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Neshap Screening Study Chromium

Emission Test Report Carolina Plating Company Greenville, South Carolina

EMISSION TEST REPORT

CAROLINA PLATING COMPANY
GREENVILLE, SOUTH CAROLINA

ESED 85/02

EMB 85-CHM-11

by

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1.0 INTRODUCTION

During the week of May 13-17, 1985, the Emission Measurement Branch of the U. S. Environmental Protection Agency conducted an emission measurement program at Carolina Plating Company's plating plant located in Greenville, South Carolina. The purpose of this program was to provide data for a screening study to determine the quantity and form of chromium emissions associated with hard chromium plating.

Comprehensive testing was conducted on a series of chromium plating tanks all of whose emissions are controlled by a single packed-bed wet scrubber. This fume scrubber controlling emissions from hard chromium plating tanks No. 1, 2, 3, and 7 at the plant was selected for source testing for the following reasons:

- Carolina Plating applies hard chromium plate to large industrial rollers. Typically the rollers remain in the tanks for 12 to 36 hours, depending on the dimensions of the rollers and the chromium plate thickness required. Although there is no industry wide "typical" part that receives hard chromium plate, it is not unusual for job shops to plate industrial rollers. The advantages of performing a source test on a tank used for plating rollers instead of other types of metal parts are: a) the long plating time accommodates continuous testing, b) the amount of chromium deposited during the test can be easily determined, and c) the surface area plated can be easily determined.

- The plating tanks appear to be typical of other hard chromium plating tanks in the electroplating industry, based on operating parameters such as current, voltage, plating time, and chromic acid concentration. The tanks are situated with the longest dimension in the vertical direction, which is common for tanks that are used to plate large industrial rollers. There are no demisting agents used in the plating tanks. The use of demisting agents is not common practice for hard chromium platers.

- The emissions capture system is highly efficient in directing fumes from the plating tanks to the control device. The vertical orientation of the tanks minimizes the exposed surface area of plating solution from which fumes must be drawn. Each of the four tanks is equipped with hoods on three sides through which a common induction fan pulls a total of 20,000 standard cubic feet per minute (scfm).

- The Napco wet packed-bed fume scrubber at this facility is typical of control devices in use at other hard chromium plating facilities. Most hard chromium plating facilities that control chromic acid emissions use impingement-type mist eliminators or packed-bed fume scrubbers. As a result, emission data obtained from testing at the outlet of the scrubber at this facility should be representative of emissions from control devices typically applied at hard chromium plating facilities.

Particulate concentrations and mass emission rates were measured at the scrubber inlet and outlet using U. S. Environmental Protection Agency (EPA) Reference Method 5.* Total chromium concentrations and hexavalent chromium concentrations were measured at the same locations by further analysis of the Method 5 samples using the alternate sample preparation and analytical procedures as described in Appendix C. Flue gas flow rates, temperature, moisture content, and composition [oxygen (O_2), carbon dioxide (CO_2), and carbon monoxide (CO)] were measured in conjunction with the particulate tests. In addition, "medium volume" (MV) particulate matter sampling was conducted at the same locations using a thimble filter and an experimental MV sampling train as described in Appendix C.

Ms. Barbara Duletsky [Midwest Research Institute (MRI)] monitored process operation throughout the test period. Mr. Dan Bivins (EPA Task Manager) of the Emission Measurement Branch (EMB) and Mr. Al Vervaert of the Industrial Studies Branch (ISB) observed the test program. Mr. J. F. Tucker, Vice-President served as the contact for Carolina Plating.

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* 40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

This report is organized into several sections addressing various aspects of the testing program. Immediately following this introduction is the "Process Operation" section which includes a description of the process and control device tested. Following this is the "Summary of Results" section which presents table summaries of the test data and discusses these results. The next section, "Sampling Locations and Test Methods" describes and illustrates the sampling locations for emissions testing and grab sampling and then explains the sampling strategies used. The final section, "Quality Assurance," notes the procedures used to ensure the integrity of the sampling program. The Appendices present the complete Test Results and Example Calculations (Appendix A); Field and Analytical Data (Appendix B); Sampling and Analytical Procedures (Appendix C); Calibration Data (Appendix D); MRI Process Data (Appendix E); and Test Participants and Observers (Appendix F).

2.0 PROCESS OPERATION

2.1 PROCESS DESCRIPTION

The Carolina Plating Roll Division is a job shop specializing in precision finishing and refinishing of industrial rolls. Operations performed at this facility include hard chromium plating, sulfamate nickel plating, machining, grinding, and mirror finishing. The plant plates rolls that are used primarily in the paper manufacturing, roofing, laminating, and coating industries. Although some parts of the finishing processes performed at this plant are unique, the actual plating process is similar to that at most other hard chromium plating operations.

There are seven hard chromium plating tanks at this facility, arranged as shown in Figure 2-1. On the average, the tanks are charged for a total of 20 hours per day. Approximately 4 hours per day are required for the change-over of rolls. During a change-over, the roll that has been plated is raised out of the plating tank, rinsed with water from a hose, and transferred to the grinding area. Then, the roll to be plated is cleaned with an abrasive cleanser and lowered into the plating solution. Plating times range from 2 to 36 hours, depending on the surface area of the roll and the plate thickness required. Usually, rolls that require longer plating times are plated overnight, and rolls that require shorter plating times are plated during the day when personnel are available to perform the change-over.

Tank Nos. 1, 2, 3, and 7 were tested during this source test program. The tanks are situated below floor level and are oriented with the largest dimension in the vertical direction. This orientation is typical of tanks used to plate industrial rolls throughout the electroplating industry. Each tank is serviced by an electric hoist that lowers and raises the rolls into and out of the plating solution. In addition, each tank is equipped with a timer that automatically turns off the electrodes at the end of the specified plating time.

The plating tanks are typical of other hard chromium plating tanks in the electroplating industry, based on operating parameters such as current, voltage, plating time, and chromic acid concentration. Table 2-1 lists maximum operating conditions for the four tanks. Although the

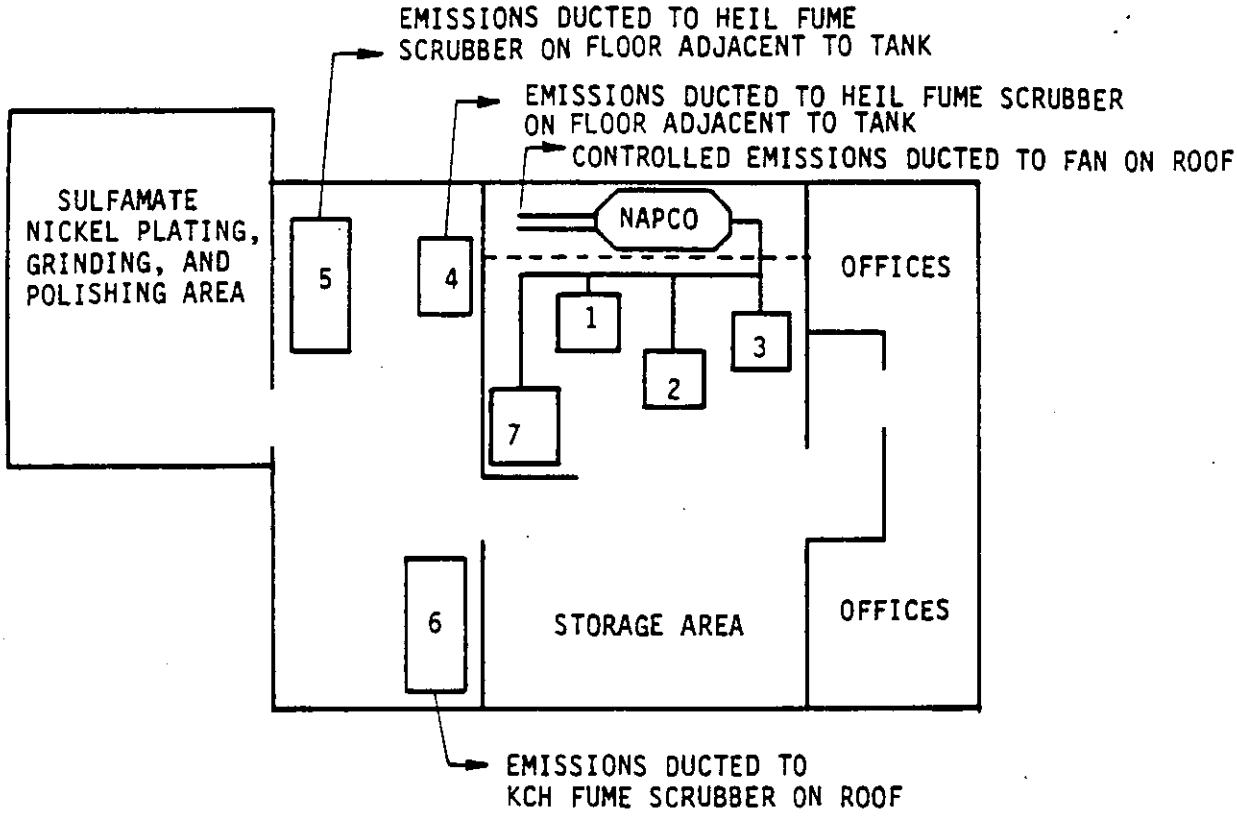

Figure 2-1. Plan view of Carolina Plating facility.

