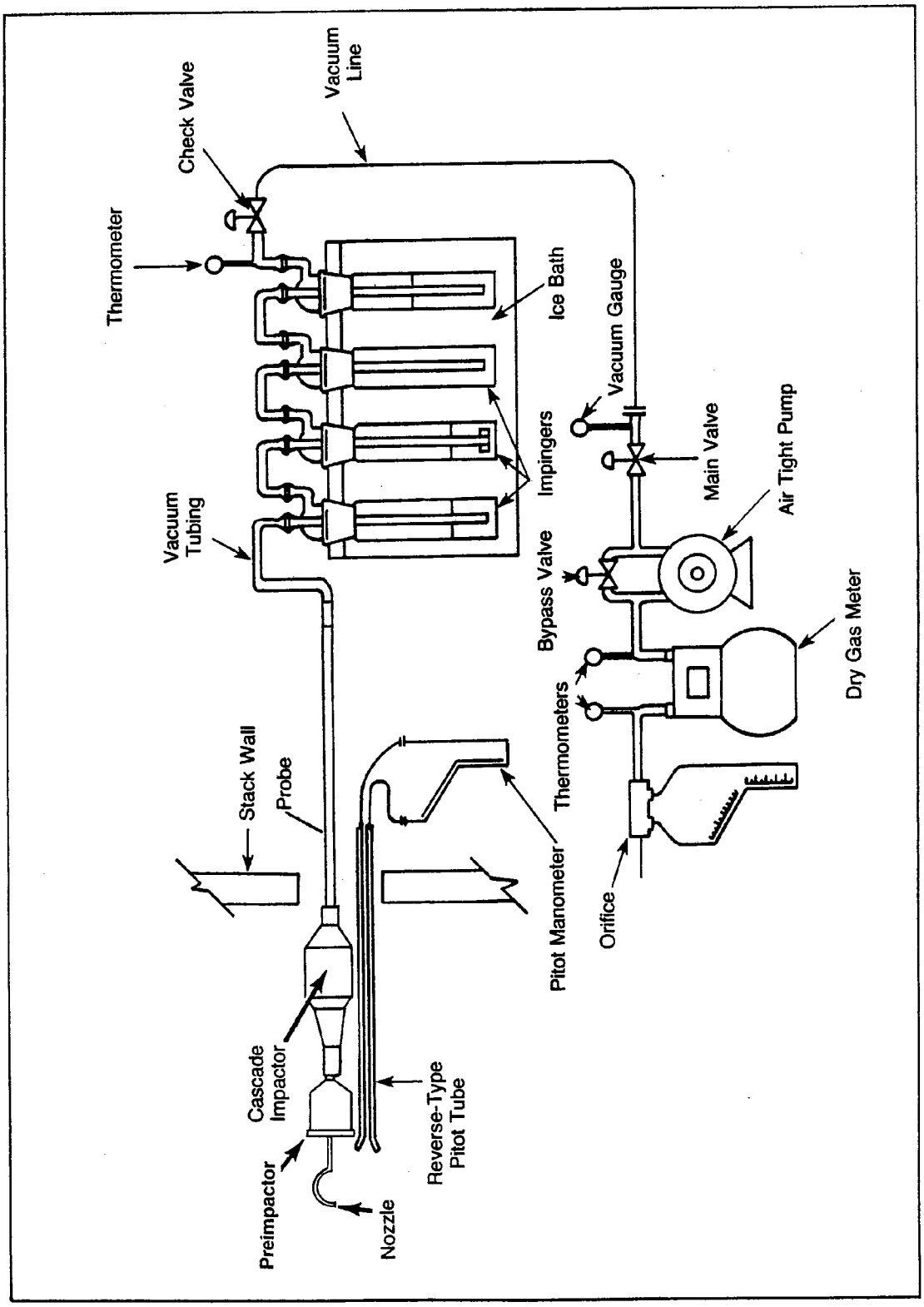


FIGURE C-5. PARTICLE SIZE DISTRIBUTION SAMPLING APPARATUS -- ANDERSEN 2000, INC.

