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COMPLIANCE TEST REPORT
FOR THE
HEMPSTEAD RESOURCE RECOVERY FACILITY
WESTBURY, NEW YORK

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RADIAN REPORT CERTIFICATION

This report has been reviewed by the following Radian personnel and is a true representation of the results obtained fom the compliance sampling program at the American Ref-fuel Hempstead Resource Recovery Facility, Westbury, New York. The sampling and analytical methods were performed in accordance with procedures outlined in the compliance test plan dated April 20, 1989 which was reviewed and approved by the New York State Department of Environmental Conservation.

APPROVALS

Project Director	Winton E, Kelly Winton E. Kelly	12/19/89 Date
Program Manager	Robert M. Dykes	12/28/89 Date
Registered Professional Engineer	P.E. North Carolina No 12555	12/22/89 Date

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TABLE 2-1. SUMMARY OF AVERAGE RESULTS, UNIT 1

Parameter	Permit Limit	Test Results 65% Load	Test Results 100% Load
PROCESS DATA			
Steam Rate, lb/hr		141,300	188,000
Combustion Efficiency,			
%, 1-hr (averages)	99.67	99.970	99.956
%, 8-hr (rolling averages)	99.92	99.969	99.956
Furnace Temperature, °F	1500	N/M[c]	N/M
STACK EMISSIONS			
Particulates, gr/dscf at 12% CO_2	0.015	0.00098	0.00123
Carbon Monoxide			
ppmV, dry at 12% CO_2		36.3	53.1
lb/hr	418	10.5	19.4
Total Hydrocarbons, lb/hr (as methane)	21.5	0.096	0.13
Organics:			
CDD/CDF, 2378 TCDD equivalent[a] ng/dscm @ 7% O_2		-	0.0179
PCB, μg/dscm @ 7% O_2		-	[d]ND [0.0650]
PAH, μg/dscm @ 7% O_2		-	0.977
Metals:			
Arsenic, μg/dscm @ 12% CO_2		-	0.211
Beryllium, μg/dscm @ 12% CO_2		-	ND[0.010]
Cadmium, μg/dscm @ 12% CO_2		-	ND[0.708]
Chromium, μg/dscm @ 12% CO_2		-	1.087
Lead, μg/dscm @ 12% CO_2		-	1.586
Mercury, μg/dscm @ 12% CO_2		-	24.964
Nickel, μg/dscm @ 12% CO_2		-	ND[0.718]
Acid Gases:			
HCl			
Concentration, ppmV at 12% CO_2	50, or	-	51
Removal Efficiency, %	90[b]	-	92
SO_2			
Concentration, ppmV at 12% CO_2		-	38
Removal Efficiency, %		-	78
NO_x, ppmV at 12% CO_2		-	235.8

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[a] 6 NYCRR Part 219 Procedures

[b] 50 ppmV emission concentration or 90% removal, whichever is least restrictive

[c] N/M - Not measured

[d] ND - Not detected, detection limits in brackets

1.0 INTRODUCTION

Radian Corporation was contracted by American Ref-Fuel Company of Hempstead to provide technical and sampling support to demonstrate that the three municipal waste combustion (MWC) systems at the Hempstead Resource Recovery Facility, Westbury, New York, comply with the emission limits, sampling requirements and monitoring requirements specified in the special conditions of the facility's Permit to Construct.

The Hempstead Resource Recovery Facility consists of three identical waste combustion/boiler/emission control trains designed by Deutsche Babcock Anlagen (DBA). Each train consists of a Dusseldorf Roller Grate system, a 4-pass boiler manufactured by Riley Stoker and Deutsche Babcock Anlagen, and a Belco dry scrubber/fabric filter system. The Hempstead Resource Recovery Facility is the first application of the DBA system in the United States.

Compliance testing was conducted from September 18 through October 3, 1989. One particle site distribution run was conducted on October 1-2, 1989, a second run was conducted on October 23-24, 1989. While not specifically required under the facility's permit to construct, the particle site distribution runs were conducted in order to provide facility-specific information for the facility's health risk assessment. This report documents the test results and provides specific information regarding testing methods, process operation, and quality assurance/quality control (QA/QC) parameters.

1.1 Test Objectives

The test program had four objectives for each train to completely demonstrate compliance with the special conditions of the Permit to Construct. These conditions are listed in Table 1-1. These objectives were:

- To demonstrate that the emission control system meets the emission limits for particulate matter (PM), carbon monoxide (CO), and total hydrocarbons (THC), specified in the Permit to Construct, Special Conditions; and achieves the HCl removal percent for hydrogen chloride (HCl) reduction.

TABLE 1-1. SUMMARY OF EMISSION LIMITS PER UNIT FOR THE HEMPSTEAD RESOURCE RECOVERY FACILITY

Parameter	Emission Limit[a]
Particulate Matter	0.015 gr/dscf @ 12% CO_2
Hydrogen Chloride	50 ppm, dry, @ 12% CO_2 or 90% reduction, whichever is less restrictive
Opacity	20% for a period of six or more minutes during any continuous sixty-minute period
Carbon Monoxide[d]	418 lb/hr
Hydrocarbons	21.5 lb/hr
Incinerator Temperature	1500°F after last point of overfire air injection
Combustion Efficiency[b]	Running 1-hour average > 99.67% (400 ppmv @ 12% CO_2) Running 8-hour average > 99.92% (100 ppmv @ 12% CO_2)
Additional Sampling Requirements	
Sulfur dioxide	NL
Nitrogen	NL
Polychlorinated dibenzo-p-dioxins[c]	NL
Polychlorinated dibenzo furans[c]	NL
Polycyclic aromatic hydrocarbons[c]	NL
Polychlorinated biphenyls[c]	NL
Arsenic	NL
Beryllium	NL
Cadmium	NL
Chromium	NL
Lead	NL
Mercury	NL
Nickel	NL
Carbon dioxide[d]	NL
Oxygen[d]	NL
Particle Size Distribution	NL

TABLE 1-1. SUMMARY OF EMISSION LIMITS PER UNIT FOR THE HEMPSTEAD RESOURCE RECOVERY FACILITY

Parameter	Emission Limit[a]
Parameters Evaluated at Both 65% and Full Load	
Particulate	0.015 gr/dscf @ 12% CO_2
Incinerator temperature	1500°F after last point of overfire air injection
Combustion efficiency	Running 1-hour average ≥ 99.67% (400 ppmv @ 12% CO_2) Running 8-hour average ≥ 99.92% (100 ppmv @ 12% CO_2)
Opacity	20% for a period of six or more minutes during any continuous sixty-minute period

NL - No Limit specified by NYSDEC.

[a] Emission limits are for each train.

[b] Combustion efficiency = $\frac{CO_2}{CO_2 + CO} \times 100$

where CO_2 and CO are the concentrations in ppmv, dry.

[c] Testing required for only one of the three incinerators at the Hempstead facility.

[d] Monitors located prior to any air pollution control equipment.

- To comply with the stack testing requirements for dioxin/furans (CDD/CDF), polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), nickel (Ni), beryllium (Be), nitrogen oxides (NO_x), and sulfur dioxide (SO_2), specified in the Permit to Construct, Special Conditions;
- To verify the relationship between HCl and SO_2 removal in the emission control system, and to demonstrate that SO_2 monitoring is an acceptable surrogate for HCl monitoring.
- To verify that monitoring of flue gas temperature at the top of the first boiler pass is a representative surrogate for furnace temperature immediately following the last point of overfire air injection.

The compliance test program also included an internal QA/QC program. The goal of the QA/QC program was to ensure that the data collected were of known precision and accuracy and that they were complete, representative, and comparable.

1.2 Compliance Test Matrix

The test matrix for the test program addressing objectives 1 and 2 is presented in Table 1-2. The testing locations and variables measured at each location are shown in Figure 1-1. The CDD/CDF, metals, particulates, particle size distribution, and HCl sampling were performed by manual methods. NO_x, SO_2, THC, CO, carbon dioxide (CO_2), and oxygen (O_2) concentrations were measured by continuous emission monitors (CEM). The CEM system was a mobile unit transported to the facility by Radian. HCl, SO_2, CO, CO_2, O_2 and moisture were measured at both the stack and spray dryer inlet. CO was measured at the spray dryer inlet only. PM, metals, CDD/CDF/PAH/PCB, particle size distribution (PSD), NO_x, and THC were measured at the stack only. CDD/CDF/PAH/PCB measurements and PSD measurements were conducted on Unit 1 only. The furnace temperature traverses were conducted on Unit 2.

TABLE 1-2. COMPLIANCE TEST MATRIX FOR EACH TRAIN AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

Sample Location/ Description	Number of Runs	Sample Method or Type	Parameters	Analytical Method	Analytical Laboratory	Sampling Time per Run (hours)
Baghouse Outlet Stack (tests conducted on each boiler, except dioxin/furan and particle sizing on only ~~on~~ Unit one)	3	Draft ASME/EPA Dioxin Protocol	Dioxin/furan, PAH/PCB	Gas Chromatography/ Mass Spectrometry	Triangle Laboratories	4
	3	EPA Method 5/ Draft Combined Metals Train	PM[a] As, Cd, Cr, Pb, Hg, Ni	Gravimetric, Atomic Absorption/ Inductively Coupled Argon Plasma	Radian Corporation	4
	2	Andersen MK III	Particle Sizing	Gravimetric	Radian	4
	3[b]	EPA Method 5	PM	Gravimetric	Radian	4
	1[c]	Draft EMSL HCl Train	HCl	Ion Chromatography	Radian	1
	3	EPA Method 104	Beryllium	Atomic Absorption	Radian	2
	3	EPA Method 7E	NO_x	Chemiluminescent	Radian	2
	3	EPA Method 6C	SO_2	Ultraviolet	Radian	2
	3	EPA Method 25A	Total Hydrocarbon	Flame ionization detector	Radian (on site)	2
	3	EPA Method 3A	CO_2/O_2	Nondispersive infrared/zirconium oxide cell	Radian (on site)	2
	3[d]	EPA Method 2	Velocity/Volumetric Flow	Pitot Tubes/Manometer Thermocouple	Radian (on site)	4
	3[d]	EPA Method 4	Moisture Content	Gravimetric	Radian (on site)	4
Spray Dryer Inlet	3[c]	Draft EMSL HCl Train	HCl	Ion Chromatography	Radian	1
	3	EPA Method 6C	SO_2	Ultraviolet Gas Filter Correlation	Radian	2
	6[b]	EPA Method 10	CO	Nondispersive infrared	Radian	2
	3	EPA Method 3A	CO_2/O_2	Nondispersive infrared/zirconium oxide cell	Radian	2
	3[d]	EPA Method 4	Moisture Content	Gravimetric	Radian (on site)	1

[a] PM = Particulate Matter

[b] Three tests performed at 65% load.

[c] Each test run consisted of multiple 20-minute samples.

[d] Methods 2 and 4 were performed with each of the wet chemistry methods.

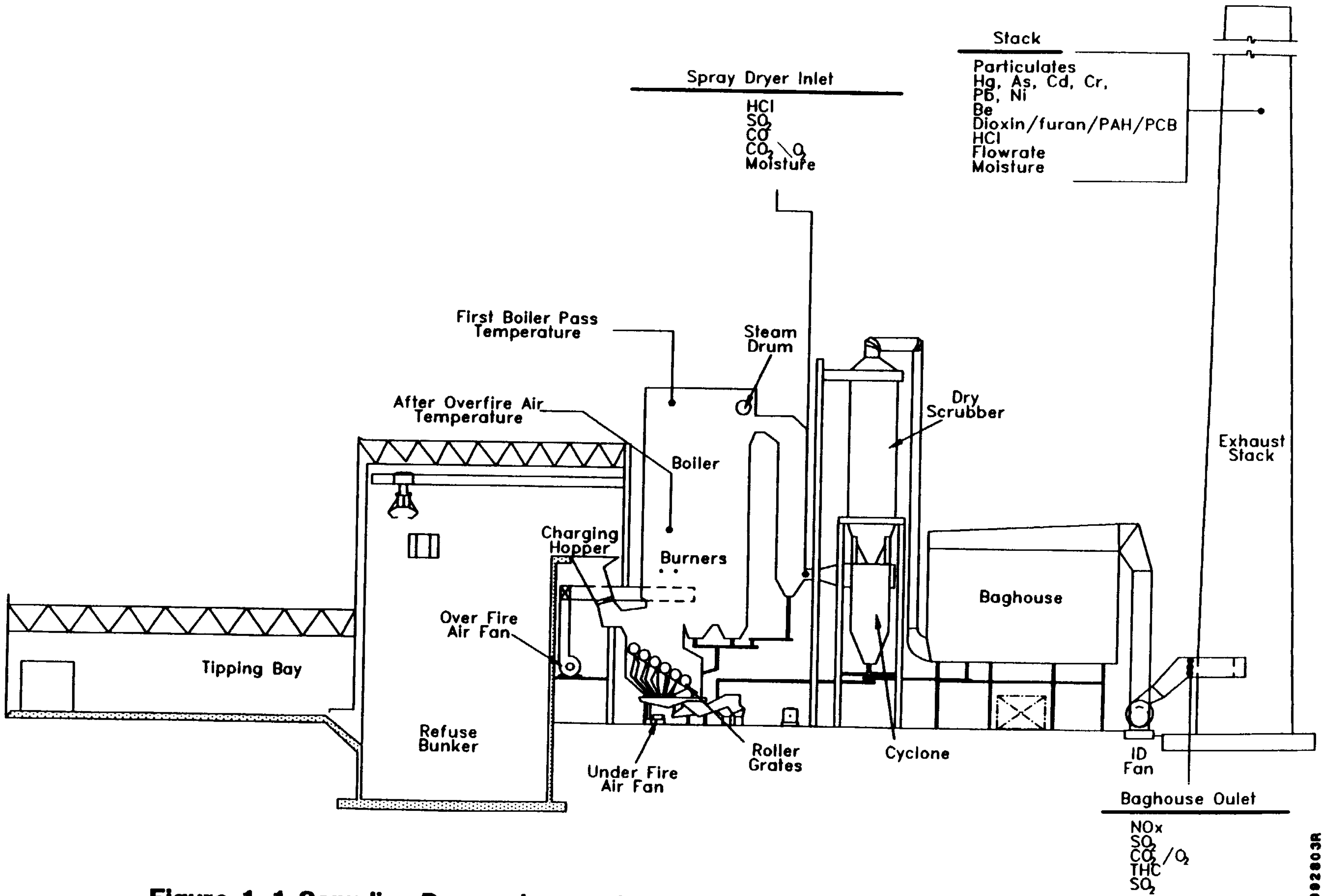

Figure 1-1. Sampling Parameters and Locations for the Hempstead Compliance Test

1.3 Process Operations Measurements

Process operating data were recorded during the compliance test program in order to document the operating conditions as well as to demonstrate that the facility meets the operation requirements of the NYDEC permit. Data were recorded using two procedures: A direct computer link to the Baily Net 90™ process control system provided most of the data; the SDA lime slurry and water rates were recorded manually.

The steam production rate was used as the measure of process operating rate during the compliance test. Steam rate is the primary setpoint for control of the combustion system, and is measured and recorded continuously by the Bailey Net 90™ system.

The design steam production rate of 210,000 lb/hr was used as the basis for 100 percent and 65 percent test load setpoints. The target setpoints were 210,000 lb/hr and 136,000 lb/hr, respectively. However, due to normal swings in the refuse quality and combustion conditions, these rates could not be held exactly. A nominal range of ±10 percent around the target was used as the criteria for accepting a test run.

1.4 Compliance Test Log

The daily test log is presented in Table 1-3. PM emission tests were conducted in triplicate on each unit at 65 percent load from September 18 through 22, 1989. The furnace temperature traverses were also completed during this time interval at both the 65 percent and 100 percent levels. The remaining emission tests were conducted from September 25 through October 24, 1989 at a 100% boiler load condition, with a second PSD conducted on October 23-24, 1989.

TABLE 1-3. EMISSIONS TEST LOG; HEMPSTEAD RESOURCE RECOVERY FACILITY (SEPT/OCT 1989)

TEST DAY	DATE	UNIT	LOCATION	LOAD CONDITION	RUN NUMBER	TEST TYPE	RUN TIME
1	09/18/89	2	STACK	65%	PM01	PARTICULATE	1341-1753
2	09/19/89	2	STACK	65%	PM02	PARTICULATE	1000-1409
2	09/19/89	2	STACK	65%	PM03	PARTICULATE	1421-1828
3	09/20/89	3	STACK	65%	PM04	PARTICULATE	1012-1528
3	09/20/89	3	STACK	65%	PM05	PARTICULATE	1601-2013
4	09/21/89	2	FURNACE	100%	HVT01	TEMPERATURE	1242-1654
4	09/21/89	2	FURNACE	65%	HVT02	TEMPERATURE	1937-2229
4	09/21/89	3	STACK	65%	PM06	PARTICULATE	0940-1346
4	09/21/89	1	STACK	65%	PM07	PARTICULATE	1513-2039
5	09/22/89	1	STACK	65%	PM08	PARTICULATE	1009-1416
5	09/22/89	1	STACK	65%	PM09	PARTICULATE	1416-1915
6	09/25/89	2	STACK	100%	TM01	METALS	1617-2041
6	09/25/89	2	STACK	100%	BE01	BERYLLIUM	1033-1247
6	09/25/89	2	STACK	100%	BE02	BERYLLIUM	1435-1645
6	09/25/89	2	STACK	100%	BE03	BERYLLIUM	1738-1945
7	09/26/89	2	STACK	100%	TM02	METALS	0908-1336
7	09/26/89	2	STACK	100%	TM03	METALS	1416-1837
7	09/26/89	2	STACK	100%	HCl1A-3C	HCl	0952-2053
7	09/26/89	2	INLET	100%	HCl1A-3C	HCl	0952-2053
8	09/27/89	1	STACK	100%	CDD01	CDD/CDF	1047-1457
8	09/27/89	1	STACK	100%	TM04	METALS	0907-1509
8	09/27/89	1	STACK	100%	BE04	BERYLLIUM	1529-1739
9	09/28/89	1	STACK	100%	CDD02	CDD/CDF	0843-1311
9	09/28/89	1	STACK	100%	TM05	METALS	0853-1329
9	09/28/89	1	STACK	100%	BE05	BERYLLIUM	1353-1816
9	09/28/89	1	STACK	100%	HCl1A-2D	HCl	1350-1908
9	09/28/89	1	INLET	100%	HCl1A-2D	HCl	1350-1908
10	09/29/89	1	STACK	100%	CDD03	CDD/CDF	1000-1503
10	09/29/89	1	STACK	100%	BE06	BERYLLIUM	1558-1807
10	09/29/89	1	STACK	100%	TM06	METALS	1012-1511
12	10/01-02/	1	STACK	100%	PSD1	PSD	0944-0406

TABLE 1-3. EMISSIONS TEST LOG; HEMPSTEAD RESOURCE RECOVERY FACILITY (SEPT/OCT 1989), continued

TEST DAY	DATE	UNIT	LOCATION	LOAD CONDITION	RUN NUMBER	TEST TYPE	RUN TIME
13	10/02/89	3	STACK	100%	TM07	METALS	0853-1330
13	10/02/89	3	STACK	100%	BE07	BERYLLIUM	0930-1221
13	10/02/89	3	STACK	100%	BE08	BERYLLIUM	1329-1541
13	10/02/89	3	STACK	100%	HCl1A-3D	HCl	1503-2039
13	10/02/89	3	STACK	100%	HCl1A-3D	HCl	1503-2039
14	10/03/89	3	STACK	100%	TM08	METALS	0916-1332
14	10/03/89	3	STACK	100%	TM09	METALS	1332-1743
14	10/03/89	3	STACK	100%	BE09	BERYLLIUM	0854-1228
15	10/12/89	1	STACK	110%	HCl1-13	HCl	1240-2024
16	10/23-24	1	STACK	100%	PSD02	PSD	1212-1012

2.0 SUMMARY OF COMPLIANCE RESULTS

The average results for the compliance tests that were performed on Units 1, 2, and 3 at the Hempstead Resource Recovery Facility are summarized in this section. The test results for Units 1, 2, and 3 are presented in Table 2-1 through 2-3, respectively. The test results show that each of the three units comply with all permit conditions and emission limits.

Particulate tests were performed at 65% and 100% of design steam rate on each of the three units. All of the particulate measurements were significantly less than the 0.015 gr/dscf permit limit. For all three units there was essentially no difference between emissions at the two loads when compared to the permit limit. The emissions were also similar between units.

Trace metals (As, Be, Cd, Cr, Hg, Pb, and Ni) were measured at 100% load for all three units. Beryllium and cadmium were not detected in the emissions from any of the units. Arsenic, lead and mercury were detected at low levels at all three units. Chromium was detected at Units 2 and 3, while nickel was detected in low levels at Unit 2.

Trace organics emissions (CDD/CDF, PCB, and PAH) were measured at 100% load at Unit 1. The CDD/CDF tests yielded a 2378-TCDD toxic equivalency result of 0.00061 ng/dscm when zero values are used for congeners that were not detected or for which estimated maximum possible concentrations were reported. This result is 0.3% of the New York State target of 0.2 ng/dscm for incinerators permitted under the new Part 219 regulations.

Using a more conservative calculation basis which assumes that the congeners that were not detected or for which estimated maximum possible concentrations were reported are present at one-half the reported limits results in a 2378-TCDD toxic equivalency of 0.0179 ng/dscm, which is 9% of the target value.

PCBs were not detected in any runs, and only one PAH species was identified in one sample.

TABLE 2-1. SUMMARY OF AVERAGE RESULTS, UNIT 1

Parameter	Permit Limit	Test Results 65% Load	 100% Load
PROCESS DATA			
Steam Rate, lb/hr		141,300	188,000
Combustion Efficiency,			
%, 1-hr (averages)	99.67	99.970	99.956
%, 8-hr (rolling averages)	99.92	99.969	99.956
Furnace Temperature, °F	1500	N/M[c]	N/M
STACK EMISSIONS			
Particulates, gr/dscf at 12% CO_2	0.015	0.00098	0.00123
Carbon Monoxide			
ppmV, dry at 12% CO_2		36.3	53.1
lb/hr	418	10.5	19.4
Total Hydrocarbons, lb/hr (as methane)	21.5	0.096	0.13
Organics:			
CDD/CDF, 2378 TCDD equivalent[a] ng/dscm @ 7% O_2		-	0.0179
PCB, µg/dscm @ 7% O_2		-	[d]ND [0.0650]
PAH, µg/dscm @ 7% O_2		-	0.977
Metals:			
Arsenic, µg/dscm @ 12% CO_2		-	0.211
Beryllium, µg/dscm @ 12% CO_2		-	ND[0.010]
Cadmium, µg/dscm @ 12% CO_2		-	ND[0.708]
Chromium, µg/dscm @ 12% CO_2		-	1.087
Lead, µg/dscm @ 12% CO_2		-	1.586
Mercury, µg/dscm @ 12% CO_2		-	24.964
Nickel, µg/dscm @ 12% CO_2		-	ND[0.718]
Acid Gases:			
HCl			
Concentration, ppmV at 12% CO_2	50, or	-	51
Removal Efficiency, %	90[b]	-	92
SO_2			
Concentration, ppmV at 12% CO_2		-	38
Removal Efficiency, %		-	78
NO_x, ppmV at 12% CO_2		-	235.8

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[a] 6 NYCRR Part 219 Procedures

[b] 50 ppmV emission concentration or 90% removal, whichever is least restrictive

[c] N/M - Not measured

[d] ND - Not detected, detection limits in brackets

TABLE 2-2. SUMMARY OF AVERAGE RESULTS, UNIT 2

Parameter	Permit Limit	Test Results 65% Load	 100% Load
PROCESS DATA			
Steam Rate, lb/hr		132,000	204,000
Combustion Efficiency,			
%, 1-hr (averages)	99.67	99.973	99.954
%, 8-hr (rolling averages)	99.92	c	99.951
Furnace Temperature, °F	1500	1582	1734
STACK EMISSIONS			
Particulates, gr/dscf @ 12% CO_2	0.015	0.00115	0.00274
Carbon Monoxide			
ppmV, dry at 12% CO_2		32.2	55.3
lb/hr	418	8.09	22.2
Total Hydrocarbons, lb/hr (as methane)	21.5	0.0994	0.033
Metals:			
Arsenic, μg/dscm @ 12% CO_2		-	0.420
Beryllium, μg/dscm @ 12% CO_2		-	[b]ND[0.013]
Cadmium, μg/dscm @ 12% CO_2		-	ND[0.647]
Chromium, μg/dscm @ 12% CO_2		-	3.25
Lead, μg/dscm @ 12% CO_2		-	4.05
Mercury, μg/dscm @ 12% CO_2		-	25.47
Nickel, μg/dscm @ 12% CO_2		-	3.00
Acid Gases:			
HCl			
Concentration, ppmV at 12% CO_2	50, or	-	42
Removal Efficiency, %	90[a]	-	92
SO_2			
Concentration, ppmV at 12% CO_2		-	23
Removal Efficiency, %		-	79
NO_x, ppmV at 12% CO_2		-	234.2

[a] 50 ppmV emission concentration or 90% removal, whichever is least restrictive

[b] ND = Not detected, detection limits in brackets

[c] Insufficient data.

TABLE 2-3. SUMMARY OF AVERAGE RESULTS, UNIT 3

Parameter	Permit Limit	Test Results 65% Load	 100% Load
PROCESS DATA			
Steam Rate, lb/hr		135200	189300
Combustion Efficiency,			
%, 1-hr (averages)	99.67	99.981	99.967
%, 8-hr (rolling averages)	99.92	99.982	99.965
Furnace Temperature, °F	1500	N/M[b]	N/M
STACK EMISSIONS			
Particulates, gr/dscf at 12% CO_2	0.015	0.00119	0.00151
Carbon Monoxide			
ppmV, dry at 12% CO_2		22.2	40.2
lb/hr	418	5.63	15.3
Total Hydrocarbons, lb/hr (as methane)	21.5	0.095	0.49
Metals:			
Arsenic, μg/dscm @ 12% CO_2		-	0.454
Beryllium, μg/dscm @ 12% CO_2		-	[c]ND[0.013]
Cadmium, μg/dscm @ 12% CO_2		-	ND[0.687]
Chromium, μg/dscm @ 12% CO_2		-	0.586
Lead, μg/dscm @ 12% CO_2		-	6.39
Mercury, μg/dscm @ 12% CO_2		-	9.28
Nickel, μg/dscm @ 12% CO_2		-	ND[0.696]
Acid Gases:			
HCl			
Concentration, ppmV at 12% CO_2	50, or	-	60
Removal Efficiency, %	90[a]	-	90
SO_2			
Concentration, ppmV at 12% CO_2		-	36
Removal Efficiency, %		-	74
NO_x, ppmV at 12% CO_2		-	247.6

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[a] 50 ppmV emission concentration or 90% removal, whichever is least restrictive

[b] N/M - Not measured

[c] ND - Not detected, detection limits in brackets

Furnace temperature traverses were performed at Unit 2 to demonstrate that the average combustion gas temperature after the addition ofoverfire air was at least 1500°F at 65% and 100% load. This requirement was met at both loads.

Measurements of HCl and SO_2 removal efficiencies were performed at each unit. The average HCl removals under normal operating conditions (SO_2 removal greater than 70 percent) complied with the permit condition. Nitrogen oxides were measured and reported according to the requirements of the special conditions of the permit.

Carbon monoxide and total hydrocarbons were well below the permit mass emission limits for all three units at 100% load. The highest carbon monoxide emissions were 22.2 lb/hr for Unit 2 versus the emissions limitation of 418 lb/hr. For total hydrocarbon, the highest emissions were 0.13 lb/hr versus an emissions limit of 21.5 lb/hr. The combustion efficiencies expressed as a ratio of CO and CO_2 were well within the permit limits at 65% and 100% of design load for 1-hour and 8-hour averages with all efficiencies between 99.96 and 99.98%.

3.0 UNIT 1 EMISSION TEST RESULTS

Compliance emission testing was performed on Unit 1 of the Hempstead Resource Recovery facility on September 27, 28, and 29 1989 at 100% steam load and on September 21 and 22, 1989 at 65% steam load. Emission tests were performed for particulates, heavy metals, combustion efficiency, acid gases, total hydrocarbons, and specific toxic organics (CDD/CDF/PAH/PCB) during 100% load. Testing for particulates and combustion efficiency was performed at the 65% load condition.

3.1 Particulate Emissions

Table 3-1 presents the results of the particulate testing performed on Unit 1 at the 100% load condition. The average effluent particulate concentration from Unit 1 at 100% load was 0.00100 grains/dscf or 0.00123 grains/dscf normalized to 12% CO_2. The average mass emission rate was 0.865 lb/hr. The average steam rate during these tests was 188,000 lb/hr. Averages for other process operation variables are given in Table 3-2.

Table 3-3 lists the sampling results for particulate testing performed on Unit 1 at 65% load. The average particulate concentration from Unit 1 at 65% load was 0.00078 grains/dscf or 0.00098 grains/dscf adjusted to 12% CO_2. The average mass emission rate was 0.529 lb/hr. The average process operation data are presented in Table 3-4.

Particle size distribution tests were also performed on Unit 1 to characterize the particulate emissions at 100% load. Two runs were performed on Unit 1. Run 1 was performed during October 2 and 3, 1989 and lasted 18.4 hours. Run 2 was performed on October 23 and 24, 1989 and lasted 21 hours. Results for Run 1 and Run 2 are presented in Tables 3-5 and 3-6, respectively. The total particulate concentration for Run 1 was 0.000419 grains/dscf or 0.000587 grains/dscf adjusted to 12% CO_2. The particulate concentration for Run 2 was 0.00253 grains/dscf or 0.00310 grains/dscf at 12% CO_2. The concentration for Run 1 was lower than the Method 5 particulate test average (0.00123 grains/dscf at 12% CO_2) and Run 2 results were higher than the average. Since the two particle

TABLE 3-1. SUMMARY OF PARTICULATE TEST RESULTS FOR UNIT 1 DURING 100% LOAD, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 1 09/27/89	RUN 2 09/28/89	RUN 3 09/29/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.95	30.20	29.83	29.99
Absolute Stack Pressure,Ps(in. Hg)	29.87	30.12	29.75	29.91
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	286.81	289.29	290.44	288.85
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	127.91	129.09	132.35	129.78
Average Meter Pressure (in. H2O)	0.83	0.88	0.98	0.90
Average Meter Temperature (F)	95.52	96.63	93.24	95.13
Moisture Collected (g)	580.10	589.20	619.10	596.13
Carbon Dioxide Concentration (%V)	9.66	9.80	9.88	9.78
Oxygen Concentration (%V)	10.02	9.78	9.69	9.83
Nitrogen Concentration (%V)	80.32	80.42	80.43	80.39
Dry Gas Meter Factor	0.98610	0.98720	0.98820	0.99
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.00750	0.00610	0.01030	0.00797
Average Sampling Rate (dscfm)	0.50	0.51	0.52	0.53
Standard Metered Volume,Vm(std) (dscf)	120.26	122.28	124.75	126.44
Standard Metered Volume,Vm(std) (dscm)	3.406	3.463	3.533	3.58
Standard Volume Water Vapor,Vw (scf)	27.35	27.78	29.19	29.30
Standard Volume Water Vapor,Vw (scm)	0.775	0.787	0.827	0.83
Stack Moisture (%V)	18.53	18.51	18.96	18.81
Mole Fraction Dry Stack Gas	0.815	0.815	0.810	0.81
Dry Molecular Weight	29.95	29.96	29.97	29.98
Wet Molecular Weight	27.73	27.75	27.70	27.73
Stack Gas Velocity,Vs (fpm)	3379.20	3464.40	3674.10	3584.95
Stack Gas Velocity,Vs (mpm)	1029.98	1055.95	1119.87	1092.69
Volumetric Flow Rate (acfm)	169856.93	174139.62	184680.52	180199.01
Volumetric Flow Rate (acmm)	4810.348	4931.634	5230.152	5103.24
Volumetric Flow Rate (dscfm)	97619.49	100602.04	104645.66	102737.20
Volumetric Flow Rate (dscmm)	2764.584	2849.050	2963.565	2909.52
Percent Isokinetic	100.42	99.08	97.18	100.32
Percent Excess Air	89.46	85.29	83.83	82.47
Fuel Factor,Fo	1.126	1.135	1.135	1.13
Ultimate CO2	18.56	18.42	18.42	18.50
Concentration of Particulate (grains/acf)	0.00055	0.00044	0.00072	0.00057
Concentration of Particulate (g/acm)	0.00127	0.00102	0.00165	0.00131
Concentration of Particulate (grains/dscf)	0.00096	0.00077	0.00127	0.00100
Concentration of Particulate (g/dscm) [a]	0.00220	0.00176	0.00292	0.00229
Concentration of Particulate (grains/dscf @12% CO2)	0.00120	0.00094	0.00155	0.00123

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 3-2. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 1 DURING PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/27/89 0906-1516 4	09/28/89 0846-1336 5	09/29/89 1006-1516 6	AVERAGE
STEAM LOAD, (Klb/hr)	184.89	188.83	190.38	188.03
STEAM PRESSURE, (psig)	916.68	923.67	925.50	921.95
STEAM TEMPERATURE, (deg. F)	839.32	838.80	839.50	839.21
PRIMARY AIR FLOW, (KSCFM)	49.73	52.76	53.43	51.97
SECONDARY AIR FLOW, (KSCFM)	26.87	25.97	26.61	26.48
FURNACE OXYGEN, (%V, wet) a	10.67	11.08	11.58	11.11
FIRST PASS TEMPERATURE, (deg. F)	NR	NR	NR	NR
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	428.66	432.53	446.72	435.97
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	NR	NR	NR	NR
SCRUBBER SLURRY RATE, (gpm)	5.9	4.7	5.9	5.50
SCRUBBER WATER RATE, (gpm)	17.4	17.5	17.0	17.30
FABRIC FILTER, (dP)	NR	NR	NR	NR
SO2 REMOVAL, (%)	NR	NR	NR	NR
OUTLET CO @ 12% (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NR = NOT RECORDED

TABLE 3-3. SUMMARY OF PARTICULATE TEST RESULTS FOR UNIT 1 DURING 65% LOAD TESTS HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 7 09/21/89	RUN 8 09/22/89	RUN 9 09/22/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.99	29.81	29.54	29.78
Absolute Stack Pressure,Ps(in. Hg)	29.91	29.73	29.46	29.70
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	284.20	285.79	283.10	284.36
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	98.68	106.26	118.89	107.95
Average Meter Pressure (in. H2O)	0.51	0.58	0.76	0.62
Average Meter Temperature (F)	107.41	105.09	109.21	107.24
Moisture Collected (g)	507.90	499.00	575.00	527.30
Carbon Dioxide Concentration (%V)	10.27	8.95	9.45	9.56
Oxygen Concentration (%V)	9.38	10.67	10.18	10.08
Nitrogen Concentration (%V)	80.35	80.38	80.37	80.37
Dry Gas Meter Factor	0.98610	0.98610	0.98610	0.98610
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.00500	0.00390	0.00610	0.00500
Average Sampling Rate (dscfm)	0.38	0.41	0.45	0.41
Standard Metered Volume,Vm(std) (dscf)	90.89	97.70	107.59	98.72
Standard Metered Volume,Vm(std) (dscm)	2.574	2.767	3.047	2.796
Standard Volume Water Vapor,Vw (scf)	23.95	23.53	27.11	24.86
Standard Volume Water Vapor,Vw (scm)	0.678	0.666	0.768	0.704
Stack Moisture (%V)	20.85	19.41	20.13	20.13
Mole Fraction Dry Stack Gas	0.791	0.806	0.799	0.799
Dry Molecular Weight	30.02	29.86	29.92	29.93
Wet Molecular Weight	27.51	27.56	27.52	27.53
Stack Gas Velocity,Vs (fpm)	2565.13	2759.52	3073.74	2799.46
Stack Gas Velocity,Vs (mpm)	781.85	841.10	936.88	853.28
Volumetric Flow Rate (acfm)	128937.65	138708.51	154503.10	140716.42
Volumetric Flow Rate (acmm)	3651.514	3928.225	4375.528	3985.089
Volumetric Flow Rate (dscfm)	72341.84	78602.23	86294.29	79079.45
Volumetric Flow Rate (dscmm)	2048.721	2226.015	2443.854	2239.530
Percent Isokinetic	103.36	101.32	102.57	102.42
Percent Excess Air	79.17	100.98	92.10	90.75
Fuel Factor,Fo	1.122	1.143	1.134	1.133
Ultimate CO2	18.63	18.28	18.42	18.45
Concentration of Particulate (grains/acf)	0.00048	0.00035	0.00049	0.00044
Concentration of Particulate (g/acm)	0.00109	0.00080	0.00112	0.00100
Concentration of Particulate (grains/dscf)	0.00085	0.00062	0.00087	0.00078
Concentration of Particulate (g/dscm) a	0.00194	0.00141	0.00200	0.00178
Concentration of Particulate (grains/dscf @12% CO2)	0.00099	0.00083	0.00111	0.00098

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 3-4. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 1 DURING 65% LOAD PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/21/89 1513-2043 7	09/22/89 1003-1423 8	09/22/89 1423-1923 9	AVERAGE
STEAM LOAD, (Klb/hr)	141.83	131.94	150.19	141.32
STEAM PRESSURE, (psig)	880.24	871.93	889.74	880.64
STEAM TEMPERATURE, (deg. F)	837.76	838.00	838.45	838.07
PRIMARY AIR FLOW, (KSCFM)	33.63	23.10	25.04	27.26
SECONDARY AIR FLOW, (KSCFM)	10.22	11.23	18.92	13.46
FURNACE OXYGEN, (%V, wet) [a]	8.65	9.46	9.03	9.05
FIRST PASS TEMPERATURE, (deg. F)	1457.41	1409.04	1444.90	1437.12
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	394.91	404.74	420.97	406.87
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	307.79	306.81	308.35	307.65
SCRUBBER SLURRY RATE, (gpm)	5.3	4.6	5.7	5.2
SCRUBBER WATER RATE, (gpm)	12.6	7.6	17.5	12.6
FABRIC FILTER, (dP)	2.45	4.11	4.48	3.68
SO2 REMOVAL, (%)	84.61	76.12	75.45	78.73
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NR = NOT RECORDED

TABLE 3-5. PARTICLE SIZE DISTRIBUTION RESULTS FOR RUN 1

Facility: American Ref-Fuel/Hempstead Plant
Run: UNIT 1 - PSD 01

Date: 10/2-3/89
TIME: 09:44 - 04:06

STAGE	Dp50 (microns)	Net Weight (grams)	Mass Fraction	Mass Fract. Less Than	Interval Geometric Midpoint (microns)	Adjusted Concentration "dM/dlog dP" (gr/dscf)	Concentration [a] (gr/dscf)
Preimp. & 1	12.17	0.00074	0.0667	0.9333	24.67	4.56E-05	0.00002795
2	7.93	0.00047	0.0424	0.8909	9.83	9.55E-05	0.00001775
3	5.18	0.00010	0.0090	0.8819	6.41	2.04E-05	0.00000378
4	3.66	0.00014	0.0126	0.8693	4.35	3.50E-05	0.00000529
5	2.16	0.00057	0.0514	0.8179	2.81	9.45E-05	0.00002153
6	1.23	0.00044	0.0397	0.7782	1.63	6.74E-05	0.00001662
7	0.75	0.00072	0.0649	0.7133	0.96	1.27E-04	0.00002720
8	0.47	0.00034	0.0307	0.6826	0.59	6.28E-05	0.00001284
BACK-UP		0.00757	0.6826	0.0000	0.11	2.25E-04	0.00028595
	TOTAL	0.01109	1.0000				0.00041900

NOTE: Preimpactor and stage 1 cut size (Dp50) was averaged from the preimpactor value of 12.195 and the first stage value of 12.149 microns.

SAMPLING PARAMETERS

Total Sampling Time (min.)	1102
Corrected Barometric Pressure (in. Hg)	29.86
Absolute Stack Pressure,Ps (in. Hg)	29.78
Stack Static Pressure (in. H2O)	-1.10
Average Stack Temperature (deg. F)	294.57
Metered Volume,Vm (cu.ft.)	435.73
Average Meter Pressure (in. H2O)	0.45
Average Meter Temperature (deg. F)	94.82
Carbon Dioxide Concentration (%V)	8.55
Oxygen Concentration (%V)	10.01
Nitrogen Concentration (%V)	81.44
Dry Gas Meter Factor	0.99
Average Sampling Rate (dscfm)	0.37
Standard Metered Volume,Vm(std) (dscf)	408.54
Stack Moisture (%V)	19.49
Mole Fraction Dry Stack Gas	0.81
Dry Molecular Weight	29.77
Wet Molecular Weight	27.47
Stack Gas Velocity,Vs (fpm)	3700.24
Volumetric Flow Rate (acfm)	185994.26
Volumetric Flow Rate (dscfm)	104226.21
Percent Isokinetic	96.8

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 3-6. PARTICLE SIZE DISTRIBUTION RESULTS FOR RUN 2

Facility: American Ref-Fuel/Hempstead Plant
Run: UNIT 1 - PSD 02

Date: 10/23-24/89
TIME: 12:12 - 10:12

STAGE	Dp50 (microns)	Net Weight (grams)	Mass Fraction	Mass Fract. Less Than	Interval Geometric Midpoint (microns)	Adjusted Concentration "dM/dlog dP" (gr/dscf)	Concentration[a] (gr/dscf)
Preimp. & 1	12.67	0.00866	0.1135	0.8865	25.16	4.82E-04	0.00028732
2	8.27	0.00669	0.0877	0.7988	10.23	1.20E-03	0.00022196
3	5.39	0.01330	0.1743	0.6245	6.68	2.38E-03	0.00044127
4	3.81	0.00867	0.1136	0.5109	4.53	1.90E-03	0.00028765
5	2.25	0.00599	0.0785	0.4324	2.93	8.72E-04	0.00019874
6	1.28	0.00547	0.0717	0.3607	1.70	7.36E-04	0.00018148
7	0.78	0.00440	0.0577	0.3030	1.00	6.78E-04	0.00014598
8	0.48	0.00504	0.0661	0.2370	0.61	8.14E-04	0.00016722
BACK-UP		0.01808	0.2370	0.0000	0.11	4.66E-04	0.00059986
	TOTAL	0.07630	1.0000				0.00253100

NOTE: Preimpactor and stage 1 cut size (Dp50) was averaged from the preimpactor value of 12.673 and the first stage value of 12.659 microns.

SAMPLING PARAMETERS

Total Sampling Time (min.)	1320.0
Corrected Barometric Pressure (in. Hg)	29.92
Absolute Stack Pressure,Ps (in. Hg)	29.84
Stack Static Pressure (in. H2O)	-1.10
Average Stack Temperature (deg. F)	290.7
Metered Volume,Vm (cu.ft.)	493.9
Average Meter Pressure (in. H2O)	0.44
Average Meter Temperature (deg. F)	102.5
Carbon Dioxide Concentration (%V)	9.78
Oxygen Concentration (%V)	9.83
Nitrogen Concentration (%V)	80.4
Dry Gas Meter Factor	1.00220
Average Sampling Rate (dscfm)	0.352369
Standard Metered Volume,Vm (std) (dscf)	465.13
Stack Moisture (%V)	18.7
Mole Fraction Dry Stack Gas	0.813
Dry Molecular Weight	30.0
Wet Molecular Weight	27.7
Stack Gas Velocity,Vs (fpm)	2767
Volumetric Flow Rate (acfm)	139087
Volumetric Flow Rate (dscfm)	79304
Percent Isokinetic	120.9

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

size test results bracket the Method 5 test results, it may be assumed that the particle size results characterize the unit over a range of operation. Figure 3-1 shows a plot of cumulative mass fraction versus particle size for the two runs. During Run 1 the PM_{10} or particulate matter with a mean diameter less than 10 microns, comprised approximately 93% of the total particulate mass. For Run 2, the mass fraction of PM_{10} was approximately 83% of the total.

The quality control measures observed during particulate sampling included leakchecking the trains, monitoring probe, filter, and impinger exit temperatures, and careful assembly and disassembly of the trains in a controlled environment to avoid contamination. All meterboxes and thermocouple readouts are calibrated prior to arrival on site and after testing was completed. The trains were leakchecked before and after each run as well as at port change. All observed leak rates were less than the prescribed 0.02 cfm. The isokinetics ranged from 97.18% to 103.36% during particulate tests at both the 100% and 65% load conditions.

3.2 CDD/CDF Results at Unit 1

Three four-hour test runs were performed at the Unit 1 stack at full design load to measure CDD/CDF, PAH, and PCB species. The results of the CDD/CDF analyses are presented in this section and the PAH and PCB results are discussed in Section 3.3.

The sampling and flue gas data for the three runs are presented in Table 3-7. The average process operating conditions during each CDD/CDF run are presented in Table 3-8. As can be seen, the steam rate, air flows and stack gas variables (flow rate, moisture, and composition) were all consistent between the three runs. No unusual operation problems or excursions were recorded during these tests.