TABLE 2-1. SPECIFICATIONS OF HARD CHROMIUM PLATING TANKS AT CAROLINA PLATING

Tank No.	Capacity, ℓ (gal)	Surface m^2 (ft^2)	Voltage, volts[a]	Current, amperes[a]	Method of cooling	Constituents, g/ℓ (oz/gal)	
						CrO_3	H_2SO_4
1	3,800 (1,000)	1.3 (14)	12	7,000	Water	250 (33)	2.5 (0.33)
2	7,600 (2,000)	1.7 (18)	12	20,000	Water	250 (33)	2.5 (0.33)
3	11,400 (3,000)	3.3 (36)	10	30,000	Water	250 (33)	2.5 (0.33)
7	9,100 (2,400)	2.2 (24)	10	15,000	Water	250 (33)	2.5 (0.33)

[a]Values represent maximum operating values.

composition of the plating solution remains constant, the operating voltage and current vary with each roll that is plated.

2.2 AIR POLLUTION CONTROL

All four tanks are equipped with hoods on three sides to capture the chromic acid mist generated during the plating process. A plan view of the exhaust system is shown in Figure 2-2. Emissions that are captured by the exhaust system are treated by a fume scrubber located on a mezzanine adjacent to the plating area. The scrubber is a double packed-bed type manufactured by Napco, Incorporated (Model No. MA-101). Each bed contains 30 cm (12-inches) of polypropylene packing. The beds are sprayed continuously with water, which drains into a holding tank and is recirculated through the scrubber. The holding tank is flushed and filled with clean water about 3 times a day. The spent liquid is either used as make-up solution for the plating tanks or is treated on site in a wastewater treatment system.

The scrubber also contains a mist elimination stage for the removal of water droplets entrained in the exhaust gas stream. This stage consists of a "Chevron-type" arrangement of baffles that changes the direction of gas flow four times at 30°-angles. The entire scrubbing unit has a design control efficiency of 96 to 99 percent for the removal of chromic acid.

The exhaust fan, which is located immediately downstream of the scrubber, is manufactured by Duall Industries, Incorporated (Model No. NH-66). The fan is rated at 9.4 cubic meters per second (m^3/s) (20,000 standard cubic feet per minute [scfm]) for air at 21°C (70°F); however, a gas flow of 4.7 m^3/s (10,000 scfm) was measured during the test series. Exhaust gases exit through a short stack located on the roof.

2.3 PROCESS CONDITIONS DURING TESTING

Process operating parameters such as plating solution temperature, operating voltage, and operating current were monitored and recorded during each test run. Copies of the actual data sheets are presented in Appendix E. Also recorded were descriptions (dimensions and surface area) and plating requirements (current and plating time) of each individual job or item being plated during each test run. This information was obtained

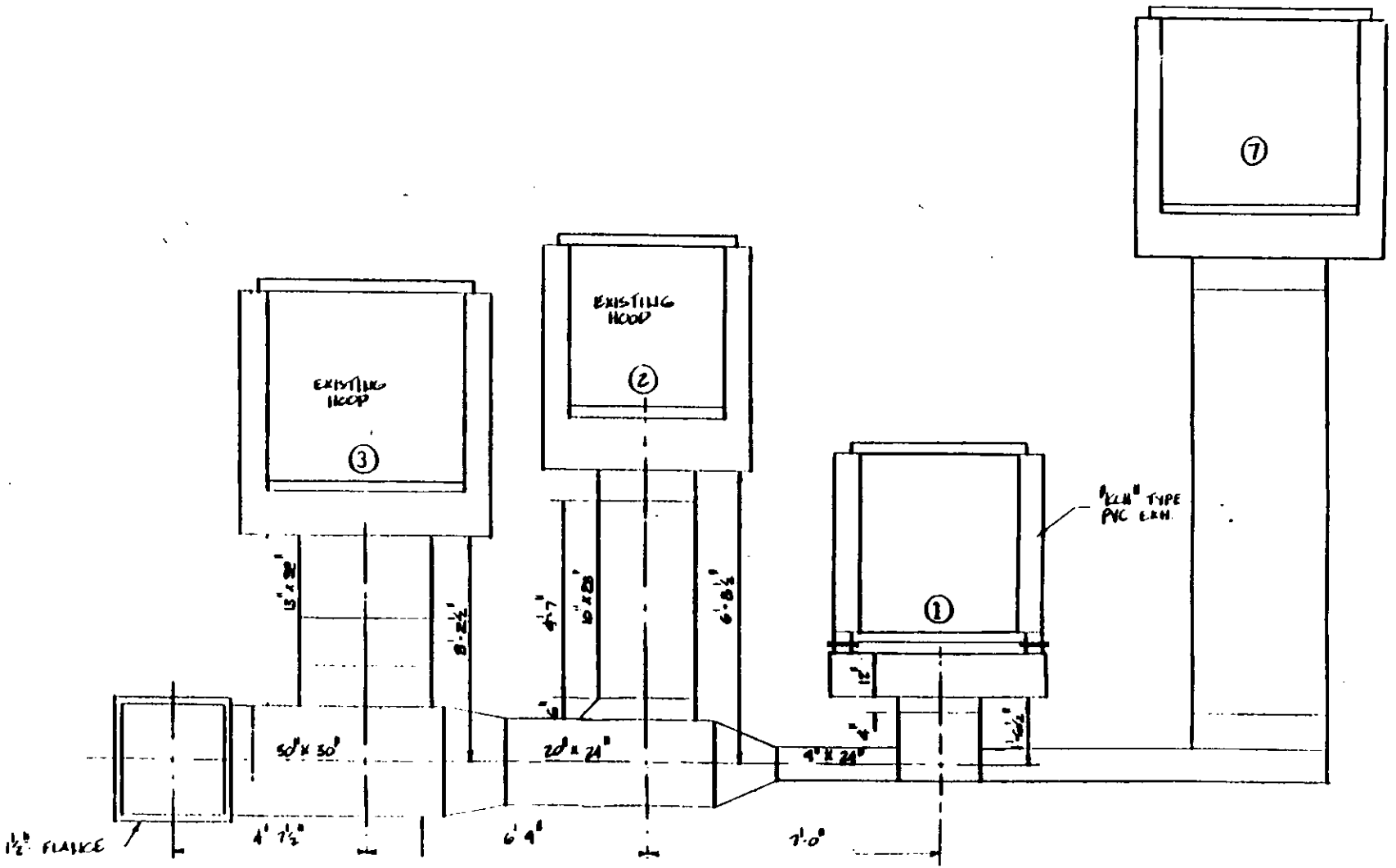

Figure 2-2. Plan view of exhaust system on Tank Nos. 1, 2, 3, and 7.

from log sheets maintained by plant personnel and is also presented in Appendix E. No operating parameters were monitored for the scrubber; however, there were no indications of any malfunction in the system during the testing period.

Test run Nos. 1 and 3 were performed without interruption. Test run No. 2 was suspended at one point because the production rate in the tanks was significantly lower than normal. Testing was resumed after 1 hour when the production rate was increased.

The total current supplied to the tanks during each test run is calculated in terms of ampere-hours and included in Appendix E. A summary of the total current values is presented in Table 2-2.

TABLE 2-2. TOTAL CURRENT SUPPLIED TO TANKS DURING SOURCE TEST RUNS

Test No.	Total current, ampere-hours	
	Inlet	Outlet
1	41,300	42,200
2	50,300	45,900
3	72,400	70,600

3.0 SUMMARY OF RESULTS

Particulate matter and experimental "medium volume" tests were conducted at the inlet and the outlet of the packed-bed wet scrubber controlling chromium plating tanks No. 1, 2, 3, and 7. Table 3.1 summarizes the testing schedule.