Particle Size Distribution Test Procedures

During particle size distribution testing, gas stream velocities were measured by inserting a calibrated S-type pitot tube into the gas stream adjacent to the sampling nozzle. A point or points of average velocity were selected from preliminary test data and rechecked prior to formal sampling. The apparatus was positioned at a point or points of average gas stream velocity during each test. A constant isokinetic sampling rate was maintained for the duration of each test. Test length was dependent on particulate loading. During each test, sampling rates were monitored. Temperature readings at the final impinger and inlet and outlet of the dry test mbmer were also recorded. All particle size distribution tests were run in conjunction with particulate tests except for the last 2 runs at Refinery A Source 1 which were performed independently.

Sample Recovery Procedures

At the conclusion of each test, the sampling trains were dismantled, openings sealed, and the components transported to the field laboratory.

A consistent procedure was employed for sample recovery.

1. The cascade impactor substrates and any loose fragments were carefully removed from their support plates with tweezers and placed in individual containers (petri dishes) for shipment to the Weston laboratories.

2. An acetone rinse of the nozzle, preimpactor, and cone of the impactor was performed.

3. Samples of acetone were retained for blank analysis.

Sample Analysis Procedures

The particle size distribution analysis proceeded as follows.

1. The cascade impactor substrates, back-up filters, and any loose fragments were desiccated for 24 hours, and weighed to the nearest 0.1 mg to constant weight.

2. Each acetone rinse sample and blank was evaporated at ambient temperature and pressure in a tared beaker, then desiccated to constant weight to the nearest 0.1 mg.

NO_x Measurement and Procedures

Test Equipment

The test train utilized for NO_x sampling was a standard EPA Method 7 Train (see Figure C-6).

A heated borosilicate gas sampling probe containing a glass wool filter was connected to a 2-liter borosilicate round-bottom boiling flask in a foam encasement. The flask was fitted with a glass 3-way valve. A mercury U-tube manometer was connected to the sample flask and to the vacuum pump of a Nutech control console by rubber vacuum tubing. Another 3-way valve was placed between the manometer and pump, and was connected to a squeeze bulb. The bulb was used to purge the sampling probe of extraneous gases prior to sample collection.

NO_x Test Procedures

During each particulate test run a series of three EPA Method 7 NO_x grab samples were obtained from the gas stream.

The heated probe was positioned near the center of the stack. The flask was evacuated to a pressure of less than three inches of mercury absolute. Flask temperature and pressure were recorded. After purging the probe with stack gas, the 3-way valve was positioned to allow a sample to enter the flask for fifteen seconds.

Sample Recovery Procedures

A consistent procedure for sample recovery was maintained throughout the test program.

After sitting for a minimum of sixteen hours, the flask and contents were shaken for two minutes. The final absolute flask temperatures and pressures were obtained and recorded and the flask contents were transferred to a leak-free polyethylene bottle. After the flask was rinsed twice with 5 ml portions of deionized distilled water and the rinses added to the bottle, the pH of the sample was adjusted to 9-12 by dropwise addition of sodium hydroxide (1N). The container was sealed, labeled, and the height of the liquid level marked. The samples, including a blank, were transported to the Weston Laboratories for analysis.

Sample Analysis Procedures

The samples were analyzed for oxides of nitrogen, except nitrous oxide, using the colorimetric phenoldisulfonic acid procedure described in EPA Method 7.