The CDD/CDF test results are presented as measured in Table 3-9 and normalized to 7% O_2 in Table 3-10. Results are presented for each 2378-substituted isomer as well as for each tetra-octa homologue total. The average total CDD was 0.174 ng/dscm at 7% O_2 and the average CDF concentration

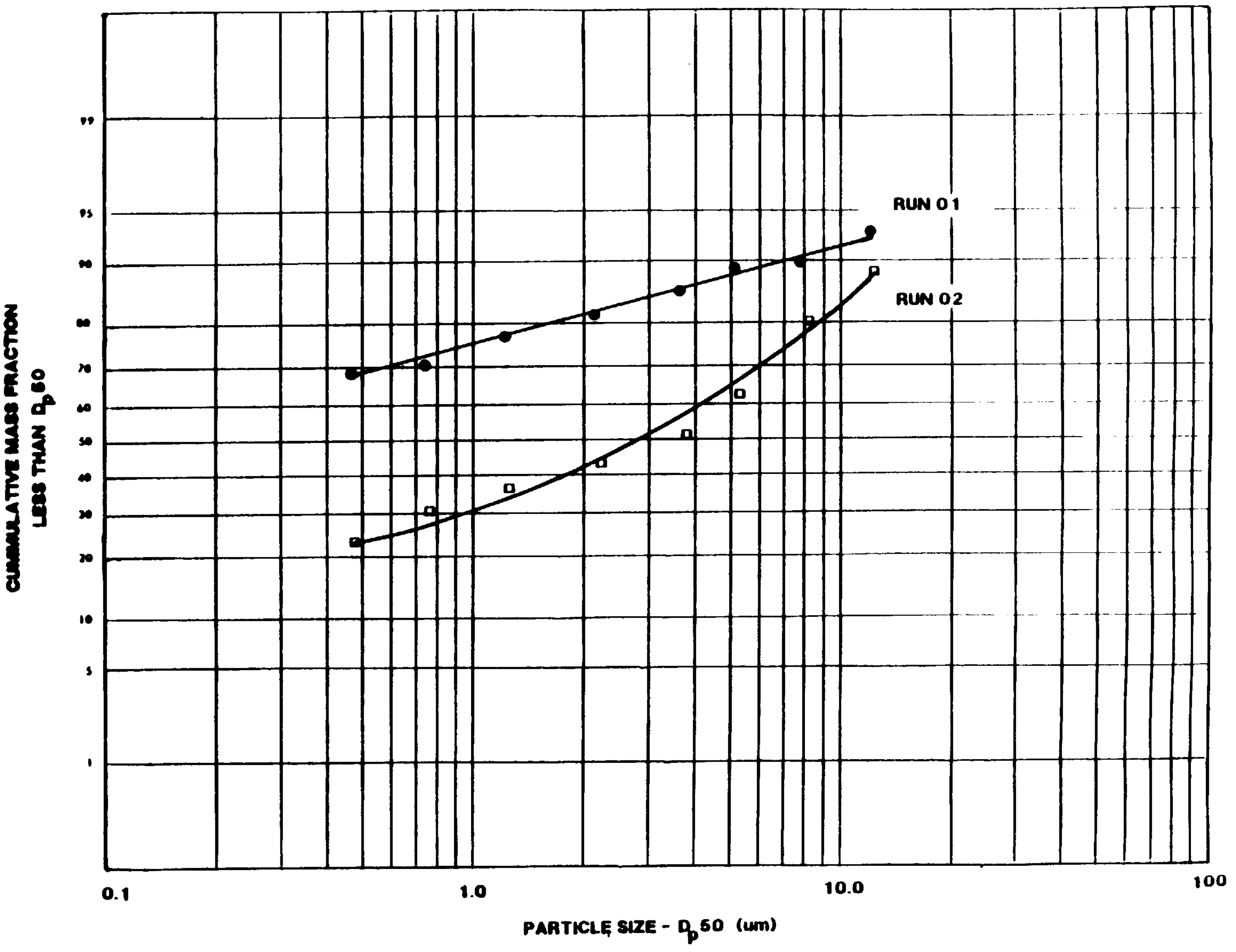

Figure 3-1. Particle Size Distribution Results, Unit 1.
American Ref-Fuel; Hempstead, N.Y. (Oct 1989)

TABLE 3-7. SUMMARY OF CDD/CDF TEST RESULTS FOR UNIT 1 DURING 100% LOAD, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER CDD/CDF	RUN 1 09/27/89	RUN 2 09/28/89	RUN 3 09/29/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.95	30.10	29.73	29.93
Absolute Stack Pressure,Ps(in. Hg)	29.87	30.02	29.65	29.85
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	287.42	289.60	291.55	289.52
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	128.63	134.25	132.91	131.93
Average Meter Pressure (in. H2O)	0.92	1.00	0.95	0.96
Average Meter Temperature (F)	95.59	93.46	91.83	93.63
Moisture Collected (g)	591.90	625.20	647.00	621.37
Carbon Dioxide Concentration (%V)	10.10	10.00	9.90	10.00
Oxygen Concentration (%V)	9.50	9.60	9.70	9.60
Nitrogen Concentration (%V)	80.40	80.40	80.40	80.40
Dry Gas Meter Factor	1.00220	1.00220	1.00220	1.00
Pitot Constant	0.84	0.84	0.84	0.84
Average Sampling Rate (dscfm)	0.51	0.54	0.53	0.53
Standard Metered Volume,Vm(std) (dscf)	122.92	129.45	126.95	126.44
Standard Metered Volume,Vm(std) (dscm)	3.481	3.666	3.595	3.58
Standard Volume Water Vapor,Vw (scf)	27.91	29.48	30.51	29.30
Standard Volume Water Vapor,Vw (scm)	0.790	0.835	0.864	0.83
Stack Moisture (%V)	18.50	18.55	19.37	18.81
Mole Fraction Dry Stack Gas	0.815	0.815	0.806	0.81
Dry Molecular Weight	30.00	29.98	29.97	29.98
Wet Molecular Weight	27.78	27.76	27.65	27.73
Stack Gas Velocity,Vs (fpm)	3456.43	3605.56	3692.85	3584.95
Stack Gas Velocity,Vs (mpm)	1053.52	1098.98	1125.58	1092.69
Volumetric Flow Rate (acfm)	173738.94	181235.31	185622.77	180199.01
Volumetric Flow Rate (acmm) [a]	4920.287	5132.584	5256.837	5103.24
Volumetric Flow Rate (dscfm)	99804.78	104266.93	104139.90	102737.20
Volumetric Flow Rate (dscmm)	2826.471	2952.839	2949.242	2909.52
Percent Isokinetic	100.40	101.20	99.37	100.32
Percent Excess Air	80.91	82.46	84.04	82.47
Fuel Factor,Fo	1.129	1.130	1.131	1.13
Ultimate CO2	18.52	18.50	18.47	18.50

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[a] Standard conditions are defined as 1 atm and 68 deg. F.

TABLE 3-8. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 1 DURING CDD/CDF TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/27/89 1046-1506 1	09/28/89 0836-1316 2	09/29/89 0956-1506 3	AVERAGE
STEAM LOAD, (Klb/hr)	187.87	191.48	189.48	189.61
STEAM PRESSURE, (psig)	918.89	925.66	924.81	923.12
STEAM TEMPERATURE, (deg. F)	839.78	839.10	839.63	839.50
PRIMARY AIR FLOW, (KSCFM)	49.75	52.71	53.43	51.96
SECONDARY AIR FLOW, (KSCFM)	27.23	25.82	26.22	26.42
FURNACE OXYGEN, (%V, wet) a	10.57	11.01	11.57	11.05
FIRST PASS TEMPERATURE, (deg. F)	NR	NR	NR	NR
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	431.22	430.72	446.22	436.05
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	NR	NR	NR	NR
SCRUBBER SLURRY RATE, (gpm)	6.8	5.5	4.0	5.4
SCRUBBER WATER RATE, (gpm)	19.0	17.6	21.8	19.5
FABRIC FILTER, (dP)	NR	NR	NR	NR
SO2 REMOVAL, (%)	NR	NR	NR	NR
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NR = NOT RECORDED

TABLE 3-9. CDD/CDF FLUE GAS CONCENTRATIONS AT FOR UNIT 1 DURING 100% LOAD, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

	CONCENTRATION[a] (ng/dscm, as measured)			
CONGENER	RUN 1	RUN 2	RUN 3	AVERAGE
DIOXINS				
2378 TCDD	[0.011]	[0.008]	[0.011]	[0.010]
Other TCDD	[0.011]	[0.008]	[0.011]	[0.010]
12378 PCDD	[0.011]	[0.005]	[0.008]	[0.008]
Other PCDD	[0.011]	[0.005]	[0.008]	[0.008]
123478 HxCDD	[0.009]	[0.005]	[0.011]	[0.008]
123678 HxCDD	[0.009]	[0.005]	[0.011]	[0.008]
123789 HxCDD	[0.011]	[0.008]	[0.011]	[0.010]
Other HxCDD	(0.026)	(0.030)	(0.022)	(0.026)
1234678-HpCDD	(0.080)	0.095	(0.047)	0.095
Other Hepta-CDD	0.057	0.000	(0.083)	0.057
Octa-CDD	(0.135)	0.273	(0.097)	0.273
Total CDD	0.057	0.368	(0.097)	0.425
FURANS				
2378 TCDF	[0.011]	[0.005]	[0.011]	[0.009]
Other TCDF	[0.011]	[0.005]	[0.011]	[0.009]
12378 PCDF	[0.009]	[0.005]	[0.008]	[0.007]
23478 PCDF	[0.009]	[0.005]	(0.014)	[0.009]
Other PCDF	(0.040)	[0.005]	(0.031)	[0.025]
123478 HxCDF	(0.098)	(0.014)	0.011	0.011
123678 HxDCF	0.055	[0.005]	[0.006]	0.055
234678 HxCDF	(0.029)	0.016	(0.019)	0.016
123789 HxCDF	[0.014]	[0.008]	[0.011]	[0.011]
Other HxCDF	0.132	0.000	0.003	0.067
1234678-HpCDF	0.316	0.106	0.058	0.160
1234789-HpCDF	0.072	(0.030)	[0.014]	0.072
Other Hepta-CDF	0.187	0.145	0.042	0.124
Octa-CDF	0.460	0.256	(0.070)	0.358
TOTAL CDF	1.221	0.521	0.114	0.619
TOTAL CDD+CDF	1.278	0.889	0.114	0.761

[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

[] = Minimum detection limit.
() = Estimated maximum pollutant concentration.
Detection limits are not included in the averages unless otherwise indicated.

Note: The average values for the totals may not equal the sum of the average cogeners reported due to the protocol used here for averaging and adding detection limits.

TABLE 3-10. OUTLET STACK CDD/CDF FLUE GAS CONCENTRATIONS ADJUSTED TO 7 PERCENT O2 AT AMERICAN REF-FUEL, UNIT 1, 100% LOAD

	CONCENTRATION[b] (ng/dscm, adjusted to 7% O2)				2378-TCDD TOXIC EQUIV.[a]	2378 TOXIC EQUIVALENCIES (ng/dscm, adjusted to 7% O2)			
CONGENER	RUN 1	RUN 2	RUN 3	AVERAGE	FACTOR	RUN 1	RUN 2	RUN 3	AVERAGE
DIOXINS									
2378 TCDD	[0.013]	[0.010]	[0.014]	[0.012]	1.0	0.00000	0.00000	0.00000	0.00000
Other TCDD	[0.013]	[0.010]	[0.014]	[0.012]	0.01	0.00000	0.00000	0.00000	0.00000
12378 PCDD	[0.013]	[0.006]	[0.010]	[0.010]	1.0	0.00000	0.00000	0.00000	0.00000
Other PCDD	[0.013]	[0.006]	[0.010]	[0.010]	0.01	0.00000	0.00000	0.00000	0.00000
123478 HxCDD	[0.011]	[0.006]	[0.014]	[0.010]	0.03	0.00000	0.00000	0.00000	0.00000
123678 HxCDD	[0.011]	[0.006]	[0.014]	[0.010]	0.03	0.00000	0.00000	0.00000	0.00000
123789 HxCDD	[0.013]	[0.010]	[0.014]	[0.012]	0.03	0.00000	0.00000	0.00000	0.00000
Other HxCDD	(0.032)	(0.037)	(0.027)	(0.032)	0.0003	0.00000	0.00000	0.00000	0.00000
1234678-HpCDD	(0.098)	0.117	(0.058)	0.117	0.001	0.00000	0.00012	0.00000	0.00004
Other Hepta-CDD	0.070	0.000	(0.103)	0.070	0.00001	0.00000	0.00000	0.00000	0.00000
Octa-CDD	(0.165)	0.336	(0.120)	0.336	0	0.00000	0.00000	0.00000	0.00000
Total CDD	0.070	0.453	(0.120)	0.174					
FURANS									
2378 TCDF	[0.013]	[0.006]	[0.014]	[0.011]	0.33	0.00000	0.00000	0.00000	0.00000
Other TCDF	[0.013]	[0.006]	[0.014]	[0.011]	0.003	0.00000	0.00000	0.00000	0.00000
12378 PCDF	[0.011]	[0.006]	[0.010]	[0.009]	0.33	0.00000	0.00000	0.00000	0.00000
23478 PCDF	[0.011]	[0.006]	(0.017)	[0.011]	0.33	0.00000	0.00000	0.00000	0.00000
Other PCDF	(0.049)	[0.006]	(0.038)	(0.031)	0.003	0.00000	0.00000	0.00000	0.00000
123478 HxCDF	(0.119)	(0.017)	0.014	0.014	0.01	0.00000	0.00000	0.00014	0.00005
123678 HxDCF	0.067	[0.006]	[0.007]	0.067	0.01	0.00067	0.00000	0.00000	0.00022
234678 HxCDF	(0.035)	0.020	(0.024)	0.020	0.01	0.00000	0.00020	0.00000	0.00007
123789 HxCDF	[0.017]	[0.010]	[0.014]	[0.014]	0.01	0.00000	0.00000	0.00000	0.00000
Other HxCDF	0.161	0.000	0.003	0.082	0.0001	0.00002	0.00000	0.00000	0.00001
1234678-HpCDF	0.385	0.131	0.072	0.196	0.001	0.00039	0.00013	0.00007	0.00020
1234789-HpCDF	0.088	(0.037)	[0.017]	0.088	0.001	0.00009	0.00000	0.00000	0.00003
Other Hepta-CDF	0.228	0.178	0.052	0.152	0.00001	0.00000	0.00000	0.00000	0.00000
Octa-CDF	0.560	0.315	(0.087)	0.438	0	0.00000	0.00000	0.00000	0.00000
TOTAL CDF	1.489	0.644	0.142	0.758					
TOTAL CDD+CDF	1.559	1.097	0.142	0.932		0.00116	0.00045	0.00021	0.00061

[a] Toxic equivalency factors specified in "Revised 6 NYCRR Part 219 Incinerators, August 1988. Paragraph 219-1.1(b)(2), Revised October 3, 1988."

[b] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

[] = Minimum detection limit.
() = Estimated maximum possible concentration.
Detection limits are not included in the averages unless otherwise indicated.

Note: The average values for the totals may not equal the sum of the average cogeners reported due to the protocol used here for averaging and adding detection limits.

was 0.758 ng/dscm at 7% O_2. The average total CDD and CDF concentration was 0.932 ng/dscm at 7% O_2.

Detection limits are reported in brackets for compounds that were not detected in the samples. At present, there is no widely accepted standard for averaging and totaling detection limits for compliance tests. The protocol used in this report for totaling and averaging the detection limits is as follows:

- If a congener was detected in one or more samples but not in all of the samples, then the average is taken only from the runs in which the native species was detected.
- If a particular congener was not detected in any runs then the average detection limit is reported.
- The totals include only species which were detected for a run. If no relevant species were detected then the highest detection limit from the group is assumed to be the detection limit for the total.

This approach yields a high average for species which were not detected in all samples. Additionally, it should be noted that the method of totaling the congeners causes the average total to be different than the sum of the average congeners in some cases. This approach for averaging and totaling detection limits is used for all of the organics test results and is consistent with the methods used for calculating the metals average results.

The 2378-TCDD toxic equivalencies are also presented in Table 3-10 using the CDD/CDF results normalized to 7% O_2. The toxic equivalencies were calculated using the procedures and toxicity factors specified in Paragraph 219-1.1(b)(2) of the NYCRR. For this calculation, all non-detected congeners were assigned a concentration of zero. The average 2378-TCDD toxic equivalency using this procedure was 0.00061 ng/dscm at 7% O_2, with a range of 0.00021 to 0.00116 ng/dscm. These results show that the emissions from this facility are 100 to 1,000 times less than the 0.2 ng/dscm toxic equivalents target for incinerators in New York State.

The 2378-TCDD toxic equivalency was also calculated using a more conservative approach than assuming zero values for all non-quantitated congeners. A value of one-half of the detection limit or the estimated maximum possible concentration was assumed for each congener. The assumed values and the resultant 2378-TCDD toxic equivalents are presented in Table 3-11. The average 2378-TCDD toxic equivalency was 0.0179 ng/dscm at 7% O_2 using this procedure.

This result is used for input to the risk assessment models for the facility and as data for use in establishing the facility-specific dioxin equivalent emission limit as required by Part 219.

The flue gas CDD/CDF emission results are consistent between test runs considering the extremely low concentrations of analytes present in the samples. The only congeners found were hepta and octa-CDD and hexa, hepta and octa-CDF. The 2378-TCDD isomer was not detected in any samples, nor was the 2378-TCDF isomer found. The detection limit for 2378-TCDD was about 0.010 ng/dscm at 7% O_2, which is well within the measurement sensitivity necessary to demonstrate attainment of the 0.20 ng/dscm toxic equivalency target of Part 219. The detection limit for other CDD and CDF congeners also was in the range of 0.006 to about 0.1 ng/dscm.

Appropriate quality control/quality assurance procedures were performed during the collection and analysis of the samples. During the collection of the samples, all procedural requirements were followed, which included maintenance of probe, filter resin traps and impinger temperatures within specification. Leakchecks were performed before sampling, at each port change, and after sampling. All leakchecks were good and were less than the 0.02 cfm permissible level. The average isokinetic sampling rate ranged from 99-101%. Finally, all three test runs yielded similar stack gas flow rates and moisture results, which indicates internal consistency between the runs.

The quality control procedures that were followed during the analytical steps included the analysis of a field blank and a laboratory method blank. No target analytes were detected in the method blank, and only octa-CDD was detected in the field blank. The level of octa-CDD in the field blank was near the detection limit, and was about 20% of the octa-CDD detected in Run 2. This is a typical result and since octa-CDD has a zero toxic equivalency factor, it has no impact on the final results.

TABLE 3-11. CDD/CDF FLUE GAS CONCENTRATIONS - ADJUSTED TO 7% O2
RISK ASSESSMENT MODEL INPUTS
FOR UNIT 1 DURING 100% LOAD,
HEMPSTEAD RESOURCE RECOVERY,
WESTBURY, NEW YORK

	ASSUMED CONCENTRATION[b] (ng/dscm, adjusted to 7% O2)				2378-TCDD TOXIC EQUIV.[a]	2378 TOXIC EQUIVALENCIES (ng/dscm, adjusted to 7% O2)			
CONGENER	RUN 1	RUN 2	RUN 3	AVERAGE	FACTOR	RUN 1	RUN 2	RUN 3	AVERAGE
DIOXINS									
2378 TCDD	0.00650	0.00500	0.00700	0.00617	1.0	0.00650	0.00500	0.00700	0.00617
Other TCDD	0.00650	0.00500	0.00700	0.00617	0.01	0.00006	0.00005	0.00007	0.00006
12378 PCDD	0.00650	0.00300	0.00500	0.00483	1.0	0.00650	0.00300	0.00500	0.00483
Other PCDD	0.00650	0.00300	0.00500	0.00483	0.01	0.00006	0.00003	0.00005	0.00005
123478 HxCDD	0.00550	0.00300	0.00700	0.00517	0.03	0.00017	0.00009	0.00021	0.00016
123678 HxCDD	0.00550	0.00300	0.00700	0.00517	0.03	0.00017	0.00009	0.00021	0.00016
123789 HxCDD	0.00650	0.00500	0.00700	0.00617	0.03	0.00020	0.00015	0.00021	0.00019
Other HxCDD	0.01600	0.01850	0.01350	0.01600	0.0003	0.00000	0.00001	0.00000	0.00000
1234678-HpCDD	0.04900	0.11744	0.02900	0.06515	0.001	0.00005	0.00012	0.00003	0.00007
Other Hepta-CDD	0.07005	0.00000	0.05150	0.04052	0.00001	0.00000	0.00000	0.00000	0.00000
Octa-CDD	0.08250	0.33554	0.06000	0.15935	0	0.00000	0.00000	0.00000	0.00000
Total CDD	0.26105	0.49848	0.19900	0.31951					
FURANS									
2378 TCDF	0.00650	0.00300	0.00700	0.00550	0.33	0.00214	0.00099	0.00231	0.00182
Other TCDF	0.00650	0.00300	0.00700	0.00550	0.003	0.00002	0.00001	0.00002	0.00002
12378 PCDF	0.00550	0.00300	0.00500	0.00450	0.33	0.00182	0.00099	0.00165	0.00149
23478 PCDF	0.00550	0.00300	0.00850	0.00567	0.33	0.00182	0.00099	0.00281	0.00187
Other PCDF	0.02450	0.00300	0.01900	0.01550	0.003	0.00007	0.00001	0.00006	0.00005
123478 HxCDF	0.05950	0.00850	0.01381	0.02727	0.01	0.00060	0.00009	0.00014	0.00027
123678 HxDCF	0.06655	0.00300	0.00350	0.02435	0.01	0.00067	0.00003	0.00004	0.00024
234678 HxCDF	0.01750	0.02013	0.01200	0.01654	0.01	0.00018	0.00020	0.00012	0.00017
123789 HxCDF	0.00850	0.00500	0.00700	0.00683	0.01	0.00009	0.00005	0.00007	0.00007
Other HxCDF	0.16113	0.00000	0.00345	0.05486	0.0001	0.00002	0.00000	0.00000	0.00001
1234678-HpCDF	0.38530	0.13086	0.07250	0.19622	0.001	0.00039	0.00013	0.00007	0.00020
1234789-HpCDF	0.08757	0.01850	0.00850	0.03819	0.001	0.00009	0.00002	0.00001	0.00004
Other Hepta-CDF	0.22768	0.17784	0.05178	0.15243	0.00001	0.00000	0.00000	0.00000	0.00000
Octa-CDF	0.56044	0.31541	0.04350	0.30645	0	0.00000	0.00000	0.00000	0.00000
TOTAL CDF	1.62266	0.69424	0.26254	0.85981	TOTAL 2378 TOXIC EQUIVALENCE	0.02159	0.01204	0.02007	0.01790
TOTAL CDD+CDF	1.88371	1.19271	0.46154	1.17932					

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[a] Toxic equivalency factors specified in "Revised 6 NYCRR Part 219 Incinerators, August 1988. Paragraph 219-1.1(b)(2), Revised October 3, 1988."

[b] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F. The values reported in this table assume the compounds that were not detected in the analysis or for which EMPC's are reported were present in the flue gas at one half of the reported limits. These values are considered to be the worst case and are used for the risk assessment model inputs.

The internal standard recoveries were generally within the target range of 40-160%, with the exception being for the labeled TCDD and TCDF for Run 3. The recovery for these standards was about 30% for this run. However, since no native species were detected, the low recovery does not affect quantitation. The field data sheets for CDD/CDF/PAH/PCB sampling can be found in Appendix E and the full laboratory report can be found in Appendix H.

3.3 PCB and PAH Results at Unit 1

A fraction of the flue gas sample that was collected for CDD/CDF determination was also analyzed for PCB and PAH compounds. The PCB analysis was performed using EPA Method 680 to quantify the mono to deca PCB homologues individually. The flue gas results are presented in Tables 3-12 and 3-13 at as-measured conditions and normalized to 7% O_2, respectively. As can be seen, no PCBs were detected in any of the samples. The detection limit for each homologue group ranged from about 0.005 to 0.10 μg/dscm at 7% O_2, with the typical detection limit being about 0.015 μg/dscm.

All internal standards recoveries and method blank results were normal for the PCB analysis. The PAH aliquot was analyzed using EPA Method 8270 using GC/MS. The flue gas results are presented in Tables 3-14 and 3-15 as measured and normalized to 7% O_2. As was the case for PCBs, there were no PAH species consistently detected in the samples. Napthalene was present in all of the samples, but was also detected in the field blank and laboratory blank at levels similar to the samples. Napthalene is a common analytical artifact in this analysis and is not considered present in a sample unless it is present at levels at least 40% higher than the blanks.

Methylnapthalene was detected in Run 3; however, it is possible that this was also an analysis artifact since no other compounds were detected. The typical detection limit for a PAH compound ranged from about 0.05 to 0.18 μg/dscm at 7% O_2 with a median of about 0.07 μg/dscm.

The laboratory reports for PCB and PAH quantitation can be found in Appendix H.

TABLE 3-12. UNIT 1 STACK GAS PCB CONCENTRATIONS

ANALYTE	CONCENTRATION, (ug/dscm)			
	RUN 1	RUN 2	RUN 3	AVERAGE
Total Mono PCB	[0.0037]	[0.0035]	[0.0042]	[0.0038]
Total Di PCB	[0.0043]	[0.0041]	[0.0050]	[0.0045]
Total Tri PCB	[0.0830]	[0.0153]	[0.0250]	[0.0411]
Total Tetra PCB	[0.0086]	[0.0082]	[0.0097]	[0.0088]
Total Penta PCB	[0.0115]	[0.0117]	[0.0134]	[0.0122]
Total Hexa PCB	[0.0095]	[0.0090]	[0.0120]	[0.0102]
Total Hepta PCB	[0.0124]	[0.0131]	[0.0161]	[0.0139]
Total Octa PCB	[0.0244]	[0.0251]	[0.0320]	[0.0272]
Total Nona PCB	[0.0167]	[0.0169]	[0.0214]	[0.0183]
Deca PCB	[0.0330]	[0.0336]	[0.0423]	[0.0363]
TOTAL PCB	[0.0830]	[0.0336]	[0.0423]	[0.0530]

[] = Minimum detection limit

Concentrations are expresed at standard conditions of 1 atm and 68 deg. F.

TABLE 3-13. UNIT 1 STACK GAS PCB CONCENTRATIONS ADJUSTED TO 7% O2

ANALYTE	CONCENTRATION, (ug/dscm @ 7% O2) RUN 1	RUN 2	RUN 3	AVERAGE
Total Mono PCB	[0.0045]	[0.0043]	[0.0052]	[0.0047]
Total Di PCB	[0.0052]	[0.0050]	[0.0062]	[0.0055]
Total Tri PCB	[0.1012]	[0.0188]	[0.0310]	[0.0503]
Total Tetra PCB	[0.0105]	[0.0101]	[0.0120]	[0.0109]
Total Penta PCB	[0.0140]	[0.0144]	[0.0166]	[0.0150]
Total Hexa PCB	[0.0116]	[0.0111]	[0.0149]	[0.0125]
Total Hepta PCB	[0.0151]	[0.0161]	[0.0200]	[0.0171]
Total Octa PCB	[0.0298]	[0.0309]	[0.0397]	[0.0335]
Total Nona PCB	[0.0204]	[0.0208]	[0.0266]	[0.0226]
Deca PCB	[0.0402]	[0.0413]	[0.0525]	[0.0447]
TOTAL PCB	[0.1012]	[0.0413]	[0.0525]	[0.0650]

[] = Minimum detection limit

Concentrations are expresed at standard conditions of 1 atm and 68 deg. F.

TABLE 3-14. UNIT 1 STACK GAS PAH CONCENTRATIONS

	CONCENTRATION, (ug/dscm)			
ANALYTE	RUN 1	RUN 2	RUN 3	AVERAGE
Napthalene	{5.593}	{8.112}	{6.359}	{6.688}
2-Methylnapthalene	[0.101]	[0.095]	0.787	0.787
2-Chloronapthalene	[0.098]	[0.093]	[0.139]	[0.110]
Acenaphthylene	[0.069]	[0.065]	[0.097]	[0.077]
Acenapthene	[0.101]	[0.095]	[0.145]	[0.114]
Fluorene	[0.092]	[0.087]	[0.134]	[0.104]
Phenanthrene	[0.052]	[0.049]	[0.072]	[0.058]
Anthracene	[0.057]	[0.055]	[0.081]	[0.064]
Fluoranthene	[0.040]	[0.038]	[0.056]	[0.045]
Pyrene	[0.043]	[0.041]	[0.050]	[0.045]
Benzo(a)anthracene	[0.043]	[0.041]	[0.047]	[0.044]
Chrysene	[0.046]	[0.044]	[0.050]	[0.047]
Benzo(b)fluoranthene	[0.046]	[0.046]	[0.047]	[0.046]
Benzo(k)fluoranthene	[0.040]	[0.041]	[0.042]	[0.041]
Benzo(a)pyrene	[0.049]	[0.049]	[0.050]	[0.049]
Benzo(e)pyrene	[0.055]	[0.057]	[0.042]	[0.051]
Perylene	[0.057]	[0.057]	[0.050]	[0.055]
Indeno(1,2,3-cd)pyrene	[0.052]	[0.052]	[0.053]	[0.052]
Dibenz(a,h)anthracene	[0.052]	[0.052]	[0.053]	[0.052]
Benzo(g,h,i)perylene	[0.043]	[0.044]	[0.045]	[0.044]
TOTAL PAH	[0.101]	[0.095]	0.787	0.787

[] = Minimum detection limit
{} = Compound found in analysis blank at the same levels.

TABLE 3-15. UNIT 1 STACK GAS PAH CONCENTRATIONS ADJUSTED TO 7% O_2

	CONCENTRATION, (ug/dscm)			
ANALYTE	RUN 1	RUN 2	RUN 3	AVERAGE
Naphthalene	{6.820}	{9.978}	{7.892}	{8.230}
2-Methylnaphthalene	[0.123]	[0.117]	0.977	0.977
2-Chloronaphthalene	[0.119]	[0.114]	[0.173]	[0.135]
Acenaphthylene	[0.084]	[0.080]	[0.120]	[0.095]
Acenapthene	[0.123]	[0.117]	[0.180]	[0.140]
Fluorene	[0.112]	[0.107]	[0.166]	[0.128]
Phenanthrene	[0.063]	[0.060]	[0.089]	[0.071]
Anthracene	[0.070]	[0.068]	[0.101]	[0.080]
Fluoranthene	[0.049]	[0.047]	[0.070]	[0.055]
Pyrene	[0.052]	[0.050]	[0.062]	[0.055]
Benzo(a)anthracene	[0.052]	[0.050]	[0.058]	[0.053]
Chrysene	[0.056]	[0.054]	[0.062]	[0.057]
Benzo(b)fluoranthene	[0.056]	[0.057]	[0.058]	[0.057]
Benzo(k)fluoranthene	[0.049]	[0.050]	[0.052]	[0.050]
Benzo(a)pyrene	[0.060]	[0.060]	[0.062]	[0.061]
Benzo(e)pyrene	[0.067]	[0.070]	[0.052]	[0.063]
Perylene	[0.070]	[0.070]	[0.062]	[0.067]
Indeno(1,2,3-cd)pyrene	[0.063]	[0.064]	[0.066]	[0.064]
Dibenz(a,h)anthracene	[0.063]	[0.064]	[0.066]	[0.064]
Benzo(g,h,i)perylene	[0.052]	[0.054]	[0.056]	[0.054]
TOTAL PAH	[0.123]	[0.117]	0.977	0.977

[] = Minimum detection limit
{} = Compound found in analysis blank at the same levels.

Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

3.4 Heavy Metals Emission Test Results

Two sampling methods were used to measure metals emissions from Unit 1 at the Hempstead Resource Recovery Facility. The EMSL Toxic Metals train was used to sample total particulates, arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb). The EPA Method 104 beryllium (Be) train was used to measure effluent Be concentrations. Inductively coupled argon plasma (ICAP) and atomic absorption (AA) techniques were used to analyze the samples. Section 10 discusses these methods in greater detail. Three runs of each sample type were performed to assure representative test results. The results of the heavy metal train testing is presented in Table 3-16 and the beryllium test results are given in Table 3-17.

The values reported in Table 3-16 include the relevant detection limits for metals which were not detected in the samples. Since the samples were analyzed in three separate fractions (see Section 10 for details), guidelines for mathematically handling detection limits were required. The guidelines used for this report are:

- If a metal was detected in one or more fractions of the sample train but not in another, metal weight in the not detected fraction was considered to be zero for adding the train results.
- If a metal was not detected in any train fractions of a sample train, the lowest detection limit reported for the individual fractions was used as the overall sample detection limit.

For the purpose of calculating average results:

- If a metal was detected in one or two of the test runs, but not all three, only those runs for which a quantitative result was obtained were used in the average. Runs where the metal was not detected were not included for averaging.
- If the metal was not detected in any of the three runs, then the average result was reported as not detected at the average detection limit.

TABLE 3-16. SUMMARY OF METALS RESULTS AT 100% LOAD - UNIT 1 HEMPSTEAD RESOURCE RECOVERY FACILITY, WESTBURY, NEW YORK

DATE:		09/27/89	09/28/89	09/28/89	
TIME:		0907-1509	0853-1329	1012-1511	
PARAMETER:		RUN 1	RUN 2	RUN 3	AVERAGE
Sample Gas Volume (dscm)[a]		3.406	3.463	3.533	3.467
CO2 (% by vol, dry)		9.66	9.8	9.88	9.78
O2 (% by vol, dry)		10.02	9.78	9.69	9.83
Moisture (% by vol)		18.5	18.5	19	18.67
Flow Rate (dscmm)		2764.6	2849.1	2963.6	2859.1
Flow Rate (acmm)		4810.3	4931.6	5230.2	4990.7
Arsenic	(ug/sample)	0.770	0.398	[0.391]	0.584
	(ug/dscm)	0.226	0.115	[0.111]	0.171
	(ug/dscm @ 12% CO2)	0.281	0.141	[0.134]	0.211
	(ug/acm)	0.130	0.066	[0.063]	0.098
	(g/hr)	0.037	0.020	[0.020]	0.029
Cadmium	(ug/sample)	[2.000]	[2.000]	[2.000]	[2.000]
	(ug/dscm)	[0.587]	[0.578]	[0.566]	[0.577]
	(ug/dscm @ 12% CO2)	[0.729]	[0.707]	[0.688]	[0.708]
	(ug/acm)	[0.337]	[0.334]	[0.321]	[0.331]
	(g/hr)	[0.097]	[0.099]	[0.101]	[0.099]
Chromium	(ug/sample)	5.250	1.570	2.300	3.040
	(ug/dscm)	1.541	0.453	0.651	0.882
	(ug/dscm @ 12% CO2)	1.915	0.555	0.791	1.087
	(ug/acm)	0.886	0.262	0.369	0.506
	(g/hr)	0.256	0.077	0.116	0.150
Mercury	(ug/sample)	101.258	57.870	50.900	70.009
	(ug/dscm)	29.729	16.711	14.407	20.282
	(ug/dscm @ 12% CO2)	36.931	20.462	17.498	24.964
	(ug/acm)	17.086	9.654	8.163	11.634
	(g/hr)	4.931	2.857	2.562	3.450
Nickel	(ug/sample)	[2.020]	[2.030]	[2.030]	[2.027]
	(ug/dscm)	[0.593]	[0.586]	[0.575]	[0.585]
	(ug/dscm @ 12% CO2)	[0.737]	[0.718]	[0.698]	[0.718]
	(ug/acm)	[0.341]	[0.339]	[0.326]	[0.335]
	(g/hr)	[0.098]	[0.100]	[0.102]	[0.100]
Lead	(ug/sample)	5.560	4.440	3.373	4.458
	(ug/dscm)	1.632	1.282	0.955	1.290
	(ug/dscm @ 12% CO2)	2.028	1.570	1.160	1.586
	(ug/acm)	0.938	0.741	0.541	0.740
	(g/hr)	0.271	0.219	0.170	0.220

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

Note: Values enclosed in brackets represent the minimum detection limits for compounds not detected in the samples. Detection limits are not included in the averages unless otherwise indicated.

TABLE 3-17. SUMMARY OF BERYLLIUM TEST RESULTS FOR UNIT 1 DURING 100% LOAD, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER BERYLLIUM	RUN 4 09/27/89	RUN 5 09/28/89	RUN 6 09/29/89	AVERAGE
Total Sampling Time (min.)	120.00	240.00	120.00	160.00
Corrected Barometric Pressure (in. Hg)	29.95	30.20	29.73	29.96
Absolute Stack Pressure,Ps(in. Hg)	29.87	30.12	29.65	29.88
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	290.83	293.25	293.58	292.56
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	69.10	138.79	67.44	91.78
Average Meter Pressure (in. H2O)	1.04	1.01	0.98	1.01
Average Meter Temperature (F)	97.04	96.97	97.85	97.29
Moisture Collected (g)	354.10	620.10	348.50	440.90
Carbon Dioxide Concentration (%V)	10.83	9.76	11.32	10.64
Oxygen Concentration (%V)	8.61	10.03	8.00	8.88
Nitrogen Concentration (%V)	80.56	80.21	80.68	80.48
Dry Gas Meter Factor	1.00220	1.00220	1.00220	1.00220
Pitot Constant	0.84	0.84	0.84	0.84
Beryllium catch (ug/sample)	< 0.02	< 0.02	< 0.02	< 0.02
Average Sampling Rate (dscfm)	0.55	0.56	0.53	0.55
Standard Metered Volume,Vm(std) (dscf)	65.88	133.43	63.73	87.68
Standard Metered Volume,Vm(std) (dscm)	1.866	3.779	1.805	2.483
Standard Volume Water Vapor,Vw (scf)	16.70	29.24	16.43	20.79
Standard Volume Water Vapor,Vw (scm)	0.473	0.828	0.465	0.589
Stack Moisture (%V)	20.22	17.97	20.50	19.56
Mole Fraction Dry Stack Gas	0.798	0.820	0.795	0.804
Dry Molecular Weight	30.08	29.96	30.13	30.06
Wet Molecular Weight	27.64	27.81	27.64	27.70
Stack Gas Velocity,Vs (fpm)	3739.29	3841.06	3672.11	3750.82
Stack Gas Velocity,Vs (mpm)	1139.74	1170.76	1119.26	1143.25
Volumetric Flow Rate (acfm)	187957.37	193072.85	184580.46	188536.89
Volumetric Flow Rate (acmm)	5322.953	5467.823	5227.319	5339.365
Volumetric Flow Rate (dscfm)	105218.82	111692.84	101837.31	106249.66
Volumetric Flow Rate (dscmm)	2979.797	3163.141	2884.033	3008.990
Percent Isokinetic	102.07	97.38	102.02	100.49
Percent Excess Air	67.93	89.86	60.08	72.63
Fuel Factor,Fo	1.135	1.114	1.140	1.129
Ultimate CO2	18.42	18.77	18.34	18.51
Concentration of Beryllium (ug/acm) [a]	< 0.00600	< 0.00306	< 0.00611	< 0.00506
Concentration of Beryllium (ug/dscm) [a]	< 0.01072	< 0.00529	< 0.01108	< 0.00903
Concentration of Beryllium (ug/dscm @ 12% CO2)	< 0.01188	< 0.00651	< 0.01175	< 0.01005
Mass Emission Rate Beryllium (g/hr)	< 0.00192	< 0.00100	< 0.00192	< 0.00161

[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

This approach yields a high average for elements not detected in all three runs. Additionally, it assumes that it is most likely that an element would be found in the train fraction with the lowest detection limit; therefore, the minimum detection limit for the entire train is based on the lowest fraction detection limit.

The analytical data for the metals train fractions are included in Appendix H.

Cadmium and Ni were not detected in any of the samples from Unit 1. Mercury was the most prevalent element detected and had an average concentration of 25.0 μg/dscm adjusted to 12% CO_2. Arsenic was only detected in Runs 1 and 2 and averaged 0.211 μg/dscm at 12% CO_2 for these two runs. Chromium concentrations for the three runs averaged 1.09 μg/dscm at 12% CO_2. Lead concentrations from the samples had an average of 1.59 μg/dscm at 12% CO_2. The average process conditions for these tests are presented in Table 3-2.

The metals trains were also used to determine particulate concentrations and the sampling quality control procedures and results for these trains is discussed in Section 3.1. The analytical quality control procedures for heavy metals included a method blank and a field blank. Since no contaminants were found in the analysis of the method blank, an analysis of the field blank was not required.

Beryllium testing for Unit 1 was performed on September 28 and 29, 1989 and consisted of three replicate runs. Beryllium was not detected in any of the samples; however, the detection limits and sampling data are presented in Table 3-17. Process data collected during the beryllium sampling are presented in Table 3-18.

The quality control procedures used for the beryllium trains are the same as for the metals trains. The isokinetics for the beryllium trains ranged from 97.38% to 102.07%. No contamination was found in the analytical blanks.

TABLE 3-18. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 1 DURING BERYLLIUM TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/27/89 1526-1746 4	09/28/89 1346-1816 5	09/29/89 1556-1816 6	AVERAGE
STEAM LOAD, (Klb/hr)	211.80	198.86	217.90	209.52
STEAM PRESSURE, (psig)	940.00	933.57	946.80	940.12
STEAM TEMPERATURE, (deg. F)	840.80	840.00	839.73	840.18
PRIMARY AIR FLOW, (KSCFM)	53.84	56.50	49.23	53.19
SECONDARY AIR FLOW, (KSCFM)	28.93	29.72	31.23	29.96
FURNACE OXYGEN, (%V, wet) a	10.19	11.18	9.13	10.17
FIRST PASS TEMPERATURE, (deg. F)	NR	NR	NR	NR
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	443.87	446.89	450.60	447.12
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	NR	NR	NR	NR
SCRUBBER SLURRY RATE, (gpm)	6.8	5.5	4.0	5.4
SCRUBBER WATER RATE, (gpm)	19.0	17.6	21.8	19.5
FABRIC FILTER, (dP)	NR	NR	NR	NR
SO2 REMOVAL, (%)	NR	NR	NR	NR
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NR = NOT RECORDED

3.5 Combustion Performance

The combustion performance of Unit 1 was determined by measuring CO, CO_2, and total hydrocarbons (THC). The NYSDEC permit conditions for Unit 1 are listed in Table 1-1. Combustion efficiency is defined as:

$$CE(\%) = 100\% \, [CO_2/(CO + CO_2)]$$

where:

$CE(\%)$ = Combustion Efficiency,
CO_2 = Carbon Dioxide concentration, mole fraction
CO = Carbon Monoxide concentration, mole fraction

Tests were performed on September 22 at 65% load and September 28 for 100% load. For 100% load, testing was performed during ten 1-hour periods and for 65% load during nine 1-hour periods. The average CO concentration for the 100% load was 53.1 ppmV at 12% CO_2, with an average emission rate of 19.4 lb/hr. For the 65% load testing, the average CO concentration was 36.3 ppmV at 12% CO_2, with an average emission rate of 10.5 lb/hr. The average combustion efficiencies are repeated in 99.956% for the 100% load testing and 99.970% for the 65% load. Tables 3-19 and 3-20 detail the combustion results for the 100% and 65% loads, respectively. Rolling 8-hour averages for CO and combustion efficiency during the 100% and 65% test periods are given in Tables 3-21 and 3-22.

Hydrocarbon emissions were less than 1.0 ppmV as methane for all of the hourly test periods except from 18:00 to 19:00 during the 100% load tests. The average THC concentration was 0.62 ppmCH_4 adjusted to 12% CO_2 for the 100% load conditions. The average THC concentration for the 65% load tests was 0.61 ppmCH_4 adjusted to 12% CO_2. The average mass emission rates for THC was 0.096 lb/hr for the 65% conditions and 0.130 lb/hr for the 100% load tests.

Strict quality control procedures were observed during the combustion tests. Prior to sampling, multipoint calibrations were performed for all pertinent analyzers to assure linearity across the instrument range. Leakchecks of the sampling system were also performed each day prior to

TABLE 3-19. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 1 AT 100% LOAD

DATE: 09/28/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
0900-1000	36.8	0.364	42.2	0.431	16.2	0.0914	99.965
1000-1100	39.6	0.702	47.2	0.860	17.4	0.176	99.961
1100-1200	36.9	0.197	44.5	0.241	16.2	0.0493	99.963
1200-1300	39.5	0.211	48.3	0.262	17.4	0.0530	99.960
1300-1400	31.0	0.369	46.9	0.475	13.6	0.0925	99.961
1400-1500	40.6	0.366	51.7	0.473	17.8	0.0919	99.957
1500-1600	52.1	0.443	62.8	0.544	22.9	0.111	99.948
1600-1700	56.4	0.476	63.6	0.562	24.8	0.119	99.947
1700-1800	50.7	0.482	63.3	0.615	22.2	0.121	99.947
1800-1900	57.2	1.562	60.3	1.710	25.1	0.392	99.950
AVERAGE	44.09	0.517	53.09	0.617	19.4	0.130	99.956

TABLE 3-20. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 1 AT 65% LOAD

DATE: 09/22/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
1000-1100	16.8	0.535	18.8	0.656	6.03	0.110	99.984
1100-1200	26.2	0.603	32.1	0.799	9.43	0.124	99.973
1200-1300	42.1	0.969	60.5	1.45	15.2	0.199	99.950
1300-1400	36.0	0.558	38.9	0.667	12.9	0.115	99.968
1400-1500	39.6	0.478	50.3	0.655	14.3	0.0982	99.958
1500-1600	22.5	0.220	26.3	0.277	8.11	0.0452	99.978
1600-1700	26.3	0.227	32.7	0.301	9.46	0.0467	99.973
1700-1800	24.9	0.130	30.9	0.177	8.96	0.0267	99.974
1800-1900	29.3	0.465	36.3	0.622	10.5	0.0956	99.970
AVERAGE	29.3	0.465	36.3	0.622	10.5	0.0956	99.970

TABLE 3-21. UNIT 1 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS 100% LOAD CONDITIONS

DATE: 09/28/89

	1 - Hour Averages		8 - Hour Rolling Averages	
TEST TIME	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)
0900-1000	42.2	99.965		
1000-1100	47.2	99.961		
1100-1200	44.5	99.963		
1200-1300	48.3	99.960		
1300-1400	46.9	99.961		
1400-1500	51.7	99.957		
1500-1600	62.8	99.948		
1600-1700	63.6	99.947	50.9	99.958
1700-1800	63.3	99.947	53.5	99.955
1800-1900	60.3	99.950	55.2	99.954
		AVERAGE	53.2	99.956

TABLE 3-22. UNIT 1 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS 65% LOAD CONDITIONS

DATE: 09/22/89

	1 - Hour Averages		8 - Hour Rolling Averages	
TEST TIME	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)
1000-1100	18.8	99.984		
1100-1200	32.1	99.973		
1200-1300	60.5	99.950		
1300-1400	38.9	99.968		
1400-1500	50.3	99.958		
1500-1600	26.3	99.978		
1600-1700	32.7	99.973		
1700-1800	30.9	99.974	36.3	99.970
1800-1900	36.3	99.970	38.5	99.968
		AVERAGE	37.4	99.969

sampling. Calibrations were performed at least twice each day and drifts were assessed to ensure data quality. Additionally, midscale calibration checks were performed each day.

EPA Methods 3A and 10 allow for ±3% of scale drift between calibrations. If an analyzer does not meet these specifications the appropriate data adjustments are required. Since the testing performed at the Hempstead facility were for state compliance purposes, the data were only corrected if it caused the pollutant levels to increase. The only analyzers which did not meet this criterion was the inlet CO_2 analyzer during September 28 and the outlet hydrocarbon analyzer on September 22.