In brief, from the results of the Method 5 testing, the uncontrolled emissions from the tanks averaged 0.22 pounds per hour of particulate matter, 0.025 pounds per hour of hexavalent chromium, and 0.052 pounds per hour of total chromium. The controlled emissions averaged 0.11 pounds per hour of particulate matter, 0.001 pounds per hour of hexavalent chromium, and 0.004 pounds per hour of total chromium. The resulting collection efficiency of the wet scrubber was 43.5% for particulate matter, 95.7% for hexavalent chromium, and 93.0% for total chromium. The "medium volume" testing results are not included in the summary of results since this is a screening technique. These results are discussed separately in Section 3.4.

In the following sections, the results addressed above and additional results are presented and discussed in detail according to the emission type and sampling location. The computer printouts of the emission calculations are can be found in Appendix A. The original field data sheets and the analytical data are located in Appendix B.

3.1 PARTICULATE MATTER, HEXAVALENT CHROMIUM, AND TOTAL CHROMIUM

Particulate matter tests (EPA Method 5) along with the determination of the associated flue gas flow rates were conducted at both the scrubber inlet and outlet. The particulate matter samples were initally analyzed using gravimetric techniques to determine the mass of particulate matter. Then the

TABLE 3.1. TESTING SCHEDULE FOR CAROLINA PLATING

Date (1985)	Sample Type	Scrubber Inlet		Scrubber Outlet	
		Run No.	Test Time 24 h clock	Run No.	Test Time 24 h clock
5-14	Medium Volume	DIF1	1230-2130		
5-15	Particulate Medium Volume	I-1 DIF2	1235-1723 1915-0730	0-1	1230-1724
5-16	Particulate Particulate Medium Volume	I-2 I-3	0901-1442 1525-2013	0-2 0-3 DIF3	0838-1419 1517- 2015-0850

samples were further analyzed for hexavalent and total chromium. Complete descriptions of each sampling location and the sampling and analytical procedures are given in Chapter 4 (and Appendix C).

3.1.1 Scrubber Inlet

The scrubber inlet represents the uncontrolled emissions from plating tanks No. 1, 2, 3, and 7. The circular horizontal inlet duct was only traversed in one direction during the particulate sampling. The single traverse was utilized because of the difficulty in gaining access to the duct and because the very fine acid mist particles present in the duct would be expected to behave like a gas resulting in a uniform cross-sectional particle distribution. Prior to the Method 5 testing at the scrubber inlet, a pitot traverse was conducted along two axes. Since the pitot traverse showed flow rates only slightly less (1%) than the Method 5 sampling, the Method 5 test data was used in the calculations and is presented in the summary tables.

Flue Gas Conditions and Isokinetic Sampling Rate - A summary of the flue gas conditions at the scrubber inlet and outlet is presented in Table 3.2. The volumetric flow rates were fairly consistent and averaged 16,500 actual cubic meters per hour (582,000 actual cubic feet per hour). The flow rate at the inlet was approximately 13% lower than the outlet flow rate; this was likely due to measurement error in the outlet flow rate measurements which were conducted in nonparallel flow.

The flue gas temperature averaged 28°C (82°F), with a moisture content of 1.5 percent. The oxygen, carbon dioxide, and carbon monoxide content was that of air at 20.9, 0.0, and 0.0 percent, respectively. The volumetric flow rate at standard conditions averaged 15,200 dry standard cubic meters per hour

TABLE 3.2. SUMMARY OF FLUE GAS CONDITIONS

Run No.	Date (1985)	Test Time 24 h clock	Volumetric Flow Rate				Stack Temperature		Moisture %	O_2 %	CO_2 %	CO %	Isokinetic %
			Actual[a]		Standard[b]								
			acmh $\times 10^6$	acfh $\times 10^6$	dscmh $\times 10^6$	dscfh $\times 10^6$	°C	°F					
Scrubber Inlet													
I-1	5/15	1235-1723	0.0171	0.6029	0.0158	0.5589	29	84	1.6	20.9	0.0	0.0	97.1
I-2	5/16	0901-1442	0.0160	0.5645	0.0149	0.5264	26	79	1.5	20.9	0.0	0.0	100.1
I-3	5/16	1525-2013	0.0163	0.5772	0.0151	0.5333	29	84	1.4	20.9	0.0	0.0	98.9
Average			0.0165	0.582	0.0152	0.540	28	82	1.5	20.9	0.0	0.0	
Scrubber Outlet													
O-1	5/15	1230-1724	0.0190	0.6723	0.0177	0.6246	29	85	2.2	20.9	0.0	0.0	95.9
O-2	5/16	0838-1419	0.0190	0.6721	0.0178	0.6278	25	77	2.2	20.9	0.0	0.0	96.5
O-3	5/16	1517-	0.0186	0.6565	0.0173	0.6103	27	81	1.7	20.9	0.0	0.0	95.8
Average			0.0189	0.667	0.0176	0.621	27	81	2.0	20.9	0.0	0.0	

[a]Volumetric flow rate in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions.
[b]Volumetric flow rate in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh).

(540,000 dry standard cubic feet per hour). Standard conditions are 20°C (68°F), 760 mm Hg (29.92 in. Hg), and dry. The isokinetic sampling rate was within the allowable range for all three sample runs.

Particulate Emissions - The particulate emissions from the plating tanks (see Table 3.3) were variable. The particulate emissions for the inlet runs averaged 6.37 milligrams per dry standard cubic meter (0.0028 grains per dry standard cubic foot) and 0.097 kilograms per hour (0.22 pounds per hour).

Hexavalent Chromium Emissions - The hexavalent chromium emissions for each test run (see Table 3.3) were consistent with the corresponding particulate run. They averaged 119, 95, and 127 milligrams of hexavalent chromium per gram of particulate emissions for runs I-1, I-2, and I-3, respectively. The hexavalent chromium emissions for the inlet tests averaged 0.736 milligrams per dry standard cubic meter (0.00032 grains per dry standard cubic foot) and 0.0113 kilograms per hour (0.025 pounds per hour).

Total Chromium Emissions - The total chromium emissions for each test run (see Table 3.3) were consistent with the corresponding particulate run and averaged 249, 207, and 260 milligrams of total chromium per gram of particulate emissions for runs I-1, I-2, and I-3 respectively. The total chromium emissions for the inlet tests averaged 1.54 milligrams per dry standard cubic meter (0.00067 grains per dry standard cubic foot) and 0.024 kilograms per hour (0.052 pounds per hour).

3.1.2 Scrubber Outlet

The scrubber outlet represents the controlled emissions from plating tanks No. 1, 2, 3, and 7. Some nonparallel (cyclonic or swirling) flow was present in the scrubber outlet stack. To estimate the effect of these flow conditions

TABLE 3.3. SUMMARY OF PARTICULATE, HEXAVALENT CHROMIUM, AND TOTAL CHROMIUM EMISSIONS

Run No.	Date (1985)	Particulate				Hexavalent Chromium				Total Chromium			
		Concentration		Mass Emissions		Concentration		Mass Emissions		Concentration		Mass Emissions	
		mg/dscm	gr/dscf	kg/h	lb/h	mg/dscm	gr/dscf	kg/h	lb/h	mg/dscm	gr/dscf	kg/h	lb/h
Scrubber Inlet													
I-1	5/15	7.548	0.00330	0.119	0.263	0.898	0.00039	0.0142	0.0313	1.868	0.00082	0.0296	0.0652
I-2	5/16	4.962	0.00217	0.074	0.163	0.473	0.00021	0.0071	0.0155	1.027	0.00045	0.0153	0.0338
I-3	5/16	6.586	0.00288	0.099	0.219	0.837	0.00037	0.0126	0.0279	1.713	0.00075	0.0259	0.0570
Average		6.37	0.00278	0.097	0.215	0.736	0.00032	0.0113	0.0249	1.54	0.00067	0.024	0.052
Scrubber Outlet													
O-1	5/15	2.620	0.00114	0.046	0.102	0.0262	0.000011	0.00046	0.00102	0.1231	0.000054	0.00218	0.00480
O-2	5/16	3.411	0.00149	0.061	0.134	0.0202	0.000009	0.00036	0.00079	0.0510	0.000022	0.00091	0.00200
O-3	5/16	2.788	0.00122	0.048	0.106	0.0301	0.000013	0.00052	0.00115	0.1120	0.000049	0.00194	0.00427
Average		2.94	0.00128	0.052	0.114	0.0255	0.000011	0.00045	0.00099	0.095	0.000042	0.0017	0.0037

on the sampling data, the angle of misalignment was determined at each sampling point during a preliminary pitot traverse. Application of these angles to the pitot traverse data resulted in a flow rate about 10% lower than the measured inlet values. Thus, the flow rate data for each Method 5 test was used in the calculations and is presented in the summary tables.