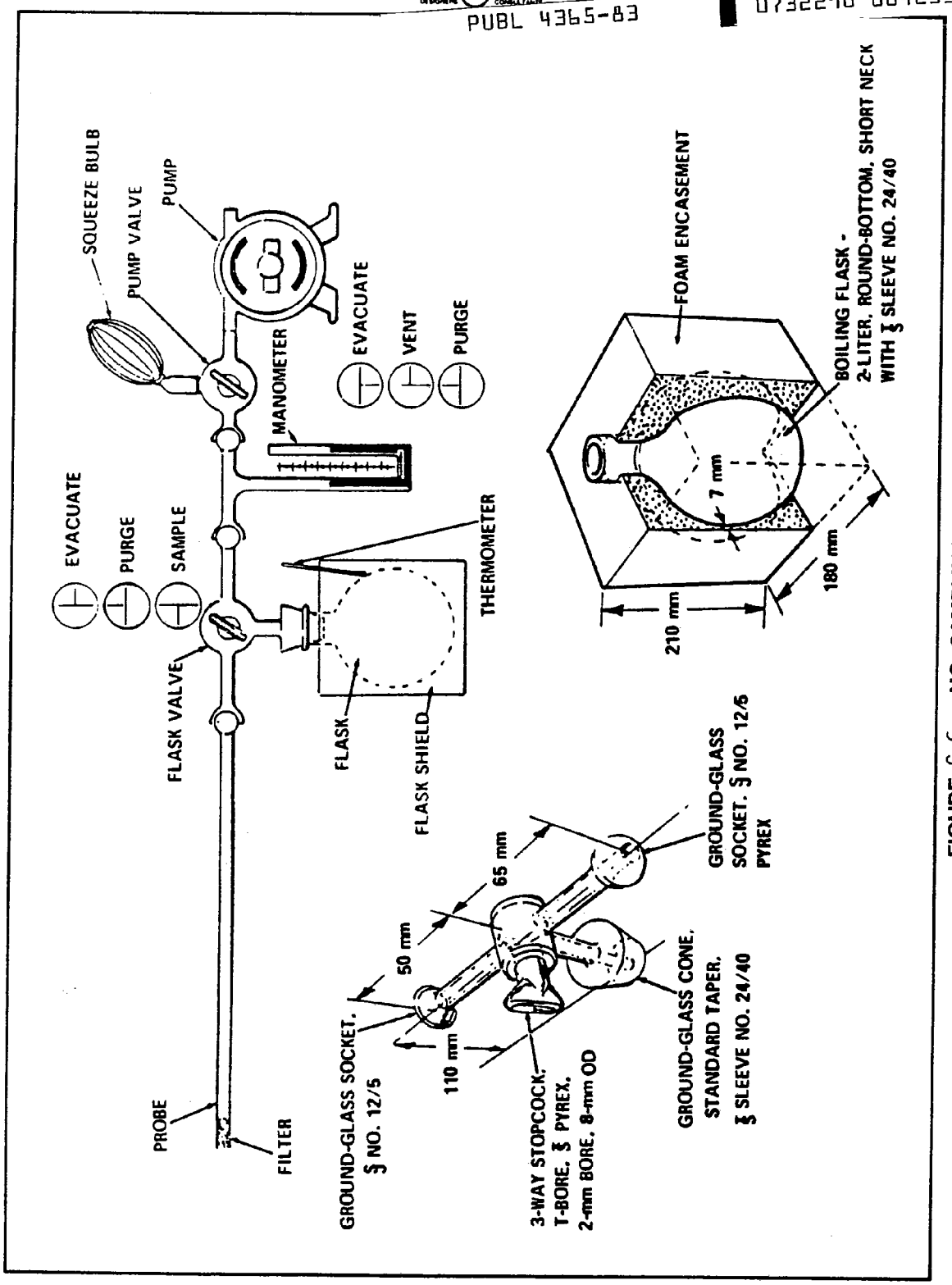


FIGURE C-6. NO_x SAMPLING TRAIN EPA METHOD 7

APPENDIX D

WESTON PROJECT PARTICIPANTS

PROJECT PARTICIPANTS

The following Weston employees participated in this project.

Peter J. Marks Vice President and Project Director Laboratory Services	econENVIRONomics Division
Barry L. Jackson Project Manager Air Quality Testing Services	econENVIRONomics Division
Jeffrey D. O'Neill Project Scientist	econENVIRONomics Division
Paul Meeter Assistant Project Scientist	econENVIRONomics Division
Thomas Davis Project Technician	econENVIRONomics Division
James S. Smith, Ph.D. Director Analytical Laboratory	econENVIRONomics Division
Dianne S. Therry Quality Assurance Coordinator	econENVIRONomics Division
Bruce Maglietto Chemist	econENVIRONomics Division
Kim Burke Chemist	econENVIRONomics Division
Ken Seace Chemist	econENVIRONomics Division
Nancy Robertson Senior Laboratory Technician	econENVIRONomics Division
Bruce Wood Instrument Maintenance Technician	econENVIRONomics Division
Marie Nadeau Technical Support	econENVIRONomics Division