The CO_2 analyzer drifted slightly negative (-3.7% of full scale). No corrections were required because a lower CO_2 value would increase the pollutant levels at 12% CO_2 and would cause a slightly lower combustion efficiency. The hydrocarbon analyzer drifted -4.9% from 14:00 to 19:00 and appropriate data corrections were applied to the measured values assuming a linear drift.

3.6 Acid Gas Emissions and Removal Efficiency

A total of 20 sample runs were performed to measure the HCl and SO_2 removal efficiency and emission rates from Unit 1. The results of these tests are summarized in Table 3-23. Seven runs were performed on September 28, with one of those being rejected because the run failed the post test leakcheck. Thirteen runs were performed on October 12. Of these 13, one result was rejected, the reported inlet HCl concentration for that run was 2.7 ppmV which is obviously not within a reasonable range. On average, the HCl and SO_2 concentrations at the SDA inlet on October 12 was about 50% higher than are typically seen at this facility. Two test results were almost twice as large as the expected inlet HCl concentrations. The only difference in operation was that the refuse feed rate was higher, and the furnace and boiler temperatures were higher.

TABLE 3-23. HCl AND SO2 COMPARISONS FOR UNIT 1 AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/28/89	1	251.7	26.17	80.8	13.4	309.5	32.9	99.3	16.9	89.36	83.03
1B	09/28/89	1	524.1	38.80	90.2	43.0	685.1	51.3	117.9	56.9	92.51	51.75
1C	09/28/89	1	442.7	53.52	106.0	60.4	515.7	64.4	123.5	72.6	87.52	41.19
2A	09/28/89	1	220.5	53.12	106.0	69.6	272.5	67.4	131.0	88.3	75.27	32.59
2B	09/28/89	1	a[335.4]	79.68	161.0	104.0		89.4	175.6	116.6		33.59
2C	09/28/89	1	682.6	142.05	177.0	102.0	772.8	165.5	200.4	118.8	78.58	40.69
2D	09/28/89	1	587.0	91.48	139.0	50.9	677.3	109.8	160.4	61.1	83.79	61.92
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	1	451.4	69.3	122.9	63.3	538.8	82.9	144.0	75.9	84.5	49.3
1	10/12/89	1	522.3	38.46	165.0	36.2	659.7	49.1	208.4	46.2	92.56	77.83
2	10/12/89	1	548.1	42.44	166.5	47.7	730.8	57.2	222.0	64.3	92.17	71.03
3	10/12/89	1	728.7	57.02	157.0	58.9	1041.0	80.5	224.3	83.2	92.27	62.93
4	10/12/89	1	678.9	68.66	203.0	72.4	662.3	74.2	198.0	78.3	88.79	60.48
5	10/12/89	1	b[2.7]	80.86	165.1	89.0		86.6	167.9	95.4		43.21
6	10/12/89	1	543.3	60.86	155.0	45.6	577.0	66.4	164.6	49.7	88.49	69.78
7	10/12/89	1	1225.3	61.04	163.0	45.6	1301.2	67.2	173.1	50.2	94.84	71.00
8	10/12/89	1	547.4	64.96	141.0	58.0	625.6	75.0	161.1	66.9	88.02	58.47
9	10/12/89	1	548.2	104.00	114.0	63.4	685.3	130.0	142.5	79.3	81.03	44.39
10	10/12/89	1	602.6	98.12	148.0	70.5	716.0	118.9	175.8	85.5	83.39	51.40
11	10/12/89	1	590.9	68.13	148.0	60.3	723.6	84.3	181.2	74.6	88.35	58.84
12	10/12/89	1	572.8	43.54	141.5	19.4	680.6	53.3	168.1	23.8	92.17	85.87
13	10/12/89	1	664.9	39.86	115.0	22.8	822.6	48.3	142.3	27.6	94.13	80.57
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	1	647.8	63.7	152.5	53.1	768.8	76.2	179.2	63.5	89.7	64.3
OVERALL	AVERAGE	1	582.3		142.1		692.1	78.6	166.9	67.8	88.0	59.0

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[a] [] Run rejected - failed post-test leak check.

[b] [] Run rejected - apparent sample or analysis error.

The objective of those tests was to vary the spray dryer stoichiometry so that a relationship could be developed between HCl and SO_2 removal efficiencies. The lime slurry feed rate to the spray dryer was manually controlled to achieve target SO_2 removals of 50%, 60%, and 70%. Previous engineering tests had shown that the HCl removal would exceed 90% at these SO_2 removals. However, this result was not found for this series of tests. The HCl removal is plotted versus the SO_2 removal efficiency in Figure 3-2, along with the best-fit correlation line using a logarithmic model. As can be seen, the actual HCl removals were less than 90% for a number of runs where the SO_2 removal was less than 70%. The prediction equation for this data set is:

$$\text{HCl removal} = 15.8306 * \ln(SO_2 \text{ removal}) + 23.5494$$

Using this predictive equation, the HCl removal that would be achieved at 70% SO_2 removal is 90.6%. This result suggests that the 70% SO_2 removal requirement as presently in place, is required to achieve 90% HCl removal.

For this test program, the acid gas removal efficiencies were deliberately reduced, consequently the overall average removals and emissions are not representative of normal operations. During normal operating conditions a minimum SO_2 removal of 70% will be maintained therefore, the test runs where 70% SO_2 removal was achieved are used to demonstrate compliance with the permit conditions. These data are summarized in Table 3-24.

The average HCl concentration at the boiler exit for these runs was 750.7 ppmV at 12% CO_2, with an average emission concentration of 51.3 ppmV at 12% CO_2. The average removal efficiency was 92.5%. These results are within the permit limits of an emission concentration of 50 ppmV at 12% CO_2, or 90% removal, whichever is least restrictive.

The average SO_2 concentration at the boiler exit for these runs was 168.9 ppmV at 12% CO_2, with an emission concentration of 38.2 ppmV. The average SO_2 removal efficiency was 78.2%.

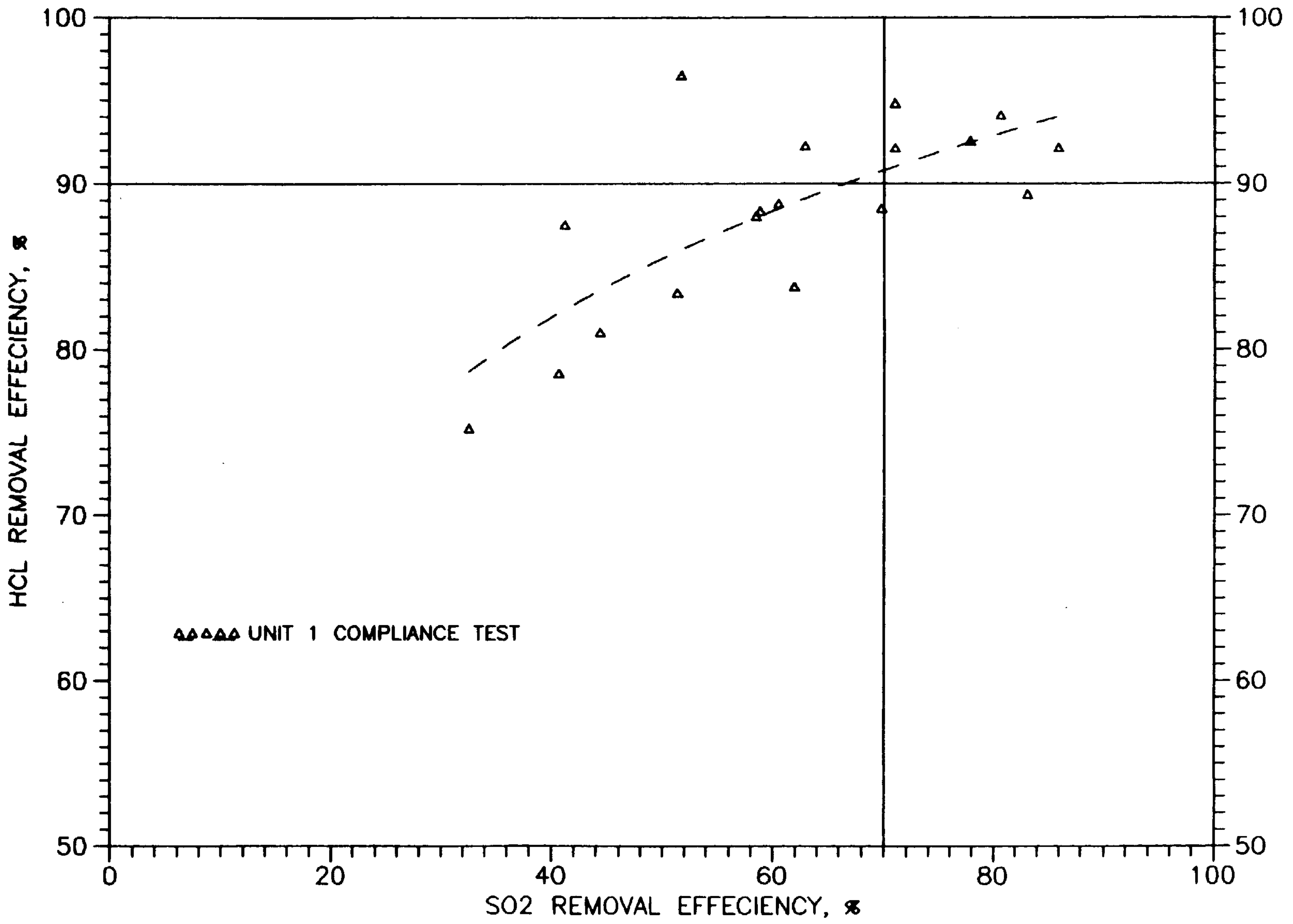

Figure 3-2. Acid Gas Relationship for Unit 1

TABLE 3-24. HCl AND SO2 COMPARISONS FOR UNIT 1 DURING COMPLIANCE TEST PROGRAM AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/28/89	1	251.7	26.17	80.8	13.4	309.5	32.9	99.3	16.9	89.4	83.0
1	10/12/89	1	522.3	38.46	165.0	36.2	659.7	49.1	208.4	46.2	92.6	77.8
2	10/12/89	1	548.1	42.44	166.5	47.7	730.8	57.2	222.0	64.3	92.2	71.0
7	10/12/89	1	1225.3	61.04	163.0	45.6	1301.2	67.2	173.1	50.2	94.8	71.0
12	10/12/89	1	572.8	43.54	141.5	19.4	680.6	53.3	168.1	23.8	92.2	85.9
13	10/12/89	1	664.9	39.86	115.0	22.8	822.6	48.3	142.3	27.6	94.1	80.6
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	1	630.9	41.9	138.6	30.9	750.7	51.3	168.9	38.2	92.5	78.2

The relationship between the acid gas removals for all three units at Hempstead is discussed in further detail in Section 6.0.

3.7 NO_x Emissions

Nitrogen oxides (NO and NO_2) were measured continuously using EPA Method 7E on September 28, 1989. Test results of the NO_x sampling at 100% load are given in Table 3-25. Hourly test averages are presented on an as-measured basis, as concentrations normalized to 12% CO_2, and as mass emission rates. The average NO_x concentrations for the tests performed on Unit 1 was 235.8 ppmV at 12% CO_2.

Quality control procedures for the NO_x monitoring tests include leakchecking the sampling system, performing a multipoint calibration during the test program, monitoring instrument drift and checking the linearity of the instrument on a daily basis. Due to the compliance nature of this test, drift corrections are only performed if these corrections cause the reported values to be higher than the uncorrected values. The NO_x analyzer drifted -4.0% of full scale during September 28 which is greater than the prescribed ±3.0% of scale. Therefore, the NO_x concentrations in Table 3-25 are adjusted for drift assuming a linear drift between initial and final calibrations.

TABLE 3-25. OUTLET NOX EMISSIONS TEST RESULTS FOR UNIT 1 HEMPSTEAD RESOURCE RECOVERY FACILITY

DATE: 09/28/89

TEST TIME	NOx CONCENTRATION (ppmV)	NOx CONCENTRATION (ppmV @ 12% CO2)	MASS EMISSIONS (lb/hr)
0900-1000	193.5	228.6	139.5
1000-1100	154.6	189.3	111.5
1100-1200	196.0	239.7	141.4
1200-1300	191.5	237.6	138.1
1300-1400	187.7	241.9	135.4
1400-1500	185.3	239.3	133.6
1500-1600	203.6	249.8	146.8
1600-1700	205.7	242.9	148.4
1700-1800	185.1	236.1	133.5
1800-1900	230.9	252.8	166.5
AVERAGE	193.4	235.8	136.5

double check

139.5 averaging column

NOTE: The mass emissions for NOx are based on the volumetric flow measured on 9/28/89 by the metals sample trains.

TABLE 3-25. OUTLET NOX EMISSIONS TEST RESULTS FOR UNIT 1
HEMPSTEAD RESOURCE RECOVERY FACILITY

DATE: 09/28/89

TEST TIME	NOx CONCENTRATION (ppmV)	NOx CONCENTRATION (ppmV @ 12% CO2)	MASS EMISSIONS (lb/hr)
0900-1000	193.5	228.6	139.5
1000-1100	154.6	189.3	111.5
1100-1200	196.0	239.7	141.4
1200-1300	191.5	237.6	138.1
1300-1400	187.7	241.9	135.4
1400-1500	185.3	239.3	133.6
1500-1600	203.6	249.8	146.8
1600-1700	205.7	242.9	148.4
1700-1800	185.1	236.1	133.5
1800-1900	230.9	252.8	166.5
AVERAGE	193.4	235.8	139.5

NOTE: The mass emissions for NOx are based on the volumetric flow measured on 9/28/89 by the metals sample trains.

changed
3/27/96

4.0 UNIT 2 EMISSION TEST RESULTS

Compliance emission testing was performed on Unit 2 of the Hempstead Resource Recovery facility on September 25 and 26, 1989 at 100% steam load and on September 18 and 19, 1989 at 65% steam load. Emission tests were performed for particulate, heavy metals, combustion efficiency, acid gases, and total hydrocarbons during the 100% load. Testing for particulate and combustion efficiency was performed at the 65% load condition.

4.1 Particulate Emissions

Table 4-1 presents the results of the particulate testing performed on Unit 2 at the 100% load condition. The average effluent particulate concentration from Unit 2 at 100% load was 0.00222 grains/dscf or 0.00274 grains/dscf normalized to 12% CO_2. The average mass emission rate was 2.116 lb/hr. It should be noted that Run 1 particulate emissions were considerably higher than Runs 2 and 3, which were more representative of the other units. The average particulate concentration for Runs 2 and 3 was 0.00144 grains/dscf with a mass emission rate of 1.39 lb/hr. The average steam rate during three runs was 204.4 klb/hr. Averages for other process operation variables are given in Table 4-2.

Table 4-3 lists the sampling results for particulate testing performed on Unit 2 at 65% load. The average particulate concentration from Unit 2 at 65% load was 0.00089 grains/dscf or 0.00115 grains/dscf adjusted to 12% CO_2. The average mass emission rate was 0.574 lb/hr. The average process operation data are presented in Table 4-4.

The quality control procedures observed during particulate testing are described in Section 3.1. The isokinetics for the six runs conducted at Unit 2 ranged from 101.13% to 105.06%. All leak rates were less than 0.02 cfm.

4.2 Heavy Metals Emission Test Results

Two sampling methods were used to measure metals emissions from Unit 2 at the Hempstead Resource Recovery Facility. The EMSL Toxic Metals

TABLE 4-1. SUMMARY OF PARTICULATE TEST RESULTS
FOR UNIT 2 DURING 100% LOAD TESTS
HEMPSTEAD RESOURCE RECOVERY,
WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 1 09/25/89	RUN 2 09/26/89	RUN 3 09/26/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	30.22	29.62	29.62	29.82
Absolute Stack Pressure,Ps(in. Hg)	30.14	29.54	29.54	29.74
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	292.83	293.92	302.10	296.28
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	145.67	143.17	154.71	147.85
Average Meter Pressure (in. H2O)	1.18	1.07	1.26	1.17
Average Meter Temperature (F)	99.74	96.46	101.75	99.32
Moisture Collected (g)	756.90	684.90	771.90	737.90
Carbon Dioxide Concentration (%V)	10.18	8.99	9.39	9.52
Oxygen Concentration (%V)	9.23	10.59	10.22	10.01
Nitrogen Concentration (%V)	80.59	80.42	80.39	80.47
Dry Gas Meter Factor	1.00220	0.98610	0.98610	0.99147
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.03420	0.01150	0.01430	0.02000
Average Sampling Rate (dscfm)	0.58	0.55	0.59	0.58
Standard Metered Volume,Vm(std) (dscf)	139.48	132.95	142.38	138.27
Standard Metered Volume,Vm(std) (dscm)	3.950	3.765	4.032	3.916
Standard Volume Water Vapor,Vw (scf)	35.69	32.29	36.40	34.79
Standard Volume Water Vapor,Vw (scm)	1.011	0.915	1.031	0.985
Stack Moisture (%V)	20.37	19.54	20.36	20.09
Mole Fraction Dry Stack Gas	0.796	0.805	0.796	0.799
Dry Molecular Weight	30.00	29.86	29.91	29.92
Wet Molecular Weight	27.55	27.54	27.49	27.53
Stack Gas Velocity,Vs (fpm)	3829.92	3886.43	4268.27	3994.87
Stack Gas Velocity,Vs (mpm)	1167.36	1184.58	1300.97	1217.64
Volumetric Flow Rate (acfm)	192512.61	195353.44	214546.47	200804.17
Volumetric Flow Rate (acmm)	5451.957	5532.409	6075.956	5686.774
Volumetric Flow Rate (dscfm)	108223.44	108601.16	116792.47	111205.69
Volumetric Flow Rate (dscmm)	3064.888	3075.585	3307.563	3149.345
Percent Isokinetic	105.06	99.79	99.37	101.41
Percent Excess Air	76.52	99.37	92.75	89.55
Fuel Factor,Fo	1.146	1.147	1.137	1.144
Ultimate CO2	18.23	18.22	18.38	18.28
Concentration of Particulate (grains/acf)	0.00213	0.00074	0.00084	0.00124
Concentration of Particulate (g/acm)	0.00487	0.00170	0.00193	0.00283
Concentration of Particulate (grains/dscf)	0.00378	0.00133	0.00155	0.00222
Concentration of Particulate (g/dscm) a	0.00866	0.00305	0.00355	0.00509
Concentration of Particulate (grains/dscf @ 12% CO2)	0.00446	0.00178	0.00198	0.00274

a Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 4-2. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 2 DURING 100% LOAD PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/25/89 1610-2050 1	09/26/89 0906-1336 2	09/26/89 1416-1846 3	AVERAGE
STEAM LOAD, (Klb/hr)	217.40	181.13	214.70	204.41
STEAM PRESSURE, (psig)	978.76	948.45	940.90	956.04
STEAM TEMPERATURE, (deg. F)	839.93	837.91	810.83	829.56
PRIMARY AIR FLOW, (KSCFM)	83.77	83.84	88.21	85.27
SECONDARY AIR FLOW, (KSCFM)	19.36	16.22	22.07	19.22
FURNACE OXYGEN, (%V, wet) a	10.73	12.17	10.88	11.26
FIRST PASS TEMPERATURE, (deg. F)	1582.34	1460.00	1472.97	1505.10
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	437.07	428.64	432.55	432.75
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	307.24	307.18	314.89	309.77
SCRUBBER SLURRY RATE, (gpm)	6.4	9.1	8.6	8.0
SCRUBBER WATER RATE, (gpm)	22.6	13.4	18.9	18.3
FABRIC FILTER, (dP)	4.95	5.24	6.68	5.62
SO2 REMOVAL, (%)	79.58	52.13 b	53.24 b	46.24
OUTLET CO @ 12% CO2 (ppmV)	50.76	80.48	68.03	66.42

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[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

[b] Acid gas removal tests at reduced SO2 removals were being performed during these periods.

TABLE 4-3. SUMMARY OF PARTICULATE TEST RESULTS
FOR UNIT 2 DURING 65% LOAD TESTS
HEMPSTEAD RESOURCE RECOVERY,
WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 1 09/18/89	RUN 2 09/19/89	RUN 3 09/19/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.97	30.01	30.01	30.00
Absolute Stack Pressure,Ps(in. Hg)	29.89	29.91	29.91	29.90
Stack Static Pressure (in. H2O)	-1.10	-1.40	-1.40	-1.30
Average Stack Temperature (F)	283.94	275.65	279.52	279.70
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	105.86	97.02	94.82	99.23
Average Meter Pressure (in. H2O)	0.58	0.48	0.51	0.52
Average Meter Temperature (F)	102.29	99.01	96.72	99.34
Moisture Collected (g)	477.60	415.20	433.10	441.97
Carbon Dioxide Concentration (%V)	9.29	8.76	9.47	9.17
Oxygen Concentration (%V)	10.20	10.81	10.07	10.36
Nitrogen Concentration (%V)	80.51	80.43	80.46	80.47
Dry Gas Meter Factor	0.98610	0.98610	1.00220	0.99147
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.00520	0.00360	0.00720	0.00533
Average Sampling Rate (dscfm)	0.41	0.38	0.38	0.39
Standard Metered Volume,Vm(std) (dscf)	98.33	90.75	90.52	93.20
Standard Metered Volume,Vm(std) (dscm)	2.785	2.570	2.563	2.639
Standard Volume Water Vapor,Vw (scf)	22.52	19.58	20.42	20.84
Standard Volume Water Vapor,Vw (scm)	0.638	0.554	0.578	0.590
Stack Moisture (%V)	18.63	17.74	18.41	18.26
Mole Fraction Dry Stack Gas	0.814	0.823	0.816	0.817
Dry Molecular Weight	29.89	29.83	29.92	29.88
Wet Molecular Weight	27.68	27.73	27.72	27.71
Stack Gas Velocity,Vs (fpm)	2753.58	2486.18	2493.99	2577.91
Stack Gas Velocity,Vs (mpm)	839.29	757.79	760.17	785.75
Volumetric Flow Rate (acfm)	138409.82	124969.03	125361.55	129580.13
Volumetric Flow Rate (acmm)	3919.766	3539.123	3550.239	3669.709
Volumetric Flow Rate (dscfm)	79806.67	73709.47	72960.49	75492.21
Volumetric Flow Rate (dscmm)	2260.125	2087.452	2066.241	2137.939
Percent Isokinetic	101.37	101.28	101.13	101.26
Percent Excess Air	92.13	103.55	90.01	95.23
Fuel Factor,Fo	1.152	1.152	1.144	1.149
Ultimate CO2	18.15	18.15	18.28	18.19
Concentration of Particulate (grains/acf)	0.00047	0.00036	0.00071	0.00052
Concentration of Particulate (g/acm)	0.00108	0.00083	0.00163	0.00118
Concentration of Particulate (grains/dscf)	0.00082	0.00061	0.00123	0.00089
Concentration of Particulate (g/dscm) [a]	0.00187	0.00140	0.00281	0.00203
Concentration of Particulate (grains/dscf @ 12% CO2)	0.00105	0.00084	0.00156	0.00115

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[a] Concentrations are expressed at standard conditions of 1atm and 68 deg. F.

TABLE 4-4. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 2 DURING 65% LOAD PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE	09/18/89	09/19/89	09/19/89	
TIMES	1336-1756	0956-1416	1416-1836	
RUN NUMBER	1	2	3	AVERAGE
STEAM LOAD, (Klb/hr)	131.16	131.95	134.68	132.60
STEAM PRESSURE, (psig)	920.89	920.15	923.56	921.53
STEAM TEMPERATURE, (deg. F)	829.19	832.15	830.37	830.57
PRIMARY AIR FLOW, (KSCFM)	39.34	35.35	38.75	37.81
SECONDARY AIR FLOW, (KSCFM)	9.48	11.54	8.68	9.90
FURNACE OXYGEN, (%V, wet) [a]	11.70	11.30	11.46	11.49
FIRST PASS TEMPERATURE, (deg. F)	1385.04	1384.44	1408.00	1392.49
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	394.93	387.00	393.63	391.85
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	308.26	305.48	308.07	307.27
SCRUBBER SLURRY RATE, (gpm)	3.1	3.5	3.2	3.3
SCRUBBER WATER RATE, (gpm)	NA	8.5	9.0	8.8
FABRIC FILTER, (dP)	2.37	2.48	2.25	2.37
SO2 REMOVAL, (%)	81.11	79.40	81.94	80.82
OUTLET CO @ 12% CO2 (ppmV)	36.21	27.61	33.00	32.27

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NA = NOT AVAILABLE

train was used to sample total particulate, arsenic (As), Cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb). The EPA Method 104 beryllium (Be) train was used to measure effluent Be concentrations. Inductively coupled argon plasma (ICAP) and atomic absorption (AA) techniques were used to analyze the samples. Section 10 discusses these methods in greater detail. Three runs of each sample type were performed to assure representative test results. The results of the heavy metal train testing is presented in Table 4-5 and the Be test results are given in Table 4-6.

The values reported in Table 4-5 include the relevant detection limits for metals which were not detected in the samples. Since the samples were analyzed in three separate fractions (see Section 10 for details), guidelines for mathematically handling detection limits were required. The guidelines used for this report are:

- If a metal was detected in one or more fractions of the sample train but not in another, metal weight in the not detected fraction was considered to be zero for adding the train results.
- If a metal was not detected in any train fractions of a sample train, the lowest detection limit reported for the individual fractions was used as the overall sample detection limit.

For the purpose of calculating average results:

- If a metal was detected in one or two of the test runs, but not all three, only those runs for which a quantitative result was obtained were used in the average. Runs where the metal was not detected were not included for averaging.
- If the metal wa snot detected in any of the three runs, then the average result was reported as not detected at the average detection limit.

The analytical data for the metals train fractions are included in Appendix H.

TABLE 4-5. SUMMARY OF METALS RESULTS AT 100% LOAD - UNIT 2
HEMPSTEAD RESOURCE RECOVERY FACILITY, WESTBURY, NEW YORK

DATE: TIME: PARAMETER:		09/25/89 1617-2041 RUN 1	09/26/89 0908-1336 RUN 2	09/26/89 1416-1837 RUN 3	AVERAGE
Sample Gas Volume (dscm)[a]		3.950	3.765	4.032	3.916
CO2 (% by vol, dry)		10.18	8.99	9.39	9.52
O2 (% by vol, dry)		9.23	10.59	10.22	10.01
Moisture (% by vol)		20.4	19.5	20.4	20.10
Flow Rate (dscmm)		3064.9	3075.6	3307.6	3149.3
Flow Rate (acmm)		5452.0	5532.4	6076.0	5686.8
Arsenic	(ug/sample)	2.323	0.724	0.980	1.342
	(ug/dscm)	0.588	0.192	0.243	0.341
	(ug/dscm @ 12% CO2)	0.693	0.257	0.311	0.420
	(ug/acm)	0.331	0.107	0.132	0.190
	(g/hr)	0.108	0.035	0.048	0.064
Cadmium	(ug/sample)	[2.000]	[2.000]	[2.000]	[2.000]
	(ug/dscm)	[0.506]	[0.531]	[0.496]	[0.511]
	(ug/dscm @ 12% CO2)	[0.597]	[0.709]	[0.634]	[0.647]
	(ug/acm)	[0.284]	[0.295]	[0.270]	[0.283]
	(g/hr)	[0.093]	[0.098]	[0.098]	[0.096]
Chromium	(ug/sample)	16.080	[5.000]	5.400	10.740
	(ug/dscm)	4.071	[1.328]	1.339	2.705
	(ug/dscm @ 12% CO2)	4.799	[1.773]	1.712	3.255
	(ug/acm)	2.289	[0.738]	0.729	1.509
	(g/hr)	0.749	[0.245]	0.266	0.507
Mercury	(ug/sample)	69.800	61.217	106.841	79.286
	(ug/dscm)	17.671	16.259	26.498	20.143
	(ug/dscm @ 12% CO2)	20.830	21.703	33.864	25.466
	(ug/acm)	9.934	9.039	14.425	11.133
	(g/hr)	3.250	3.000	5.259	3.836
Nickel	(ug/sample)	15.160	[2.020]	4.680	9.920
	(ug/dscm)	3.838	[0.537]	1.161	2.499
	(ug/dscm @ 12% CO2)	4.524	[0.716]	1.483	3.004
	(ug/acm)	2.158	[0.299]	0.632	1.395
	(g/hr)	0.706	[0.099]	0.230	0.468
Lead	(ug/sample)	2.000	7.680	27.900	12.527
	(ug/dscm)	0.506	2.040	6.920	3.155
	(ug/dscm @ 12% CO2)	0.597	2.723	8.843	4.054
	(ug/acm)	0.285	1.134	3.767	1.728
	(g/hr)	0.093	0.376	1.373	0.614

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

Note: Values enclosed in brackets represent the minimum detection limits for compounds not detected in the samples. Detection limits are not included in the averages unless otherwise indicated.

TABLE 4-6. SUMMARY OF BERYLLIUM TEST RESULTS FOR UNIT 2 DURING 100% LOAD, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER BERYLLIUM	RUN 1 9/25/89	RUN 2 9/25/89	RUN 3 9/25/89	AVERAGE
Total Sampling Time (min.)	120.00	120.00	120.00	120.00
Corrected Barometric Pressure (in. Hg)	30.22	30.22	30.22	30.22
Absolute Stack Pressure,Ps(in. Hg)	30.14	30.14	30.14	30.14
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	292.96	294.29	294.58	293.94
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	66.07	71.03	71.44	69.51
Average Meter Pressure (in. H2O)	0.89	1.07	1.09	1.01
Average Meter Temperature (F)	87.54	102.19	97.83	95.85
Moisture Collected (g)	293.30	349.30	366.30	336.30
Carbon Dioxide Concentration (%V)	8.96	9.66	10.12	9.58
Oxygen Concentration (%V)	10.84	9.94	9.30	10.03
Nitrogen Concentration (%V)	80.20	80.40	80.58	80.39
Dry Gas Meter Factor	0.98610	0.98610	0.98610	0.98610
Pitot Constant	0.84	0.84	0.84	0.84
Beryllium catch (ug/sample)	< 0.02	< 0.02	< 0.02	< 0.02
Average Sampling Rate (dscfm)	0.53	0.56	0.56	0.55
Standard Metered Volume,Vm(std) (dscf)	63.59	66.60	67.52	65.90
Standard Metered Volume,Vm(std) (dscm)	1.801	1.886	1.912	1.866
Standard Volume Water Vapor,Vw (scf)	13.83	16.47	17.27	15.86
Standard Volume Water Vapor,Vw (scm)	0.392	0.466	0.489	0.449
Stack Moisture (%V)	17.86	19.83	20.37	19.35
Mole Fraction Dry Stack Gas	0.821	0.802	0.796	0.806
Dry Molecular Weight	29.87	29.94	29.99	29.93
Wet Molecular Weight	27.75	27.58	27.55	27.62
Stack Gas Velocity,Vs (fpm)	3471.13	3741.09	3788.77	3667.00
Stack Gas Velocity,Vs (mpm)	1058.00	1140.28	1154.82	1117.70
Volumetric Flow Rate (acfm)	174478.05	188047.71	190444.15	184323.30
Volumetric Flow Rate (acmm)	4941.218	5325.511	5393.378	5220.036
Volumetric Flow Rate (dscfm)	101160.74	106235.23	106819.48	104738.48
Volumetric Flow Rate (dscmm)	2864.872	3008.582	3025.128	2966.194
Percent Isokinetic	102.48	102.21	103.05	102.58
Percent Excess Air	104.75	87.95	77.57	90.09
Fuel Factor,Fo	1.123	1.135	1.146	1.135
Ultimate CO2	18.61	18.42	18.23	18.42
Concentration of Beryllium (ug/acm) [a]	< 0.00644	< 0.00599	< 0.00587	< 0.00610
Concentration of Beryllium (ug/dscm) [a]	< 0.01111	< 0.01060	< 0.01046	< 0.01072
Concentration of Beryllium (ug/dscm @ 12% CO2)	< 0.01487	< 0.01317	< 0.01240	< 0.01348
Mass Emission Rate Beryllium (g/hr)	< 0.00191	< 0.00191	< 0.00190	< 0.00191

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

Cadmium was not detected in any of the samples from Unit 2. Mercury was the most prevalent element detected and had an average concentration of 25.5 μg/dscm adjusted to 12% CO_2. Arsenic emissions averaged 0.42 μg/dscm at 12% CO_2 for the three runs. Chromium concentrations for Runs 1 and 3 averaged 3.26 μg/dscm at 12% CO_2. Chromium was not detected in Run 2. Nickel was not detected in Run 2 but averaged 3.00 μg/dscm for Runs 1 and 3. Lead concentrations from the samples had an average of 4.05 μg/dscm at 12% CO_2. The average process conditions for these tests are presented in Table 4-2.

Beryllium testing for Unit 2 was performed on September 25, 1989 and consisted of three replicate runs. Beryllium was not detected in any of the samples; however, the detection limits and sampling data are presented in Table 4-6. Process data averages for the beryllium test periods are included in Table 4-7.

The quality control measures used during heavy metals sampling are described briefly in Section 3. All train leak rates were less than 0.02 cfm. No contamination was found in any of the analytical blanks.

4.3 Combustion Performance

The combustion performance of Unit 2 was determined by measuring CO, CO_2, and total hydrocarbons (THC) and by monitoring temperature at the exit of the first pass of the boiler. Combustion testing for Unit 2 was performed on September 26, 1989 at 100% load and on September 19, 1989 for the 65% load condition. The NYSDEC permit conditions for Unit 2 are listed in Table 1-1. Combustion efficiency is defined as:

$$CE(\%) = 100\% \, [CO_2/(CO + CO_2)]$$

where:

CE(%) = Combustion Efficiency, percent

CO_2 = Carbon Dioxide concentration, mole fraction

CO = Carbon Monoxide concentration, mole fraction

Tests were performed on September 19 at 65% load and September 26 at 100% load. For 100% tests, testing was performed for 10 one-hour periods. The average CO concentration was 55.3 ppmV at 12% CO_2, with an average emission

TABLE 4-7. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 2 DURING BERYLLIUM TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/25/89 1030-1250 1	09/25/89 1430-1650 2	09/25/89 1730-1950 3	AVERAGE
STEAM LOAD, (Klb/hr)	177.33	205.73	217.47	200.18
STEAM PRESSURE, (psig)	945.73	967.33	979.33	964.13
STEAM TEMPERATURE, (deg. F)	839.60	838.93	841.47	840.00
PRIMARY AIR FLOW, (KSCFM)	79.18	88.40	82.57	83.38
SECONDARY AIR FLOW, (KSCFM)	14.48	18.29	19.41	17.39
FURNACE OXYGEN, (%V, wet) a	11.69	11.31	10.72	11.24
FIRST PASS TEMPERATURE, (deg. F)	1457.60	1532.27	1596.27	1528.71
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	416.60	432.53	436.13	428.42
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	307.73	306.80	307.73	307.42
SCRUBBER SLURRY RATE, (gpm)	7.5	10.6	8.9	9.0
SCRUBBER WATER RATE, (gpm)	11.4	15.3	19.3	15.3
FABRIC FILTER, (dP)	4.60	4.72	4.91	4.74
SO2 REMOVAL, (%)	80.38	80.32	79.53	80.08
OUTLET CO @ 12% CO2 (ppmV)	64.33	59.75	48.83	57.64

rate of 22.2 lb/hr. The average 1-hour combustion efficiency was 99.96%. Table 4-8 lists the combustion results during the 100% load conditions. Table 4-9 lists the combustion results for the 65% load tests. The average 1-hour combustion efficiency during the 65% load conditions was 99.973%. Eight-hour rolling averages for CO and combustion efficiency are presented in Tables 4-10 and 4-11 for the 100% and 65% load tests, respectively.

Hydrocarbon emissions were less than 1.0 ppmV as methane during all tests. The average THC emission rate was 0.033 lb/hr as methane for the 100% load conditions. The average THC emission rate for the 65% load tests was 0.994 lb/hr as methane. The results of the furnace temperature profile tests are discussed in Section 4-5.

Strict quality control procedures were observed during the combustion tests. Prior to sampling multipoint calibrations were performed for all pertinent analyzers to assure linearity across the instrument range. Leakchecks of the sampling system were also performed each day prior to sampling. Calibrations were performed at least twice each day and drifts were assessed to ensure data quality. Additionally, midscale calibration checks were performed each day.

All combustion testing analyzers exhibited calibration drifts less than 3% of scale for both the 100% load tests and the 65% load tests except for the CO analyzer on September 26, 1989. The CO analyzer exhibited a +5.2% of scale drift. Since this drift would cause the measured values to be biased high, no corrections were performed.

4.4 HCl and SO_2 Acid Gas Emissions

Twelve test runs were performed at Unit 2 to measure HCl and SO_2 concentrations at the boiler exit and simultaneously at the stack. One run was rejected because the probe heater in the inlet sample train was adjusted incorrectly. Condensation occurred and part of the HCl was lost prior to the impinger train.

The lime slurry feed was deliberately decreased for test purposes similarly to the approach used at Unit 1. The complete test results are

TABLE 4-8. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 2 AT 100% LOAD

DATE: 09/26/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
1000-1100	32.6	0.0219	35.4	0.0265	16.05	0.00614	99.970
1100-1200	35.1	0.0192	43.4	0.0259	17.2	0.00539	99.964
1200-1300	67.1	0.442	94.1	0.656	33.02	0.124	99.922
1300-1400	42.3	0.203	58.4	0.295	20.8	0.0571	99.951
1400-1500	42.3	0.008	45.6	0.00915	20.8	0.00215	99.962
1500-1600	47.7	0.064	55.3	0.0811	23.5	0.0180	99.954
1600-1700	50.9	0.125	64.3	0.169	25.02	0.0350	99.946
1700-1800	51.2	0.149	57.2	0.184	25.2	0.0420	99.952
1800-1900	48.5	0.090	61.0	0.121	23.8	0.0252	99.949
1900-2000	34.7	0.066	38.3	0.0801	17.05	0.0185	99.968
AVERAGE	45.2	0.119	55.3	0.165	22.25	0.0334	99.954

TABLE 4-9. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 2 AT 65% LOAD

DATE: 09/19/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
1100-1200	18.2	0.00529	22.2	0.00671	5.83	0.000967	99.982
1300-1400	33.3	0.850	49.8	1.23	10.66	0.155	99.959
1400-1500	31.7	0.714	41.1	0.955	10.13	0.130	99.966
1500-1600	26.7	0.641	34.8	0.864	8.53	0.117	99.971
1600-1700	28.3	0.528	34.3	0.667	9.06	0.0965	99.971
1700-1800	20.9	0.537	24.0	0.650	6.69	0.0981	99.980
1800-1832	18.0	0.530	18.9	0.602	5.77	0.0969	99.984
AVERAGE	25.3	0.544	32.2	0.710	8.09	0.0994	99.973

TABLE 4-10. UNIT 2 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS 100% LOAD CONDITIONS

DATE: 09/26/89

TEST TIME	1 - Hour Averages: CO (ppmV @ 12% CO2)	1 - Hour Averages: COMBUSTION EFFICIENCY (%)	8 - Hour Rolling Averages: CO (ppmV @ 12% CO2)	8 - Hour Rolling Averages: COMBUSTION EFFICIENCY (%)
1000-1100	35.4	99.970		
1100-1200	43.4	99.964		
1200-1300	94.1	99.922		
1300-1400	58.4	99.951		
1400-1500	45.6	99.962		
1500-1600	55.3	99.954		
1600-1700	64.3	99.946		
1700-1800	57.2	99.952	56.7	99.953
1800-1900	61.0	99.949	59.9	99.950
1900-2000	38.3	99.968	59.3	99.951
		AVERAGE	58.6	99.951

TABLE 4-11. UNIT 2 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS
65% LOAD CONDITIONS

DATE: 09/19/89

TEST TIME	1 - Hour Averages CO (ppmV @ 12% CO2)	1 - Hour Averages COMBUSTION EFFICIENCY (%)	8 - Hour Rolling Averages CO (ppmV @ 12% CO2)	8 - Hour Rolling Averages COMBUSTION EFFICIENCY (%)
1100-1200	22.2	99.982		
1300-1400	49.8	99.959		
1400-1500	41.1	99.966		
1500-1600	34.8	99.971		
1600-1700	34.3	99.971		
1700-1800	24.0	99.980		
1800-1832	18.9	99.984	INSUFFICIENT DATA TO CALCULATE 8-HOUR AVERAGES	

presented in Table 4-12. As was the case for Unit 1, HCl removal efficiencies of less than 90% were obtained when the slurry rate was reduced and SO_2 removals were less than 70%. The relationship between HCl and SO_2 removal is shown in Figure 4-1. For these data, the predictive algorithm is:

$$\text{HCl removal} = 6.45181 * \ln(SO_2 \text{ removal}) + 62.7393$$

At 70% SO_2 removal, the predicted HCl removal would be 90.1%.

Similarly to Unit 1, since this unit will also operate with a minimum SO_2 removal setpoint of 70%, all test runs with SO_2 removal less than 70% were deleted for demonstration of compliance with the permit limits. The data used to calculate normal operations are presented in Table 4-13.

The average HCl concentration at the boiler exit was 516 ppmV at 12% CO_2, while the average stack concentration was 41.6 ppmV. The average HCl removal efficiency was 92.0%. The removal efficiency and stack emission concentration complied with the permit limit of 90% removal or 50 ppmV at 12% CO_2 concentration. The SO_2 concentration at the boiler exit averaged 118.5 ppmV at 12% CO_2, with an average stack SO_2 concentration of 23.4 ppm. The average SO_2 removal was 78.9%.

4.5 NO_x Emissions

Nitrogen oxides (NO and NO_2) were measured continuously using EPA Method 7E on September 26, 1989. Test results of the NO_x sampling at 100% load are given in Table 4-14. Hourly test averages are presented on an as-measured basis, as concentrations normalized to 12% CO_2, and as mass emission rates. The average NO_x concentrations for the tests performed on Unit 2 was 234.2 ppmV at 12% CO_2.

Quality control procedures for the NO_x monitoring tests include leakchecking the sampling system, performing a multipoint calibration during the test program, monitoring instrument drift and checking the linearity of the instrument on a daily basis. Due to the compliance nature of this test, drift corrections are only performed if these corrections cause the reported values to be higher than the uncorrected values. The NO_x analyzer drifted

TABLE 4-12. HCl AND SO2 COMPARISONS FOR UNIT 2 AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/26/89	2	419.4	14.7	127.0	11.5	481.6	17.5	145.8	13.6	96.37	90.65
1B	09/26/89	2	347.6	73.8	88.2	44.6	431.4	100.7	109.5	60.8	76.66	44.46
1C	09/26/89	2	515.8	76.5	62.4	47.4	684.0	105.7	82.7	65.4	84.55	20.84
1D	09/26/89	2	a[252.0]	78.5	121.1	58.8		92.0	124.3	69.0		44.49
1E	09/26/89	2	573.6	63.6	105.9	54.8	636.8	77.6	117.6	66.8	87.82	43.15
2A	09/26/89	2	421.6	46.7	94.0	23.1	509.5	60.5	113.6	29.9	88.13	73.68
2B	09/26/89	2	426.9	33.3	73.6	18.9	556.9	46.8	96.0	26.5	91.59	72.37
2C	09/26/89	2	403.7	20.6	75.7	60.4	465.8	26.0	87.3	76.1	94.43	12.84
2D	09/26/89	2	398.7	43.1	85.2	31.5	501.5	57.8	107.2	42.3	88.47	60.55
3A	09/26/89	2	498.2	27.4	92.1	46.4	519.9	32.0	96.1	54.1	93.85	43.70
3B	09/26/89	2	503.5	57.7	94.3	33.2	551.8	69.4	103.3	39.9	87.43	61.37
3C	09/26/89	2	172.8	52.8	98.1	36.7	191.0	64.4	108.4	44.8	66.30	58.71
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	2	387.5	49.1	82.5	38.9	458.9	61.1	95.5	48.0	78.1	44.7

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[a] [] Run rejected - no heat on sample probe.