Flue Gas Conditions and Isokinetic Sampling Rate - A summary of flue gas conditions at the scrubber outlet is presented in Table 3.2. The volumetric flow rates for the three outlet runs were very consistent. The outlet volumetric flow rate averaged 18,900 actual cubic meters per hour (667,000 actual cubic feet per hour) with a flue gas temperature of 27 ^{o}C (81 ^{o}F) and a moisture content of 2.0 percent. The oxygen, carbon dioxide, and carbon monoxide concentrations were that of ambient air at 20.9, 0.0, and 0.0 percent, respectively. The volumetric flow rate at standard conditions averaged 17,600 dry standard cubic meters per hour (621,000 dry standard cubic feet per hour). Standard conditions are 20 ^{o}C (68 ^{o}F), 760 mm Hg (29.92 in. Hg), and dry. These flow rate measurements are likely to be biased high due to the nonparallel flow conditions.

The isokinetic sampling rates were well within the allowable range for all runs.

Particulate Emissions - The particulate emissions from the control equipment to the atmosphere were variable (see Table 3.3) with all runs being within approximately 20% of the averages. Over all three runs, the particulate emissions averaged 2.94 milligrams per dry standard cubic meter (0.00128 grains per dry standard cubic foot) and 0.052 kilograms per hour (0.114 pounds per hour).

Hexavalent Chromium Emissions - The hexavalent chromium emissions for each test run were fairly consistent with their corresponding particulate run and averaged 10.0, 5.9, and 10.8 milligrams of hexavalent chromium per gram of

particulate emissions for runs 0-1, 0-2, and 0-3, respectively. The hexavalent chromium emissions averaged 0.0255 milligrams per dry standard cubic meter (0.000011 grains per dry standard cubic feet) and 0.00045 kilograms per hour (0.00099 pounds per hour).

Total Chromium Emissions - The total chromium emissions were variable (see Table 3.3) when compared to the corresponding particulate runs and averaged 47, 15, and 40 milligrams of total chromium per gram of particulate for runs 0-1, 0-2, and 0-3 respectively. The total chromium emissions averaged 0.095 milligrams per dry standard cubic meter (0.000042 grains per dry standard cubic foot) and 0.0017 kilograms per hour (0.0037 pounds per hour).

3.2 EMISSIONS IN UNITS OF PROCESS RATE AND CONTROL EQUIPMENT COLLECTION EFFICIENCY

The emission rates in units of process rate are given in terms of grams of emissions per hour per square foot of tank surface area, and in units of milligrams of emissions per amperage input to the plating operation. To determine the collection efficiency of the scrubber, the milligrams per hour per square foot (uncontrolled emissions and controlled emissions) were used for the calculations.

3.2.1 Emissions in Units of Process Rate

Two process parameters were used to determine the emissions in terms of units of the process rate as shown in Table 3.4. The first was milligrams of emissions per amperage input into the plating operation. The second was grams of emissions per hour per square foot of tank surface area. The surface area of the tank was 92 ft^2 for all tests.

TABLE 3.4. SUMMARY OF EMISSION RATES IN UNITS OF PROCESS RATE AND EFFICIENCY

Run Nos.	Process Rate amps/hr	Uncontrolled Emissions						Controlled Emissions						Collection Efficiency**		
		particulate		hexavalent chromium		total chromium		particulate		hexavalent chromium		total chromium		particulate	hexavalent chromium	total chromium
		mg/amp	g/hr/ft^{2*}	mg/amp	g/hr/ft^{2*}	mg/amp	g/hr/ft^{2*}	mg/amp	g/hr/ft^{2*}	mg/amp	g/hr/ft^{2*}	mg/amp	g/hr/ft^{2*}	%	%	%
I-1	41,300	2.88	1.29	0.345	0.154	0.717	0.322	--	--	--	--	--	--			
O-1	42,300	--	--	--	--	--	--	1.09	0.50	0.011	0.005	0.052	0.024	61.2	96.8	92.5
I-2	50,300	1.47	0.80	0.141	0.077	0.304	0.166	--	--	--	--	--	--			
O-2	45,900	--	--	--	--	--	--	1.33	0.66	0.008	0.004	0.020	0.010	17.5	94.8	94.0
I-3	72,400	1.37	1.08	0.174	0.137	0.358	0.282	--	--	--	--	--	--			
O-3	70,600	--	--	--	--	--	--	0.68	0.52	0.007	0.006	0.027	0.021	51.9	95.6	92.6
Average		1.91	1.06	0.22	0.12	0.46	0.26	1.03	0.56	0.009	0.005	0.033	0.018	43.5	95.7	93.0

*Emission rate in units of grams per hour per square foot of tank surface (g/hr/ft^2) using tank surface of 92 ft^2.

**Collection efficiency of control equipment is based on the uncontrolled and controlled emission rate in units of emissions per hour per ft^2 of tank surface.

3.2.2 Control Equipment Collection Efficiency

The collection efficiency of the packed-bed scrubber (see Table 3.4) averaged 43.5 percent by weight for particulate matter, 95.7 percent by weight for hexavalent chromium, and 93.0 percent by weight for total chromium.

The much greater collection efficiency for hexavalent chromium emissions as compared to particulate emissions is probably a result of one or a combination of two things: (1) the solubility of hexavalent chromium in water, and/or (2) the measured hexavalent chromium results at the outlet (which were extremely low) could be biased low.

3.3 SUMMARY OF ANALYTICAL RESULTS FOR HEXAVALENT AND TOTAL CHROMIUM

The summary of analytical results for the hexavalent chromium and total chromium analyses of samples collected is presented in Table 3.5. The analytical data sheets are contained in Appendix B. The results shown in Table 3.5 for hexavalent and total chromium are the results obtained by the EPA tentative method for "Determination of Hexavalent Chromium Emissions from Stationary Sources" and the "EPA Protocol for Emissions Sampling for both Hexavalent and Total Chromium" (see Appendix C). When, for total chromium analysis, the table indicates that the sample "residue" was analyzed, then the values presented for total chromium content are the a sum of (1) the hexavalent chromium in the sample filtrate from the extraction of the sample and (2) the chromium in the residue from the extraction as measured by Neutron Activation Analysis. When the table indicates that the "total" sample was analyzed, then the values presented for total chromium content are from the direct analysis for total chromium by Neutron Activation Analysis. A table showing the total chromium calculations for each sample can be found at the end of Appendix A of this report.

TABLE 3.5. SUMMARY OF ANALYTICAL RESULTS FOR HEXAVALENT AND TOTAL CHROMIUM

Run No.	Sample Type	Sample No. Analyzed	Amount of Sample mg or ml	Hexavalent Chromium		Amount of Sample Analyzed	Total Chromium		Sample Prep Method[a]
				Results mg	Concentration mg/g		Results mg	Concentration mg/g	
				Scrubber Inlet					
I-1	Particulate Front Half	C-227	60.5	7.200	119	Residue	14.977	247.6	1
I-1	Impinger Contents	C-233	Total	0.007	negligible	Total	0.011	negligible	2
I-2	Particulate Front Half	C-228	38.6	3.680	95.3	Residue	7.993	207.1	1
I-3	Particulate Front Half	C-229	51.3	6.520	127	Residue	13.345	260.1	1
I-3	Impinger Contents	C-234	Total	0.0004	negligible	Total	0.002	negligible	2
DIF1	Thimble Filter	C-237	100.0	23.099	231	Residue	31.883	318.8	1
DIF2	Thimble Filter	C-221	147.3	29.099	198	Residue	43.209	293.3	1
				Scrubber Outlet					
O-1	Particulate Front Half	C-224	15.5	0.155	10.0	Residue	0.728	47.0	1
O-1	Impinger Contents	C-231	Total	0.0008	negligible	Total	0.002	negligible	2
O-2	Particulate Front Half	C-225	20.4	0.121	5.93	Residue	0.305	15.0	1
O-3	Particulate Front Half	C-226	16.1	0.174	10.8	Residue	0.647	40.2	1
O-3	Impinger Contents	C-232	Total	<0.0005	negligible	Total	0.001	negligible	2
DIF3	Thimble Filter	C-222	55.2	6.499	118	Residue	10.090	182.8	1
				Blank Samples					
---	Filter & Acetone Blank	C-230		<0.0005		Residue	no value	---	
---	Thimble Blank	C-223		0.001		Residue	no value	---	

[a]Sample preparation methods are as follows:

1 = For the Method 5 and thimble filters: Hexavalent chromium was extracted from the filter, acetone rinse, (and water rinse for Method 5 filters) and the filtrate from this process was analyzed for Cr^{+6}. The residue from the extraction was analyzed for total chromium. Total chromium results reported (mg) are the sum of both measurements (blank corrected).

2 = For impinger contents: The liquid samples were concentrated; one measured aliquot was taken for hexavalent chromium analysis and one measured aliquot taken for total chromium analysis. Chromium concentrations are expressed as mg Cr per g of particulate matter catch.

For this testing program, there is some sample analysis variability due to the small amount of hexavalent chromium present. However, the average values for the runs are believed to be fairly accurate.

Quality assurance audit samples were analyzed for both the hexavalent and total chromium methods. As shown in Table 3.6 no bias was present and the results are considered acceptable.

3.4 SUMMARY OF RESULTS FOR THE MEDIUM VOLUME SAMPLING TRAIN

EPA employed the use of the "medium volume" sampling train during the test program. This technique is a screening method and was used prior to testing to obtain an estimate of uncontrolled emissions. The data collected is not intended for the purposes of source evaluation or emissions estimates. The method was additionally evaluated to determine its ability to collect samples over a wide variation in stack velocities and to collect samples over an extended period of time. Tables 3.7 and 3.8 present the data obtained. This data cannot be compared to the emission data from the Method 5 testing since was collected at different times and under different process operating conditions.

TABLE 3.6. SUMMARY OF ANALYTICAL RESULTS FOR HEXAVALENT AND TOTAL CHROMIUM QUALITY ASSURANCE SAMPLES

Run No.	Sample Type	Sample No.	True Value	Hexavalent Chromium Results µg/ml	Hexavalent Chromium % Dev.	Total Chromium Results µg	Total Chromium % Dev.
Quality Assurance Samples							
--	Quality Assurance	C-76	150 µg/ml Cr^{+6}	149	-0.7	---	---
--	Quality Assurance	C-239	10 µg Cr	---	---	10.88	+8.8
--	Quality Assurance	C-240	450 µg Cr	---	---	412.5	-8.3

TABLE 3.7. SUMMARY OF FLUE GAS CONDITIONS FOR RUNS CONDUCTED USING "MEDIUM VOLUME" SAMPLING TRAIN

Run No.	Date (1985)	Test Time 24 h clock	Volumetric Flow Rate				Stack Temperature		Moisture %
			Actual[a]		Standard[b]				
			acmh x 10^6	acfh x 10^6	dscmh x 10^6	dscfh x 10^6	^oC	^oF	
Scrubber Inlet									
DIF1	5/14	1230-1440, 1535-2130	0.0163	0.5762	0.0149	0.5269	33	92	1.5
DIF2	5/15, 5/16	1915-0730	0.0167	0.5904	0.0155	0.5482	28	82	1.6
Average			0.0165	0.583	0.0152	0.538	31	87	1.6
Scrubber Outlet									
DIF3	5/16, 5/17	2015-0850	0.0184	0.650	0.0171	0.604	27	81	1.7

[a]Volumetric flow rate in actual cubic meters per hour (acmh) and actual feet per hour (acfh) at stack conditions.
[b]Volumetric flow rate in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh).

TABLE 3.8. SUMMARY OF PARTICULATE, HEXAVALENT CHROMIUM, AND TOTAL CHROMIUM EMISSIONS FOR RUNS CONDUCTED USING "MEDIUM VOLUME" SAMPLING TRAIN

Run No.	Date (1985)	Particulate				Hexavalent Chromium				Total Chromium			
		Concentration		Mass Emissions		Concentration		Mass Emissions		Concentration		Mass Emissions	
		mg/dscm	gr/dscf	kg/h	lb/h	mg/dscm	gr/dscf	kg/h	lb/h	mg/dscm	gr/dscf	kg/h	lb/h
Scrubber Inlet													
DIF1	5/14	3.633	0.00159	0.054	0.119	0.839	0.000367	0.0125	0.0276	1.158	0.00051	0.0173	0.0381
DIF2	5/15-5/16	2.806	0.00123	0.044	0.096	0.554	0.000242	0.0086	0.0190	0.823	0.00036	0.0128	0.0282
Average		3.22	0.00141	0.049	0.108	0.696	0.00030	0.011	0.023	0.99	0.00044	0.015	0.033
Scrubber Outlet													
DIF3	5/16-5/17	0.310	0.00014	0.005	0.012	0.036	0.000016	0.00062	0.0014	0.057	0.00002	0.001	0.002

4.0 SAMPLING LOCATIONS AND TEST METHODS

This section describes the sampling locations and test methods used to characterize emissions from hard chromium plating tanks No. 1, 2, 3, and 7 at Carolina Plating Company in Greenville, South Carolina. Two sampling locations were used in the emission testing program. At each sampling location (one at the scrubber inlet and one at the scrubber outlet), emissions testing was conducted for particulate matter, total chromium content, and hexavalent chromium content. Particulate and chromium sampling was also conducted at both sampling locations using the "medium volume" train under development by John Brown (EMB). The relative positions and the type of testing conducted at each location are shown in the simplified process flow diagram (see Figure 4-1) and accompanying Table 4.1. The subsections which follow further describe each sampling location and applicable test methods.

4.1 SCRUBBER INLET (SAMPLING LOCATION A)

Particulate matter, hexavalent chromium, and total chromium were measured at the inlet to the packed-bed scrubber controlling emissions from chromium plating tanks No. 1, 2, 3, and 7 as shown in Figure 4-2. One sampling port was installed on the side of the horizontal circular duct (36 inches in diameter). This port was located 20 inches (0.55 duct diameters) upstream of a bend in the duct to the scrubber and 37 inches (1.03 duct diameters) downstream from another bend. Because of the close proximity of potential flow disturbances, this location did not meet EPA Method 1 sampling requirements; however, there was no other location available for inlet testing. For the particulate testing, a