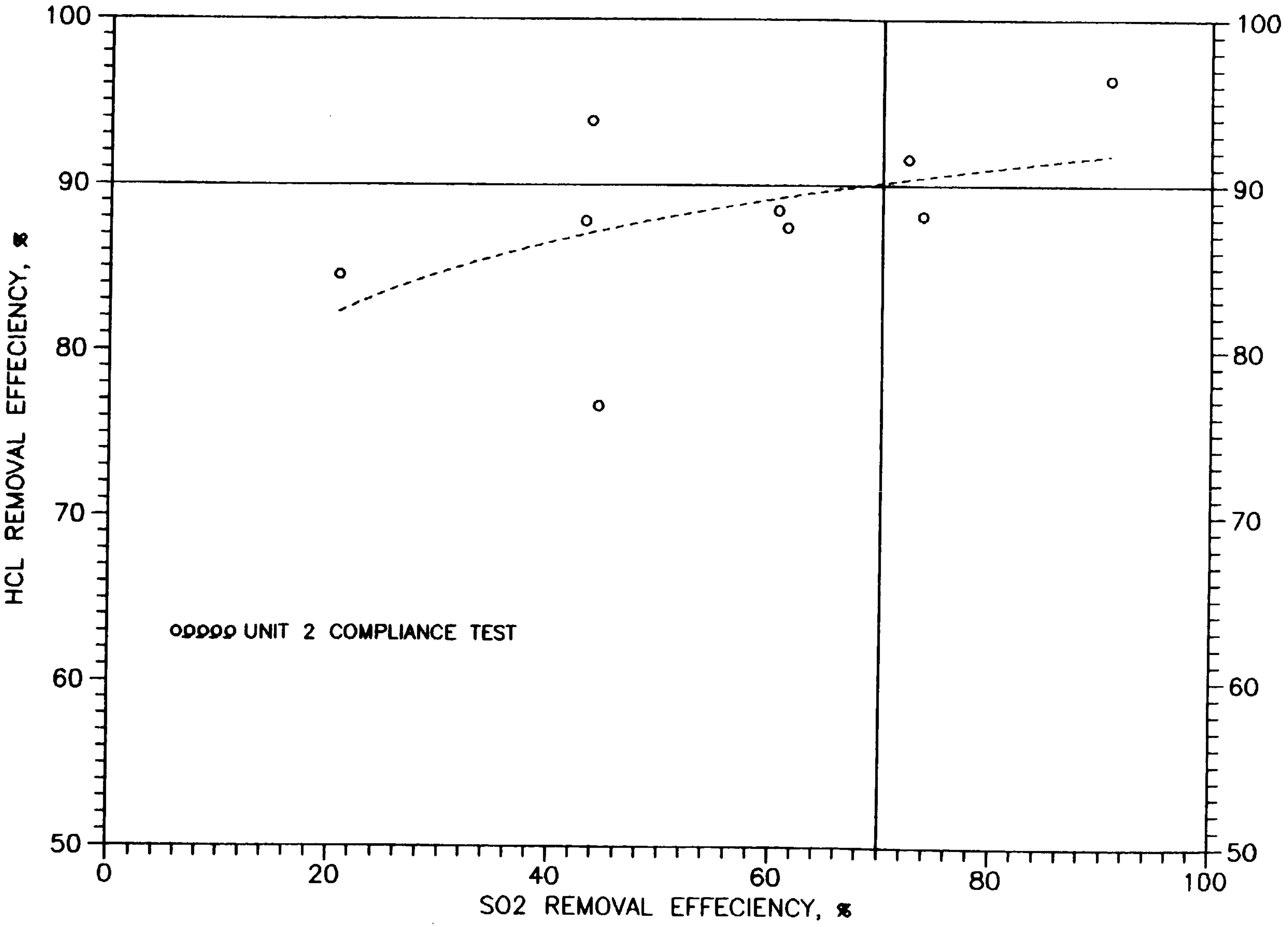

Figure 4-1. Acid Gas Relationship for Unit 2

TABLE 4-13. HCl AND SO2 COMPARISONS FOR UNIT 2 DURING COMPLIANCE TEST PROGRAM AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/26/89	2	419.4	14.7	127.0	11.5	481.6	17.5	145.8	13.6	96.4	90.6
2A	09/26/89	2	421.6	46.7	94.0	23.1	509.5	60.5	113.6	29.9	88.1	73.7
2B	09/26/89	2	426.9	33.3	73.6	18.9	556.9	46.8	96.0	26.5	91.6	72.4
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	2	422.6	31.6	98.2	17.8	516.0	41.6	118.5	23.4	92.0	78.9

TABLE 4-14. OUTLET NOX EMISSIONS TEST RESULTS FOR UNIT 2 HEMPSTEAD RESOURCE RECOVERY FACILITY

DATE: 09/28/89

TEST TIME	NOx CONCENTRATION (ppmV)	NOx CONCENTRATION (ppmV @ 12% CO2)	MASS EMISSIONS (lb/hr)
1000-1100	177.9	215.8	143.7
1100-1200	163.8	220.9	132.3
1200-1300	149.3	221.4	120.6
1300-1400	147.2	214.0	118.9
1400-1500	206.3	246.9	166.7
1500-1600	196.7	248.5	158.9
1600-1700	172.8	234.4	139.6
1700-1800	204.5	251.5	165.2
1800-1900	175.0	235.4	141.4
1900-2000	207.6	252.7	167.7
AVERAGE	180.1	234.2	145.5

NOTE: The mass emissions for NOx are based on the volumetric flow measured on 9/26/89 by the metals samples trains.

-6.1% of full scale during September 26 which is greater than the prescribed ±3.0% of scale. Therefore, the NO_x concentrations in Table 4-14 are adjusted for drift assuming a linear drift between initial and final calibrations.

5.0 UNIT 3 EMISSION TEST RESULTS

Compliance emission testing was performed on Unit 3 of the Hempstead Resource Recovery facility on October 2 and 3, 1989 at 100% steam load and on September 20 and 21, 1989 at 65% steam load. Emission tests were performed for particulate, heavy metals, combustion efficiency, acid gases, and total hydrocarbons during the 100% load. Testing for particulate and combustion efficiency was performed at the 65% load condition.

5.1 Particulate Emissions

Table 5-1 presents the results of the particulate testing performed on Unit 3 at the 100% load condition. The average effluent particulate concentration from Unit 3 at 100% load was 0.00115 grains/dscf or 0.00151 grains/dscf normalized to 12% CO_2. The average mass emission rate was 1.089 lb/hr. The average steam rate during these tests was 189.34 lb/hr. Averages for other process operation variables are given in Table 5-2.

Table 5-3 lists the sampling results for particulate testing performed on Unit 3 at 65% load. The average particulate concentration from Unit 5 at 65% load was 0.00091 grains/dscf or 0.00119 grains/dscf adjusted to 12% CO_2. The average mass emission rate was 0.575 lb/hr. The average process operation data are presented in Table 5-4.

5.2 Heavy Metals Emission Test Results

Two sampling methods were used to measure metals emissions from Unit 3 at the Hempstead Resource Recovery Facility. The EMSL Toxic Metals train was used to sample total particulate, arsenic (As), Cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb). The EPA Method 104 beryllium (Be) train was used to measure effluent Be concentrations. Inductively coupled argon plasma (ICAP) and atomic absorption (AA) techniques were used to analyze the samples. Section 10 discusses these methods in greater detail. Three runs of each sample type were performed to assure representative test results.

TABLE 5-1. SUMMARY OF PARTICULATE TEST RESULTS
FOR UNIT 3 DURING 100% LOAD TESTS
HEMPSTEAD RESOURCE RECOVERY,
WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 7 10/02/89	RUN 8 10/03/89	RUN 9 10/03/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.75	29.54	29.54	29.61
Absolute Stack Pressure,Ps(in. Hg)	29.67	29.46	29.46	29.53
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	295.75	292.77	291.19	293.24
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	142.11	141.57	150.47	144.71
Average Meter Pressure (in. H2O)	1.05	1.03	1.24	1.11
Average Meter Temperature (F)	99.63	98.26	99.53	99.14
Moisture Collected (g)	715.00	604.60	656.70	658.77
Carbon Dioxide Concentration (%V)	9.98	8.55	8.96	9.16
Oxygen Concentration (%V)	9.32	11.10	11.00	10.47
Nitrogen Concentration (%V)	80.70	80.35	80.04	80.36
Dry Gas Meter Factor	1.00220	1.00220	0.98820	0.99753
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.00870	0.00720	0.01450	0.01013
Average Sampling Rate (dscfm)	0.56	0.55	0.58	0.56
Standard Metered Volume,Vm(std) (dscf)	133.96	132.84	138.98	135.26
Standard Metered Volume,Vm(std) (dscm)	3.794	3.762	3.936	3.831
Standard Volume Water Vapor,Vw (scf)	33.71	28.51	30.96	31.06
Standard Volume Water Vapor,Vw (scm)	0.955	0.807	0.877	0.880
Stack Moisture (%V)	20.11	17.67	18.22	18.66
Mole Fraction Dry Stack Gas	0.799	0.823	0.818	0.813
Dry Molecular Weight	29.97	29.81	29.87	29.89
Wet Molecular Weight	27.56	27.73	27.71	27.67
Stack Gas Velocity,Vs (fpm)	3895.34	3782.62	4043.12	3907.02
Stack Gas Velocity,Vs (mpm)	1187.30	1152.94	1232.34	1190.86
Volumetric Flow Rate (acfm)	195801.06	190135.05	203229.26	196388.46
Volumetric Flow Rate (acmm)	5545.086	5384.625	5755.453	5561.721
Volumetric Flow Rate (dscfm)	108321.07	108056.90	114965.86	110447.94
Volumetric Flow Rate (dscmm)	3067.653	3060.171	3255.833	3127.886
Percent Isokinetic	100.81	100.21	98.54	99.85
Percent Excess Air	77.66	109.59	108.41	98.55
Fuel Factor,Fo	1.160	1.146	1.105	1.137
Ultimate CO2	18.01	18.23	18.92	18.39
Concentration of Particulate (grains/acf)	0.00055	0.00048	0.00091	0.00065
Concentration of Particulate (g/acm)	0.00127	0.00109	0.00208	0.00148
Concentration of Particulate (grains/dscf)	0.00100	0.00084	0.00161	0.00115
Concentration of Particulate (g/dscm) a	0.00229	0.00191	0.00368	0.00263
Concentration of Particulate (grains/dscf @ 12% CO2)	0.00121	0.00117	0.00216	0.00151

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 5-2. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 3 DURING 100% LOAD PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	10/02/89 0846-1336 7	10/03/89 0916-1336 8	10/03/89 1336-1636 9	AVERAGE
STEAM LOAD, (Klb/hr)	217.13	171.59	179.29	189.34
STEAM PRESSURE, (psig)	998.73	965.11	975.89	979.91
STEAM TEMPERATURE, (deg. F)	838.87	838.00	839.79	838.89
PRIMARY AIR FLOW, (KSCFM)	68.91	62.16	64.09	65.05
SECONDARY AIR FLOW, (KSCFM)	21.98	20.61	22.57	21.72
FURNACE OXYGEN, (%V, wet) [a]	13.79	13.29	10.69	12.59
FIRST PASS TEMPERATURE, (deg. F)	NR	NR	NR	NR
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	430.60	431.93	438.68	433.74
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	NR	NR	NR	NR
SCRUBBER SLURRY RATE, (gpm)	NA	NA	18.1	18.1
SCRUBBER WATER RATE, (gpm)	NA	NA	11.8	11.8
FABRIC FILTER, (dP)	NR	NR	NR	NR
SO2 REMOVAL, (%)	NR	NR	NR	NR
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NA = NOT AVAILABLE
NR = NOT RECORDED

TABLE 5-3. SUMMARY OF PARTICULATE TEST RESULTS FOR UNIT 3 DURING 65% LOAD TESTS HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

SAMPLING PARAMETER PARTICULATE	RUN 4 09/20/89	RUN 5 09/20/89	RUN 6 09/21/89	AVERAGE
Total Sampling Time (min.)	240.00	240.00	240.00	240.00
Corrected Barometric Pressure (in. Hg)	29.93	29.94	29.99	29.96
Absolute Stack Pressure,Ps(in. Hg)	29.85	29.86	29.91	29.87
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	278.58	282.65	289.19	283.47
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	97.43	101.50	97.72	98.88
Average Meter Pressure (in. H2O)	0.51	0.56	0.52	0.53
Average Meter Temperature (F)	107.69	112.04	107.95	109.23
Moisture Collected (g)	431.70	438.10	460.00	443.27
Carbon Dioxide Concentration (%V)	8.71	9.15	9.54	9.13
Oxygen Concentration (%V)	10.73	10.50	10.00	10.41
Nitrogen Concentration (%V)	80.56	80.35	80.46	80.46
Dry Gas Meter Factor	1.00220	1.00220	1.00220	1.00220
Pitot Constant	0.84	0.84	0.84	0.84
Particulate Catch (g)	0.00400	0.00830	0.00400	0.00543
Average Sampling Rate (dscfm)	0.38	0.39	0.38	0.38
Standard Metered Volume,Vm(std) (dscf)	90.98	94.08	91.39	92.15
Standard Metered Volume,Vm(std) (dscm)	2.576	2.664	2.588	2.610
Standard Volume Water Vapor,Vw (scf)	20.35	20.66	21.69	20.90
Standard Volume Water Vapor,Vw (scm)	0.576	0.585	0.614	0.592
Stack Moisture (%V)	18.28	18.00	19.18	18.49
Mole Fraction Dry Stack Gas	0.817	0.820	0.808	0.815
Dry Molecular Weight	29.82	29.88	29.93	29.88
Wet Molecular Weight	27.66	27.74	27.64	27.68
Stack Gas Velocity,Vs (fpm)	2482.71	2606.60	2549.12	2546.14
Stack Gas Velocity,Vs (mpm)	756.73	794.49	776.97	776.06
Volumetric Flow Rate (acfm)	124794.47	131021.80	128132.86	127983.04
Volumetric Flow Rate (acmm)	3534.179	3710.537	3628.722	3624.480
Volumetric Flow Rate (dscfm)	72695.60	76182.07	72921.24	73932.97
Volumetric Flow Rate (dscmm)	2058.740	2157.476	2065.129	2093.782
Percent Isokinetic	102.01	101.60	103.11	102.24
Percent Excess Air	101.67	97.87	88.83	96.12
Fuel Factor,Fo	1.168	1.137	1.143	1.149
Ultimate CO2	17.90	18.39	18.29	18.19
Concentration of Particulate (grains/acf)	0.00040	0.00079	0.00038	0.00052
Concentration of Particulate (g/acm)	0.00090	0.00181	0.00088	0.00120
Concentration of Particulate (grains/dscf)	0.00068	0.00136	0.00068	0.00091
Concentration of Particulate (g/dscm) [a]	0.00155	0.00312	0.00155	0.00207
Concentration of Particulate (grains/dscf @ 12% CO2)	0.00093	0.00179	0.00085	0.00119

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

TABLE 5-4. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 3 DURING 65% LOAD PARTICULATE TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	09/20/89 1024-1534 4	09/20/89 1554-2014 5	09/21/89 0924-1354 6	AVERAGE
STEAM LOAD, (Klb/hr)	132.30	135.54	137.55	135.13
STEAM PRESSURE, (psig)	920.00	920.59	929.71	923.43
STEAM TEMPERATURE, (deg. F)	826.63	828.15	830.21	828.33
PRIMARY AIR FLOW, (KSCFM)	37.71	37.32	32.90	35.98
SECONDARY AIR FLOW, (KSCFM)	11.72	13.95	13.91	13.19
FURNACE OXYGEN, (%V, wet) a	10.53	10.69	10.52	10.58
FIRST PASS TEMPERATURE, (deg. F)	1372.25	1396.3	1409.29	1392.61
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	393.59	397.00	390.04	393.54
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	307.22	307.30	307.21	307.24
SCRUBBER SLURRY RATE, (gpm)	7.9	9.8	7.9	8.5
SCRUBBER WATER RATE, (gpm)	10.2	9.5	10.2	10.0
FABRIC FILTER, (dP)	4.69	4.78	5.58	5.02
SO2 REMOVAL, (%)	78.45	79.06	75.32	77.61
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NR = NOT RECORDED

The results of the heavy metals testing is presented in Table 5-5 and the Be test results are given in Table 5-6.

The values reported in Table 5-5 include the relevant detection limits for metals which were not detected in the samples. Since the samples were analyzed in three separate fractions (see Section 10 for details), guidelines for mathematically handling detection limits were required. The guidelines used for this report are:

- If a metal was detected in one or more fractions of the sample train but not in another, metal weight in the not detected fraction was considered to be zero for adding the train results.
- If a metal was not detected in any train fractions of a sample train, the lowest detection limit reported for the individual fractions was used as the overall sample detection limit.

For the purpose of calculating average results:

- If a metal was detected in one or two of the test runs, but not all three, only those runs for which a quantitative result was obtained were used in the average. Runs where the metal was not detected were not included for averaging.
- If the metal was not detected in any of the three runs, then the average result was reported as not detected at the average detection limit.

The analytical data for the metals train fractions are included in Appendix H.

Cadmium and Ni were not detected in any of the samples from Unit 3. Mercury was the most prevalent element detected and had an average concentration of 9.28 μg/dscm adjusted to 12% CO_2. Arsenic was only detected in Runs 2 and 3 and averaged 0.454 μg/dscm at 12% CO_2 for these two runs. Chromium was only detected in Run 2 with a concentration of 0.59 μg/dscm at 12% CO_2. Lead concentrations from the samples had an average of 6.39 μg/dscm at 12% CO_2. The average process conditions for these tests are presented in Table 5-2.

TABLE 5-5. SUMMARY OF METALS RESULTS AT 100% LOAD - UNIT 3
HEMPSTEAD RESOURCE RECOVERY FACILITY, WESTBURY, NEW YORK

DATE:		10/02/89	10/03/89	10/03/89	
TIME:		0853-1330	0916-1332	1332-1743	
PARAMETER:		RUN 1	RUN 2	RUN 3	AVERAGE
Sample Gas Volume (dscm)[a]		3.794	3.762	3.936	3.831
CO2 (% by vol, dry)		9.98	8.55	8.96	9.16
O2 (% by vol, dry)		9.32	11.1	11	10.47
Moisture (% by vol)		20.1	17.7	18.2	18.67
Flow Rate (dscmm)		3067.7	3060.2	3255.8	3127.9
Flow Rate (acmm)		5545.1	5384.6	5755.5	5561.7
Arsenic	(ug/sample)	[0.390]	0.464	2.158	1.311
	(ug/dscm)	[0.103]	0.123	0.548	0.336
	(ug/dscm @ 12% CO2)	[0.124]	0.173	0.734	0.454
	(ug/acm)	[0.057]	0.070	0.310	0.190
	(g/hr)	[0.019]	0.023	0.107	0.065
Cadmium	(ug/sample)	[2.000]	[2.000]	[2.000]	[2.000]
	(ug/dscm)	[0.527]	[0.532]	[0.508]	[0.522]
	(ug/dscm @ 12% CO2)	[0.634]	[0.746]	[0.681]	[0.687]
	(ug/acm)	[0.292]	[0.302]	[0.287]	[0.294]
	(g/hr)	[0.097]	[0.098]	[0.099]	[0.098]
Chromium	(ug/sample)	[5.000]	1.570	[5.000]	1.570
	(ug/dscm)	[1.318]	0.417	[1.270]	0.417
	(ug/dscm @ 12% CO2)	[1.585]	0.586	[1.701]	0.586
	(ug/acm)	[0.729]	0.237	[0.718]	0.237
	(g/hr)	[0.243]	0.077	[0.248]	0.077
Mercury	(ug/sample)	23.594	26.700	30.600	26.965
	(ug/dscm)	6.219	7.097	7.774	7.030
	(ug/dscm @ 12% CO2)	7.477	9.961	10.412	9.284
	(ug/acm)	3.440	4.034	4.398	3.957
	(g/hr)	1.145	1.303	1.519	1.322
Nickel	(ug/sample)	[2.020]	[2.030]	[2.030]	[2.027]
	(ug/dscm)	[0.532]	[0.540]	[0.516]	[0.529]
	(ug/dscm @ 12% CO2)	[0.640]	[0.757]	[0.691]	[0.696]
	(ug/acm)	[0.294]	[0.307]	[0.292]	[0.298]
	(g/hr)	[0.098]	[0.099]	[0.101]	[0.099]
Lead	(ug/sample)	7.690	7.160	41.320	18.723
	(ug/dscm)	2.027	1.903	10.498	4.809
	(ug/dscm @ 12% CO2)	2.437	2.671	14.060	6.389
	(ug/acm)	1.121	1.082	5.939	2.714
	(g/hr)	0.373	0.349	2.051	0.924

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

Note: Values enclosed in brackets represent the minimum detection limits for compounds not detected in the samples. Detection limits are not included in the averages unless otherwise indicated.

TABLE 5-6. SUMMARY OF BERYLLIUM TEST RESULTS
FOR UNIT 3 DURING 100% LOAD,
HEMPSTEAD RESOURCE RECOVERY,
WESTBURY, NEW YORK

SAMPLING PARAMETER BERYLLIUM	RUN 7 10/02/89	RUN 8 10/02/89	RUN 9 10/03/89	AVERAGE
Total Sampling Time (min.)	120.00	120.00	120.00	120.00
Corrected Barometric Pressure (in. Hg)	29.75	29.75	29.54	29.68
Absolute Stack Pressure,Ps(in. Hg)	29.67	29.67	29.46	29.60
Stack Static Pressure (in. H2O)	-1.10	-1.10	-1.10	-1.10
Average Stack Temperature (F)	293.54	292.46	295.58	293.86
Stack Area (sq.in.)	7238.23	7238.23	7238.23	7238.23
Metered Volume,Vm (cu.ft.)	68.07	74.44	74.65	72.38
Average Meter Pressure (in. H2O)	1.06	1.17	1.12	1.12
Average Meter Temperature (F)	91.21	103.06	91.73	95.33
Moisture Collected (g)	355.90	395.20	317.10	356.07
Carbon Dioxide Concentration (%V)	10.20	10.30	8.68	9.73
Oxygen Concentration (%V)	9.07	8.91	11.22	9.73
Nitrogen Concentration (%V)	80.73	80.79	80.10	80.54
Dry Gas Meter Factor	0.98820	0.98820	0.98820	0.98820
Pitot Constant	0.84	0.84	0.84	0.84
Beryllium catch (ug/sample)	< 0.02	< 0.02	< 0.02	< 0.02
Average Sampling Rate (dscfm)	0.54	0.57	0.58	0.56
Standard Metered Volume,Vm(std) (dscf)	64.24	68.79	69.90	67.64
Standard Metered Volume,Vm(std) (dscm)	1.819	1.948	1.979	1.916
Standard Volume Water Vapor,Vw (scf)	16.78	18.63	14.95	16.79
Standard Volume Water Vapor,Vw (scm)	0.475	0.528	0.423	0.475
Stack Moisture (%V)	20.71	21.31	17.62	19.88
Mole Fraction Dry Stack Gas	0.793	0.787	0.824	0.801
Dry Molecular Weight	29.99	30.00	29.84	29.95
Wet Molecular Weight	27.51	27.45	27.75	27.57
Stack Gas Velocity,Vs (fpm)	3828.45	4021.28	3935.10	3928.27
Stack Gas Velocity,Vs (mpm)	1166.91	1225.68	1199.42	1197.34
Volumetric Flow Rate (acfm)	192438.76	202131.33	197799.64	197456.58
Volumetric Flow Rate (acmm)	5449.866	5724.359	5601.686	5591.970
Volumetric Flow Rate (dscfm)	105964.25	110617.78	112056.48	109546.17
Volumetric Flow Rate (dscmm)	3000.908	3132.696	3173.439	3102.348
Percent Isokinetic	98.84	101.39	101.69	100.64
Percent Excess Air	73.99	71.65	112.85	86.16
Fuel Factor,Fo	1.160	1.164	1.115	1.146
Ultimate CO2	18.02	17.95	18.74	18.24
Concentration of Beryllium (ug/acm) [a]	< 0.00605	< 0.00562	< 0.00572	< 0.00580
Concentration of Beryllium (ug/dscm) [a]	< 0.01099	< 0.01027	< 0.01010	< 0.01045
Concentration of Beryllium (ug/dscm @ 12% CO2)	< 0.01293	< 0.01196	< 0.01397	< 0.01295
Mass Emission Rate Beryllium (g/hr)	< 0.00198	< 0.00193	< 0.00192	< 0.00194

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[a] Concentrations are expressed at standard conditions of 1 atm and 68 deg. F.

Beryllium testing for Unit 3 was performed on October 2 and 3, 1989 and consisted of three replicate runs. Beryllium was not detected in any of the samples; however, the detection limits and sampling data are presented in Table 5-6. Process data collected during the beryllium tests are presented in Table 5-7.

The quality control measures used during heavy metals sampling are described briefly in Section 3. All train leak rates were less than 0.02 cfm. No contamination was found in any of the analytical blanks.

5.3 Combustion Performance

The combustion performance of Unit 3 was determined by measuring CO, CO_2, and total hydrocarbons (THC)by monitoring the temperature at the exit of the first pass of the boiler. The NYSDEC permit conditions for Unit 3 are listed in Table 1-1. Combustion efficiency is defined as:

$$CE(\%) = 100\% \; [CO_2/(CO + CO_2)]$$

where:

$CE(\%)$ = Combustion Efficiency, percent
CO_2 = Carbon Dioxide concentration, mole fraction
CO = Carbon Monoxide concentration, mole fraction

Tests were performed on September 20 at 65% load and October 2 at 100% load. For 100% tests, testing was performed for 12 one-hour periods. The average CO concentration was 40.1 ppmV at 12% CO_2, with an average emission rate of 15.3 lb/hr. The average 1-hour combustion efficiency was 99.7%. Table 5-8 lists the combustion results during the 100% load conditions. Table 5-9 lists the combustion results for the 65% load tests. The average 1-hour combustion efficiency for the 65% load conditions was 99.98%. Eight-hour rolling averages for CO and combustion efficiency are presented in Tables 5-10 and 5-11 for the 100% and 65% load tests, respectively.

TABLE 5-7. SUMMARY OF AVERAGE PROCESS OPERATING DATA FOR UNIT 3 DURING BERYLLIUM TESTS, HEMPSTEAD RESOURCE RECOVERY, WESTBURY, NEW YORK

DATE TIMES RUN NUMBER	10/02/89 0926-1226 7	10/02/89 1326-1546 8	10/03/89 0846-1236 9	AVERAGE
STEAM LOAD, (Klb/hr)	218.05	222.43	174.65	205.04
STEAM PRESSURE, (psig)	1000.11	1007.47	967.75	991.78
STEAM TEMPERATURE, (deg. F)	839.68	839.73	838.50	839.30
PRIMARY AIR FLOW, (KSCFM)	67.22	70.88	63.44	67.18
SECONDARY AIR FLOW, (KSCFM)	21.98	20.90	20.75	21.21
FURNACE OXYGEN, (%V, wet) a	13.28	15.25	14.47	14.33
FIRST PASS TEMPERATURE, (deg. F)	NR	NR	NR	NR
ECONOMIZER OUTLET GAS TEMPERATURE, (deg. F)	428.74	439.73	432.42	433.63
DRY SCRUBBER EXIT TEMPERATURE, (deg. F)	NR	NR	NR	NR
SCRUBBER SLURRY RATE, (gpm)	NA	NA	9.8	9.8
SCRUBBER WATER RATE, (gpm)	NA	NA	24.6	24.6
FABRIC FILTER, (dP)	NR	NR	NR	NR
SO2 REMOVAL, (%)	NR	NR	NR	NR
OUTLET CO @ 12% CO2 (ppmV)	NR	NR	NR	NR

[a] Furnace oxygen is by plant oxygen analyzer in the first pass. Known to be possibly high due to interference from overfire air.

NA = NOT AVAILABLE
NR = NOT RECORDED

TABLE 5-8. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 3 AT 100% LOAD

DATE: 10/02/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
0900-1000	21.3	0.103	23.9	0.119	10.1	0.0279	99.980
1000-1100	27.1	0.147	31.0	0.171	12.8	0.0398	99.974
1100-1200	31.1	0.302	38.4	0.371	14.7	0.0814	99.968
1200-1300	36.5	0.428	44.4	0.526	17.3	0.116	99.963
1300-1400	46.3	0.348	60.8	0.450	21.9	0.0940	99.949
1400-1500	26.7	0.020	29.5	0.022	12.6	0.00529	99.975
1500-1600	31.0	0.161	39.6	0.196	14.7	0.0436	99.967
1600-1700	35.5	0.205	45.0	0.251	16.8	0.0554	99.962
1700-1800	33.1	0.141	43.8	0.177	15.6	0.0380	99.964
1800-1900	32.5	0.195	42.8	0.250	15.3	0.0526	99.964
1900-2000	34.9	0.066	45.1	0.084	16.5	0.0179	99.962
2000-2100	31.6	0.058	37.5	0.070	14.9	0.0158	99.969
AVERAGE	32.3	0.181	40.2	0.224	15.3	0.0489	99.967

TABLE 5-9. COMBUSTION PERFORMANCE TEST RESULTS FOR UNIT 3 AT 65% LOAD

DATE: 09/20/89

TEST TIME	BOILER EXIT CO (ppmV)	STACK THC (ppmCH4)	BOILER EXIT CO (ppmV @ 12% CO2)	STACK THC (ppmCH4 @ 12% CO2)	CO (lb/hr)	THC (lb/hr)	COMBUSTION EFFICIENCY (%)
1000-1100	18.2	0.815	24.8	1.16	5.90	0.151	99.979
1300-1400	25.8	0.763	32.7	1.03	8.39	0.142	99.973
1400-1500	19.6	0.634	25.3	0.859	6.35	0.118	99.979
1500-1600	15.4	0.516	20.2	0.706	5.00	0.0957	99.983
1600-1700	13.0	0.357	16.3	0.475	4.21	0.0663	99.986
1700-1800	20.2	0.444	26.6	0.609	6.55	0.0824	99.978
1800-1900	9.48	0.300	11.3	0.370	3.08	0.0556	99.991
1900-2000	15.4	0.408	19.7	0.547	5.01	0.0757	99.984
2000-2100	19.0	0.367	23.0	0.481	6.15	0.0682	99.981
AVERAGE	17.3	0.511	22.2	0.693	5.63	0.0949	99.981

TABLE 5-10. UNIT 3 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS
100% LOAD CONDITIONS

DATE: 10/02/89

TEST TIME	1 - Hour Averages		8 - Hour Rolling Averages	
	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)
0900-1000	23.9	99.980		
1000-1100	31.0	99.974		
1100-1200	38.4	99.968		
1200-1300	44.4	99.963		
1300-1400	60.8	99.949		
1400-1500	29.5	99.975		
1500-1600	39.6	99.967		
1600-1700	45.0	99.962	39.1	99.967
1700-1800	43.8	99.964	41.6	99.965
1800-1900	42.8	99.964	43.0	99.964
1900-2000	45.1	99.962	43.9	99.963
2000-2100	37.5	99.969	43.0	99.964
		AVERAGE	42.1	99.965

TABLE 5-11. UNIT 3 ROLLING 8-HOUR AVERAGE COMBUSTION PERFORMANCE TEST RESULTS 65% LOAD CONDITIONS

DATE: 09/20/89

TEST TIME	1 - Hour Averages		8 - Hour Rolling Averages	
	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)	CO (ppmV @ 12% CO2)	COMBUSTION EFFICIENCY (%)
1000-1100	24.8	99.979		
1300-1400	32.7	99.973		
1400-1500	25.3	99.979		
1500-1600	20.2	99.983		
1600-1700	16.3	99.986		
1700-1800	26.6	99.978		
1800-1900	11.3	99.991		
1900-2000	19.7	99.984	22.1	99.982
2000-2100	23.0	99.981	21.9	99.982
		AVERAGES	22.0	99.982

Hydrocarbon emissions were less than 1.0 ppmV as methane during all tests. The average THC emission rate was 0.049 lb/hr as methane for the 100% load conditions. The average THC emission rate for the 65% load tests was 0.095 lb/hr. The results of the furnace temperature profile tests are discussed in Section 5.5.

Strict quality control procedures were observed during the combustion tests. Prior to sampling multipoint calibrations were performed for all pertinent analyzers to assure linearity across the instrument range. Leakchecks of the sampling system were also performed each day prior to sampling. Calibrations were performed at least twice each day and drifts were assessed to ensure data quality. Additionally, midscale calibration checks were performed each day.

During the combustion tests on Unit 3, the CO_2 analyzers exhibited negative drift between -3.0% and -4.0% for all tests; however, no corrections were performed because the adjustments would cause a decrease in the CO_2 corrected pollutant levels and an increase in combustion efficiency. Additionally, the CO instrument drifted -4.96% during the 65% load testing. The CO values reported in Table 5-9 have been adjusted assuming a linear drift between calibrations.

5.4 Acid Gas Emission and Removal Efficiency

A total of ten test runs were performed at Unit 3 with one run being rejected because of failure of the post-test leak check of the inlet train. The lime rate was also varied during tests at Unit 3, with the target SO_2 removals being 50%, 60% and 70%. The results from all test runs are presented in Table 5-12, and the removal efficiency relationship is shown in Figure 5-1. For Unit 3, the correlation between HCl and SO_2 removal is:

$$\text{HCl removal} = 6.91511 * \ln(SO_2 \text{ removal}) + 60.3106$$

At 70% SO_2 removal, the corresponding HCl removal would be 89.7%.

TABLE 5-12. HCl AND SO2 COMPARISONS FOR UNIT 3 AT THE HEMPSTEAD RESOURCE RECOVERY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	10/02/89	3	482.5	57.5	120.0	54.7	536.1	65.7	133.3	62.5	87.75	53.11
1B	10/02/89	3	465.1	88.5	102.0	80.4	600.1	113.0	131.6	102.6	81.17	22.02
1C	10/02/89	3	[a][419.5]	113.6	109.0	56.0		151.5	148.6	74.7		49.77
2A	10/02/89	3	491.1	75.1	116.0	35.5	677.4	100.2	160.0	47.3	85.21	70.42
2B	10/02/89	3	371.4	40.9	110.0	23.0	479.3	52.2	141.9	29.4	89.12	79.31
2C	10/02/89	3	478.5	43.0	119.0	27.3	617.4	53.8	153.5	34.1	91.29	77.78
3A	10/02/89	3	378.4	35.5	84.0	24.1	522.0	47.9	115.9	32.5	90.83	71.95
3B	10/02/89	3	542.6	38.0	108.0	31.4	638.4	45.2	127.1	37.3	92.93	70.64
3C	10/02/89	3	487.7	69.4	115.0	50.4	609.6	85.9	143.8	62.4	85.91	56.63
3D	10/02/89	3	573.7	49.2	85.3	40.8	809.9	67.9	120.4	56.3	91.62	53.27
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	3	421.0	61.1	94.8	42.4	550.5	71.7	124.3	47.7	78.7	55.2

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[a] [] Run rejected - failed post-test leak check.

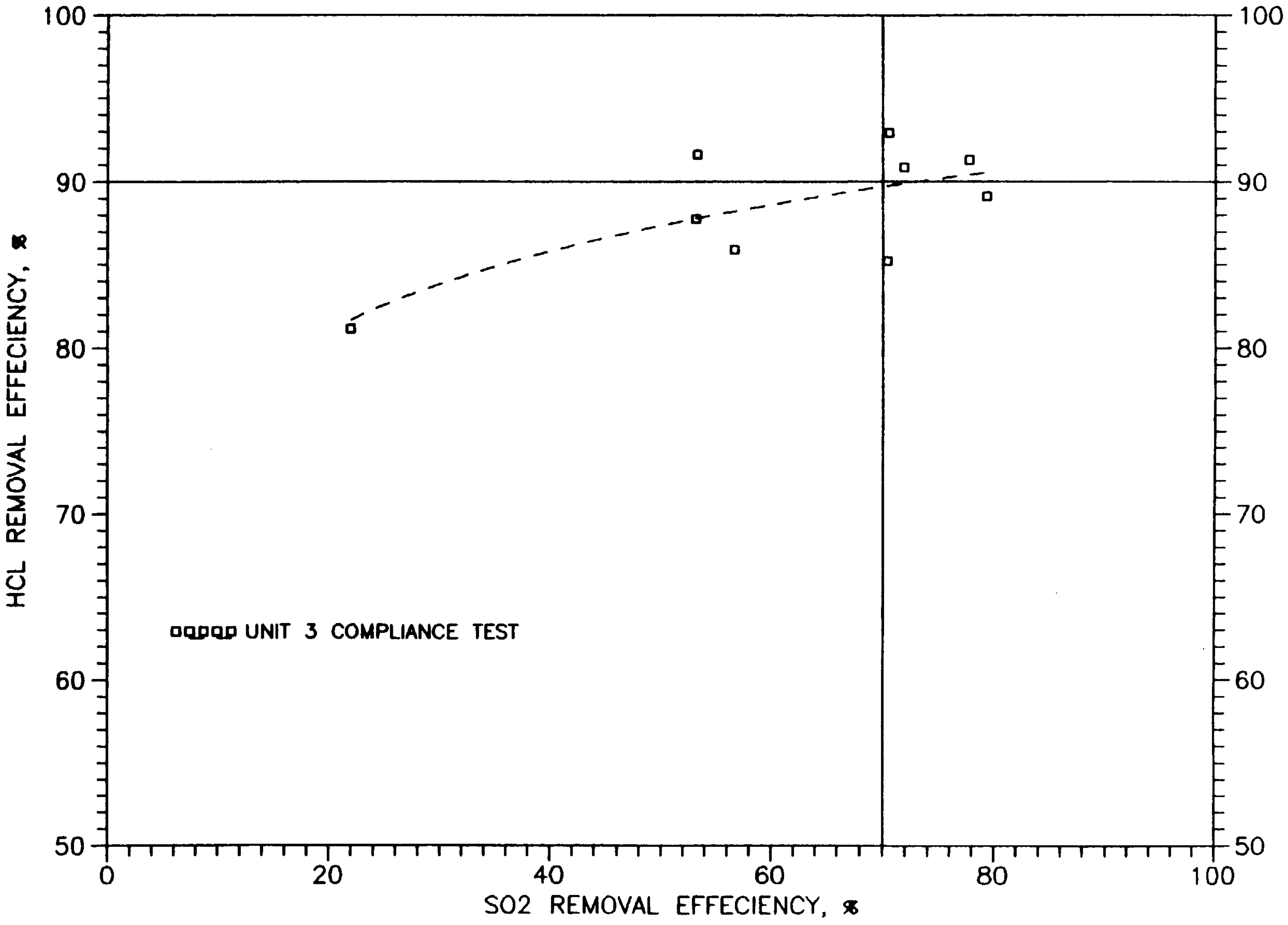

Figure 5-1. Acid Gas Relationship for Unit 3

For the purpose of demonstrating compliance, all test runs with SO_2 removals less than 70% were omitted, and the remaining runs were averaged. These results are presented in Table 5-13.

The average HCl concentration at the boiler exit when the SO_2 removal was at least 70% was 587 ppmV at 12% CO_2, with an average stack emission concentration of 59.8 ppmV. The average HCl removal was 89.9%. When rounded to the significant digits indicated in the permit conditions, Unit 3 meets the permit requirement of 90% removal.

The SO_2 concentration at the boiler exit was 139.7 ppmV with a stack concentration of 36.1 ppmV at 12% CO_2. The average SO_2 removal for these tests was 74.0%.

The relationship between acid gas removals and emission concentrations are discussed in additional detail in Section 6.0.

5.5 NO_x Emissions

Nitrogen oxides (NO and NO_2) were measured continuously using EPA Method 7E on October 2, 1989. Test results of the NO_x sampling at 100% load are given in Table 5-14. Hourly test averages are presented on an as-measured basis, as concentrations normalized to 12% CO_2, and as mass emission rates. The average NO_x concentrations for the tests performed on Unit 3 was 247.6 ppmV at 12% CO_2.

Quality control procedures for the NO_x monitoring tests include leakchecking the sampling system, performing a multipoint calibration during the test program, monitoring instrument drift and checking the linearity of the instrument on a daily basis. Due to the compliance nature of this test, drift corrections are only performed if these corrections cause the reported values to be higher than the uncorrected values. The NO_x analyzer drifted -3.7% of full scale during October 2 which is greater than the prescribed ±3.0% of scale. Therefore, the NO_x concentrations in Table 5-14 are adjusted for drift assuming a linear drift between initial and final calibrations.

TABLE 5-13. HCl AND SO2 COMPARISONS FOR UNIT 3 DURING COMPLIANCE TEST PROGRAM AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
2A	10/02/89	3	491.1	75.1	116.0	35.5	677.4	100.2	160.0	47.3	85.2	70.4
2B	10/02/89	3	371.4	40.9	110.0	23.0	479.3	52.2	141.9	29.4	89.1	79.3
2C	10/02/89	3	478.5	43.0	119.0	27.3	617.4	53.8	153.5	34.1	91.3	77.8
3A	10/02/89	3	378.4	35.5	84.0	24.1	522.0	47.9	115.9	32.5	90.8	72.0
3B	10/02/89	3	542.6	38.0	108.0	31.4	638.4	45.2	127.1	37.3	92.9	70.6
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	3	452.4	46.5	107.4	28.3	586.9	59.8	139.7	36.1	89.9	74.0

TABLE 5-14. OUTLET NOX EMISSIONS TEST RESULTS FOR UNIT 3 HEMPSTEAD RESOURCE RECOVERY FACILITY

DATE: 10/02/89

TEST TIME	NOx CONCENTRATION (ppmV)	NOx CONCENTRATION (ppmV @ 12% CO2)	MASS EMISSIONS (lb/hr)
0900-1000	192.1	220.6	149.2
1000-1100	199.2	231.8	154.7
1100-1200	211.0	259.7	163.8
1200-1300	198.6	243.9	154.2
1300-1400	193.6	250.5	150.3
1400-1500	191.1	214.6	148.4
1500-1600	205.8	250.4	159.8
1600-1700	213.7	261.8	165.9
1700-1800	203.1	256.2	157.7
1800-1900	203.5	261.5	158.0
1900-2000	207.6	262.2	161.2
2000-2100	215.2	258.4	167.1
AVERAGE	202.9	247.6	157.5

NOTE: The mass emissions for NOx are based on the volumetric flow measured on 10/02/89 by the metals sample trains.

6.0 DISCUSSION OF HCl AND SO_2 REMOVAL RELATIONSHIP

A total of forty-two test runs were performed at Units 1, 2 and 3 during the compliance test program. The results for each unit have been presented separately in Sections 3, 4 and 5. The purpose of this section is to present the results in a composite manner so that the similarities between the HCl/SO_2 removal performance for the three units can be observed, and any apparent differences can be discussed further. The relationships between HCl and SO_2 emission concentrations are also presented, as well as the relationships between sorbent rate, emission concentrations, and removal efficiencies.

The HCl and SO_2 test results for all three units are presented in Tables 6-1 to 6-3. These data have been presented previously, and are repeated here for convenience of reference. The HCl and SO_2 removal relationships for the three units is shown in Figure 6-1. The best-fit correlation for HCl removal as a function of SO_2 removal is almost identical for Units 2 and 3, while the predicted HCl removal at Unit 1 is considerably less for SO_2 removals less than 70 percent. Above 70 percent SO_2 removal, the HCl removal performance for Unit 1 is predicted to be better than Units 2 and 3. While there is a significant amount of scatter in the data there does appear to be a definite grouping of data points for Unit 1 for SO_2 removals less than 70 percent.

One possible explanation for the apparent difference in HCl removal performance for Unit 1 is the differences in acid gas concentrations that were present during testing at the three units. The HCl and SO_2 concentrations at the SDA inlet at Unit 1 were generally higher than those at Units 2 and 3. The average SO_2 concentration on October 12 was 179 ppmv at 12% CO_2 versus an average of 108 and 138 ppmv for Units 2 and 3 respectively. This is a difference of about 30 to 66 percent more SO_2 present in the inlet stream. The average HCl concentration on October 12 was 769 ppm at 12% CO_2 versus 503 and 610 ppm for Units 2 and 3, which is a difference of 26 to 53% more HCl at Unit 1. In addition, the average steam rate and therefore, the average flue gas rate was about 20 percent higher during Unit 1 tests. The combination of higher concentrations of inlet acid gases and a higher flue gas rate resulted in generally lower molar ratios of calcium to acid gas for Unit 1 tests, as is shown in Table 6-4.

TABLE 6-1. HCl AND SO2 FOR UNIT 1 AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/28/89	1	251.7	26.17	80.8	13.4	309.5	32.9	99.3	16.9	89.36	83.03
1B	09/28/89	1	524.1	38.80	90.2	43.0	685.1	51.3	117.9	56.9	92.51	51.75
1C	09/28/89	1	442.7	53.52	106.0	60.4	515.7	64.4	123.5	72.6	87.52	41.19
2A	09/28/89	1	220.5	53.12	106.0	69.6	272.5	67.4	131.0	88.3	75.27	32.59
2B	09/28/89	1	[a][335.4]	79.68	161.0	104.0		89.4	175.6	116.6		33.59
2C	09/28/89	1	682.6	142.05	177.0	102.0	772.8	165.5	200.4	118.8	78.58	40.69
2D	09/28/89	1	587.0	91.48	139.0	50.9	677.3	109.8	160.4	61.1	83.79	61.92
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	1	451.4	67.5	116.5	56.6	538.8	82.9	144.0	75.9	84.5	49.3
1	10/12/89	1	522.3	38.46	165.0	36.2	659.7	49.1	208.4	46.2	92.56	77.83
2	10/12/89	1	548.1	42.44	166.5	47.7	730.8	57.2	222.0	64.3	92.17	71.03
3	10/12/89	1	728.7	57.02	157.0	58.9	1041.0	80.5	224.3	83.2	92.27	62.93
4	10/12/89	1	678.9	68.66	203.0	72.4	662.3	74.2	198.0	78.3	88.79	60.48
5	10/12/89	1	[b][2.7]	80.86	165.1	89.0		86.6	167.9	95.4		43.21
6	10/12/89	1	543.3	60.86	155.0	45.6	577.0	66.4	164.6	49.7	88.49	69.78
7	10/12/89	1	1225.3	61.04	163.0	45.6	1301.2	67.2	173.1	50.2	94.84	71.00
8	10/12/89	1	547.4	64.96	141.0	58.0	625.6	75.0	161.1	66.9	88.02	58.47
9	10/12/89	1	548.2	104.00	114.0	63.4	685.3	130.0	142.5	79.3	81.03	44.39
10	10/12/89	1	602.6	98.12	148.0	70.5	716.0	118.9	175.8	85.5	83.39	51.40
11	10/12/89	1	590.9	68.13	148.0	60.3	723.6	84.3	181.2	74.6	88.35	58.84
12	10/12/89	1	572.8	43.54	141.5	19.4	680.6	53.3	168.1	23.8	92.17	85.87
13	10/12/89	1	664.9	39.86	115.0	22.8	822.6	48.3	142.3	27.6	94.13	80.57
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	1	647.8	62.3	151.4	50.1	768.8	76.2	179.2	63.5	89.7	64.3
OVERALL AVERAGE		1	582.3	64.0	139.8	52.2	692.1	78.6	166.9	67.8	88.0	59.0

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[a] [] Run rejected - failed post-test leak check.

[b] [] Run rejected - apparent sample or analysis error.

TABLE 6-2. HCl AND SO2 FOR UNIT 2 AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	09/26/89	2	419.4	14.7	127.0	11.5	481.6	17.5	145.8	13.6	96.37	90.65
1B	09/26/89	2	347.6	73.8	88.2	44.6	431.4	100.7	109.5	60.8	76.66	44.46
1C	09/26/89	2	515.8	76.5	62.4	47.4	684.0	105.7	82.7	65.4	84.55	20.84
1D	09/26/89	2	[a][252.0]	78.5	121.1	58.8		92.0	124.3	69.0		44.49
1E	09/26/89	2	573.6	63.6	105.9	54.8	636.8	77.6	117.6	66.8	87.82	43.15
2A	09/26/89	2	421.6	46.7	94.0	23.1	509.5	60.5	113.6	29.9	88.13	73.68
2B	09/26/89	2	426.9	33.3	73.6	18.9	556.9	46.8	96.0	26.5	91.59	72.37
2C	09/26/89	2	403.7	20.6	75.7	60.4	465.8	26.0	87.3	76.1	94.43	12.84
2D	09/26/89	2	398.7	43.1	85.2	31.5	501.5	57.8	107.2	42.3	88.47	60.55
3A	09/26/89	2	498.2	27.4	92.1	46.4	519.9	32.0	96.1	54.1	93.85	43.70
3B	09/26/89	2	503.5	57.7	94.3	33.2	551.8	69.4	103.3	39.9	87.43	61.37
3C	09/26/89	2	172.8	52.8	98.1	36.7	191.0	64.4	108.4	44.8	66.30	58.71
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	2	425.6	46.4	90.6	37.1	502.7	62.5	107.7	49.1	86.9	52.2

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[a] [] Run rejected - no heat on sample probe.