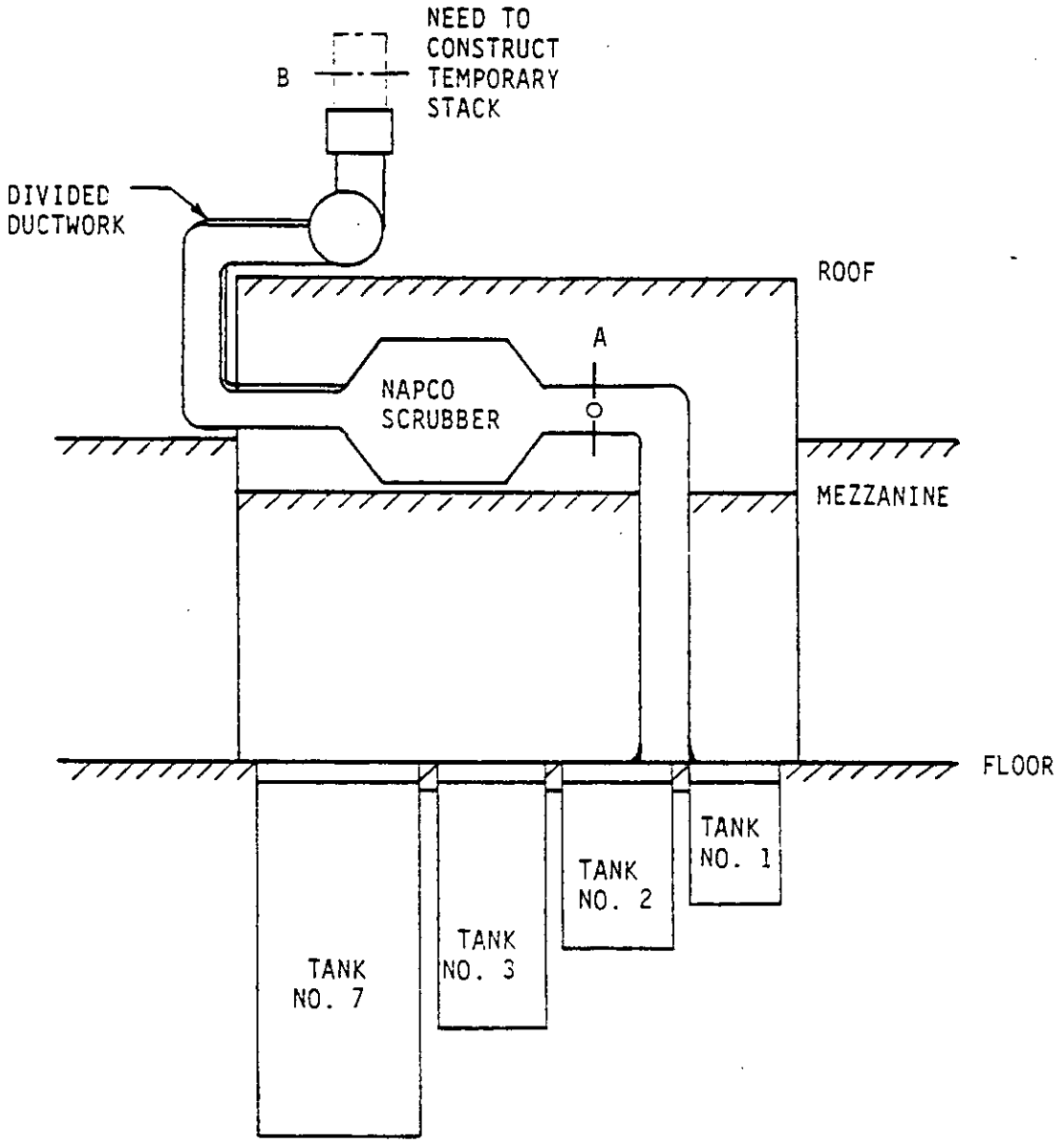

Figure 4-1. Simplified Process Air Flow Diagram of Chrome Plating Tanks and Emission Control Equipment at Carolina Plating.

TABLE 4.1. SAMPLING PLAN FOR CAROLINA PLATING

Sample Type	Sampling Locations	Number of Samples	Methods
Particulate matter	A, B	3 (M5) 2 (MV at A) 1 (MV at B)	EPA Method 5 or MV Train
Hexavalent chromium	A, B	3 (M5) 2 (MV at A) 1 (MV at B)	EPA 5 or MV Train using Tentative EPA Method for Hexavalent Chromium
Total chromium	A, B	3 (M5) 2 (MV at A) 1 (MV at B	EPA 5 or MV Train using EPA Protocol for Total Chromium

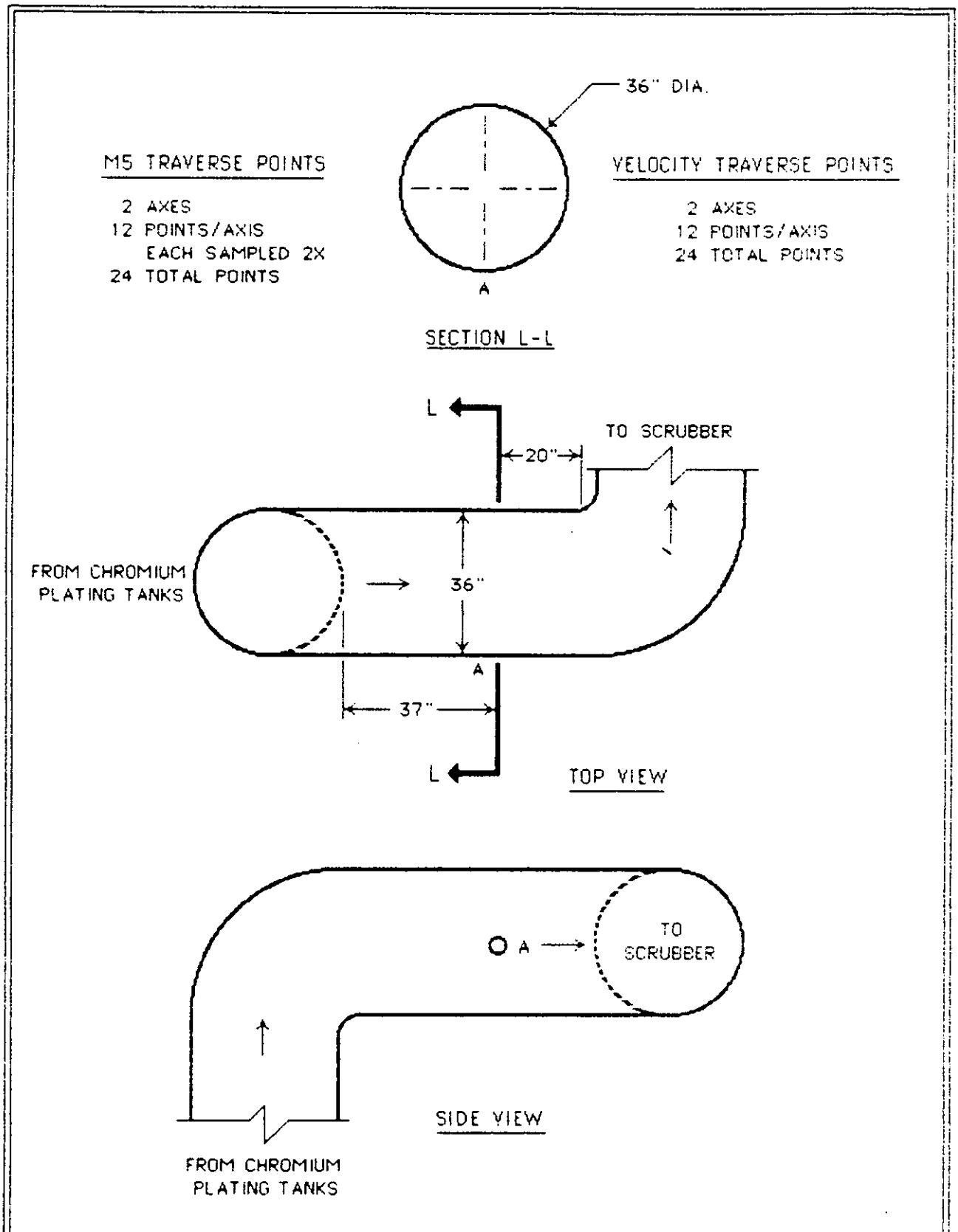

FIGURE 4-2. SCRUBBER INLET (SAMPLING LOCATION A)

single traverse was chosen. This was because of the difficulty in gaining access to the duct and because the very fine acid mist particles in the duct would be expected to have the characteristics of a gas and thus, the cross-sectional distribution of the particles in the duct should be uniform. To check the cross-sectional flow distribution at this location, a pitot traverse was conducted along two axes through the single port. The axis perpendicular to the sampling axis was traversed by inserting the pitot tube through the available port at a predetermined angle for a predetermined distance, both of which were calculated geometrically.

For the Method 5 testing, (used for particulate matter, hexavalent chromium, and total chromium determinations), 24 points were sampled, 12 going into the port and 12 coming out of the port. Each of the 24 points was sampled for 12 minutes for a total of 288 minutes of sampling per run. Each of the three runs were conducted to coincide with the sampling at the scrubber outlet location.

"Medium volume" (MV) sampling, was also conducted at the scrubber inlet. The two runs were 485 and 735 minutes in duration and were each conducted at a single sampling point. To avoid interference between the two trains, the MV sampling was performed so as not to coincide with the Method 5 sampling.

4.2 SCRUBBER OUTLET (SAMPLING LOCATION B)

Particulate matter, hexavalent chromium, and total chromium were measured at the scrubber outlet as shown in Figure 4-3. Four sampling ports were installed 90^{o} apart on the 22 3/16" diameter stack extension; however, only the NW and NE ports were used in this testing program. The ports were located about 24 inches (1.08 duct diameters) upstream from the stack exit and 64 inches (2.88 duct diameters) downstream from the mist eliminator.