TABLE 6-3. HCl AND SO2 FOR UNIT 3 AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

			AS MEASURED				NORMALIZED TO 12% CO2				HCl	SO2
RUN NUMBER	DATE	UNIT NUMBER	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	INLET HCl (ppmV)	OUTLET HCl (ppmV)	INLET SO2 (ppmV)	OUTLET SO2 (ppmV)	REMOVAL EFFICIENCY (%)	REMOVAL EFFICIENCY (%)
1A	10/02/89	3	482.5	57.5	120.0	54.7	536.1	65.7	133.3	62.5	87.75	53.11
1B	10/02/89	3	465.1	88.5	102.0	80.4	600.1	113.0	131.6	102.6	81.17	22.02
1C	10/02/89	3	[a][419.5]	113.6	109.0	56.0		151.5	148.6	74.7		49.77
2A	10/02/89	3	491.1	75.1	116.0	35.5	677.4	100.2	160.0	47.3	85.21	70.42
2B	10/02/89	3	371.4	40.9	110.0	23.0	479.3	52.2	141.9	29.4	89.12	79.31
2C	10/02/89	3	478.5	43.0	119.0	27.3	617.4	53.8	153.5	34.1	91.29	77.78
3A	10/02/89	3	378.4	35.5	84.0	24.1	522.0	47.9	115.9	32.5	90.83	71.95
3B	10/02/89	3	542.6	38.0	108.0	31.4	638.4	45.2	127.1	37.3	92.93	70.64
3C	10/02/89	3	487.7	69.4	115.0	50.4	609.6	85.9	143.8	62.4	85.91	56.63
3D	10/02/89	3	573.7	49.2	85.3	40.8	809.9	67.9	120.4	56.3	91.62	53.27
			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	AVERAGE	3	474.6	55.2	106.6	40.8	610.0	78.3	137.6	53.9	88.4	60.5

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[a] [] Run rejected - failed post-test leak check.

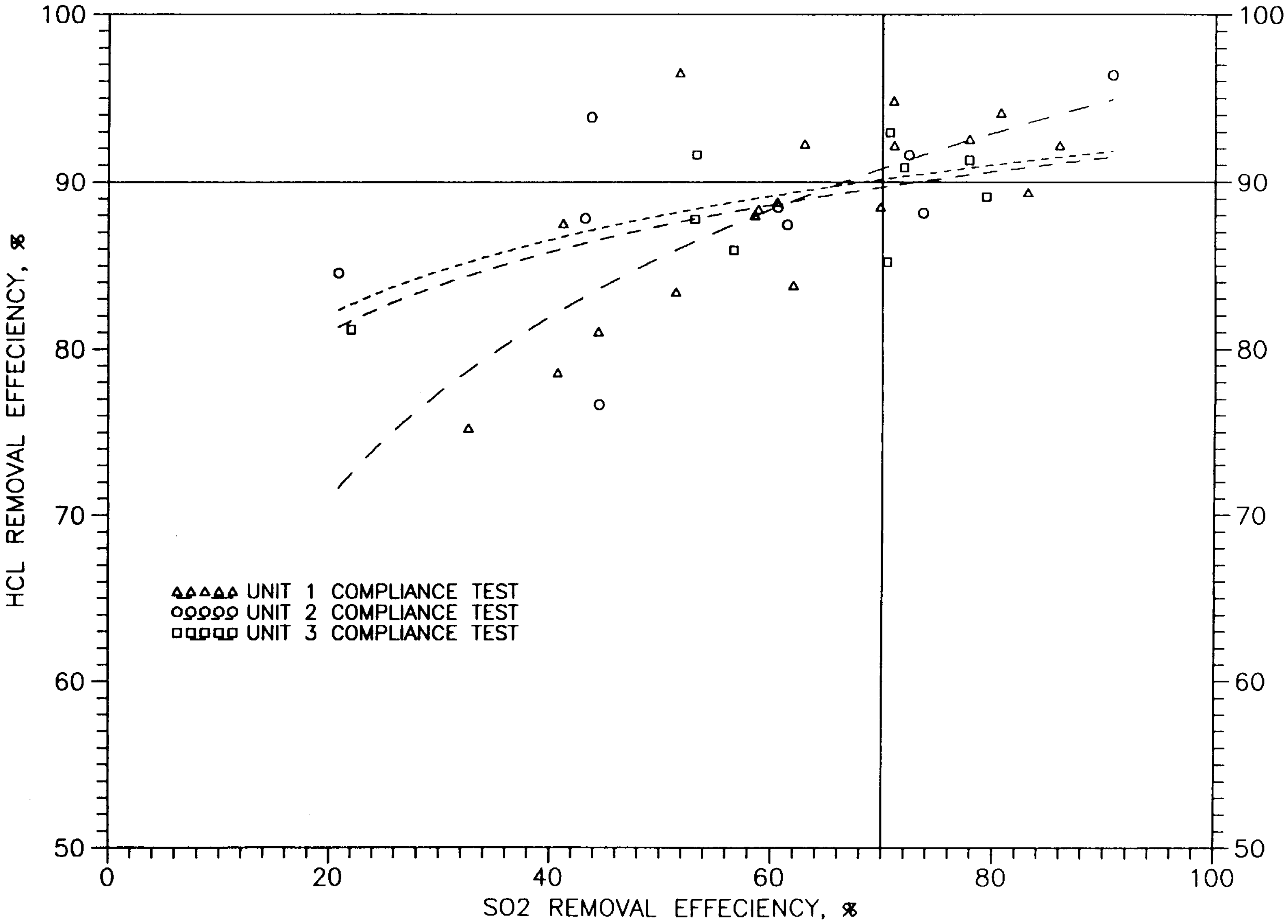


Figure 6-1. HCl Removal versus SO2 Removal

TABLE 6-4. SUMMARY OF SPRAY DRYER ABSORBER OPERATION, UNITS 1,2, AND 3

RUN	UNIT	BOILER OUTLET TEMP. (deg. F)	SDA OUTLET TEMP. (deg. F)	STACK TEMP. (deg. F)	STEAM FLOW (Klb/hr)	STACK FLOW RATE (dscfm)	SLURRY FLOW (gpm)	SLURRY SPECIFIC GRAVITY	SLURRY SOLIDS CONTENT %	CaO MASS RATE (lb/hr)	INLET HCl		INLET SO2		MOLAR RATIO (moles CaO to moles acid gas)	REMOVAL EFFICIENCY		OUTLET CONCENTRATION	
											CONC. (ppmv)	MASS RATE (lb/hr)	CONC. (ppmv)	MASS RATE (lb/hr)		HCl (%)	SO2 (%)	HCl @12% CO2 (ppmv)	SO2 (ppmv)
1A	1	438	308	320	189.4	101000	11.5	1.043	7.5	414	252	144	81	81	2.27	89.36	83.03	32.9	16.9
1B	1	442	308	308	186.4	101000	4.8	1.043	7.5	173	524	301	90	91	0.56	92.51	51.75	51.3	56.9
1C	1	449	314	299	202.8	101000	4.8	1.043	7.5	173	443	254	106	107	0.60	87.52	41.19	64.4	72.6
2A	1	455	314	319	208.9	101000	4.5	1.043	7.5	162	221	126	106	107	0.85	75.27	32.59	67.4	88.3
2B	1	455	320	318	236.8	101000	5.0	1.043	7.5	180			161	162			33.59	89.4	116.6
2C	1	440	320	312	187.2	101000	5.0	1.043	7.5	180	683	392	177	178	0.39	78.58	40.69	165.5	118.8
2D	1	460	320	324	217.2	101000	12.0	1.043	7.5	432	587	337	139	140	1.13	83.79	61.92	109.8	61.1
	AVERAGE	448	315	314	204.1	101000	6.8	1.043	7.5	245	451	222	123	124	0.83	84.51	49.25	83.0	75.89
1	1	465	322	305	231.6	121000	15.3	1.040	7.0	513	522	359	165	199	1.14	92.56	77.83	49.1	46.2
2	1	472	325	310	225.2	121000	14.4	1.040	7.0	482	548	377	167	201	1.04	92.17	71.03	57.2	64.3
3	1	471	320	311	209.8	121000	14.2	1.040	7.0	476	729	501	157	190	0.86	92.27	62.93	80.5	83.2
4	1	448	306	292	237.2	121000	6.4	1.040	7.0	214	679	467	203	245	0.37	88.79	60.48	74.2	78.3
5	1	449	310	292	242.0	121000	3.9	1.040	7.0	131			165	199			43.21	86.6	95.4
6	1	448	311	291	239.9	121000	11.3	1.040	7.0	379	543	373	155	187	0.84	88.49	69.78	66.4	49.7
7	1	447	308	292	233.5	121000	9.5	1.040	7.0	318	1225	842	163	197	0.39	94.84	71.00	67.2	50.2
8	1	461	313	294	240.4	121000	8.2	1.040	7.0	275	547	376	141	170	0.63	88.02	58.47	75.0	66.9
9	1	472	318	304	240.6	121000	8.8	1.040	7.0	295	548	377	114	138	0.72	81.03	44.39	130.0	79.3
10	1	479	317	307	244.4	121000	12.8	1.040	7.0	429	603	414	148	179	0.90	83.39	51.40	118.9	85.5
11	1	479	314	306	237.8	121000	11.0	1.040	7.0	369	591	406	148	179	0.79	88.35	58.84	84.3	74.6
12	1	475	302	298	229.4	121000	10.7	1.040	7.0	358	573	394	142	171	0.79	92.17	85.87	53.3	23.8
13	1	467	304	293	219.5	121000	7.7	1.040	7.0	258	665	457	115	139	0.55	94.13	80.57	48.3	27.6
	AVERAGE	464	313	300	233.2	121000	10.3	1.040	7.0	346	648	411	152	184	0.69	89.68	64.29	76.2	63.46
1A	2	424	306	290	190.0	105000	15.0	1.056	9.6	700	419	250	127	133	2.27	96.37	90.65	17.5	13.6
1B	2	433	308	292	197.5	105000	8.6	1.056	9.6	401	348	207	88	92	1.67	76.66	44.46	100.7	60.8
1C	2	434	307	292	194.8	105000	8.6	1.056	9.6	401	516	308	62	65	1.37	84.55	20.84	105.7	65.4
1D	2	442	308	295	228.6	105000	5.0	1.056	9.6	233			121	127			44.49	92.0	69.0
1E	2	448	306	292	227.9	105000	5.0	1.056	9.6	233	574	342	106	111	0.65	87.82	43.15	77.6	66.8
2A	2	446	310	296	204.5	105000	6.0	1.056	9.6	280	422	251	94	99	1.00	88.13	73.68	60.5	29.9
2B	2	446	305	296	189.8	105000	6.0	1.056	9.6	280	427	255	74	77	1.06	91.59	72.37	46.8	26.5

TABLE 6-4. SUMMARY OF SPRAY DRYER ABSORBER OPERATION, UNITS 1,2, AND 3 (continued)

RUN	UNIT	BOILER OUTLET TEMP. (deg. F)	SDA OUTLET TEMP. (deg. F)	STACK TEMP. (deg. F)	STEAM FLOW (Klb/hr)	STACK FLOW RATE (dscfm)	SLURRY FLOW (gpm)	SLURRY SPECIFIC GRAVITY	SLURRY SOLIDS CONTENT %	CaO MASS RATE (lb/hr)	INLET HCl CONC. (ppmv)	INLET HCl MASS RATE (lb/hr)	INLET SO2 CONC. (ppmv)	INLET SO2 MASS RATE (lb/hr)	MOLAR RATIO (moles CaO to moles acid gas)	REMOVAL EFFICIENCY HCl (%)	REMOVAL EFFICIENCY SO2 (%)	OUTLET CONCENTRATION HCl @12% CO2 (ppmv)	OUTLET CONCENTRATION SO2 @12% CO2 (ppmv)
2C	2	454	342	307	224.8	105000	6.0	1.056	9.6	280	404	241	76	79	1.10	94.43	12.84	26.0	76.1
2D	2	448	320	304	197.1	105000	6.0	1.056	9.6	280	399	238	85	89	1.07	88.47	60.55	57.8	42.3
3A	2	454	317	309	215.6	105000	5.5	1.056	9.6	257	498	297	92	97	0.82	93.85	43.70	32.0	54.1
3B	2	451	314	305	221.2	105000	5.5	1.056	9.6	257	504	300	94	99	0.81	87.43	61.37	69.4	39.9
3C	2	450	316	304	218.8	105000	5.5	1.056	9.6	257	173	103	98	103	1.52	66.30	58.71	64.4	44.8
	AVERAGE	444	313	299	209.2	105000	6.9	1.056	9.6	322	426	233	93	98	1.11	86.87	52.23	62.5	49.1
1A	3	442	315	294	232.5	101000	4.3	1.039	6.7	138	483	277	120	121	0.43	87.75	53.11	65.7	62.5
1B	3	444		292	218.0	101000	4.5	1.039	6.7	144	465	267	102	103	0.49	81.17	22.02	113.0	102.6
1C	3	452	331	304	218.6	101000	9.3	1.039	6.7	298			109	110			49.77	151.5	74.7
2A	3	454	328	297	223.4	101000	14.6	1.039	6.7	468	491	282	116	117	1.47	85.21	70.42	100.2	47.3
2B	3	454	314	302	217.6	101000	14.6	1.039	6.7	468	371	213	110	111	1.79	89.12	79.31	52.2	29.4
2C	3	454		299	221.8	101000	14.6	1.039	6.7	468	479	275	119	120	1.48	91.29	77.78	53.8	34.1
3A	3	453	318	302	213.2	101000	10.4	1.039	6.7	333	378	217	84	85	1.38	90.83	71.95	47.9	32.5
3B	3	455		304	238.5	101000	10.4	1.039	6.7	333	543	311	108	109	1.00	92.93	70.64	45.2	37.3
3C	3			302	234.8	101000	10.4	1.039	6.7	333	488	280	115	116	1.05	85.91	56.63	85.9	62.4
3D	3			302		101000	10.4	1.039	6.7	333	574	329	85	86	1.01	91.62	53.27	67.9	56.3
	AVERAGE	451	321	300	224.3	101000	10.4	1.039	6.7	332	475	245	107	108	1.12	88.43	60.49	78.3	53.9

The relationship between HCl emission concentration and SO_2 emission concentration for the three units is shown in Figure 6-2.

As expected, there is a large degree of data scatter for the concentration relationship. However, it does not appear that a distinct difference is present for the emissions from Units 1, 2, or 3. At higher SO_2 and HCl emission concentrations (which correspond generally to lower removals), the predicted performance for Unit 1 falls between that for Units 2 and 3.

The relationships between the molar ratio of calcium to acid gas is shown in Figures 6-3 and 6-4 for HCl and SO_2 removal efficiency, and in Figures 6-5 and 6-6 for HCl and SO_2 emission concentration.

As can be observed in Figures 6-3 and 6-4, the molar ratio of sorbent does not appear to have a strong effect on the HCl removal that is achieved, while the SO_2 removal appears definitely to be a function of relative amount of lime that is used. During these tests there was no attempt to closely control the temperature at the spray dryer exit. It is probable that variations in SDA exit temperature account for part of the data scatter present in Figures 6-3 and 6-4.

The same general trends are present for the relationships between molar ratio and the HCl and SO_2 emission concentrations. For Units 1 and 3, the HCl emission concentration may be a weak function of molar ratio, while the SO_2 emission concentration appears to have a much stronger trend.

These results show that the surrogate SO_2 monitoring approach provides a reliable measure of HCl removal. The fact that SO_2 emission concentration and removal efficiency are a function of molar ratio provides a process control loop so that the slurry flow can be adjusted to achieve a minimum of 70 percent SO_2 removal on a continuous basis. The relationships between HCl and SO_2 removal show that, on an average basis, when the SO_2 removal is maintained at a minimum of 70 percent, the HCl removal will be at least 90 percent.

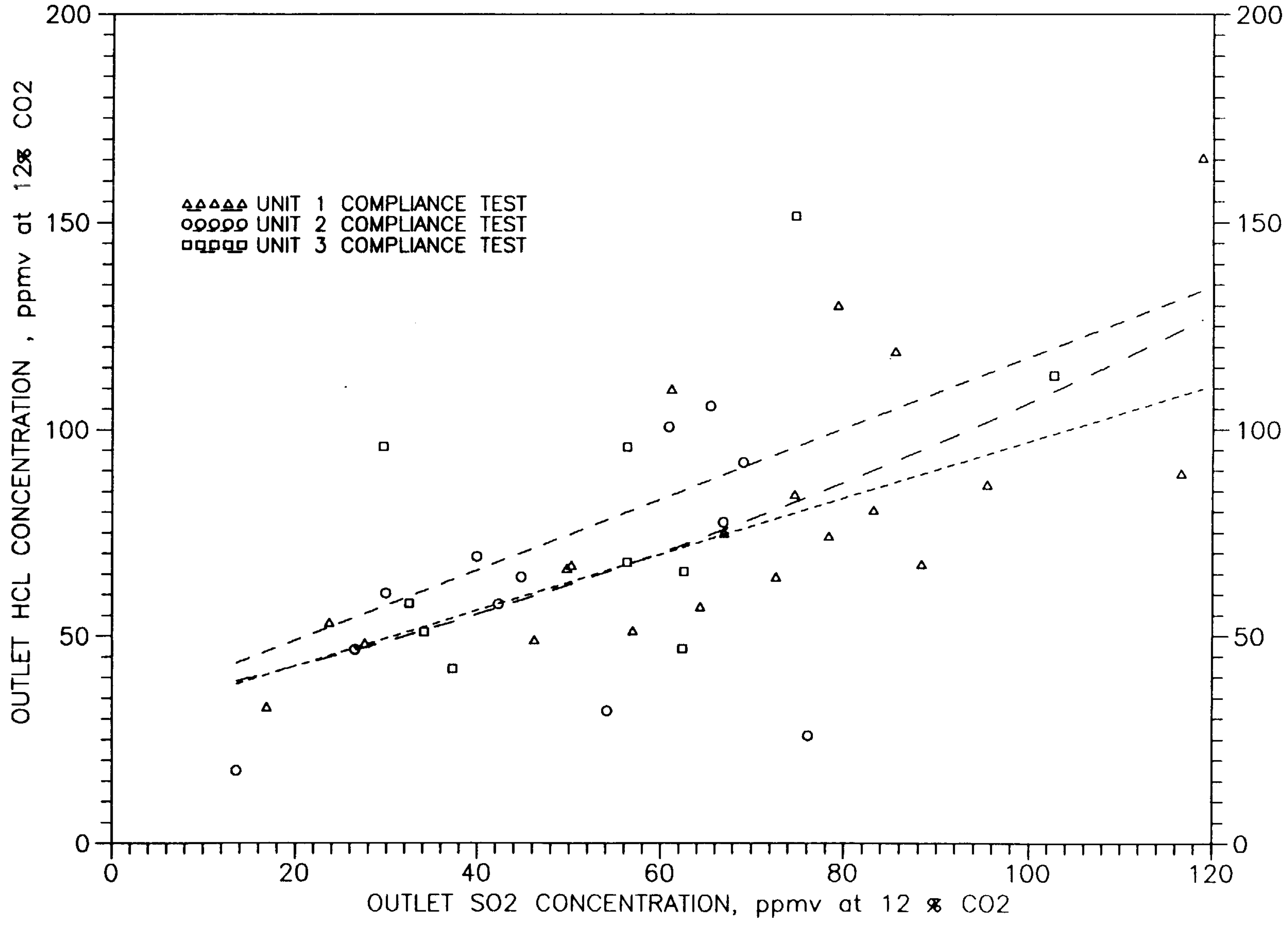


Figure 6-2. HCl Emission Concentration versus SO2 Emission Concentration

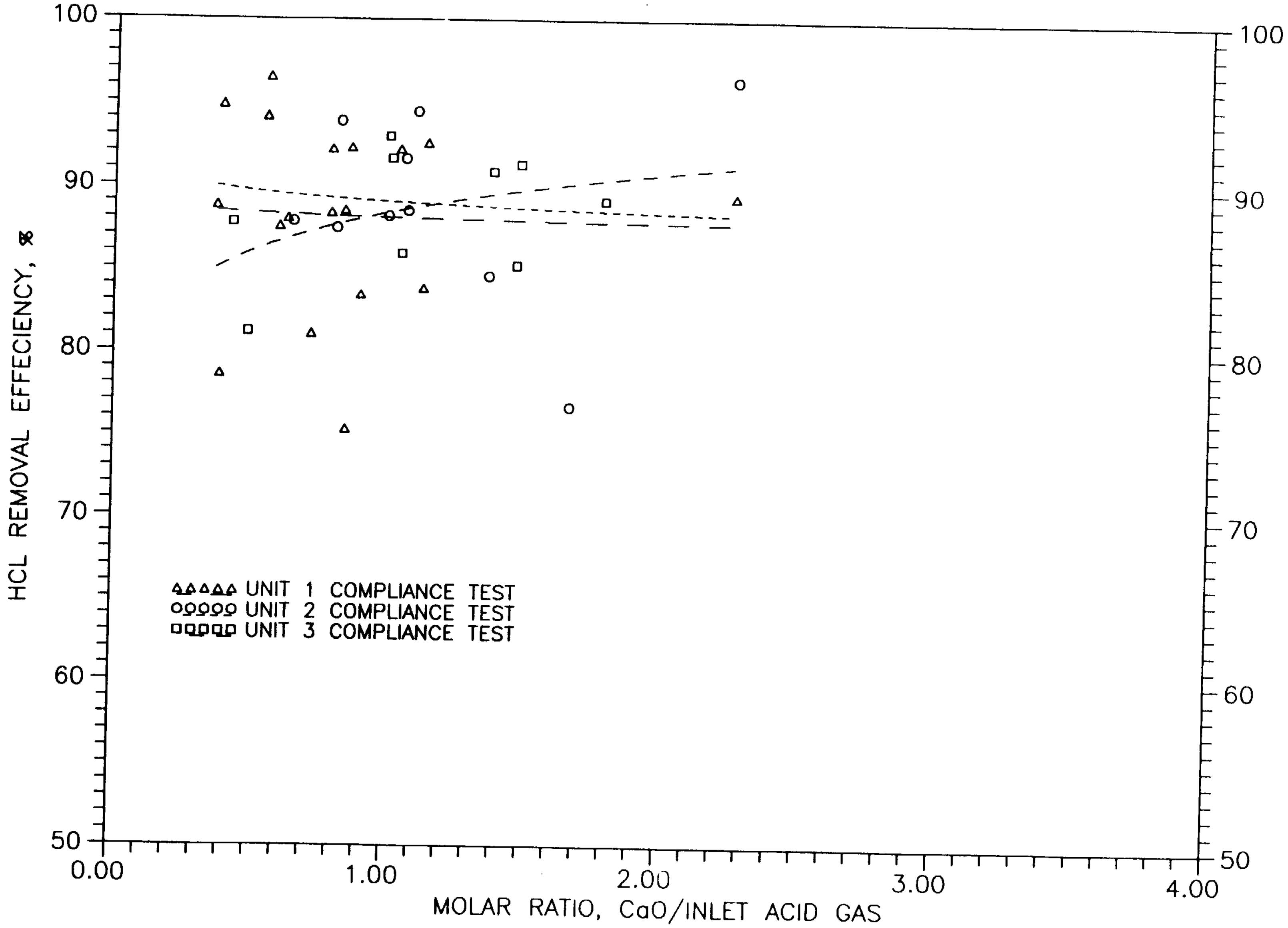


Figure 6-3. Molar Ratio versus HCl Removal Efficiency

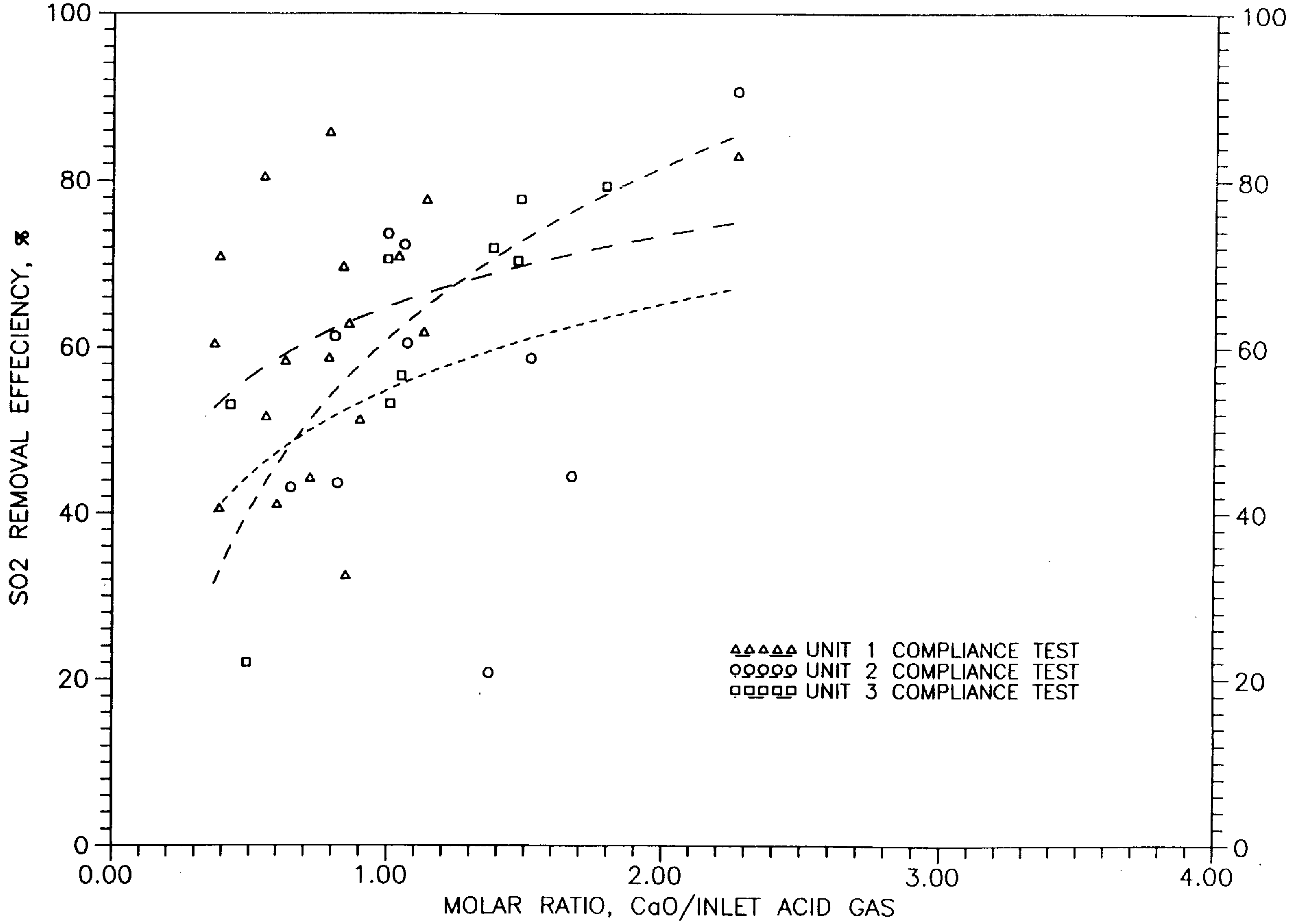


Figure 6-4. Molar Ratio versus SO2 Removal Efficiency

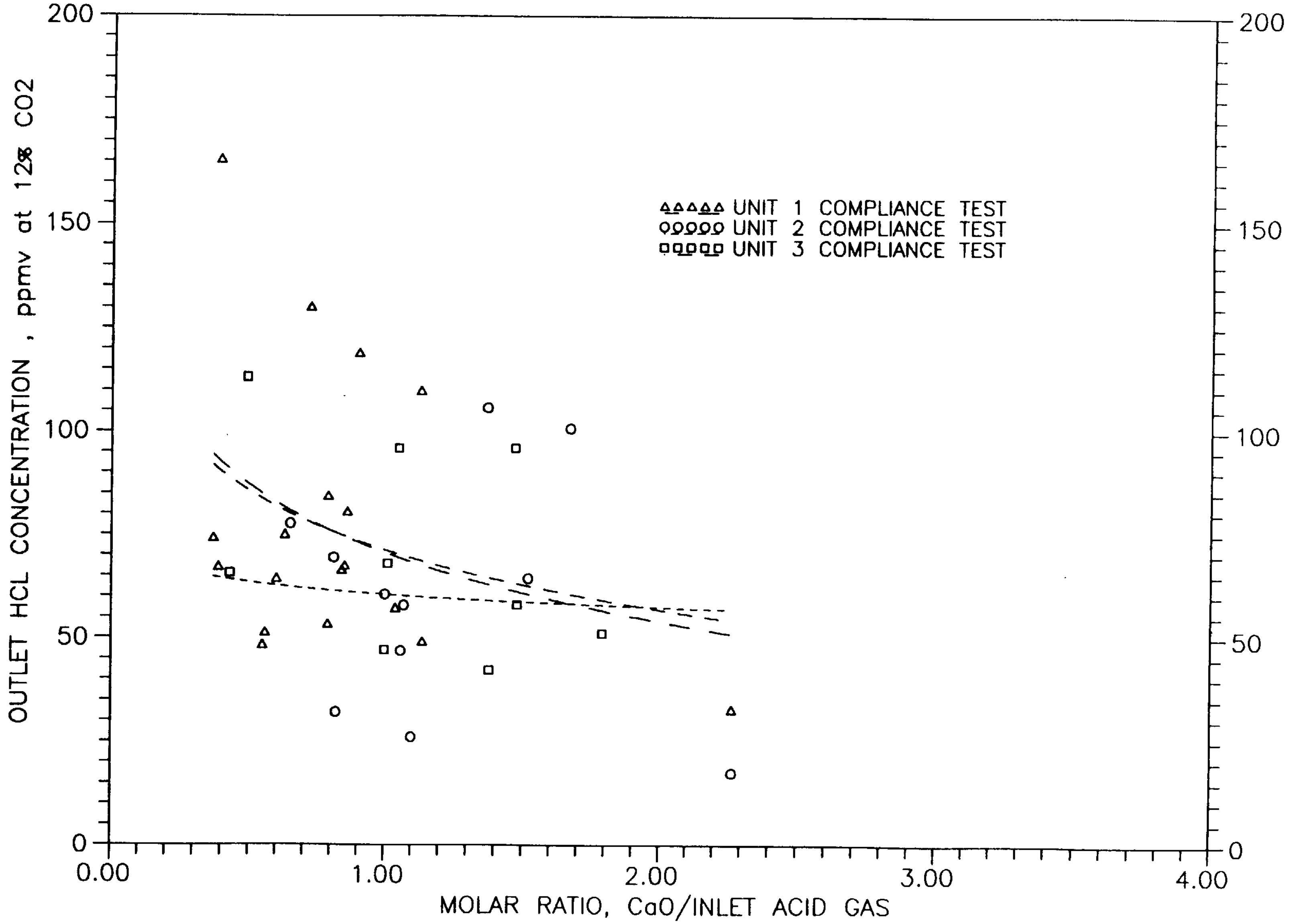


Figure 6-5. Molar Ratio versus HCl Emission Concentration

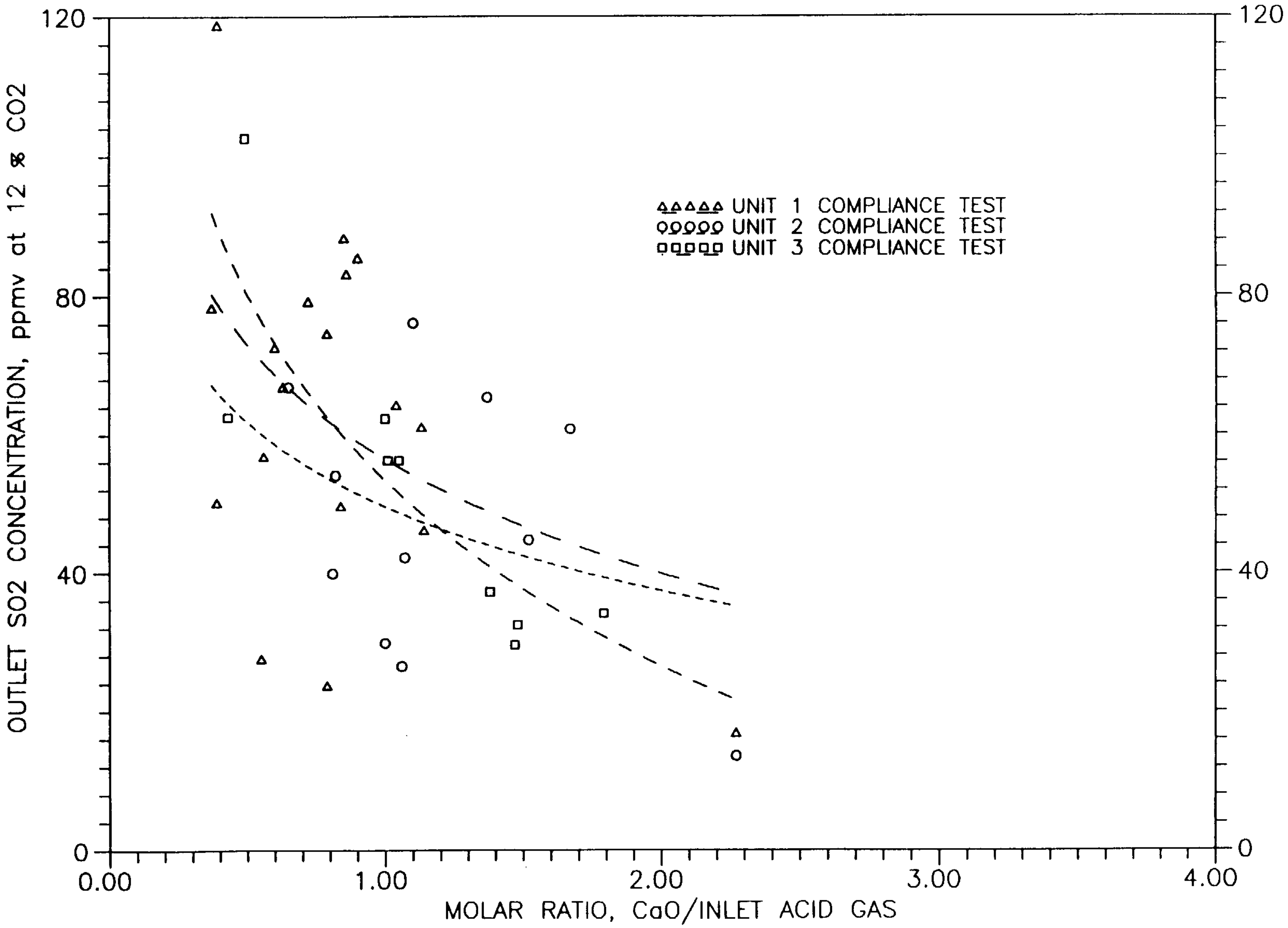


Figure 6-6. Molar Ratio versus SO2 Emission Concentration

7.0 FURNACE TEMPERATURE PROFILE RESULTS

The special conditions of the permit for the Hempstead Resource Recovery Facility require that the flue gas temperature in the furnace be maintained above 1500°F after the last point of overfire air injection. In addition, the permit provides for the use of a surrogate indicator if the temperature cannot be measured at the last point of overfire air injection. At the Hempstead facility, the temperature at the top of the first pass of the boiler has been selected as the surrogate furnace temperature. The thermocouples at the top of the first pass are located at 208 ft elevation.

Overfire air nozzles are located at the 146 foot, 8 inch level in the furnace. The only test ports that provided acceptable access for a traverse of the first pass cross-section are located at 165 foot elevation. At this location, about 18 feet of vertical distance is available for combustion gas and overfire air mixing to occur and for the furnace gases to cool.

Since the temperature at the last point of overfire air injection (the 147' elevation) could not be measured, an alternate approach is necessary to determine that temperature. The measurements at the top of the first pass and at the 165 ft elevation are used to determine the temperature profile curves for the first pass. The temperature profile curves are based on the principle that the temperature change in the furnace first pass is linear between the overfire air ports and the superheater. The linear regression between the two measured temperatures at the two elevations can be extrapolated to the overfire air port elevation. The temperature at the 147 ft level can then be calculated from these curves.

The furnace cross-section at the 165 foot elevation is shown in Figure 7-1. Three test ports are located on each side of the first pass. The flue gas temperature was recorded at 30 second intervals for 5 minutes at each

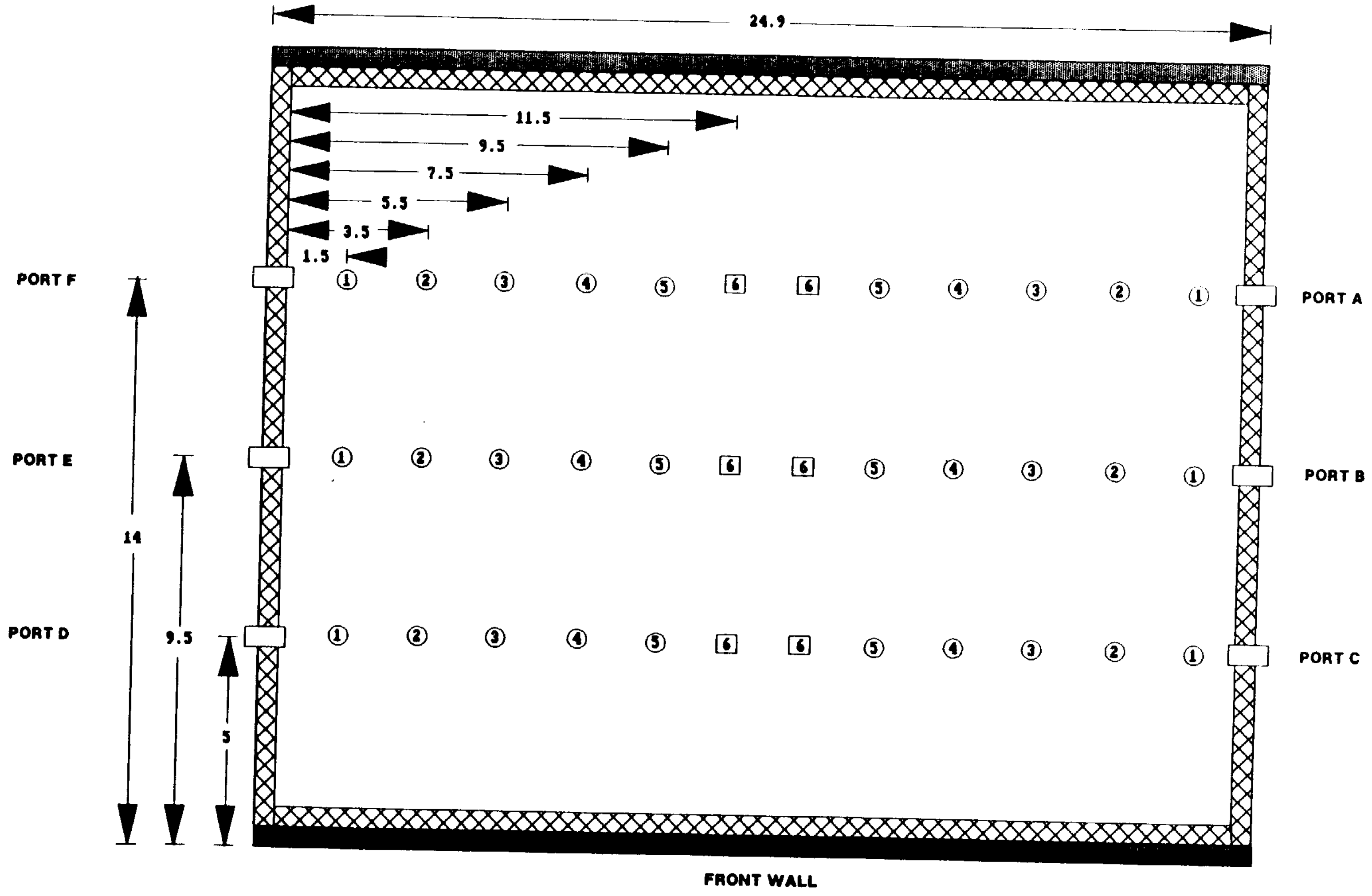


FIGURE 7-1. FURNACE CROSS SECTION AND TRAVERSE POINT LAYOUT, UNIT 2.
AMERICAN REF-FUEL/HEMPSTEAD FACILITY (Oct 1989)
(All Dimensions In Feet)

of 5 test points in each port. The corresponding top of first pass temperatures were recorded at 1 minute intervals using the Bailey NET 90™ data acquisition system.

The temperature at the 165 ft level was measured using a water cooled high velocity thermocouple (HVT) with multiple shields. The sensing element was a Type K thermocouple. In this device, the sensing element is shielded from the surrounding radiant heat loss sinks by ceramic sleeves. The flue gas is drawn past the sensing element using an air-driven aspirator.

The traverse point layout used for the measurements is also shown in Figure 7-1. Because of backspace limitations, the full cross-section could not be reached with the maximum length probe that could be used. The center of the furnace could not be reached from either side of the furnace. This is equivalent to one additional traverse point in each port. For the purpose of calculating an average temperature, it was assumed that the point that could not be reached would be the same temperature as Point 5 on each traverse line.

A furnace traverse was performed at 65% and 100% operating capacities. The results of these tests are summarized in Tables 7-1 and 7-2. During the 100% traverse, measurements at all planned traverse points were completed. However, during the 65% traverse, the thermocouple in the HVT was broken during the changeover to Port D. Since a spare was not readily available, testing was concluded without traversing Port D.

The average test results at 65% and 100% loads were used to develop the first pass temperature profiles which are presented in Figure 7-2. A schematic of the furnace and boiler system is also included in Figure 7-2 to provide an illustration of the test points relative to the overfire air ports.

At 65% load, the average temperature at the top of the first pass was 1430°F, with an average traverse temperature result of 1582°F. Using these data in a linear equation, the temperature profile at 65% load is

TABLE 7-1. SUMMARY OF RESULTS FOR FURNACE TRAVERSE TESTS AT 65% LOAD

TRAVERSE POINT NO.	TRAVERSE POINT TEMPERATURE deg. F	FIRST PASS TEMPERATURE deg. F
A1	1516	1378
A2	1391	1369
A3	1308	1321
A4	1417	1340
A5	1526	1325
A6*	1526	1325
B1	1491	1448
B2	1456	1405
B3	1460	1410
B4	1592	1382
B5	1481	1328
B6*	1481	1328
C1	1598	1534
C2	1659	1560
C3	1687	1542
C4	1764	1541
C5	1742	1485
C6*	1742	1485
D1	POINTS IN PORT D WERE NOT MEASURED DUE TO TEST EQUIPMENT FAILURE	
D2		
D3		
D4		
D5		
D6*		
E1	1575	1416
E2	1757	1421
E3	1818	1466
E4	1703	1496
E5	1601	1474
E6*	1601	1474
F1	1502	1478
F2	1403	1424
F3	1603	1418
F4	1659	1453
F5	1693	1435
F6*	1693	1435
AVERAGE	1582	1430

* Value asumed to be the same as point 5 for each port.

TABLE 7-2. SUMMARY OF RESULTS FOR FURNACE TRAVERSE TESTS AT 100% LOAD

TRAVERSE POINT NO.	TRAVERSE POINT TEMPERATURE deg. F	FIRST PASS TEMPERATURE deg. F
A1	2052	1591
A2	1915	1580
A3	1959	1578
A4	2098	1586
A5	1994	1570
A6*	1994	1570
B1	1599	1506
B2	1733	1525
B3	1631	1415
B4	1829	1458
B5	2038	1581
B6*	2038	1581
C1	1551	1374
C2	1536	1658
C3	1722	1366
C4	1809	1414
C5	1957	1534
C6*	1957	1534
D1	1582	1551
D2	1585	1586
D3	1527	1537
D4	1575	1558
D5	1573	1557
D6*	1573	1557
E1	1575	1416
E2	1757	1421
E3	1818	1466
E4	1703	1496
E5	1601	1474
E6*	1601	1474
F1	1502	1478
F2	1403	1424
F3	1603	1418
F4	1659	1453
F5	1693	1435
F6*	1693	1435
AVERAGE	1734	1504

* Value assumed to be the same as point 5 for each port.

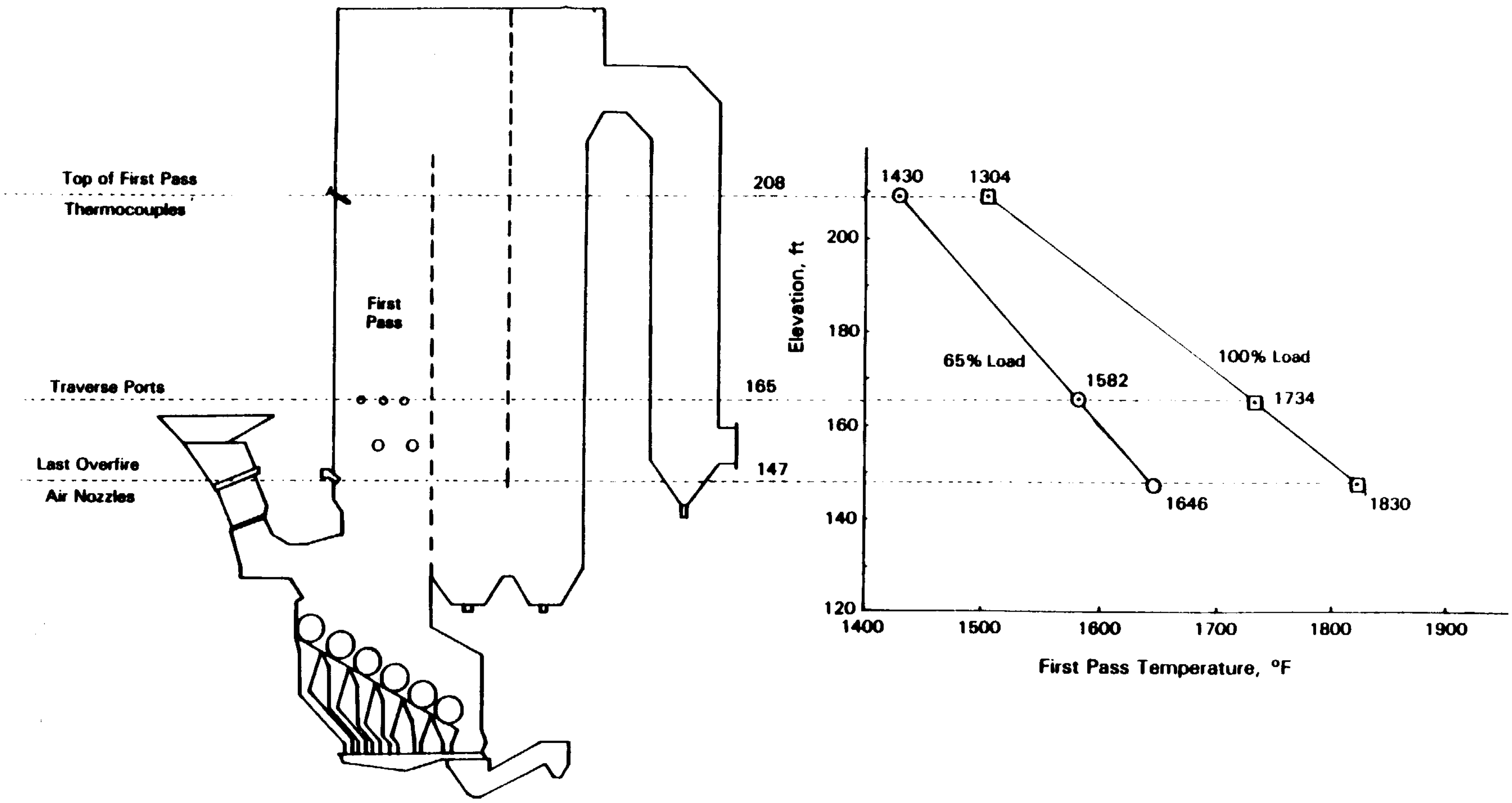


Figure 7-2. First Pass Temperature Profiles at Unit 2, Hempstead Resource Recovery Facility

Temperature = 2165.26 - 3.53488 (height in first pass)

Using this equation, the temperature at the 147 ft level is 1546°F. The ratio of the temperature at the overfire air port level to the surrogate top of first pass temperature is 1.15.

The average temperatures during 100% load testing were 1734°F and 1504°F at the traverse location and at the top of the first pass, respectively. The temperature profile in the first pass at 100 percent load is

Temperature = 2616.56 - 5.3488 (height in first pass)

From this equation, the temperature at the overfire air port level is 1830°F. The ratio of the temperature at the point of last overfire air injection to the surrogate temperature is 1.22.

The field data sheets and complete results are included in Appendix F.

8.0 PROCESS DESCRIPTION

8.1 General Description

The Town of Hempstead Resource Recovery Unit in Hempstead, New York consists of three identical combustion units for the conversion of municipal solid waste into usable energy. The three units are located next to each other and share a common steam turbine generator. Each line is an independent system for firing waste, generating steam, and treating the combustion by-products. The units are equipped with roller grates, natural circulation steam boilers, and air pollution control systems including a cyclone, a dry scrubber and baghouse. Figure 8-1 shows a schematic flow diagram of the process.

8.2 Waste-Fuel Handling

Municipal waste is delivered to the facility's tipping hall by trucks. The trucks are weighed prior to dumping the refuse. Refuse screening is performed by periodic inspections and by surveying the truck drivers to determine the suitability of discharging the refuse. In compliance with the Part 360 regulations for solid waste, untreatable waste such as white goods (refrigerators, ranges, etc.) and other items not suitable for combustion are excluded from the facility.

Waste is dumped into the refuse bunker which is capable of storing up to 13,000 tons. The bunker is totally enclosed and is equipped with two full-span overhead travelling cranes. Each crane is operated from a remote pulpit with dual control capability. The refuse crane operator thoroughly mixes the solid waste in the bunker to promote homogeneity for firing. The operator then transfers the blended waste to the feed hoppers.

Each of the furnace/boiler units has an independent feed hopper which includes a waste delivery chute and a ram feeder. The ram feeders transfer waste to the grates at a controlled rate. Cylinder stroke length

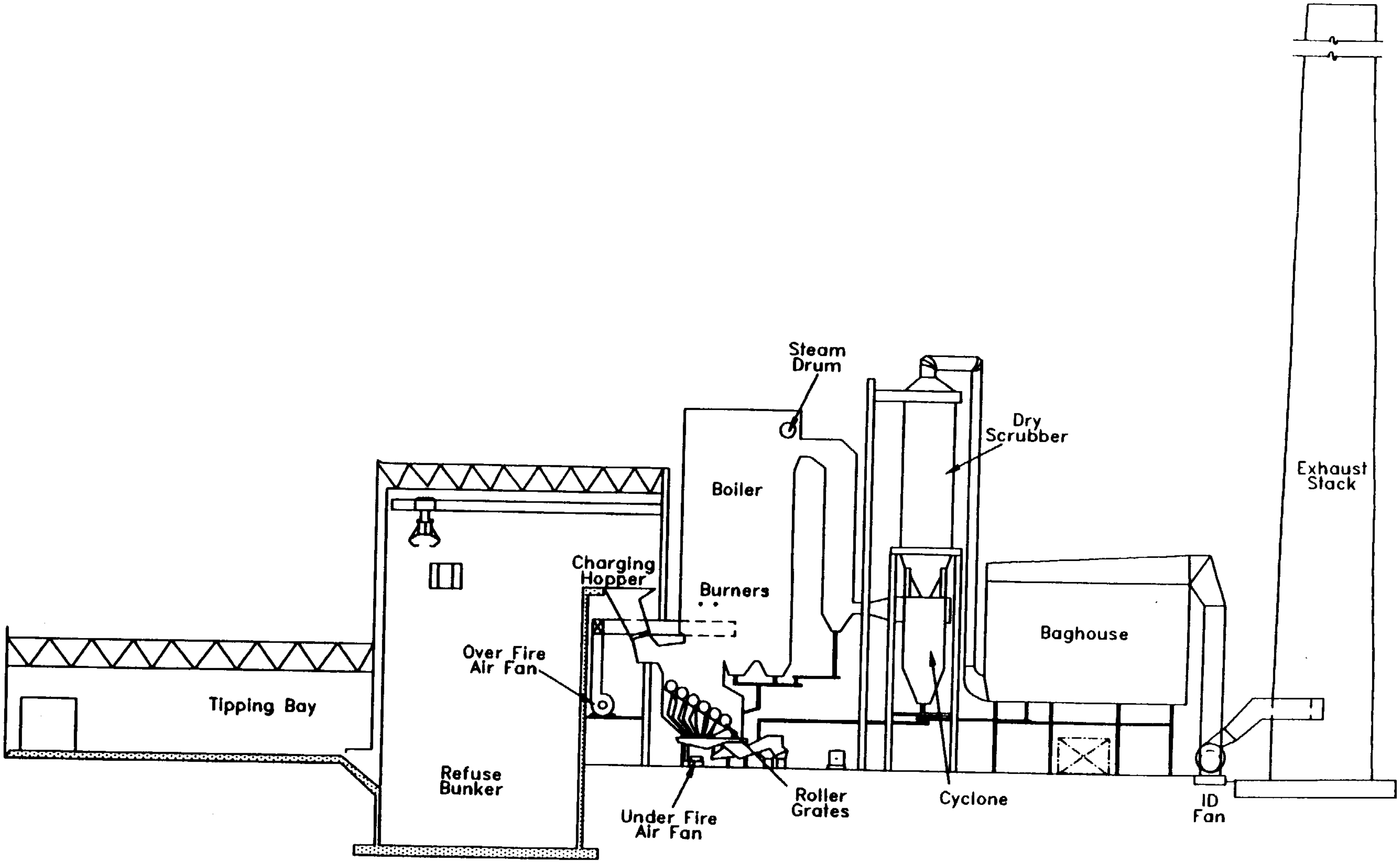


Figure 8-1 Schematic Diagram of One of the Three Identical MSW Systems at the Hempstead Resource Recovery Facility

and cycle speed are varied and controlled to match the refuse characteristics and steam demand.

8.3 Combustion Process

Each mass burn waste-to-energy combustion unit is designed for a heat input rate of 773 tons per day (TPD) of 5200 Btu/lb refuse.

The combustion units utilize Deutsche Babcock Anlagen roller grate system technology. The roller grates consist of six cylindrical rotating rollers. Each roller is independently driven and rotates away from the ram feeder.

Supplemental fuel is used for startup and as required to maintain furnace temperatures. If the temperature in the furnace drops below 1500°F after the last point of overfire air injection, temperature control burners are ignited and remain in service until the cause for the low furnace temperature is corrected. The supplemental fuel is No. 2 distillate oil.

The boiler units are four-pass, natural circulation, water-tube steam generators. The boilers generate steam at 870 psia and 842°F, at a maximum continuous rating of 210,000 lb/hr. All boilers are of a single drum configuration, with one radiation pass, a platen-type superheater section, and a convection generation zone followed by a bare tube economizer. Economizer exit flue gas temperature range is from 432°F to 550°F.

Each combustion unit is designed to operate at a 90% excess air rate. The combustion air supply for each boiler consists of one overfire air fan and one underfire air fan. Primary (underfire) air originates in the refuse bunker, and is distributed to the combustion chamber via ducts, plenums, and dampers. Overfire (secondary) air nozzles are located above the grate in the front and rear walls of the grate enclosure.

8.4 Air Pollution Control System

Each unit is equipped with an air pollution control system incorporating a cyclone, a sorbent injection dry scrubber, and a fabric filter baghouse. The air pollution control devices are a Deutsche Babcock Anlagen design.

Preliminary particulate reduction takes place in the cyclone, thereby decreasing the load on the fabric filters. Larger and heavier particles are removed from the gas stream in the cyclone by impaction and gravitational effects.

Flue gas enters the dry scrubber immediately above the cyclone. Sorbent is injected into the flue gas stream in an aqueous slurry containing hydrated lime ($Ca(OH)_2$) to reduce acid gas emissions. Ten sorbent injection nozzles introduce the sorbent into the dry scrubber. Injection rate is controlled by the acid gas concentration in the flue gas.

The subsequent baghouse consists of twelve fabric filter compartments. The baghouse is of a reverse air design and is designed to reduce the total particulate concentration below 0.01 gr/dscf normalized to 12% CO_2. Exit gas from the fabric filter system is pulled through an induced draft (ID) fan and exhausted to the flue. Each line has a separate 381.5 ft. flue which exhausts the scrubbed gas to the atmosphere. The flues for the three units are enclosed in a common stack shell.

9.0 SAMPLING LOCATIONS

The sampling locations that were used during the compliance test program are shown in Figure 9-1. The types of measurements that were made and the description of each location are discussed below.

9.1 Spray Dryer Inlet

Samples were collected at the spray dryer inlet to measure the flue gas concentration of HCl, SO_2, CO, CO_2, O_2 and moisture. HCl and moisture was measured using an impinger train, and the other species were measured using an extraction continuous instrument system. Measurement of flue gas flow rate was not performed at this location. All of the species measured at this location were gaseous, therefore, duct traversing was not required.

The sampling port was located in an expanding section of ductwork that connects the boiler exit to the cyclone inlet. This location is illustrated in Figure 9-2. This location was expected to be well mixed and no other flue gas dilution streams were near this test point. The sampling port was a 3-inch threaded pipe nipple with a cap.

9.2 Baghouse Outlet

Samples were collected at the baghouse outlet to measure SO_2, CO_2, O_2, NO_x and THC using an extractive instrument system. Flue gas flow rate was not measured at this location.

A CEM probe was installed in one of the 4-inch sampling ports. Each port was fitted with a 150# flange with a blind cover.

The sampling location was downstream of the ID fan in the ductwork connecting the ID fan to the stack flue. No other streams were added prior to this point so the gases were well-mixed and no duct traversing was required.

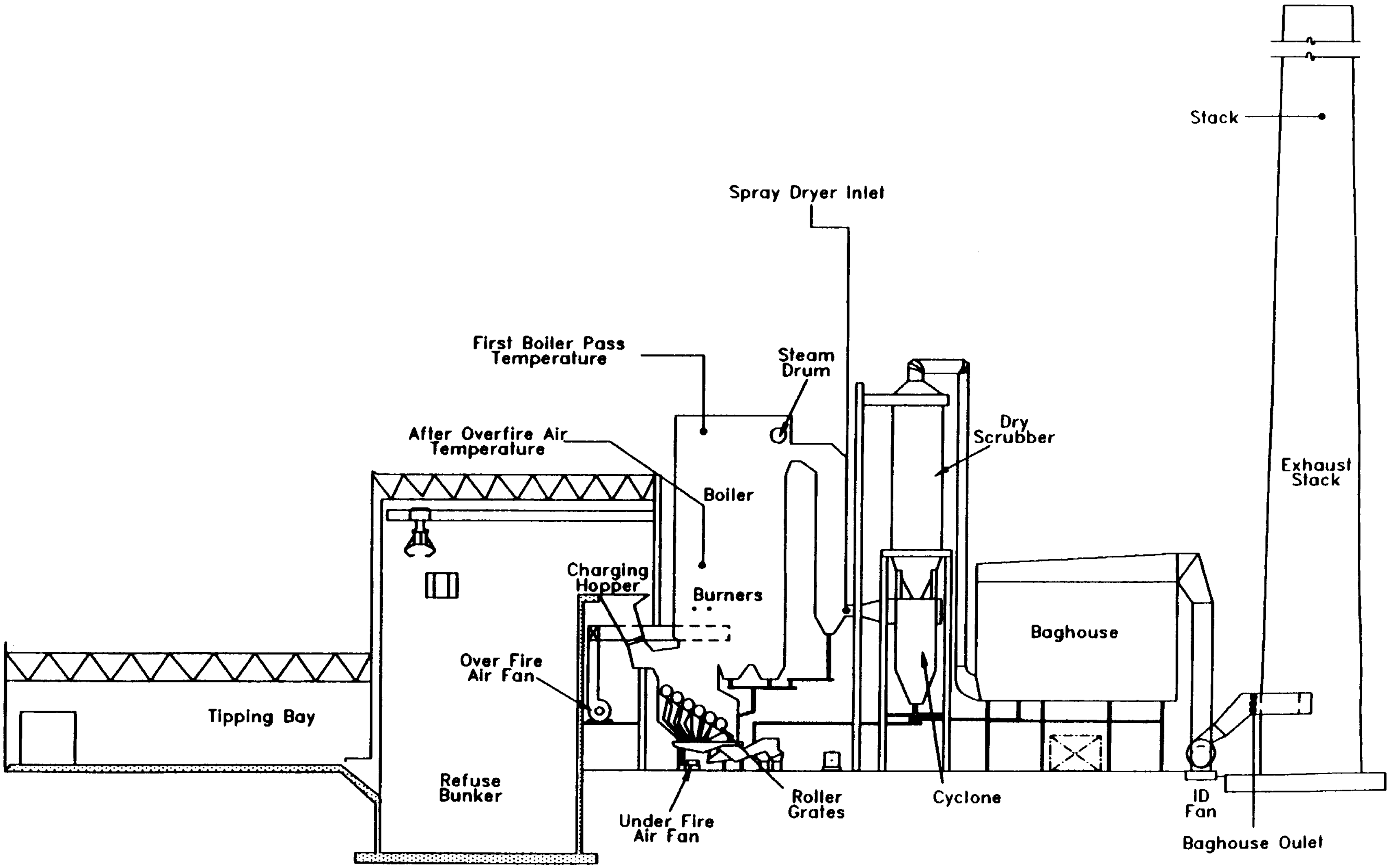


Figure 9-1. Sampling Locations for the Hempstead Resource Facilty

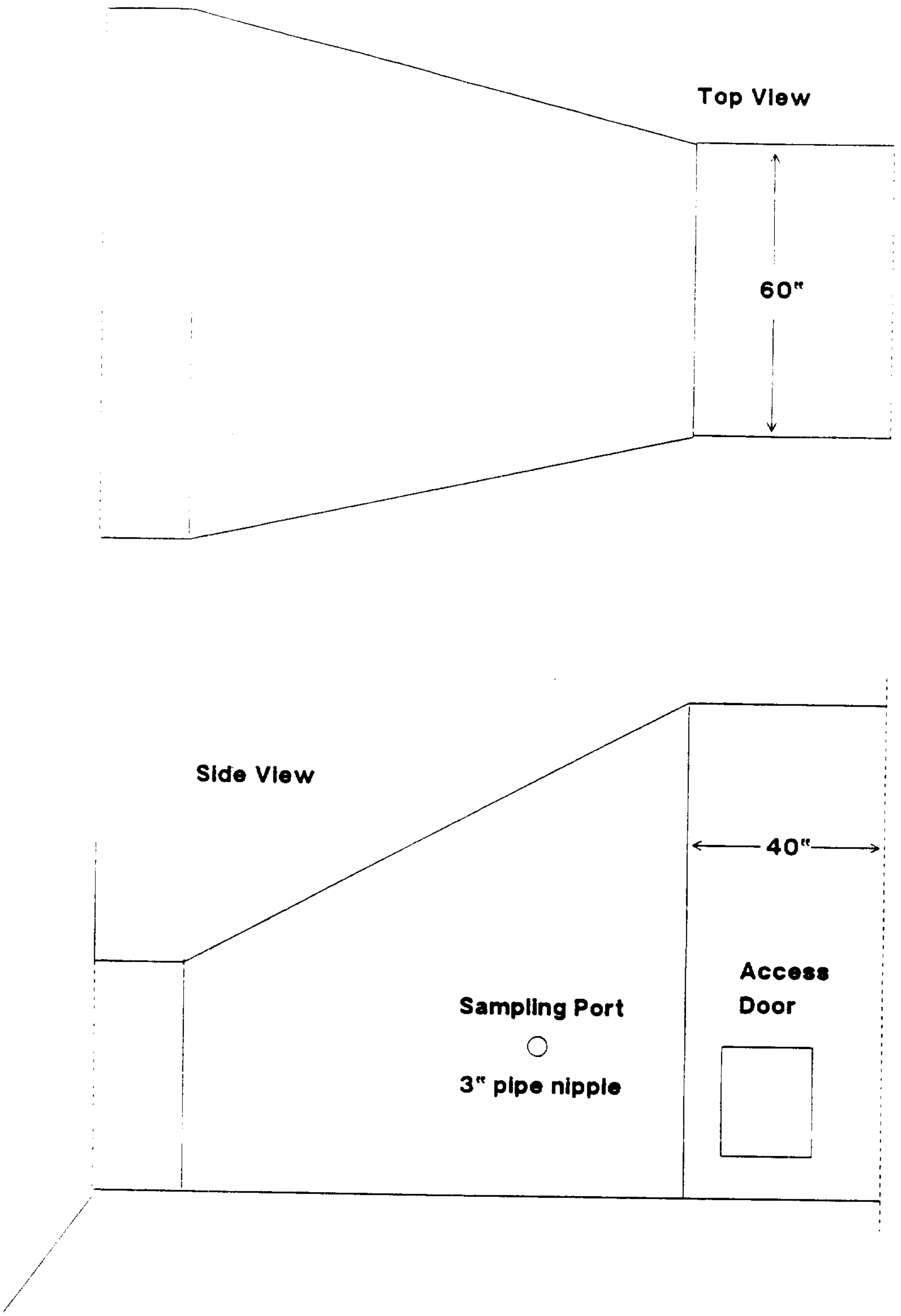


Figure 9-2. Spray Dryer Inlet Sampling Location

9.3 Outlet Stack

Samples were collected at the 202 ft. level platform on the stack to measure particulate, metals, dioxin/furans, HCl, moisture and gas flow rate. The exhaust flues for the three units are identical and are enclosed in a common concrete shell. The flues exhaust scrubbed flue gas to the atmosphere at a height of 381.5 feet above the ground level. Compliance testing was performed 175 feet downstream from the nearest flow disturbance using ports located at a height of 208 feet above ground. This represents 22 effective duct diameters downstream of the nearest disturbance using the stack diameter of 8.0 ft. The nearest downstream disturbance is the exhaust tip which is 22 duct diameters above the sampling point. EPA Method 1 criteria for the minimum number of sampling points requires that the location be eight effective duct diameters downstream and two diameters upstream from the nearest flow disturbances. The three stack sampling locations all meet these requirements. However, the orientation of the sampling ports is less than the 90° required by EPA Method 1 for circular ducts. The geometry of the stack shell and the proximity of the three stacks to each other did not provide sufficient backspace for sampling ports at 90° angles. All combinations that would have provided adequate backspace between the flue and the stack shell for one port would have resulted in insufficient clearance between the other two flues for a port at 90° orientation. There was also insufficient space for traversing using four ports at 90° angles. Port angles of 87°, 75° and 81° were used for Units 1, 2 and 3, respectively. This variance from Method 1 should not effect the representativeness of the samples. The large number of duct diameters away from disturbances provided uniform velocity profiles across the ducts, and the small particle size should result in good mixing. Figure 9-3 shows a diagram of the stack shell and the enclosed sampling locations for the three units. Figure 9-4 presents the traverse point lay out for each stack.

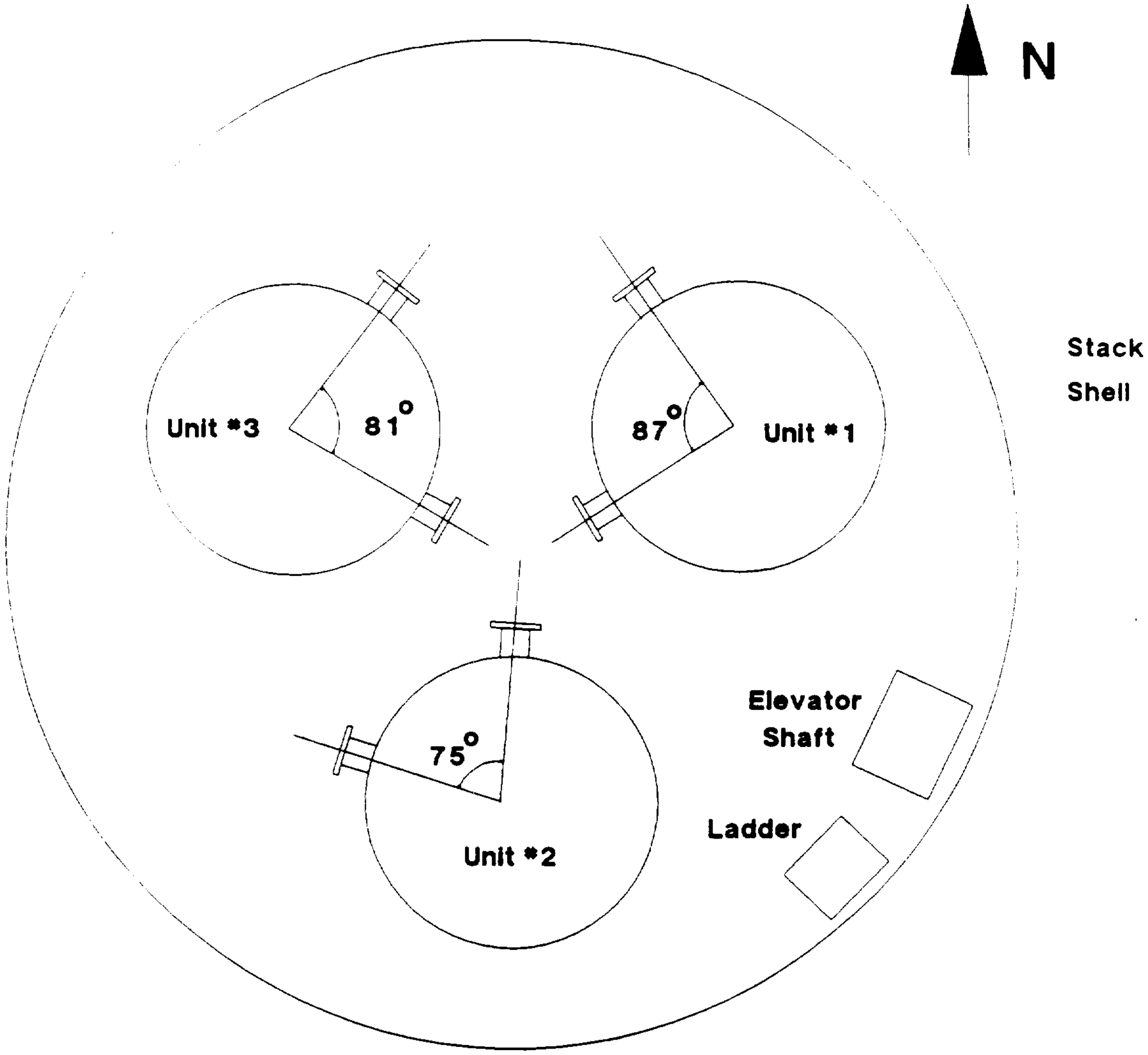
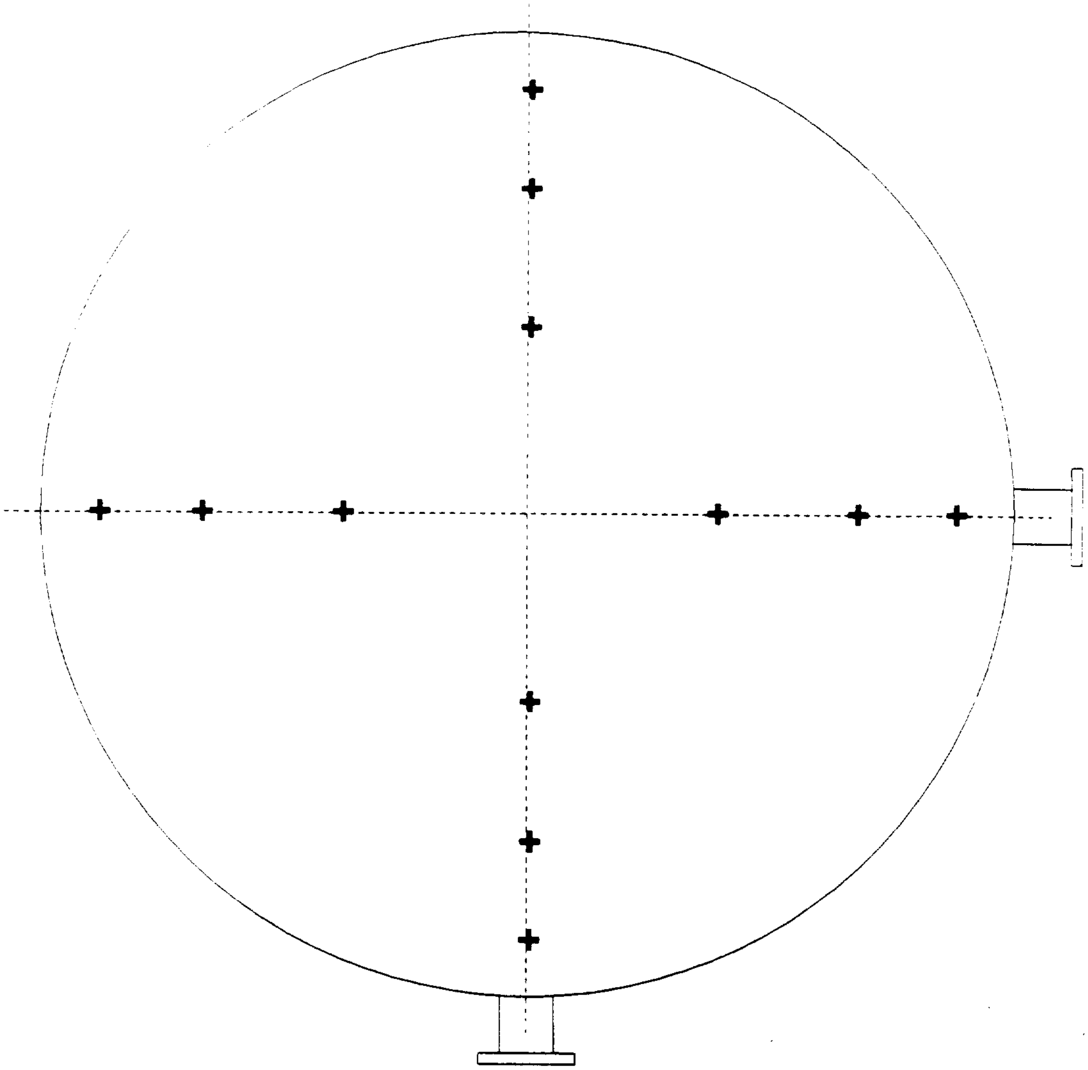


Figure 9-3. Stack Sampling Port Locations Hempstead Resource Recovery Facility



Point	Percent of Diameter	Inches from Inside Wall
1	4.4	4.2
2	14.7	14.1
3	29.5	28.3
4	70.5	67.7
5	85.3	81.9
6	95.6	91.8

Figure 9-4. Traverse Point Layout at the Stack

10.0 SAMPLING AND ANALYTICAL PROCEDURES BY ANALYTE

The sampling and analytical procedures used for the Hempstead compliance test program were the most recent revisions of the published methods. In some cases, the methods were modified to incorporate the most recent developments which have been accepted by the sampling community. In this section, descriptions of each sampling and analytical method by analyte are provided.

The sampling durations, minimum sampling volumes, and detection limits are summarized for the manual sampling methods in Table 10-1. A copy of the sampling matrix listing the sampling and analytical methods is shown in Table 10-2.

10.1 CDD/CDF/PCB/PAH Sampling Method

The CDD/CDF/CB/CP/PCB/PAH sampling and analytical method is a combination of the American Society of Mechanical Engineers (ASME) and EPA draft protocol and the EPA Methods 8270 and 680. The methods were combined and updated by Triangle Laboratories, Inc., who performs the analyses.

10.1.1 Equipment and Sampling Preparation for CDD/CDF/PCB/PAH Sampling

The CDD/CDF/PCB/PAH sampling method uses the sampling train shown in Figure 10-1. Radian modifies the protocol configuration to include a horizontal condenser rather than a vertical condenser. The horizontal condenser lowers the profile of the train and reduces breakage. The XAD trap following the condenser is still maintained in a vertical position.

The solvents used for train recovery are acetone (pesticide grade), followed by methylene chloride. The use of the highest grade acetone for train recovery is essential to prevent the introduction of chemical impurities which interfere with the quantitative analytical determinations.

In addition to the standard EPA Method 5 requirements, the CDD/CDF sampling method includes several unique preparation steps which ensure that

TABLE 10-1. PROPOSED SAMPLING TIMES, MINIMUM SAMPLING VOLUMES AND DETECTION LIMITS FOR THE HEMPSTEAD COMPLIANCE TEST

Location	Sampling Train	Sampling Time (hours)	Minimum Sample Volume (dscf)	Analyte	Detection Limit	
					Flue gas	Analytical
Outlet	CDD/CDF/PCB/PAH	4[a]	120	CDD/CDF	0.3 ng/dscm	0.01 ng
				PCB	3 ng/dscm	10 ng
				PAH	30 ng/dscm	100 ng
Outlet	PM	4[a]	120	PM	0.006 gr/dscf	50-100 mg
				As	0.3 ug/dscm	0.002 ug/ml
				Cd	0.6 ug/dscm	0.006 ug/ml
				Cr	1.6 ug/dscm	0.015 ug/ml
				Pb	0.2 ug/dscm	0.002 ug/ml
				Hg	25 ug/dscm	0.25 ug/ml
				Ni	1.6 ug/dscm	0.015 ug/ml
Outlet	Beryllium	2[a]	60	Be	0.003 ug/dscm	0.0005 ug/ml
Outlet	HCl	0.3	40 liters[b]	Cl		
Inlet	HCl	0.3	40 liters[b]	Cl		

[a] An approximate sampling rate of 0.5 ft^3/min was used to calculate sampling time.
[b] An approximate sampling rate of 2 liters/min was used to calculate the sample volume.

TABLE 10-2. COMPLIANCE TEST MATRIX FOR EACH TRAIN AT THE HEMPSTEAD RESOURCE RECOVERY FACILITY

Sample Location/ Description	Number of Runs	Sample Method or Type	Parameters	Analytical Method	Analytical Laboratory	Sampling Time per Run (hours)
Baghouse Outlet Stack (tests conducted on each boiler, except dioxin/furan and particle sizing on only one)	3	**Draft ASME/EPA Dioxin Protocol**	Dioxin/furan, PAH/PCB	Gas Chromatography/ Mass Spectrometry	Triangle Laboratories	4
	3	**EPA Method 5/ Draft Combined Metals Train**	PM[a] As, Cd, Cr, Pb, Hg, Ni	Gravimetric, Atomic Absorption/ Inductively Coupled Argon Plasma	Radian Corporation	4
	2	**Andersen MK III**	Particle Sizing	Gravimetric	Radian	4
	3[b]	**EPA Method 5**	PM	Gravimetric	Radian	4
	1[c]	**Draft EMSL HCl Train**	HCl	Ion Chromatography	Radian	1
	3	**EPA Method 104**	Beryllium	Atomic Absorption	Radian	2
	3	**EPA Method 7E**	NO_x	Chemiluminescent	Radian	2
	3	**EPA Method 6C**	SO_2	Ultraviolet	Radian	2
	3	**EPA Method 25A**	Total Hydrocarbon	Flame ionization detector	Radian (on site)	2
	3	**EPA Method 3A**	CO_2/O_2	Nondispersive infrared/oxide cell	Radian (on site)	2
	3[d]	**EPA Method 2**	Velocity/Volumetric Flow	Pitot Tubes/Manometer	Radian (on site)	4
	3[d]	**EPA Method 4**	Moisture Content	Gravimetric	Radian (on site)	4
Spray Dryer Inlet	3[c]	**Draft EMSL HCl Train**	HCl	Ion Chromatography	Radian	1
	3	**EPA Method 6C**	SO_2	Ultraviolet	Radian	2
	3	**EPA Method 10**	CO	Nondispersive infrared	Radian	2
	3	**EPA Method 3A**	CO_2/O_2	Nondispersive infrared/oxide cell	Radian	2
	3[d]	**EPA Method 4**	Moisture Content	Gravimetric	Radian (on site)	1

[a] PM = Particulate Matter
[b] Tests to be performed at 65% load.
[c] Each test run will consist of three 20-minute samples which will be averaged.
[d] Methods 2 and 4 will be performed with each of the wet chemistry methods.

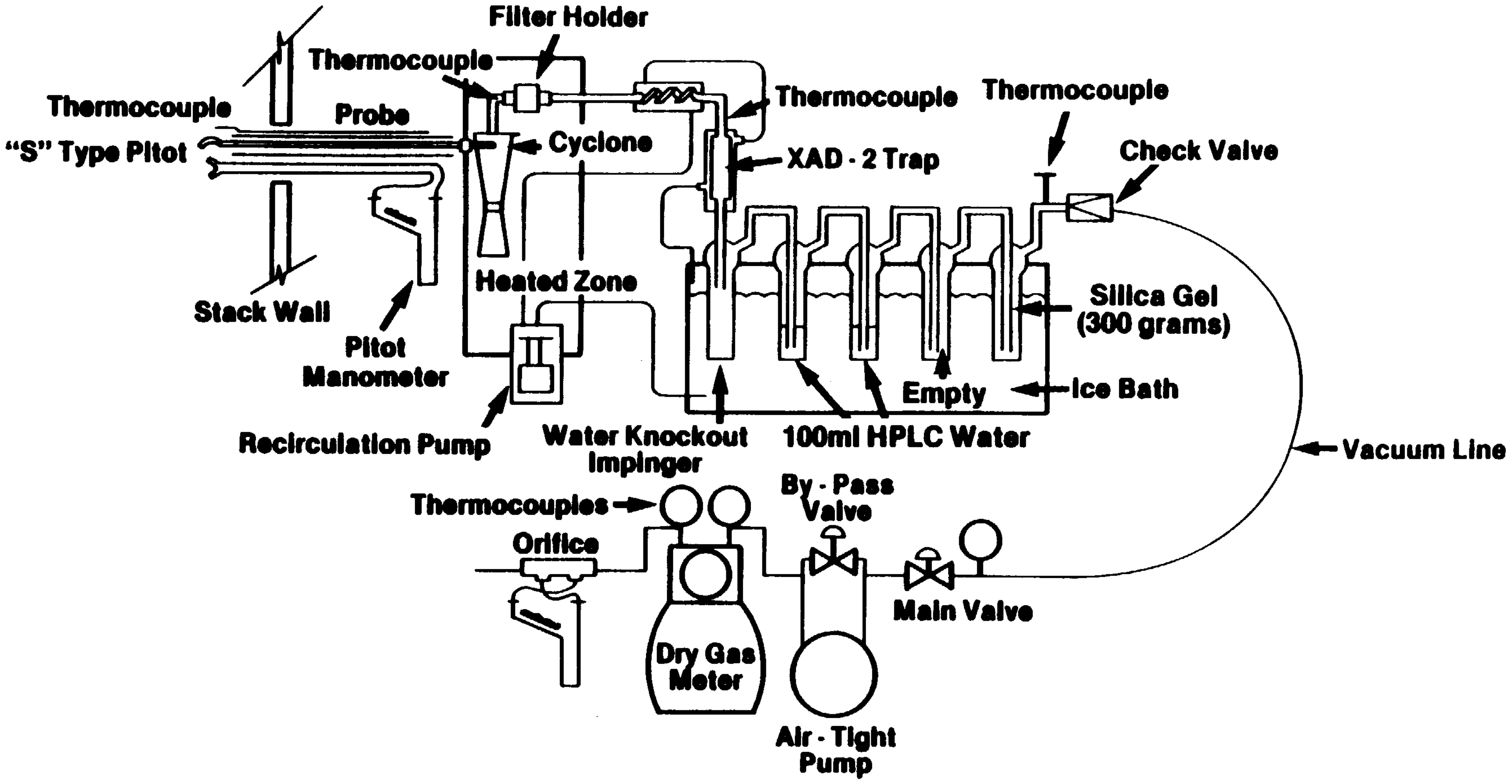


Figure 10-1 CDD/CDF/PCB/PAH Sampling Train Configuration

the sampling train components are not contaminated with organics that may interfere with analysis. The glassware, glass fiber filters and XAD resins are cleaned and checked for residuals before being packed.

10.1.1.1 Glassware

Glassware is washed in soapy water, rinsed with distilled water, baked and then rinsed with acetone followed by methylene chloride. This includes all the glass components of the sampling train including the glass nozzles plus any sample bottles, erlenmeyer flasks, petri dishes, graduated cylinders or stirring rods that are used during recovery. Non-glass components (such as the teflon-coated filter screens and seals, tweezers, teflon squeeze bottles, nylon probe brushes and nylon nozzle brushes) are cleaned following the same procedure except that baking is eliminated. The specifics of the cleaning procedure are presented in Table 10-3.

10.1.1.2 XAD and Filters

The cleaned XAD resin is spiked with five CDD/CDF internal standards. Due to the special handling considerations required for the CDD/CDF internal standards, the spiking is performed by Triangle Laboratories. For convenience and to minimize contamination, the XAD resin and filters are also cleaned by Triangle Laboratories and the XAD is loaded into the glass traps.

The XAD resin and glass fiber filters are placed together in a soxhlet and extracted in HPLC grade water, methyl alcohol, methylene chloride and hexane, sequentially. At the conclusion of the soxhlet extractions, one filter and 30 grams of XAD resin are analyzed for background contamination following the same procedure followed for the flue gas samples. The XAD and filter blank are analyzed for CDD/CDF, PCB and PAH. The pressure drop for the XAD traps is checked before and after the resin is loaded to ensure that the pressure drop across the XAD traps is less than 7 inches of mercury.

TABLE 10-3. CDD/CDF/PCB/PAH GLASSWARE CLEANING PROCEDURE
(Train Components and Sample Containers)

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox®).
2. Tap water rinse to remove soap.
3. Distilled/deionized H20 rinse (X3).[a]
4. Bake at 450°F for 2 hrs.[b]
5. Acetone rinse (X3), (pesticide grade).
6. Methylene chloride (X3)
7. Cap glassware with clean glass plugs or methylene chloride rinsed aluminum foil.
8. Mark cleaned glassware with color-coded identification sticker.

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[a] (X3) - three times.

[b] Step (4) is not used for probe liners and non-glass components of the train that cannot withstand 450°F (i.e., teflon-coated filter screen and seals, tweezers, teflon squeeze bottles, nylon probe and nozzle brushes). The probe liners are too large for the baking ovens.

10.1.1.3 Equipment

The remaining preparation includes calibration and leakchecking of all the train equipment. This includes meterboxes, thermocouples, nozzles, pitot tubes, and umbilicals. Referenced calibration procedures are followed when available, and the results properly documented and retained. The data forms used are included in Appendix B. If a referenced calibration technique for a particular piece of apparatus is not available, then a state-of-the-art technique is used. A discussion of the techniques used to calibrate this equipment is presented below.

10.1.1.4 Type-S Pitot Tube Calibration

The EPA has specified guidelines concerning the construction and geometry of an acceptable Type-S pitot tube. If the specified design and construction guidelines are met, a pitot tube coefficient of 0.84 can be used. Information related to the design and construction of the Type-S pitot tube is presented in detail in Section 3.1.1 of EPA Document 600/4-77--027b. Only Type-S pitot tubes meeting the required EPA specifications are used. Pitot tubes are inspected and documented as meeting EPA specifications prior to the field sampling.

10.1.1.5 Sampling Nozzle Calibration

Glass nozzles are used for isokinetic sampling. Calculation of the isokinetic sampling rate requires that the cross sectional area of the sampling nozzle be accurately and precisely known. All nozzles are thoroughly cleaned, visually inspected and calibrated according to the procedure outlined in Section 3.4.2 of EPA Document 600/4-77-027b.

10.1.1.6 Temperature Measuring Device Calibration

Accurate temperature measurements are required during source sampling. Bimetallic stem thermometers and thermocouple temperature sensors are calibrated using the procedure described in Section 3.4.2 of EPA

Document 600/4-77-027b. Each temperature sensor is calibrated at a minimum of three points over the anticipated range of use against a NBS-traceable mercury-in-glass thermometer. All sensors are calibrated prior to field sampling.

10.1.1.7 Dry Gas Meter Calibration

Dry gas meters (DGMs) are used in the CDD/CDF sample trains to monitor the sampling rate and to measure the sample volume. All DGMs are calibrated to document the volume correction factor just prior to the departure of the equipment to the field. Post-test calibration checks are performed as soon as possible after the equipment has been returned to Research Triangle Park (RTP). Pre- and post-test calibrations should agree to within five percent.

Prior to calibration, a positive pressure leak-check of the system is performed using the procedure outlined in Section 3.3.2 of EPA Document 600/4-77-237b. The system is placed under approximately 10 inches of water pressure and a gauge oil manometer is used to determine if a pressure decrease can be detected over a one-minute period. If leaks are detected, they are eliminated before actual calibrations are performed.

After the sampling console is assembled and leak-checked, the pump is allowed to run for 15 minutes. This allows the pump and DGM to warm up. The valve is then adjusted to obtain the desired flow rate. For the pre-test calibrations, data are collected at orifice manometer settings (H) of 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 in H_2O. Gas volumes of 5 ft^3 are used for the two lower orifice settings, and volumes of 10 ft^3 are used for the higher settings. The individual gas meter correction factors (i) are calculated for each orifice setting and averaged. The method requires that each of the individual correction factors fall within ±2 percent of the average correction factor or the meter is cleaned, adjusted, and recalibrated. In addition, Radian requires that the average correction factor be within 1.00 ±1 percent. For the post-test calibration, the meter is calibrated three times at the average orifice setting and vacuum which were used during the actual test.

Rockwell Model 175 DGMs are used. DGM calibrations are performed at Radian's RTP laboratory using a Rockwell Model 175 DGM as an intermediate standard. The "intermediate standard" is calibrated every six months against the EPA spirometer at EPA's Emissions Measurement Laboratory in RTP.

10.1.1.8 Preliminary Measurements

Prior to sampling, certain preliminary measurements are required to ensure representative isokinetic sampling. These include marking the traverse points on the probe, a preliminary velocity traverse, cyclonic flow check and calculation of the K-factor.

Exact measurements of the diameter of the stack and port nipples as well as distances to upstream and downstream disturbances are necessary. Using these measurements and EPA Reference Method 1, the distances used for marking the traverse points on the probe are determined.

A preliminary velocity traverse is conducted to determine the average velocity and stack temperature values to be used in calculating the K-factor. A cyclonic flow check is performed to ensure that the sampling location meets EPA Reference Method 1 requirements for parallel flow.

10.1.1.9 Assembling the Train

Assembling the CDD/CDF sampling train is done both in the recovery trailer and at the stack location. First, the empty, clean impingers are assembled and laid out in the proper order. The first impinger is a knockout impinger which has a short tip. The purpose of this impinger is to collect condensate which forms in the coil and XAD trap. However, the gas is not bubbled through the condensate to prevent carryover to the next impinger. The next two impingers are modified tip impingers which contain 100 ml of HPLC water each. The fourth impinger is empty, and the fifth impinger contains 200 to 300 grams of silica gel. To aid in loading the silica gel, it is preferable if the top of the fifth impinger nestles over the bottom. When the impingers are loaded, they are wrapped with teflon tape to secure the two sections of the impinger. Then each impinger is weighed and the weight recorded along with information on the contents of the impingers. The impingers are connected together using U-tube connectors and arranged in the impinger bucket as shown in Figure 10-2. The height of all the impingers should be approximately the same to obtain a leakfree seal. The open ends of the train are sealed with methylene chloride-rinsed foil.

The second step is to load the filter into the filter holder. The filter holder is then capped off and placed with the XAD trap and condenser coil (capped) into the impinger bucket. A supply of pre-cleaned foil and socket joints are also placed in the bucket for the convenience of the samplers. The train components are transferred to the sampling location and assembled as previously shown in Figure 10-1. Sealing greases are not used.

10.1.2 Sampling Operations

The CDD/CDF trains are leakchecked at the start and finish of sampling as required in EPA Method 5 as well as before and after each port change. If a piece of glassware needs to be emptied or replaced, a final leakcheck is performed before the glassware piece is removed. After the train is re-assembled, an initial leakcheck is performed.

To leakcheck the assembled train, the nozzle end is capped off and a vacuum of 15 in. Hg is pulled in the system. When the system is evacuated, the volume of gas flowing through the system is timed for 60 seconds. The leakrate is required to be less than 0.02 acfm (ft^3/min). After the leakrate is determined, the cap is slowly removed from the nozzle end until the vacuum drops off, and then the pump is turned off.