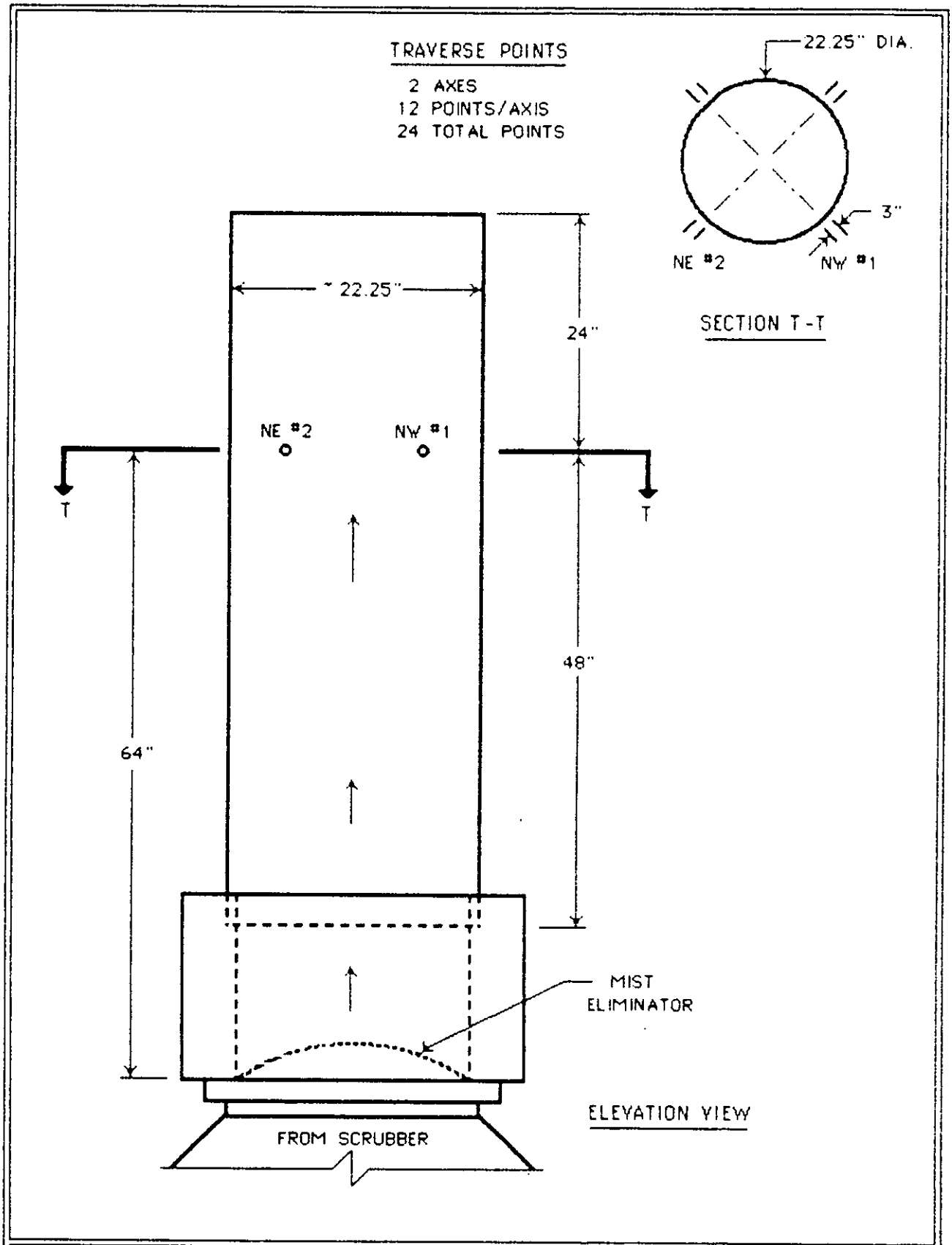

FIGURE 4-3. SCRUBBER OUTLET (SAMPLING LOCATION B)

For the EPA Method 5 sampling (used for particulate matter, hexavalent chromium, and total chromium determinations), a total of 24 points, as per Method 1, were sampled. Each point was sampled for 12 minutes for a total sampling time of 288 minutes. Because of the potential for cyclonic flow conditions (which are fairly common at scrubber outlet sampling locations), a preliminary traverse was conducted to determine the misalignment angles for each of the sampling points. The angles measured indicated that cyclonic flow was present; however, since the emissions were fumes and would be expected to behave like a gas, testing in the normal manner was considered to be less biased.

One sampling run was conducted at the outlet location using the MV sampling train. This run was 735 minutes in duration and was conducted at a single sampling point. As was done at the inlet location, the MV sampling was performed so as not to coincide with the Method 5 sampling.

4.3 VELOCITY AND GAS TEMPERATURE

A type S pitot tube and an inclined draft gauge manometer were used to measure the gas velocity pressure (Δp). Velocity pressures were measured at each sampling point across the duct to determine an average value according to the procedures outlined in Method 2 of the Federal Register.* The temperature at each sampling point was measured using a calibrated Palmer bimetallic coil thermometer.

4.4 MOLECULAR WEIGHT

Flue gas composition was determined utilizing procedures described in Method 3 of the Federal Register.* A bag sample was collected during each particulate test run. The bag contents were analyzed using an Orsat Gas Analyzer.

4.5 PARTICULATE MATTER

Method 5, as described in the Federal Register,* was used to measure particulate grain loading at locations A and B. All tests were conducted isokinetically by traversing the cross-sectional area of the stack and regulating the sample flow rate relative to the flue gas flow rate as measured by the pitot tube attached to the sample probe. A sampling train consisting of a heated, glass-lined probe, a heated 79 mm (3 inch) diameter glass fiber filter (Reeve Angel), and a series of Greenburg-Smith impingers was employed for each test. An acetone rinse and a water rinse of the nozzle, probe, and filter holder portions of the sample train were made at the end of each test. The acetone rinse and the particulate caught on the filter media were dried at room temperature, the water rinse was taken to dryness in an oven; all three were then desiccated to a constant weight, and weighed on an analytical balance. Total filterable particulate matter was determined by adding these three values.

The "medium volume" (MV) sampling train was also used to measure particulate matter at locations A and B. MV sampling was conducted at a single sampling point. See Appendix C for detailed Method 5 and MV sampling procedures.

4.6 HEXAVALENT CHROMIUM CONTENT

Hexavalent chromium content was determined utilizing procedures described in the tentative EPA Method "Determination of Hexavalent Chromium Emissions from Stationary Sources" (see Appendix C). The Method 5 filter catch collected and weighed for each Method 5 run was taken and analyzed for hexavalent chromium content using this method. It was also used to determine the hexavalent chromium content of the MV sampling train filter catch and the impinger contents.

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* 40 CFR 60, Appendix A, Reference Methods 2, 3, and 5, July 1, 1980.

4.7 TOTAL CHROMIUM CONTENT

Total chromium content was determined using procedures described in the "EMB Prototcol for Sample Preparation and Emission Calculation of Field Samples for Total Chromium" in combination with Neutron Activation Analysis (NAA) (see Appendix C). Samples collected during Method 5 runs and first submitted for analysis for hexavalent chromium were then analyzed for total chromium using this method. The total chromium content of the MV sampling train filter catch and the impinger contents were also determined using these procedures.

5.0 QUALITY ASSURANCE

Because the end product of testing is to produce representative emission results, quality assurance is one of the main facets of stack sampling. Quality assurance guidelines provide the detailed procedures and actions necessary for defining and producing acceptable data. One such document used in this test program to ensure the collection of acceptable data and to provide a definition of unacceptable data was the EPA Quality Assurance Handbook Volume III, EPA-600/4-77-027.

Relative to this test program, EMB used the following steps to ensure that the testing and analytical procedures produce quality data.

- o Calibration of field sampling equipment (Appendix E).
- o Checks of train configuration and on calculations.
- o Use of designated analytical equipment and sampling reagents.

In addition, the analytical balance used for filter weighing by Entropy was audited with Class "S" weights.

Audit solutions prepared by the EPA were used to check the analytical procedures of the laboratories conducting the hexavalent and total chromium analyses. Table 5.1 presents the results of these analytical audits. The audit tests show that the analytical techniques were good.

The sampling equipment, reagents, and analytical procedures for this test series were in compliance with all necessary guidelines set forth for accurate test results as described in Volume III of the Quality Assurance Handbook.

TABLE 5.1. AUDIT REPORT CHROMIUM ANALYSIS

Plant: Carolina Plating Task No.: 3018

Date samples received: _____ Date analyzed: 6/14 - 6/17

Sample analyzed by: RTI - DH

Reviewed by: Peter Grohse Date of review: _____

Sample Number	$\mu g/ml$ Cr^{+6} or Cr	Source of Sample	Audit Value	Relative Error, %
C-76	150 µg/ml of Cr^{+6}	QAD	149 µg/ml	- 0.7 %
(QA-22) C-239	10 µg of Cr	QAD	10.88 µg	+ 8.8%
(QA-23) C-240	450 µg of Cr	QAD	412.5 µg	- 8.3%

APPENDIX A

TEST RESULTS AND EXAMPLE CALCULATIONS

PLANT	Carolina Plating	PROBE LENGTH & TYPE	4' Glass
DATE	5/15/85	NOZZLE I.D.	0.375
SAMPLING LOCATION	Inlet	ASSUMED MOISTURE, %	3
SAMPLE TYPE	CR & PART.	SAMPLE BOX NUMBER	V11
RUN NUMBER	I-1	METER BOX NUMBER	RAC7
OPERATOR	F. Clay & P. Schindler	METER ΔH @	1.930
AMBIENT TEMPERATURE	80°F	C FACTOR	N/A
BAROMETRIC PRESSURE	29.170	PROBE HEATER SETTING	33
STATIC PRESSURE, [P(s)]	-1.600	HEATER BOX SETTING	100°F
FILTER NUMBER(s)		REFERENCE Δp	N/A
METER CAL FACTOR	1.005		