If the leakrate requirement is not met, the train is systematically checked by first capping the train at the filter, at the first impinger, etc., until the leak is located and corrected.

In the event that a final leakrate is found to be above the minimum acceptable rate (0.02 acfm) upon removal from a port, the sample volume is corrected for that interval as specified in the sampling protocol. Basically,

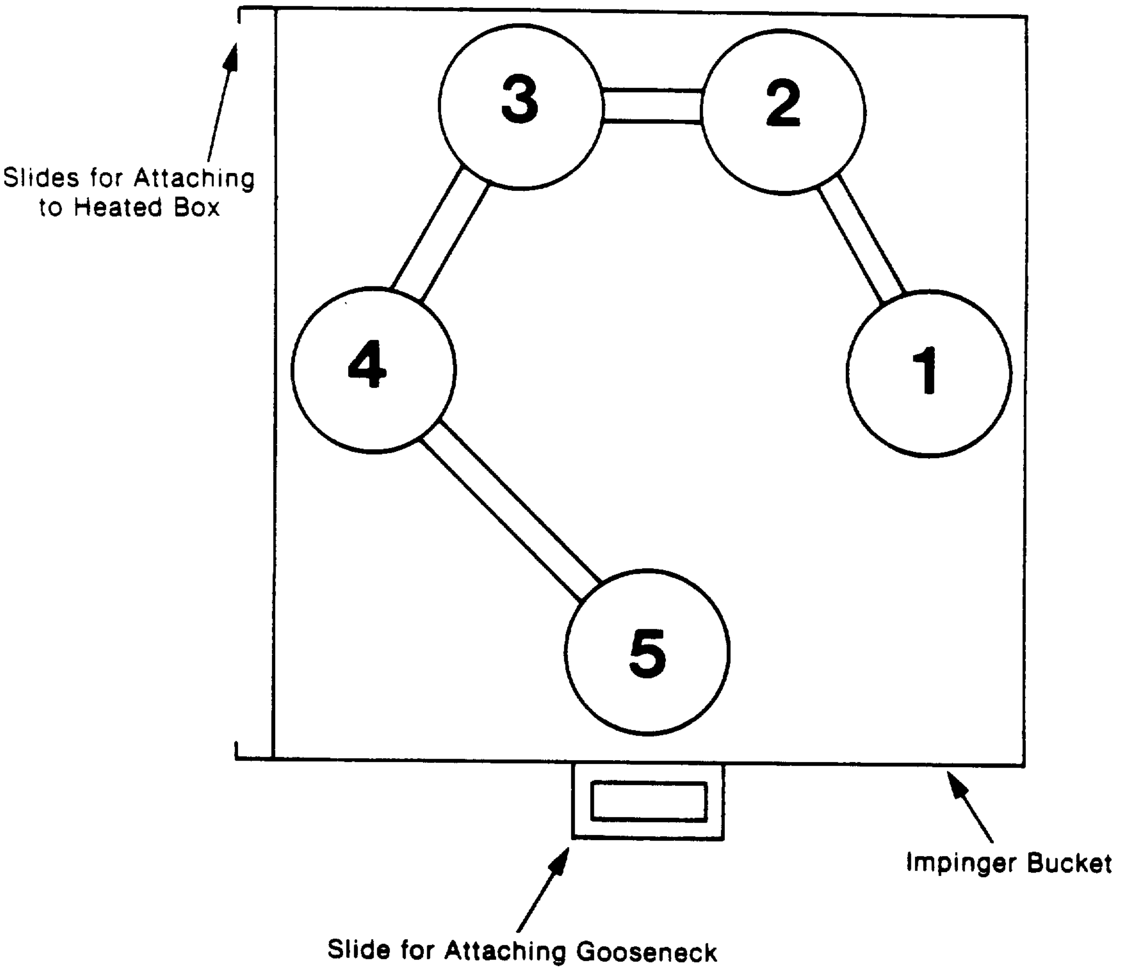

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Figure 10-2. Impinger Configuration for CDD/CDF/PCB/PAH Sampling Train the excessive leakrate is reduced by the minimum acceptable rate and then multiplied by the sampling time for that port.

After the leakrate is determined, the heaters are turned on for the probe liner and heated box. When the system reaches the appropriate temperatures, the sampling train is ready for operation. The leakrates and sampling stop/start times are recorded on the sampling task log. Also, any other events that occur during sampling are recorded on the task log such as pitot cleaning, thermocouple malfunctions, heater malfunctions and any other unusual occurrences.

The action taken if a sampling train fails a leakcheck because of a broken probe liner depends on the time at which the break occurred. If the probe liner breaks while the DGM is not running (i.e., during port changes or after the run is completed), the probe liner is replaced, the run is completed, and recovery done by sections. The run is considered acceptable. If the break occurs while the DGM is running, the probe liner is replaced, the run is completed and recovery done by sections. If the recovered sample appears unusual, the sample is discarded and an additional run is performed later. If the recovered sample appears normal, the run is tentatively acceptable.

Sampling train data are recorded every five minutes on data forms. A checklist for CDD/CDF sampling is included in Table 10-4. The purpose of the checklist is to remind samplers of the critical steps during sampling.

A sampling operation that is unique to CDD/CDF sampling is maintaining the gas temperature entering the XAD trap below 68°F. The gas is cooled by the condenser and the XAD trap, itself, has a water jacket in which ice water is circulated.

10.1.3 Sample Recovery

To facilitate transfer from the sampling location to the recovery trailer, the sampling train is disassembled into four sections: the probe

TABLE 10-4. SAMPLING CHECKLIST USED FOR THE HEMPSTEAD COMPLIANCE TEST

Before test starts:

1. Check impinger set. (right order & number)
   Verify probe markings, and re-mark if necessary.
2. Check that you have all the correct pieces of glassware.
3. Check for data sheets and barometric pressure.
4. Bag sampling equipment needs to be ready (with bags labelled and ready to go).
5. Examine meter box - level it and comfirm that the pump is operational.
6. Assemble train to the filter and leakcheck at 15 in Hg.
   Add probe to train and do final leakcheck; record leakrate and pressure on sampling log.
7. Check out thermocouples - make sure they are reading correctly.
8. Turn on heats and check to see that they are increasing.
9. Leakcheck pitots.
10. Check that cooling water is flowing and on.
    Add ice to impinger buckets.
11. Check isokinetic k-factor - make sure it is correct. (Refer to previous results to confirm assumptions).
    (Two people should calculate this independently to double check it.)
12. Have a spare probe liner, probe sheath, meter box and filter ready to go at location.

During Test:

1. Notify crew chief of any sampling problems ASAP. Train operator should fill in sampling log.
2. Perform simultaneous/concurrent testing with other locations (if applicable). Maintain filter temperature between 248°F + _ 25°F. Keep temperature as steady as possible. Maintain XAD trap and impinger temperatures below 68°F. Maintain probe temperature above 212°F.
3. Leakcheck between ports and record on sampling log.

TABLE 10-4. SAMPLING CHECKLIST USED FOR THE HEMPSTEAD COMPLIANCE TEST (cont'd.)

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4. Record sampling rate times and location for the fixed gas (CO, CO_2, O_2) sample (if applicable).
5. Blowback pitot tubes at inlet location every 15 minutes.
6. Change filter if pressure drop exceeds 15" Hg.
7. Check impinger solutions every 1/2 hr; if bubbling into impinger prior to silica gel, empty out first impinger into pre-weighed bottle and replace.
8. Check impinger silica gel every 1/2 hr; if indicator disappears request a prefilled impinger from van lab and replace.
9. Check manometer fluid levels and zero every hour.

After test is completed:

1. Record final meter reading.
2. Check completeness of data sheet.
3. Do final leakcheck of sampling train at maximum vacuum during test.
4. Leakcheck each leg of pitot tubes.
5. Disassemble train. Cap sections. Take down to recovery trailer.
6. Probe recovery (use 950 ml bottles)
   a) Bring probes into recovery trailer (or other enclosed area).
   b) For acetone rinses (all trains)
      - Attach flask to end of probe
      - Add about 50 mls of acetone
      - Put in brush down probe, and brush back and forth
      - Rinse back and forth in probe
      - Empty out acetone in sample jar
      - Do this 3 times
   c) For $MeCl_2$ rinses
      Rinse 3 times with flask attached (no brushing)
7. Reattach nozzle and cap for next day, store in dry safe place.
8. Make sure Crew Chief has data sheets.

---

liner, the XAD trap and condenser, filter holder, and the impingers in their bucket. Each of these sections is capped with methylene chloride-rinsed aluminum foil before removal to the recovery trailer. Once in the trailer, field recovery follows the scheme shown in Figure 10-3. The samples are placed in amber glass bottles to prevent light degradation. Field recovery will result in the sample components listed in Table 10-5. The samples are shipped as these components to the analytical laboratory by truck.

10.1.3.1 Quality Control (blanks)

Two different blanks are collected for CDD/CDF/PCB/PAH analysis: a lab proof blank and a field blank. The blanks collected and analyzed are shown in Table 10-6. Laboratory proof blanks are obtained from a complete set of MM5 sample train glassware that has been cleaned according to the procedure presented previously in Table 10-3. The pre-cleaned glassware, which consists of a probe liner, filter holder, condenser coil and impinger set, is loaded and then recovered by rinsing with acetone and methylene chloride three times each. A filter and XAD trap are also included in the laboratory proof blank. All sets of glassware are blanked, but only one set of samples is analyzed. Analysis of the rinse is used to check the effectiveness of the glassware cleaning procedure. The CDD/CDF/PCB/PAH flue gas results may be adjusted using the laboratory proof blank, if required. In addition, blanks of each solvent lot used at the test site are saved for potential analysis.

A field blank is collected from a set of CDD/CDF/PCB/PAH glassware that has been used to collect at least one sample and has been recovered. The train is re-loaded and left at a sampling location during a test run. The train is then recovered. The purpose of the field blank is to measure the level of contamination that occurs from handling, loading, recovering, and transporting the sampling train.

10.1.4 Analytical Procedures for CDD/CDF/PAH/PCB

The analytical procedure used to obtain CDD/CDF, PAH and PCB concentrations from a single MM5 flue gas sample is not yet fully developed

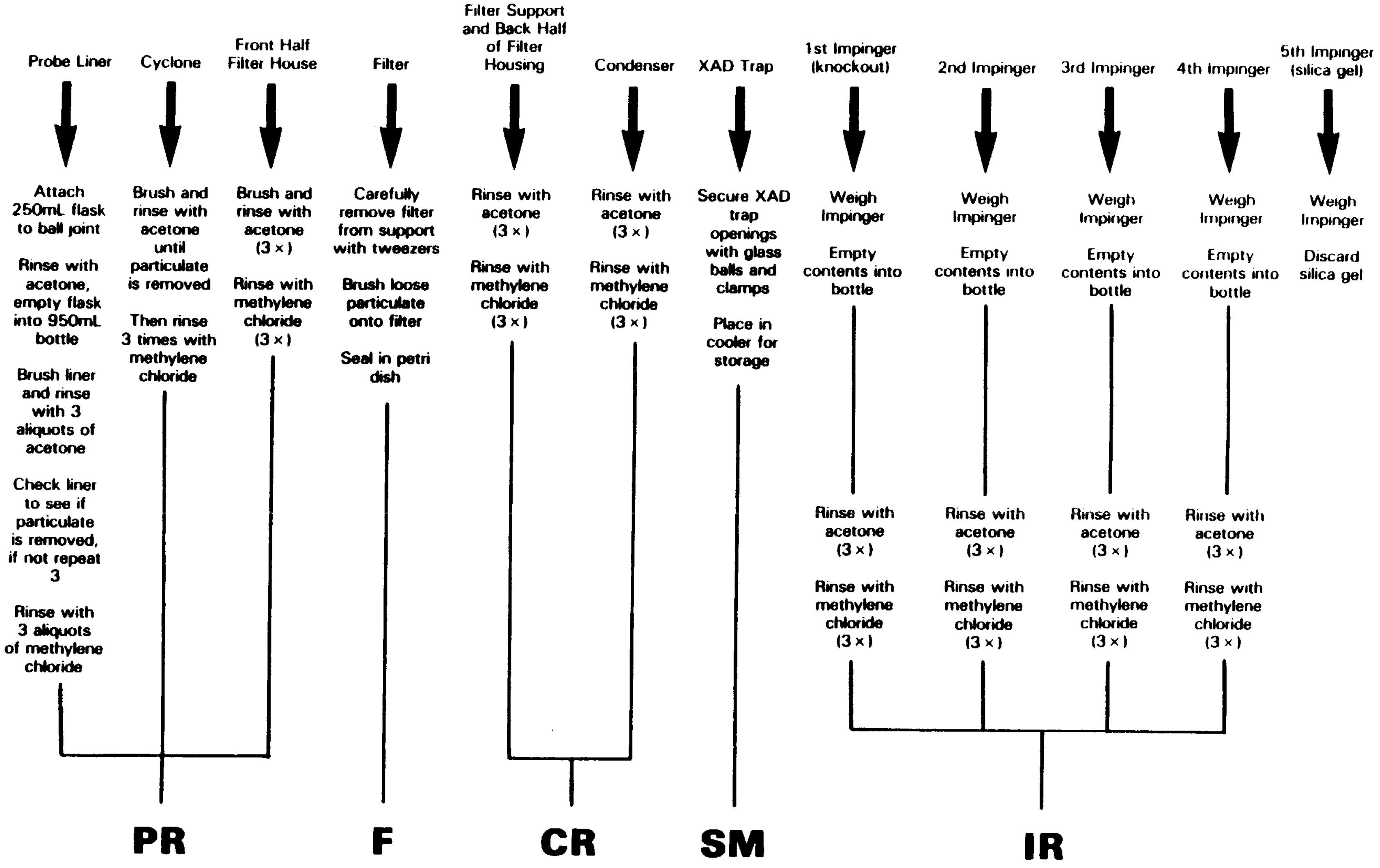

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Figure 10-3. CDD/CDF/PCB/PAH Field Recovery Scheme

TABLE 10-5. CDD/CDF/PCB/PAH SAMPLING TRAIN COMPONENTS SHIPPED TO ANALYTICAL LABORATORY

Container/ Component	Code	Glassware
1	F	Filter(s)
2	PR	Rinses[a] of nozzle, probe, cylcone, and front half of filter holder
3	CR	Rinses[a] of back half of filter holder, filter support and condenser
4	IR	First, second, third and fourth impinger contents and rinses[a]
5	SM	XAD-2® resin

[a] Rinses include acetone and methylene chloride recovered into the same sample bottle.

TABLE 10-6. CDD/CDF/PAH/PCB BLANKS COLLECTED FOR THE HEMPSTEAD COMPLIANCE TEST

Blank	Collection	Analysis
Laboratory Proof Blanks	All sets of train glassware, submit one set for analysis.	Archive for potential analysis.[a]
Field Blanks	One run collected and analyzed for each sampling location.	Analyze with flue gas samples.
Reagent Blanks	One 500 ml sample for each reagent and lot.	Archive for potential analysis.[a]

[a] The field blank is analyzed first with the flue gas samples. If the field blank is satisfactory, then the laboratory proof blanks and reagent blanks are not analyzed. If the field blank is unsatisfactory, the laboratory proof blanks or reagent blanks may be analyzed to determine the specific source of contamination.

and validated. Triangle Laboratories, Inc., has prepared a special protocol for this test program which combines EPA Method 8270 for PAH; EPA Method 680 for PCB; and the ASME/EPA 1984 draft protocol for CDD/CDF. The detection limit for PAH is about 1 microgram per train. The detection limit for PCB is about 1 nanogram per train and for CDD/CDF the detection limit is about 5 picogram per train.

Analysis for CDD/CDF is for the congeners listed in Table 10-7. Both screening and confirmation analyses are performed. Analysis for PCB and PAH is for the compounds/isomers shown in Table 10-8. The analyses are performed by Triangle Laboratories, Inc., Research Triangle Park, North Carolina.

10.1.4.1 Preparation of Samples for Extraction

Upon receiving the sample shipment, the samples are checked against the Chain-of-Custody forms and then assigned an analytical laboratory sample number. Each sample component is reweighed to determine if leakage occurred during travel. Color, appearance, and other particulars of the samples are noted. Samples are extracted within 21 days of collection.

10.1.4.2 Equipment Preparation

Glassware used in the analytical procedures (including Soxhlet apparatus and disposable bottles) is cleaned by washing twice with detergent, rinsing with distilled water, and then rinsing with acetone, methanol, and methylene chloride. The glassware is allowed to air dry.

10.1.4.3 Calibration of GC/MS System

An initial calibration of the GC/MS system is performed to demonstrate instrument linearity over the concentration range of interest. High resolution gas chromatography/high resolution mass spectrometry (resolution at least 10,000) are used for the CDD/CDF analytical techniques. All other analyses (PCB and PAH) are performed using low resolution mass

TABLE 10-7. CDD/CDF CONGENERS TO BE ANALYZED FOR THE HEMPSTEAD COMPLIANCE TEST PROGRAM

	New York[2] 2,3,7,8 Toxic Equivalency Factor
DIOXINS	
2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 TCDD)	1
Other tetrachlorinated dibenzo-p-dioxins (TCDD)	0.01
1,2,3,7,8 pentachlorodibenzo-p-dioxin (1,2,3,7,8 PeCDD)	1
Other pentachlorinated dibenzo-p-dioxins (PeCDD)	0.01
1,2,3,4,7,8 hexachlorodibenzo-p-dioxin (1,2,3,4,7,8 HxCDD)	0.03
1,2,3,6,7,8 hexachlorodibenzo-p-dioxin (1,2,3,6,7,8 HxCDD)	0.03
1,2,3,7,8,9 hexachlorodibenzo-p-dioxin (1,2,3,7,8,9 HxCDD)	0.03
Other hexachlorinated dibenzo-p-dioxins (HxCDD)	0.0003
1,2,3,4,6,7,8 heptachlorodibenzo-p-dioxin (1,2,3,4,6,7,8 HpCDD)	0.001
Other heptachlorinated dibenzo-p-dioxins (HpCDD)	0.00001
Total octachlorinated dibenzo-p-dioxins (OCDD)	0
FURANS	
2,3,7,8 tetrachlorodibenzofurans (2,3,7,8 TCDF)	0.33
Other tetrachlorinated dibenzofurans (TCDF)	0.003
1,2,3,7,8 pentachlorodibenzofuran (1,2,3,7,8 PeCDF)	0.33
2,3,4,7,8 pentachlorodibenzofuran (2,3,4,7,8 PeCDF)	0.33
Other pentachlorinated dibenzofurans (PeCDF)	0.003
1,2,3,4,7,8 hexachlorodibenzofuran (1,2,3,4,7,8 HxCDF)	0.01
1,2,3,6,7,8 hexachlorodibenzofuran (1,2,3,6,7,8 HxCDF)	0.01
2,3,4,6,7,8 hexachlorodibenzofuran (2,3,4,6,7,8 HxCDF)	0.01
1,2,3,7,8,9 hexachlorodibenzofuran (1,2,3,7,8,9 HxCDF)	0.01
Other hexachlorinated dibenzofurans (HxCDF)	0.0001
1,2,3,4,6,7,8 heptachlorodibenzofuran (1,2,3,4,6,7,8 HpCDF)	0.001
1,2,3,4,7,8,9 heptachlorodibenzofuran (1,2,3,4,7,8,9 HpCDF)	0.001
Other heptachlorinated dibenzofurans (HpCDF)	0.00001
Total octachlorinated dibenzofurans (OCDF)	0

TABLE 10-8. PCB AND PAH TO BE ANALYZED FOR THE HEMPSTEAD COMPLIANCE TEST PROGRAM

POLYCHLORINATED BIPHENYLS

Total Monochlorobiphenyls
  2-chlorobiphenyl

Total Dichlorobiphenyls
  2,3-dichlorobiphenyl

Total Trichlorobiphenyls
  2,4,5-trichlorobiphenyl

Total Tetrachlorobiphenyls
  2,2',4,6-tetrachlorobiphenyl

Total Pentachlorobiphenyls
  2,2',3',4,5-pentachlorobiphenyl

Total Hexachlorobiphenyls
  2,2',4,4',5,6'-hexachlorobiphenyl

Total Heptachlorobiphenyls
  2,2',3,4,5',6,6'-heptachlorobiphenyl

Total Octachlorobiphenyls
  2,2',3,3,',4,5',6,6'-octachlorobiphenyl

Total nonachlorobiphenyls
  2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl

Decachlorobiphenyl

POLYNUCLEAR AROMATIC HYDROCARBONS

Naphthalene-d8
Acenaphthalene-d10
Acenaphthene
Fluorene
10-Anthracene
Fluoranthene
Pyrene
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anthracene
Benzo(g,h,i)perylene
Anthrene
2-chloronaphthalene

spectrometry. A typical calibration range would consist of points at 4:100, 40:100, and 400:100 for the ratio of analytes to isotopically-labeled internal standards. Relative response factors are calculated for each congener or compound of interest. The response factors are verified on a daily basis using a continuing calibration standard consisting of mid-level standard (typically the 40:100 standard).

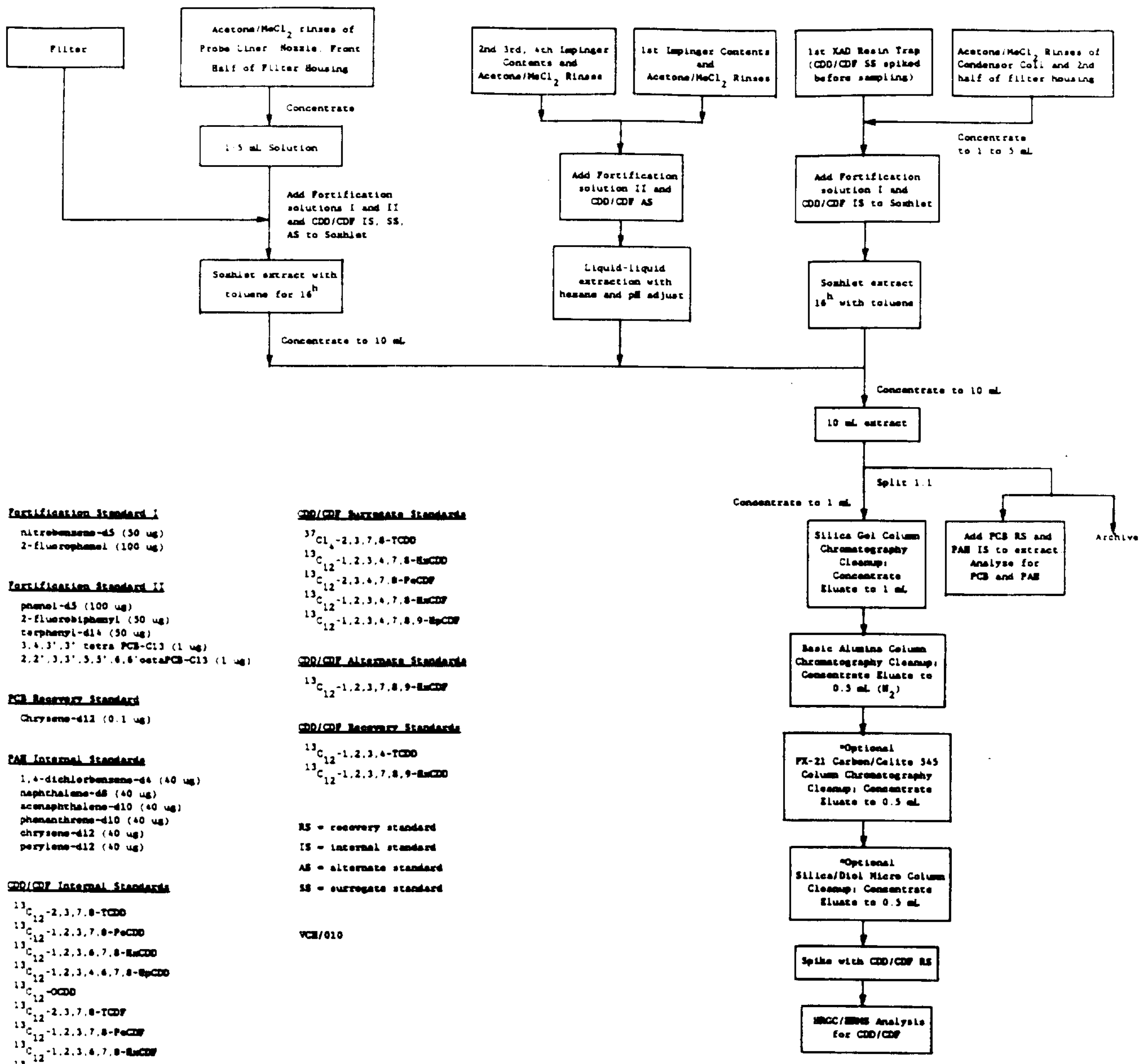
10.1.4.4 Sample Extraction

The flue gas samples are analyzed as total train samples according to the scheme in Figure 10-4. For the CDD/CDF analysis, isotopically-labeled surrogate compounds and internal standards are added to the samples before the extraction process is initiated. The internal standards and surrogates are described in Appendix C. These surrogate compounds and internal standards go through the entire extraction/cleanup process and are measured on the GC/MS. The recoveries of the surrogate compounds are determined to provide additional data on the efficiency of the sample preparation and cleanup procedure and the performance of the instrumentation. Internal standard recoveries are determined and the results for the native species are adjusted according to the internal standard recoveries. The CDD/CDF surrogate compounds are not used to adjust the results of the native species.

For the other analytes (PCB and PAH), isotopically-labeled surrogate compounds are added to the samples before the extraction process is initiated. These surrogates are used to monitor the efficiency of the extraction/cleanup. The internal standards used in the quantitative analysis of these analytes are added to the samples immediately prior to analysis, and used to perform the quantitative calculations.

10.1.4.5 Analysis by GC/MS

The CDD/CDF samples are analyzed by high resolution gas chromatography followed by high resolution mass spectrometry. The PCB and PAH analyses are performed by high resolution gas chromatography followed by low resolution mass spectrometry. In the case of the PCBs, two primary ions from the molecular ion isotope cluster are monitored to determine if the ratio



Fortification Standard I

nitrobenzene-d5 (50 ug)
2-fluorophenol (100 ug)

Fortification Standard II

phenol-d5 (100 ug)
2-fluorobiphenyl (50 ug)
terphenyl-d14 (50 ug)
3,4,3',3' tetra PCB-C13 (1 ug)
2,2',3,3',5,5',6,6'octaPCB-C13 (1 ug)

PCB Recovery Standard

Chrysene-d12 (0.1 ug)

PAH Internal Standards

1,4-dichlorbenzene-d4 (40 ug)
naphthalene-d8 (40 ug)
acenaphthalene-d10 (40 ug)
phenanthrene-d10 (40 ug)
chrysene-d12 (40 ug)
perylene-d12 (40 ug)

CDD/CDF Internal Standards

$^{13}C_{12}$-2,3,7,8-TCDD
$^{13}C_{12}$-1,2,3,7,8-PeCDD
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD
$^{13}C_{12}$-OCDD
$^{13}C_{12}$-2,3,7,8-TCDF
$^{13}C_{12}$-1,2,3,7,8-PeCDF
$^{13}C_{12}$-1,2,3,6,7,8-HxCDF
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF

CDD/CDF Surrogate Standards

$^{37}Cl_4$-2,3,7,8-TCDD
$^{13}C_{12}$-1,2,3,4,7,8-HxCDD
$^{13}C_{12}$-2,3,4,7,8-PeCDF
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF

CDD/CDF Alternate Standards

$^{13}C_{12}$-1,2,3,7,8,9-HxCDF

CDD/CDF Recovery Standards

$^{13}C_{12}$-1,2,3,4-TCDD
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD

RS = recovery standard
IS = internal standard
AS = alternate standard
SS = surrogate standard

VCH/010

Figure 10-4. Extraction and Analysis Schematic for CDD/CDF/PCB/PAH Flue Gas Samples

between them is within the acceptable range of the theoretical value, and a third ion, representing (M-70)+, is monitored for an additional confirmation of identification of PCBs has been made. If the masses are observed in the correct ratio and the confirmation ion is observed, a positive identification of PCB has been made. Since potentially interfering compounds (compounds closely related chemically to the PCBs which are not PCBs) can be present, criteria for positive identification of PCBs must be very strict.

Data from the mass spectrometer are recorded and stored on a computer file as well as printed on paper. A duplicate analysis is performed on every tenth sample in the sample batch. A method blank which is carried through the complete extraction procedure is also analyzed. Results such as amount detected, detection limit, retention time, and internal standard and surrogate standard recoveries are calculated by computer. The chromatograms are retained by the analytical laboratory and are included in Appendix H.

10.1.5 Data Reduction

The CDD/CDF laboratory results, reported in ng, will be converted to ng/dscm, ng/dscm @ 7% O_2, ng/dscm @ 12 CO_2 lb/hr, kg/hr and 2,3,7,8 toxic equivalents using the following equations:

$$\frac{\text{ng}}{\text{dscm}} = \frac{\text{ng reported}}{\text{sample volume (dscm)}}$$

$$\frac{\text{ng}}{\text{dscm @ 7\% O}_2} = \frac{\text{ng}}{\text{dscm}} \times \frac{(20.9 - 7.0)}{(20.9 - \%\text{O}_2\text{ dry})}$$

$$\frac{\text{ng}}{\text{dscm @ 12\% CO}_2} = \frac{\text{ng}}{\text{dscm}} \times \frac{12}{(\%\text{ CO}_2\text{ dry})}$$

$$\frac{\text{ng}}{\text{dscm}}\text{ as 2378 toxic equivalent} = \frac{\text{ng}}{\text{dscm}} \times \text{2378 TCDD toxic equivalent factor} \quad 2$$

$$\frac{\text{kg}}{\text{hr}} = \frac{\text{ng}}{\text{dscm}} \times \frac{\text{dscm}}{\text{min}} \times \frac{\text{60 min}}{\text{hr}} \times \frac{\text{g}}{10^9\text{ ng}} \times \frac{\text{kg}}{\text{1000 g}}$$

$$\frac{\text{lb}}{\text{hr}} = \frac{\text{kg}}{\text{hr}} \times \frac{\text{lb}}{\text{0.45359 kg}}$$

The PCB and PAH concentrations are calculated similarly except that the analytical data are reported in micrograms.

10.2 Particulate and Trace Metals Sampling Method

Sampling for particulate matter and toxic metals (As, Cd, Cr, Hg, Ni, Pb) is performed according to the EPA draft protocol entitled "Methodology for the Determination of Trace Metal Emissions in Exhaust Gases from Stationary Source Combustion Processes." This method is applicable for the determination of particulates and Pb, Zn, P, Cr, Cu, Ni, Mn, Cd, Se, As, Hg, Be, Th, Ag, Sb, and Ba emissions from municipal waste incinerators, sewage sludge incinerators, and hazardous waste incinerators. However, for the Hempstead Compliance test analyses were performed for As, Cd, Cr, Hg, Ni, and Pb, only.

10.2.1 Equipment and Sampling Preparation for Particulate/Metals Sampling

The methodology uses the sampling train shown in Figure 10-5. The 5-impinger train consists of an all glass probe including a glass nozzle followed by a heated quartz-lined filter, a series of impingers and the usual EPA Method 5 meterbox and vacuum pump. The contents of the sequential impingers are: a knockout impinger, 2 impingers with a 5 percent nitric acid/10 percent hydrogen peroxide solution, one 1.5 percent potassium permanganate/10 percent sulfuric acid solution impinger, and an impinger containing silica gel. Sampling train components are recovered and analyzed in separate front and back half fractions.

10.2.1.1 Glassware

Glassware is rinsed with hot tap water, washed in hot soapy water, rinsed with tap water (3X) and then rinsed with deionized distilled water (3X). The glassware is then subjected to the following series of soaks/rinses:

- Soak in a 10 percent (v/v) nitric acid solution, for a minimum of 8 hours;
- Deionized distilled water rinse (3X); and

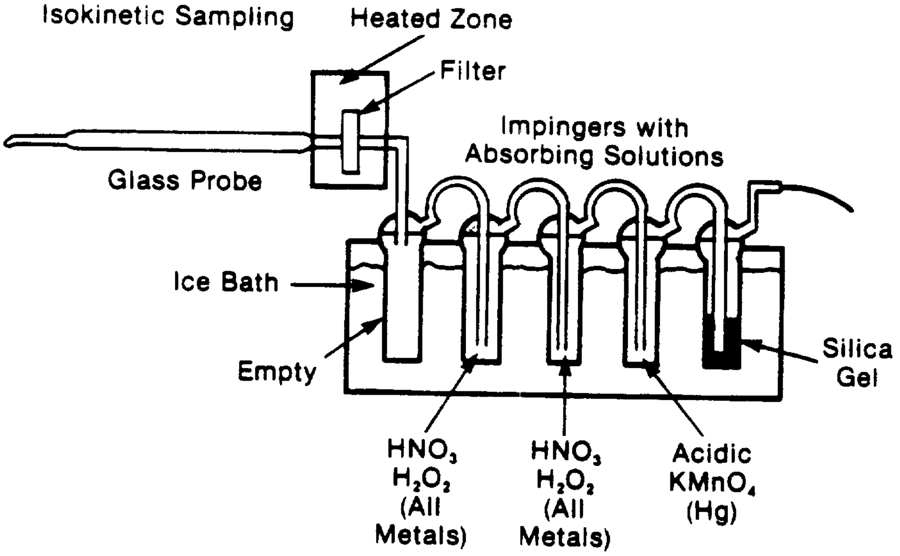


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Figure 10-5. EMSL Metals Sampling Train Configuration

- Acetone rinse.

The cleaned glassware is allowed to air dry in a contamination-free environment. All glass components of the sampling train plus any sample bottles, erlenmeyer flasks, petri dishes, graduated cylinders, or stirring rods that are used during sample recovery are cleaned according to this procedure.

10.2.1.2 Equipment

The remaining preparation includes calibration and leakchecking of all train equipment. This includes meterboxes, thermocouples, nozzles, pitot tubes, and umbilicals. A discussion of the techniques used to calibrate and leakcheck this equipment was presented in Section 10.1.1.

10.2.2 Sampling Operations

A discussion of general sampling operations was presented in Section 10.1.2.

10.2.3 Sample Recovery

To facilitate transfer from the sampling location to the recovery trailer, the sampling train is disassembled into three sections: the probe liner, filter holder, and impingers in their bucket. Each of these sections is capped with teflon tape or parafilm before removal to the recovery trailer. Once in the trailers, the sampling train is recovered as separate front and back half fractions. Diagrams illustrating front half and back half sample preparation and analysis procedures are shown in Figures 10-6 and 10-7, respectively. Approximate detection limits for the various metals of interest are summarized in Table 10-9. The liquid level of each sample container is marked on the bottle in order to determine if any sample loss occurred during shipment. If sample loss has occurred, the sample may be voided or a method may be used to incorporate a correction factor to scale the final results depending on the volume of the loss.

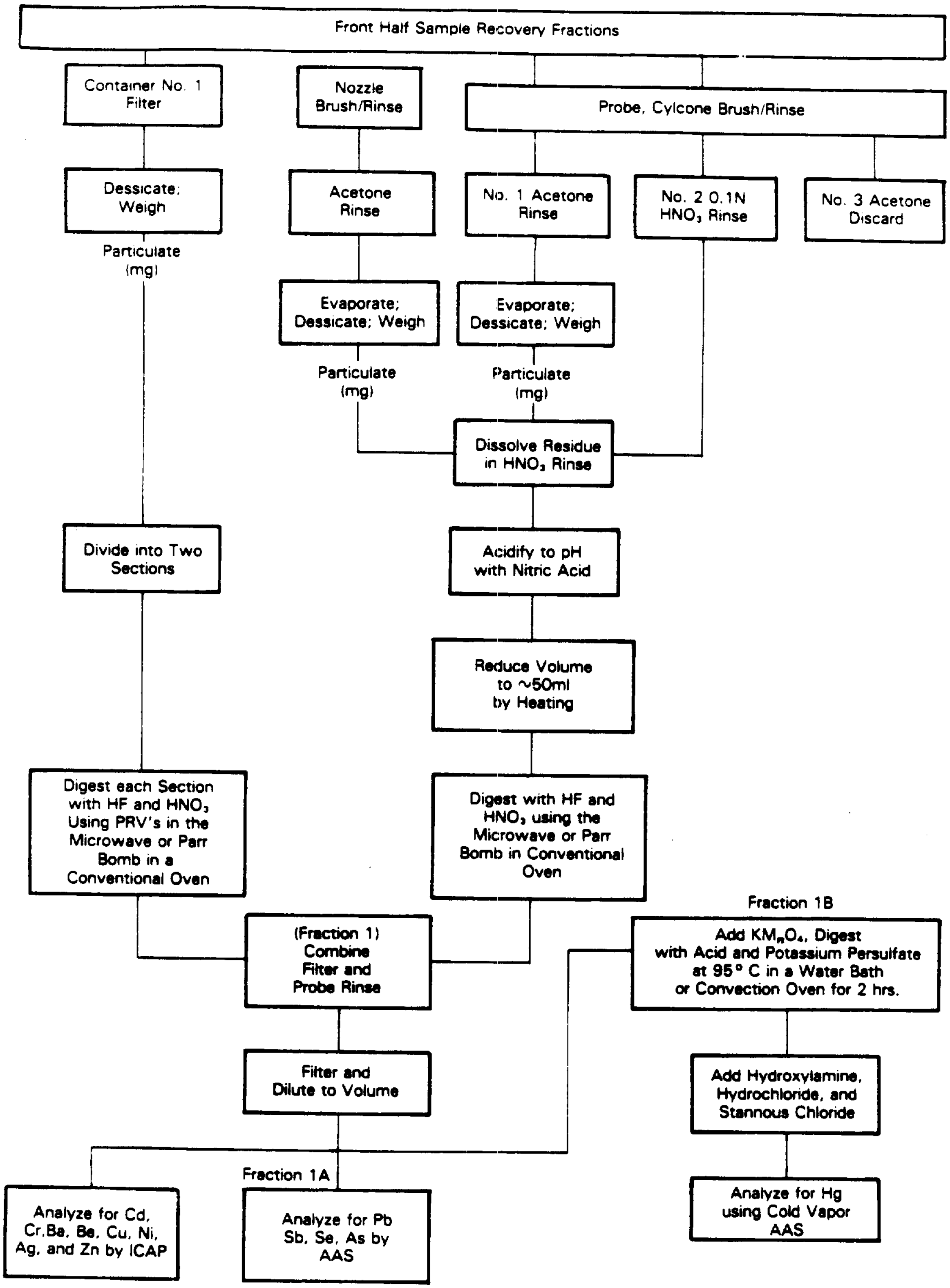

Figure 10-6. Digestion and Analysis Scheme for EMSL Trace Metal Train Components - Front Half

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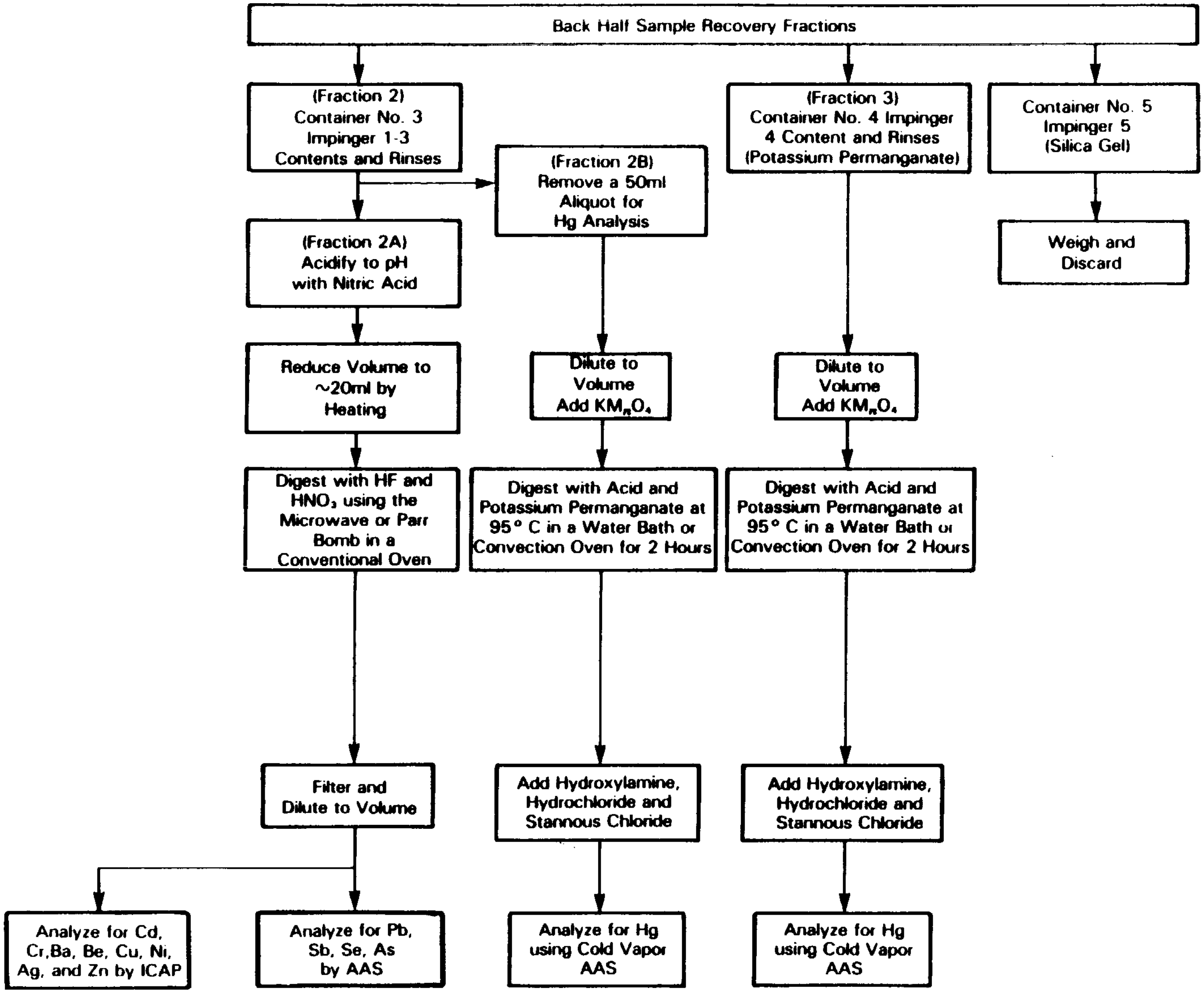

Figure 10-7. Digestion and Analysis Scheme for EMSL Trace Metal Train Components - Back Half

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TABLE 10-9. APPROXIMATE DETECTION LIMITS FOR METALS OF INTEREST USING EMSL DRAFT METHOD

Metal	Method[a]	Detection Limit (ug/mL)	Front Half (250 mL sample size)	Back Half (100 mL sample size)
Chromium	ICAP	0.015	3.75	1.50
Cadmium	ICAP	0.006	1.50	0.60
Arsenic	GFAAS	0.002	0.5/1.50	0.2
Lead	GFAAS	0.002	0.5	0.2
Mercury	CVAAS	---	6.25/60	2.5/25
Nickel	ICAP	0.015	3.75	1.50

[a] ICAP - Inductively Coupled Argon Plasma;
GFAAS - Graphite Furnace Atomic Absorption Spectroscopy;
CVAAS - Cold Vapor Atomic Absorption Spectroscopy.

10.2.4 Particulate/Trace Metals Analytical Procedures

The acetone probe and nozzle rinses are combined and evaporated to dryness and weighed along with the filter to determine a particulate weight. The probe rinse from Container No.1 is reduced to near dryness and then digested with concentrated nitric acid and hydrofluoric acid solutions in either a microwave pressure relief vessel or a Parr® Bomb. The filter from Container No. 2 is also digested in this manner. The microwave digestion technique takes place over a period of approximately 120 minutes at 600 Watts, while the Parr® Bomb digestion technique takes place over a period of 6 hours at 140°C (285°F). Both the digested filter and the digested probe rinse are combined to yield Fraction 1. This fraction is diluted with water to yield a matrix of 6 percent nitric acid and 4 percent hydrofluoric acid.

The digested filter and probe rinse from Containers 1 and 2, respectively (Fraction 1), are analyzed by inductively coupled argon plasma spectroscopy (ICAP) for all metals except mercury. If arsenic or lead levels are less than 2 ppm, graphite furnace atomic absorption spectroscopy (AAS) is used to analyze for these elements. The total volume of the absorbing solutions and rinses for impingers 1 and 2 (combined Solution A) and for impinger 3 (Solution B) should be measured and recorded. A 20 mL aliquot is taken from both Solution A and Solution B. These 2 aliquots (Fraction 2) are then combined, digested with acid in 95°C water bath for 2 hours, and analyzed for mercury by cold vapor AAS.

Half of the remaining volume of Solution A is then combined with half of the remaining volume of Solution B. This solution is acidified to pH 2 and reduced to near dryness. It is then digested with nitric acid and hydrogen peroxide. This solution (Fraction 3) is analyzed by ICAP and AAS for the remaining metals of interest. If iron and aluminum are present in any of the sample aliquots at levels about 50 ppm, then the samples are diluted so that each of these metals is at a concentration of less than 50 ppm before analyzing for As, Se, and lead to account for these interferences. The remaining undigested portions of Solutions A and B are archived at Radian for future potential analysis.

Container 5, the 4th impinger which contains an acidic potassium permanganate solution specifically for the collection of mercury, is digested at 95°C in a water bath for approximately two hours and analyzed by Cold Vapor AAS for Hg. Container 7 contains the spent silica gel from impinger 5. The silica gel is be weighed for moisture content to the nearest 0.5 g and then discarded.

10.2.5 Data Reduction

The particulate laboratory results, reported in mg, are converted to mg/dscm, mg/dscm @ 7% O_2, gr/dscf @ 12% CO_2, lb/hr and kg/hr. The following equations are used:

$$\frac{\text{mg}}{\text{dscm}} - \frac{\text{mg reported}}{\text{sample volume (dscm)}} \quad (1000\ \text{ug} - \text{mg})$$

$$\frac{\text{mg}}{\text{dscm @ 7\% }O_2} - \frac{\text{mg}}{\text{dscm}} \times \frac{(20.9 - 7.0)}{(20.9 - \%O_2\ \text{dry})}$$

$$\frac{\text{mg}}{\text{dscm @ 12\% }CO_2} - \frac{\text{mg}}{\text{dscm}} \times \frac{12}{(\%\ CO_2\ \text{dry})}$$

$$\frac{\text{kg}}{\text{hr}} - \frac{\text{mg}}{\text{dscm}} \times \frac{\text{dscm}}{\text{min}} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{\text{g}}{103\ \text{mg}} \times \frac{\text{kg}}{1000\ \text{g}}$$

$$\frac{\text{lb}}{\text{hr}} - \frac{\text{kg}}{\text{hr}} \times \frac{\text{lb}}{0.45359\ \text{kg}}$$

$$\frac{\text{gr}}{\text{dscf}} - \frac{\text{mg @ 12\% }CO_2}{\text{dscm}} \times \frac{\text{dscm}}{0.028317\ \text{dscf}} \times \frac{\text{g}}{10^3\ \text{mg}} \times \frac{\text{lb}}{453.59\ \text{g}} \times \frac{7000\ \text{gr}}{\text{lb}}$$

10.3 Beryllium Measurement by EPA Method 104

EPA Method 104 is used to collect flue gas samples for beryllium emissions. In summary, the flue gas sample is collected isokinetically, digested in an acid solution, and analyzed by atomic absorption spectrophotometry.

10.3.1 Equipment and Sample Preparation

The Method 104 sampling train is shown in Figure 10-8. The Method 104 sampling train configuration is identical to a Method 5 sampling

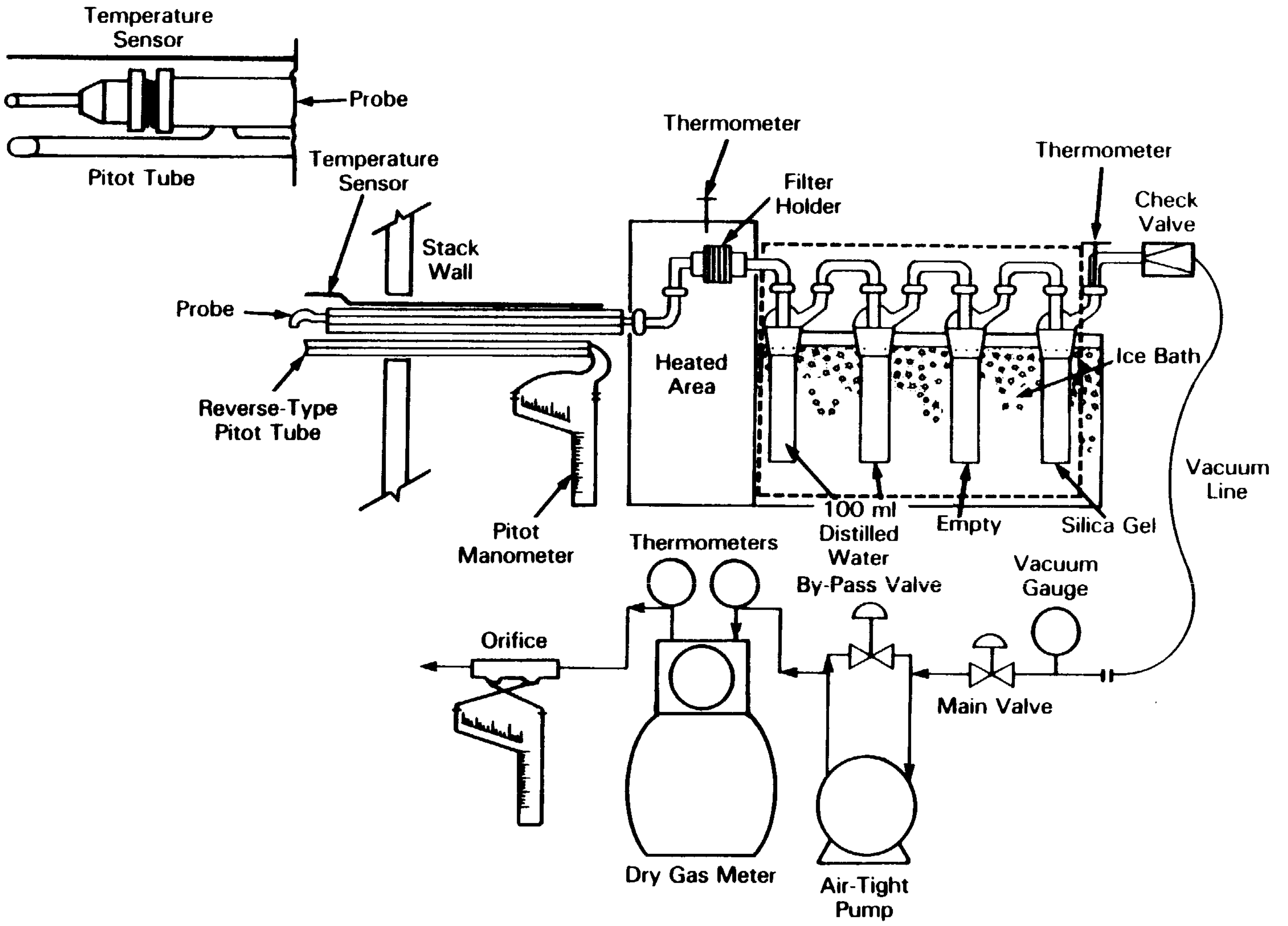

Figure 10-8. EPA Method 104 Sampling Train

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train. However, a Millipore AA (membrane) filter is required. The method recommends placing a glass fiber filter (such as a Whatman 41) behind the membrane filter, to prevent tearing. The membrane filter need not be pre-weighed.

Four impingers are used in the sampling train. The first two impingers contain 100 ml of deionized, distilled water. The third impinger's empty and the fourth impinger contains 200-250 grams of silica gel. The first, third, and fourth impingers may be modified tip impingers. The second impinger should be a Greenburg-Smith impinger.

10.3.1.1 Glassware

All sampling and recovery glassware is soaked in 50 percent by volume hydrochloric acid for 2 hours followed by rinsing with deionized, distilled water. The impingers may be dried with ACS reagent-grade acetone.

10.3.1.2 Equipment

Additional preparation includes the calibration and leakchecking of all train equipment. This includes meterboxes, thermocouples, nozzles, pitot tubes, and umbilicals. A discussion of the techniques used to calibrate and leakcheck this equipment was presented in Section 10.1.1.

10.3.2 Sampling Operations

Sampling operations for Method 104 are the same as those discussed in Section 10.1.2 except for the filter temperature. Membrane filters such as the Millipore AA are typically limited to about 225°F. Thus, the probe and filter heaters should be adjusted to prevent condensation in the probe liner but remain below approximately 200°F. The filter may be moved to after the first impinger to insure that the filter does not exceed its temperature limit, if necessary.

10.3.3 Sample Recovery

The sampling train is disassembled at the stack into three sections: the probe line, filter holder, and impingers in their bucket. Each section is capped with teflon tape or glass caps before removal to the recovery trailer. The field recovery and sample preparation scheme for Method 104 is shown in Figure 10-9.

10.3.4 Analytical Procedure

The Be samples are analyzed by atomic adsorption as shown in Figure 10-9. The samples are analyzed at 234.8 nm using a nitrous oxide/acetylene flame. Aluminum, silicon and other elements can interfere if present in large quantities.

10.3.5 Sample Calculations

$$C_{Be} = \frac{M_{Be} - M_{blank}}{V_{std}}$$

where

C_{Be} = concentration of beryllium the flue gas (ug/dscm)

M_{Be} = total mass of beryllium in ug.

M_{blank} = total mass of beryllium in acetone and reagent blanks (ug)

V_{std} = volume of the flue gas samples (dscm) adjusted to standard conditions (1 atm and 68°F)

10.4 Continuous Emissions Monitors (CEM) by EPA Methods 3A, 7E, 6C, 10, and 25A

EPA Methods 3A, 7E, 6C, 10, and 25A are continuous monitoring methods for measuring CO_2, O_2, NO_x, SO_2, CO, and THC (total hydrocarbons), respectively. Flue gas samples will be analyzed by these instrument methods at the stack for NO_x, SO_2, THC, and O_2. Samples will be taken at the spray drier inlet for O_2, CO_2, SO_2, and CO. A diagram of the system is shown in Figure 10-10.

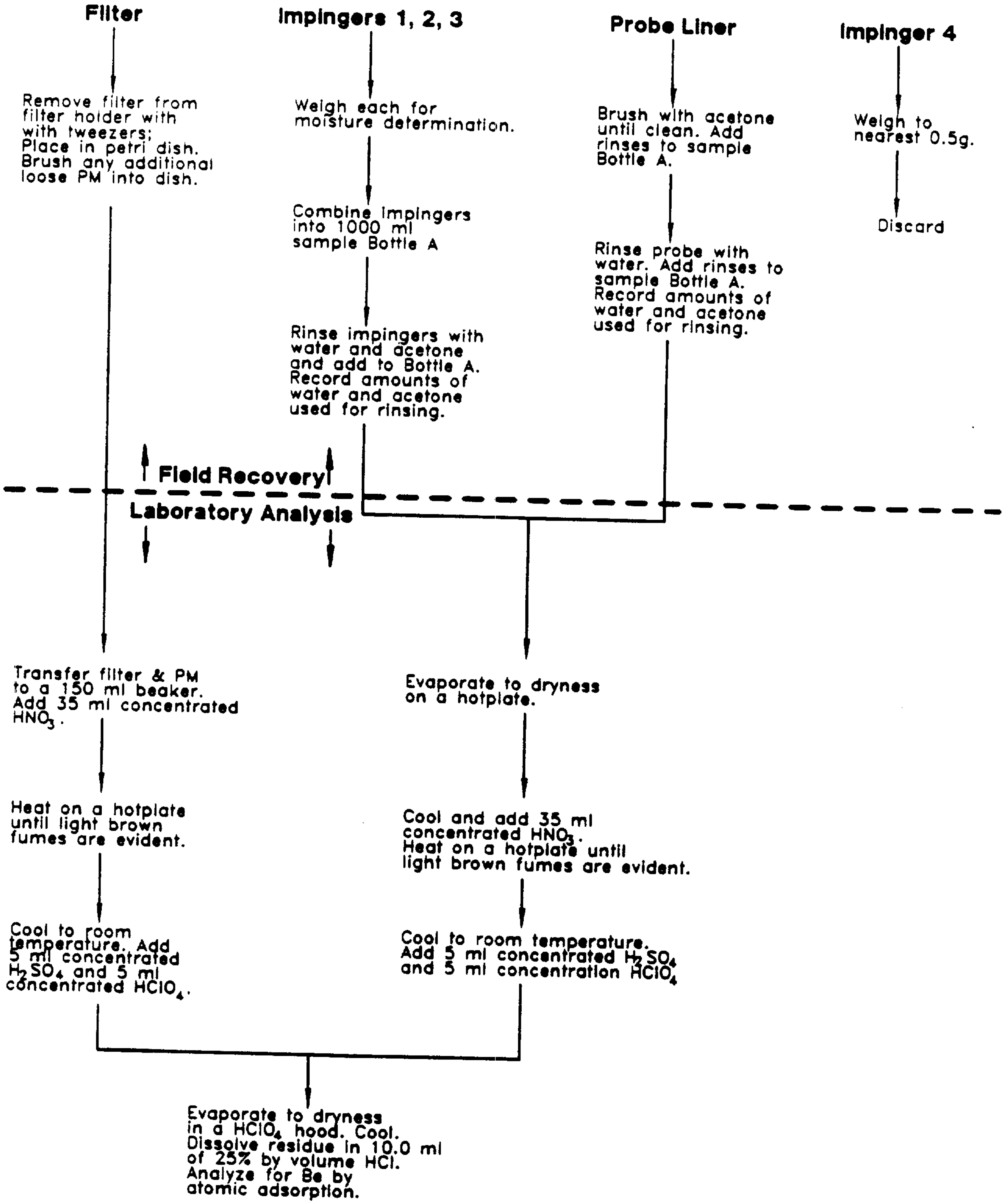

Figure 10-9. Method 104 Field Recovery and Sample Preparation Scheme

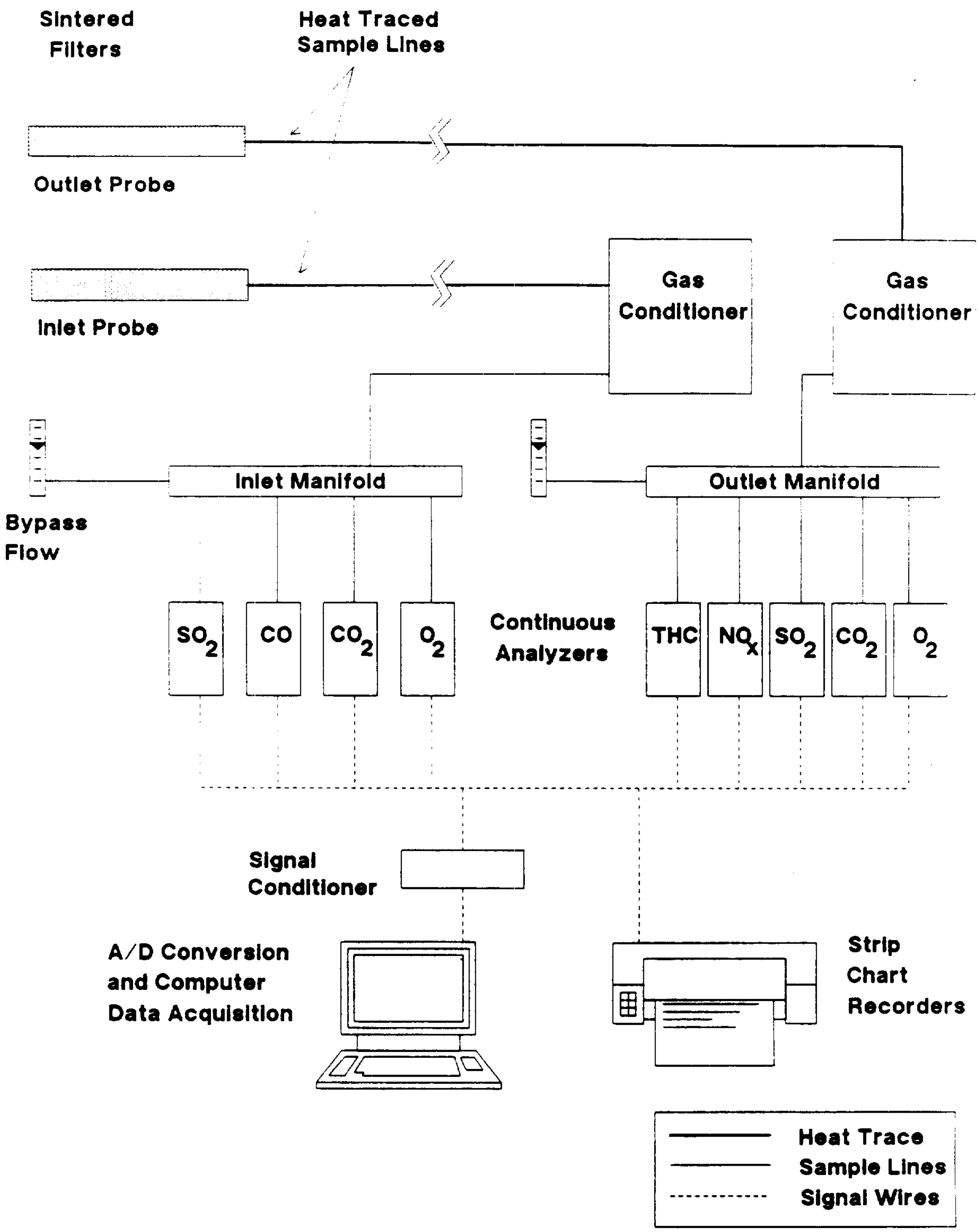

Figure 10-10. Schematic of CEM System

An extractive system is used to obtain flue gas samples for the CEM systems. Samples will be withdrawn continuously at a single point from both the stack breeching and the spray dryer inlet and transferred to the CEM trailer through heat-traced teflon line. The flue gas is conditioned (temperature lowered and moisture removed) before the flue gas stream is split using a manifold to the various analyzers.

10.4.1 Sample Probes

A CEM probe consists of a one micron sintered filter, a filter sheath, and a stainless steel sample line mounted to a port cap. The probe is placed at a point of average velocity in the stack. The point of average velocity is determined by a prior velocity traverse.

10.4.2 Heated Lines

Heated sample lines are used to transfer the flue gas samples to the instrument trailer. These lines are heated in order to prevent condensation. Condensate could clog sample lines or provide a medium for the flue gas sample to react and change composition.

All heat trace lines contain three 3/8" teflon tubes. One tube carries the sample, one tube is used for calibration, response times, and leakchecks, and the other is available as a backup. Temperatures are monitored with Type K thermocouples.

10.4.3 Gas Conditioning

A TECO Model 600 gas conditioner is used to reduce the particulate and moisture content of the flue gas. The TECO 600 system incorporates filters and refrigerated traps to remove particulate and reduce moisture. The gas conditioner is located in the CEM trailer.

10.4.4 CEM Principles of Operation

10.4.4.1 SO_2 Analysis

The Western 721A SO_2 analyzer is essentially a continuous spectrophoto-meter in the ultraviolet range. SO_2 selectively absorbs ultraviolet (UV) light at a wavelength of 202.5 nm. To take advantage of this property of SO_2, the analyzer emits UV light at 202.5 nm and measures the absorbance (A) of the radiation through the sample cell by the decrease in intensity. Beer's law, $A = abc$, is used to convert the absorbance into SO_2 concentration (A = absorbance, a = absorptivity, b = path length, c = concentration).

The TECO 40 SO_2 analyzer works on the principle of pulsed fluorescence. A pulsed source of ultraviolet radiation electronically excites the SO_2 molecules in the sample cell. The excited SO_2 molecules then decay back to their ground state by fluorescence, emitting a photon. However, this reaction is quenched by the presence of CO_2 and O_2. To compensate for this effect, the concentration of SO_2 is adjusted with a "quenching factor," discussed later in this section. Light emitted by the decaying SO_2 molecules has a different wavelength than the incident UV light. An optical filter selectively blocks the original incident UV light beam and allows only the emitted light to pass. Light which permeates the filter enters a photomultiplier tube which amplifies the signal and gives a response proportional to the SO_2 concentration.

10.4.4.2 NO_x Analysis

The principle of operation of this instrument is a chemiluminescent reaction in which ozone (O_3) reacts with nitric oxide (NO) to form oxygen (O_2) and nitrogen dioxide (NO_2). During this reaction, a photon is emitted which is detected by a photomultiplier tube. The instrument is capable of analyzing total oxides of nitrogen ($NO + NO_2$) by thermally converting NO_2 to NO in a separate reaction chamber prior to the photomultiplier tube, if desired.

10.4.4.3 O_2 Analysis

The Thermox WDG III measures oxygen using an electrochemical cell. Porous platinum electrodes are attached to the inside and outside of the cell which provide the instrument voltage response. Zirconium oxide contained in the cell conducts electrons when it is hot due to the mobility of O_2 ions in its crystal structure. A difference in O_2 concentration between the sample side of the cell and the reference (outside) side of the cell produces a voltage. This response voltage is proportional to the logarithm of the O_2 concentration ratio. A linearizer circuit board is used to make the response linear. Reference gas is ambient air at 20.9 percent O_2 by volume.

The Beckman 755 O_2 analyzer uses electron paramagnetic resonance to detect O_2 molecules. Unlike most substances, oxygen has a triplet electron ground state which leaves one electron unpaired, making it a paramagnetic molecule. This electron may have one of two spin quantum states ($m_s = \pm 1/2$). By applying an alternating electromagnetic field of the proper frequency, the Beckman 755 O_2 analyzer induces resonance between the two spin quantum states. In effect, the O_2 analyzer measures the electromagnetic energy absorbed by O_2 molecules at the resonant frequency.

10.4.4.4 CO_2 Analysis

Non-dispersive infrared CO_2 analyzers emit a specific wavelength of infrared radiation through the sample cell which is selectively absorbed by CO_2 molecules. The intensity of radiation which reaches the end of the sample cell is compared to the intensity of radiation through a CO_2-free reference cell. A reference cell is used to determine background absorbance which is subtracted from the sample absorbance. The detector uses two chambers filled with CO_2 which are connected by a deflective metallic diaphragm. One side receives radiation from the sample cell and the other side receives radiation from the reference cell. Since more radiation is absorbed in the sample cell than in the reference cell, less radiation reaches the sample side of the detector. This causes a deflection of the diaphram due to increased heat from radiation absorption on the reference side. Deflection of the diaphram creates an electrical potential which is proportional to absorbance. Absorbance is directly proportional to CO_2 concentration in the gas.

10.4.4.5 CO Analysis

The TECO Model 48 gas filter correlation analyzer and the Bendix Model 8501 NDIR analyzers both measure CO using the same principle of operation as CO_2 analysis. The instruments are identical except that a different wavelength of infrared radiation is used; 5 nm is selective for CO.

10.4.4.6 THC Analysis

EPA Method 25A applies to the measurement of total gaseous organic concentrations of primarily alkanes, alkenes, and/or arenes (aromatic hydrocarbons). The flue gas is analyzed by a Beckman 402 analyzer. The Beckman 402 analyzer uses a flame ionization detector (FID). As the flue gas enters the analyzer, the hydrocarbons are combusted in a hydrogen flame. The ions and electrons formed in the flame enter an electrode gap, decrease the gas resistance, and permit a current flow in an external circuit. The resulting current is proportional to the instantaneous concentration of the total hydrocarbons. This method is not selective between species. The results are reported on a methane basis and methane is used as the calibration gas.

10.4.5 Calibration

All the CEM instruments are calibrated (and linearized, if necessary) on a multipoint basis once on-site. A minimum of three certified calibration gases (zero and two upscale points) is required for calibrations of this type. Radian performs the multipoint calibrations with four certified gases: Zero gas (generally N_2), a low scale gas concentration, a midrange concentration, and a high scale concentration (span gas). The criterion for acceptable linearity is a correlation coefficient (R^2) of greater than or equal to 0.998, where the independent variable is cylinder gas concentration and the dependent variable is instrument response. If an instrument does not meet these requirements, it is linearized by adjusting potentiometers on the linerarity card within the instrument or by other adjustments, if necessary. Multipoint calibrations are also performed once each week while on-site. The specific calibration gases and operating ranges for each instrument for each location are summarized in Table 10-10.

The CEM analyzers are calibrated before and after each test run on a two point basis: zero gas (generally N_2), and a high-range span gas. These calibrations are used to calculate instrument drift as a percent of span during each test run.

After each initial calibration, midrange gases for all instruments are analyzed, with no adjustment permitted, as a quality control (QC) check. If the quality control midrange gas concentration observed is within ±10 percent of the certified concentration, the calibration is accepted and the operator may begin sampling. If the QC check does not fulfill this requirement, another calibration is performed and linearization may be performed if deemed necessary.

10.4.4.6 Data Aquisition

The data acquisition system used for the Hempstead Compliance test program consists of an Omega signal conditioner, a Tecmar A/D converter and a COMPAQ 286 computer. All instrument outputs are connected in parallel to stripchart recorders and the Omega signal conditioner. The stripchart recorders are a back-up system to the data logger. The signal conditioner adjusts the voltage response range from the output range of the instrument (typically 0-100 mV or 0-10 mV) to 0-5 volts. The A/D converter then digitizes the analog inputs for use by the computer. A Radian computer program translates the digitized voltages into relevant concentrations in engineering units (ppm V, %V, etc.). The computer program has several modes of operation: calibration, data acquistion, data reduction, data view, data edit, and data import. The import function is used to combine other data files for comparison and correlation.

TABLE 10-10. CEM INSTRUMENT CALIBRATION GASES FOR THE HEMPSTEAD COMPLIANCE TEST

Analyte	Specifications[a]
CO_2	
Instrument	Beckman 865
Location	Baghouse Outlet and Economizer Outlet
Range	0-20%V
Span Gas Value	18%V
Zero Gas Value	0%V(UHP N_2)
Midrange QC Gas Value	9%V
Low Range QC Gas Value	5%V
CO[b]	
Instrument	TECO 48H
Location	Economizer Outlet
Range	100 ppmV
Span Gas Value	80 ppmV
Zero Gas Value	0 ppmV(UHP N_2)
Midrange QC Gas Value	40 ppmV
Low Range QC Gas Value	18 ppmV

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[a] All calibration gases are certified as EPA Protocol 1 gas mixtures and are accepted as accurate within ±1% of the certified concentrations.

[b] Multiple ranges are available and these values are subject to change based on preliminary measurements.

TABLE 10-10. CEM INSTRUMENT CALIBRATION GASES FOR THE HEMPSTEAD COMPLIANCE TEST (continued)

Analyte	Specifications[a]
O_2	
Instrument	Thermox WDG III
Location	Baghouse Outlet and Economizer Outlet
Range	0-25%V
Span Gas Value	20.0%V
Zero Gas Value	0.2%V
Midrange QC Gas Value	10%V
Low Range QC Gas Value	5%V
SO_2[b]	
Instrument	Western 721A
Location	Economizer Outlet
Range	500 ppmV
Span Gas Value	300 ppmV
Zero Gas Value	0 ppmV
Midrange QC Gas Value	100 ppmV
Lowrange QC Gas Value	50 ppmV

---

[b] Multiple ranges are available and these values are subject to change based on on preliminary measurements.

TABLE 10-10. CEM INSTRUMENT CALIBRATION GASES FOR THE HEMPSTEAD COMPLIANCE TEST (continued)

Analyte	Specificationsa
SO_2[b]	
Instrument	Western 721A
Location	Baghouse Outlet
Range	500 ppmV
Span Gas Value	100 ppmV
Zero Gas Value	0 ppmV(UHP N_2)
Midrange QC Gas Value	50 ppmV
Low Range QC Gas Value	20 ppmV
NO_x	
Instrument	TECO 10AR
Location	Baghouse Outlet
Range	250 ppmV
Span Gas Value	200 ppmV
Zero Gas Value	0 ppmV(UHP N_2)
Midrange QC Gas Value	100 ppmV
Low Range QC Gas Value	50 ppmV
THC[b,c]	
Instrument	Beckman 402
Location	Baghouse Outlet
Range	50 ppmCH_4
Span Gas Value	25 ppmCH_4
Zero Gas Value	0 ppmCH_4
Midrange QC Gas Value	10 ppmCH_4
Low Range QC Gas Value	5 ppmCH_4

---

[b] Multiple ranges are available and these values are subject to change based on preliminary measurements.

[c] All THC calibration gases are methane in ultra-high purity air. Concentrations are expressed as parts per million methane.

10.4.4.7 Daily Operating Procedure

The following is a detailed procedure for calibrating and operating the CEM system:

(1) Turn on COMPAQ computer and EPSON printer, put printer on-line, and load the PCDAS program.

(2) Turn on strip chart recorders (SCR) and make appropriate notes on charts and in logbook (write down all procedures and observations in logbook and on SCRs as the day progresses).

(3) Turn on the gas conditioner and blowback compressor. Blow-back the system.

(4) Open all calibration gas cylinders so that they may be introduced to the instruments via control panel valves.

(5) Introduce ultra high purity nitrogen to the system to zero all instruments except the two Thermox O_2 analyzers. Make adjustments to the zero potentiometers as required to zero the instruments. Be sure to check and maintain all flows throughout calibration and operation.

(6) Record the zero values in the computer calibration routine.

(7) Introduce 0.2 percent O_2 to set the low scale response for the Thermox O_2 analyzers and repeat Step 6 for these instruments.

(8) Introduce the mixed span gases for O_2, CO_2, and CO. Make adjustments as required to these instruments.

(9) Enter these values in the computer calibration routine.

(10) Introduce the NO_x span gas.

(11) Make adjustments to the NO_x instruments as required and enter the value into the computer calibration routine.

(12) Introduce the SO_2 span gas for the 0-5000 ppm range, repeat Step 11 for the Western SO_2 analyzer.

(13) Switch the Western SO_2 analyzer range to 0-500 ppm introduce the span gas for this range and repeat Step 11 for this instrument.

(14) Follow the procedure in Step 12 for the TECO SO_2 analyzers on the 0-1000 ppm range.

(15) Check the calibration table on the computer, and make a hardcopy. Put the computer in the standby mode.

(16) Introduce QC gases to instruments in the same sequence as the calibration gases. Record three minutes of data for each, once the responses have stablized. If the QC gas response is not within ±10 percent of the cylinder concentration, the operator must recalibrate the instrument.

(17) Begin sampling stack gas, with the computer on stand by.

(18) Perform initial leakcheck of system.

(19) Start the data acquisition system when signaled by radio.

(20) Carefully check all flows and pressures during the operation of the instruments and watch for apparent problems in any of the instruments, such as unusual readings or unreasonable fluctuations. Check the gas conditioning system periodically and drain the traps.

(21) Stop the data acquisition system at the end of the test when signalled.

(22) Perform final leakcheck of system.

(23) Perform the final calibration (Repeat steps 5-16) except make no adjustments to the system.

(24) Check for drift on each channel.

10.5 HCl Sampling Method

HCl sampling followed the EPA/EMSL draft protocol entitled "The Determination of HCl Emissions from Municipal and Hazardous Waste Incinerators." In this method, an integrated gas sample is extracted from the stack and passed through acidified water. In acidified water, HCl solubilizes and forms chloride (Cl^-) ions. Ion chromatography (IC) is used to detect the Cl^- ions present in the sample. This method was developed by the Source Branch of the Quality Assurance Division of the Environmental Measurement Systems Laboratory (EMSL).

10.5.1 Equipment and Sampling Preparation for HCl Sampling

A diagram of the HCl sampling train is shown in Figure 10-11. The sampling train consists of a borosilicate glass probe (~6 mm inside diameter) with a plug of glass wool in the probe tip to remove particulate matter, a

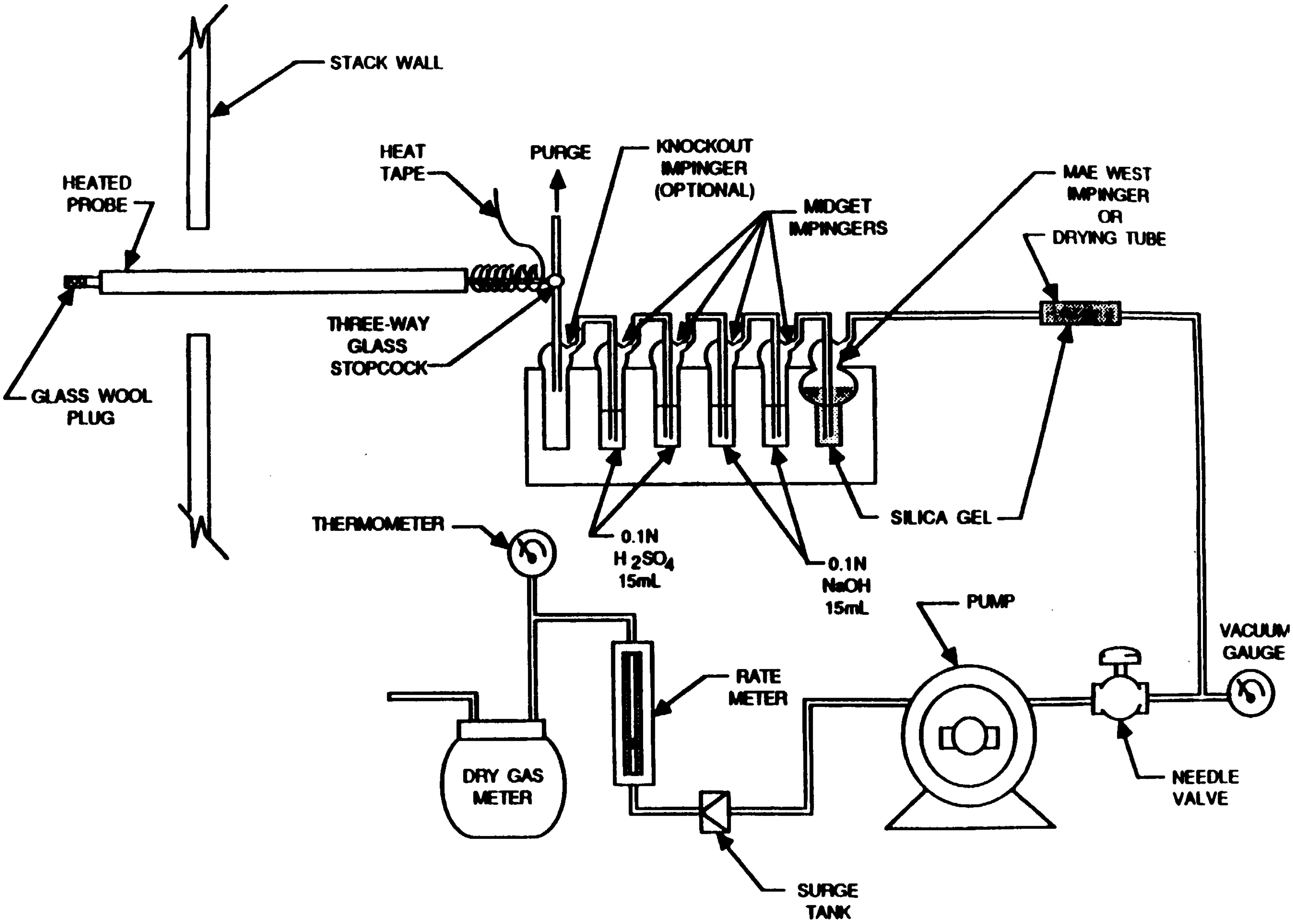

Figure 10-11. EMSL HCl Sampling Train Configuration

three-way stopcock, 6 midget impingers and a dry gas meter (DGM) system. The train consists of a knockout impinger followed by two impingers containing 0.1 N H_2SO_4 to collect HCl, two impingers containing 0.1 N NaOH to capture any Cl_2 present in the flue gas that might cause DGM damage, and finally one silica gel impinger. A drying tube may be used in place of the last impinger.

10.5.1.1 Equipment

Sampling preparation includes calibration and leakchecking of all train equipment. This includes meterboxes, thermocouples, and umbilicals. Referenced calibration procedures are followed when available, and the results properly documented and retained. If a referenced calibration technique for a particular piece of apparatus is not available, then a state-of-the-art technique is used. A discussion of the techniques used to calibrate this equipment is presented below.

10.5.1.2 Temperature Measuring Device Calibration

This discussion was presented previously in Section 10.1.1.

10.5.1.3 Dry Gas Meter Calibration

This discussion was presented previously in Section 10.1.1.

10.5.1.4 Assembling the Train

Assembly of the HCl sampling train is done both in the recovery trailer and at the stack location. First, the empty clean midget impingers are assembled and laid out in the proper order. The first impinger is a knockout impinger which has a short tip so that the sample does not bubble through the collected condensate. The next two impingers contain 15 mL 0.1 N H_2SO_4 each, followed by two impingers filled with 15 mL each of 0.1 N NaOH, and one silica gel impinger. When the impingers are loaded, they may be wrapped with teflon tape to secure the two sections of the impinger. Each impinger is then weighed and the weight recorded along with information on the contents of the impingers. The impingers are connected together using U-tube connectors and arranged in the impinger bucket. The height of all the impingers should be approximately the same to obtain a leakfree seal. The open ends of the train are sealed with aluminum foil.

10.5.2 Sampling Operations

The HCl train is leakchecked at the start and finish of sampling as required by the draft protocol. The leakchecking procedure is as follows:

- Leakcheck probe and three-way stopcock prior to inserting probe in stack;
- Connect stopcock to probe outlet and sample line to needle valve;
- Plug probe inlet and pull a vacuum of at least 10 in Hg;
- Turn off needle valve and check to make sure vacuum remains stable for at least 30 seconds.

After leakchecking, the heaters are turned on for the probe and stopcock. When the system reaches the appropriate temperature, the probe is purged at a rate of about 2 L/min for at least 5 minutes prior to sampling. To collect sample, turn the stopcock to permit stack gas to be pulled through the impinger train. Adjust the sampling rate to 2 liters/min and maintain this rate to within 10 percent during the entire sampling run. The leakrate, sampling start/stop times, and any other events (i.e., heater malfunctions, etc.) are be recorded on the sampling task log. Upon completion of a sampling run, repeat the leakcheck procedure. Sampling train data are recorded every five minutes, and include readings of the DGM, DGM temperature, flowrate meter, and vacuum gauge.

10.5.3 Sample Recovery

The impingers are disconnected from the probe and removed to the recovery trailer. Once in the trailer, the contents of the two acidified impingers are quantitatively recovered with deionized distilled water. The sample bottle should be sealed, mixed, labeled and the fluid level marked. The contents of the impingers and connecting glassware from the second set of impingers (containing the 0.1 N NaOH) are discarded.

10.5.4 HCl Analytical Procedures

Before analysis, the samples are checked against the chain-of-custody forms and then given an analytical laboratory sample number. Then, each sample is reweighed to determine if any leakage occurred and any color or other particulars of the samples are noted.

The ion chromatographic conditions depend on the type of analytical column and whether suppressed or nonsuppressed IC is used. Prior to sample analysis, a stable baseline is established and water samples are injected until no Cl^- appears in the chromatogram. Then, the IC is calibrated using standards spanning the appropriate concentration range, starting with the lowest concentration standard. Next, inject, in duplicate, a QC check sample, followed by a water blank and the field samples. The calibration standards are re-injected at the end of the analysis to allow compensation for any drift in the instrument response during analysis of the field samples. The HCl sample concentration are calculated from either the Cl^- peak area or peak height and the calibration curve.

10.5.5 Data Reduction

The sample volume is calculated according to the equation:

$$V_{m(std)} = \frac{17.64^\circ\ R}{\text{in. Hg}} \times Y \times \frac{V_m P_{bar}}{Tm}$$

where,

$V_{m(std)}$ = dry gas sample volume measured by DGM corrected to standard conditions, dscm

Y = DGM calibration factor

V_m = DGM volume, dry basis, dcm

P_{bar} = barometric pressure, in Hg

T_m = meter temperature, °R

The concentration of HCl in the flue gas can then be calculated by the equation:

$$C = \frac{10^{-3} \text{ mg/ug} \times [102.84\ (S-B)]}{V_{m(std)}}$$

where,

C = HCl concentration, dry basis, mg/dscm

S = analysis of sample, ug Cl^-/mL

B = analysis of blanks, ug Cl^-/mL

10.6 Volumetric Flowrate Determination by EPA Method 2

Volumetric flowrate is measured according to EPA Method 2. A type K thermocouple and S-type pitot tube are used to measure flue gas temperature and velocity, respectively.

10.6.1 Sampling and Equipment Preparation

For EPA Method 2, the pitot tubes are calibrated before use following the directions in the method. Also, the pitots are leakchecked before and after each run.

10.6.2 Sampling Operations

The parameters that are measured includes the pressure drop across the pitots, stack temperature, stack draft and ambient pressure. These parameters are measured at each traverse point, as applicable. A computer program is used to calculate the average velocity during the sampling period.

10.7 Moisture Determination by EPA Method 4

The average flue gas moisture content of the flue gas is determined according to EPA Method 4. Before sampling, the initial weight of the impingers is recorded. When sampling is completed, the final weights of the impingers are recorded, and the weight gain is calculated. The weight gain and the volume of gas sampled are used to calculate the moisture content (percent) of the flue gas. The calculations are performed by computer.

10.8 Particle Size Distribution

Particle size distribution measurements of the outlet flue gas stream is obtained with an in-stack cascade impactor. An in-stack cascade impactor classifies particles according to their aerodynamic diameters. The aerodynamic diameter of a particle is the diameter of a unit density sphere that has the same terminal settling velocity as the particle.

The expected particulate loading at the outlet stack (0.005 grains/dscf) requires the use of an Andersen MK III impactor. The impactor consists of eight stages plus a final filter. Each stage has a number of concentric round jets offset on each succeeding stage such that the one plate serves both as jet and impaction surface. The sampling train is shown in Figure 10-12.

Since the flue gas is expected to be in the range of 400°F, glass fiber substrates are used. The Andersen MK III is operated in the range from 0.3 to 0.7 acfm and the flue gas is sampled isokinectically (100 ±20 percent). A weight gain of 50 mg is recommended which at the expected particulate loading will require each sampling run to be four hours in duration.

10.8.1 Equipment and Sampling Preparation

The glass fiber substrates and the stainless steel impactor housing and plates both require pre-test preparation.

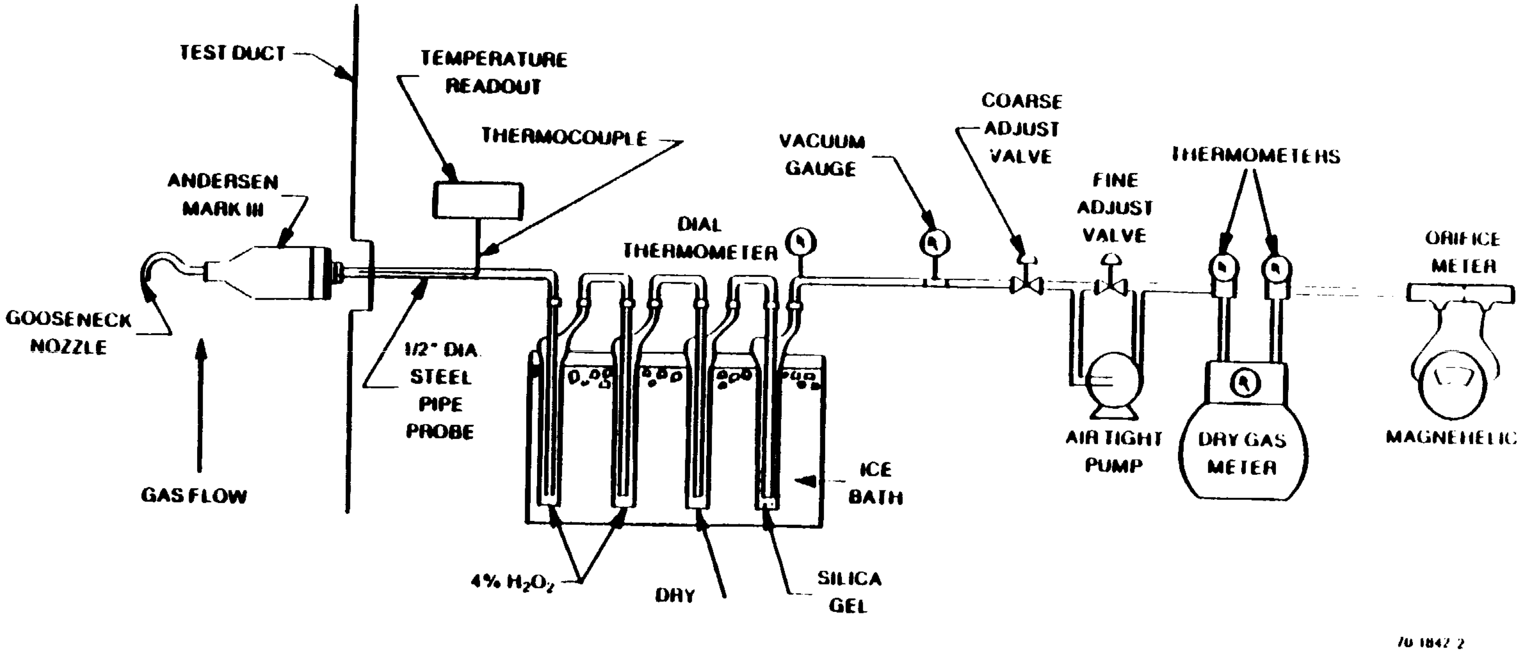

Figure 10-12. Anderson MK III In-Stack Impactor Sampling Train

10.8.1.1 Glass Fiber Substrates

Glass fiber substrates may interact with the flue gas and cause weight gain not due to particulate gain. Reeve Angel 934AH substrates are used because they exhibit minimal interaction. Also, a field blank is collected to document any interaction that may occur. The final filter has an efficiency of 99.95 percent on 0.3 DOP particles as required by ASTM Standard Method D.

Each glass fiber substrate is tared before sampling. Initially, the substrates are dessicated at a known relative humidity for two hours. Then each substrate is weighed to a constant weight to the nearest 0.01 mg (two weighings agree within 0.05 mg). Then each substrate is stored in individual petri dishes which is marked with an identification number and the tare weight. These data are also recorded in the log book.

10.8.1.2 Impactor

Prior to use, the impactor housing is cleaned with soapy water, rinsed with water and dried with acetone. The jet plates and spacers are cleaned in a sonic cleaner using a mild detergent. All the gaskets and spacers are inspected, and any worn or bent pieces are replaced.

10.8.2 Sampling

As the substrates are loaded into the impactor, the identification number and tare weight are recorded. The stage order is checked for correctness, as the stages are assembled. Once the impactor is assembled, it is wrapped with heating tape, maintained in an upright vertical position and pre-heated to approximately 400°F.

The impinger train is prepared according to EPA Method 5. The impingers and contents are weighed and the weights recorded. Then, the impactor and nozzle are attached to the probe and the probe attached to the impinger train. Once assembled, the sampling train is leak-checked at 15" of Hg. The leakrate must be below 0.02 cfm.

Prior to sampling, a preliminary velocity traverse is conducted to determine a point of average velocity and to determine an isokinetic sampling rate. The sampling rate is adjusted to give the desired separation. A few preliminary runs are conducted to determine if the sampling rate is appropriate.

Sampling is conducted at a single point of average velocity at the pre-determined fixed sampling rate. The sampling rate is not adjusted during the run.

10.8.3 Sample Recovery and Analysis

After sampling is completed, the impactor is cooled in a vertical position. The impingers are weighed to determine water weight gain. After the impactor has cooled, each stage is carefully recovered. Any particles lost to surfaces upstream of a stage substrate are added to that substrate. Particles from the nozzle and pre-separator are added to the first stage.

Each substrate is examined for particle bounce, overloading and re-entrainment. Sufficient mass should be present to obtain a valid weighing. If acceptable, the substrates are dessicated for two hours and weighed to a constant weight.

10.8.4 Calculations

Data obtained during impactor sampling is input to Radian's Particle Sizing Data Reduction program. The results of the program summarizes flue gas characteristics and impactor operating parameters and calculates the experimental stage (Dp_{50}) cutpoints, cumulative mass fractions, geometric midpoints and differential mass concentrations. The experimental data are smoothed by a spline fit to form a composite curve.