Trav. Point No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H2O)	Orifice ΔH (in. H2O) Desired	Orifice ΔH (in. H2O) Actual	Dry Gas Meter Temp. (Deg. F)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
	0/0	186.505	--	--	--	--	--			--	
1	0.12	199.220	0.180	3.89	3.89	83.0	6.5		60	80	
2	0.24	212.850	0.200	4.43	4.43	96.0	7.5		72	80	
3	0.36	224.550	0.130	2.93	2.93	106.0	5.0		64	80	
4	0.48	236.000	0.130	2.93	2.93	108.0	5.0		63	82	
5	0.60	248.225	0.150	3.39	3.39	111.0	5.5		61	83	
6	1.12	260.550	0.150	3.41	3.41	114.0	5.5		60	83	
7	1.24	273.300	0.160	3.65	3.65	116.0	6.0		59	83	
8	1.36	285.700	0.180	4.10	4.10	116.0	6.5		59	84	
9	1.48	300.040	0.195	4.45	4.45	118.0	7.0		60	85	
10	2.00	315.300	0.205	4.69	4.69	119.5	7.5		60	85	
11	2.12	329.965	0.210	4.82	4.82	121.0	7.5		60	85	
12	2.24	344.630	0.215	4.93	4.93	121.0	8.0		59	85	
12	2.60	359.410	0.210	4.82	4.82	121.0	7.8		59	85	
11	2.48	374.100	0.210	4.81	4.81	120.5	7.8		60	85	
10	3.00	388.500	0.200	4.59	4.59	121.0	7.5		59	85	
9	3.12	402.250	0.180	4.12	4.12	120.5	6.5		59	85	
8	3.24	415.775	0.175	4.00	4.00	119.5	6.5		59	85	
7	3.36	428.700	0.160	3.65	3.65	119.0	6.0		58	86	
6	3.48	440.070	0.120	2.74	2.74	119.0	4.5		58	86	
5	4.00	451.565	0.125	2.84	2.84	117.0	4.8		58	86	
4	4.12	462.675	0.115	2.61	2.61	116.5	4.5		57	86	
3	4.24	472.775	0.100	2.27	2.27	116.5	4.0		57	86	
2	4.36	486.040	0.175	3.97	3.97	116.0	6.5		56	86	
1	4.48	498.277	0.140	3.20	3.20	119.5	5.0		54	85	
FINAL											
DIFF./AVG.		311.772	0.16660		3.802	115				84	

PLANT	Carolina Plating	PROBE LENGTH & TYPE	5' Glass
DATE	5/16/95	NOZZLE I.D.	0.375
SAMPLING LOCATION	Inlet	ASSUMED MOISTURE, %	0.5
SAMPLE TYPE	CR & PART.	SAMPLE BOX NUMBER	V11
RUN NUMBER	I-2	METER BOX NUMBER	RAC7
OPERATOR	F. Clay & P. Schindler	METER ΔH @	1.930
AMBIENT TEMPERATURE	75°F	C FACTOR	N/A
BAROMETRIC PRESSURE	29.040	PROBE HEATER SETTING	33
STATIC PRESSURE, [P(s)]	-1.600	HEATER BOX SETTING	
FILTER NUMBER(s)		REFERENCE Δp	N/A
METER CAL FACTOR	1.005		

Trav. Point. No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H20)	Orifice ΔH (in. H20) Desired	Actual	Dry Gas Meter Temp. (Deg. F)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
	0/0	500.320	--	--	--	--	--			--	
1	0.12	511.280	0.120	2.71	2.71	78.5	9.5		53	75	
2	0.24	522.350	0.120	2.78	2.78	92.5	10.0		62	74	
3	0.36	534.035	0.130	3.04	3.04	97.5	10.5		62	74	
4	0.48	546.275	0.140	3.33	3.33	108.0	11.5		61	75	
5	0.60	558.215	0.130	3.12	3.12	113.0	10.5		57	75	
6	1.12	570.455	0.140	3.38	3.38	115.5	11.3		57	75	
7	1.24	582.975	0.145	3.50	3.50	116.5	11.7		55	75	
8	1.36	596.120	0.160	3.87	3.87	118.0	13.0		54	76	
9	1.48	609.700	0.170	4.12	4.12	119.5	14.0		53	76	
10	2.00	623.652	0.180	4.36	4.36	120.0	15.2		53	77	
11	2.12	637.088	0.170	3.89	3.89	89.5	14.0		54	79	
12	2.24	650.525	0.180	4.23	4.23	106.5	15.0		52	81	
12	2.60	664.660	0.190	4.52	4.52	114.0	16.0		52	81	
11	2.48	678.640	0.180	4.31	4.31	118.0	15.3		51	81	
10	3.00	692.380	0.170	4.09	4.09	120.5	14.2		50	81	
9	3.12	705.735	0.160	3.86	3.86	122.5	13.2		51	81	
8	3.24	718.705	0.150	3.61	3.61	122.5	12.0		50	82	
7	3.36	730.410	0.120	2.89	2.89	122.5	9.8		51	82	
6	3.48	741.175	0.100	2.40	2.40	121.0	8.2		52	83	
5	4.00	752.680	0.120	2.87	2.87	119.0	9.5		51	83	
4	4.12	765.880	0.160	3.83	3.83	120.0	13.0		51	83	
3	4.24	779.900	0.180	4.35	4.35	121.5	15.0		50	80	
2	4.36	793.050	0.150	3.62	3.62	123.0	12.5		50	81	
1	4.48	803.373	0.090	2.18	2.18	123.5	7.5		52	80	
FINAL											
DIFF/AVG.		303.053	0.14684		3.535	113				79	

PLANT	Carolina Plating	PROBE LENGTH & TYPE	5' Glass
DATE	5/16/85	NOZZLE I.D.	0.375
SAMPLING LOCATION	Inlet	ASSUMED MOISTURE, %	1
SAMPLE TYPE	CR & PART.	SAMPLE BOX NUMBER	V11
RUN NUMBER	I-3	METER BOX NUMBER	RAC7
OPERATOR	F. Clay & P. Schindler	METER ΔH @	1.930
AMBIENT TEMPERATURE	80°F	C FACTOR	N/A
BAROMETRIC PRESSURE	29.020	PROBE HEATER SETTING	33
STATIC PRESSURE, [P(s)]	-1.600	HEATER BOX SETTING	
FILTER NUMBER(s)		REFERENCE Δp	N/A
METER CAL FACTOR	1.005		

Trav. Point. No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H20)	Orifice ΔH (in. H20) Desired	Actual	Dry Gas Meter Temp. (Deg. F)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
	0/0	805.302	--	--	--	--	--			--	
1	0.12	816.630	0.120	2.79	2.79	100.5	4.8		62	76	
2	0.24	828.730	0.140	3.29	3.29	112.0	5.2		68	81	
3	0.36	839.653	0.120	2.83	2.83	117.5	4.0		66	84	
4	0.48	851.635	0.130	3.07	3.07	118.5	5.0		62	84	
5	0.60	864.000	0.140	3.32	3.32	120.5	5.2		60	84	
6	1.12	875.970	0.130	3.08	3.08	121.5	5.0		58	85	
7	1.24	888.345	0.140	3.33	3.33	122.5	5.1		56	85	
8	1.36	901.145	0.150	3.57	3.57	123.5	5.3		56	85	
9	1.48	914.775	0.170	4.04	4.04	124.0	6.2		57	86	
10	2.00	929.180	0.190	4.53	4.53	124.5	7.0		55	85	
11	2.12	943.930	0.200	4.77	4.77	124.5	7.2		53	85	
12	2.24	959.030	0.210	5.01	5.01	125.0	7.5		54	85	
12	2.60	974.135	0.210	4.98	4.98	126.0	7.6		55	85	
11	2.48	988.980	0.200	4.74	4.74	126.0	7.2		55	85	
10	3.00	1003.040	0.180	4.27	4.27	126.0	6.5		54	85	
9	3.12	1016.725	0.170	4.02	4.02	125.0	6.0		54	85	
8	3.24	1029.653	0.150	3.54	3.54	124.0	5.4		55	85	
7	3.36	1042.142	0.140	3.30	3.30	123.0	5.2		54	85	
6	3.48	1054.115	0.130	3.06	3.06	122.5	4.8		54	85	
5	4.00	1066.070	0.130	3.06	3.06	121.0	4.8		53	85	
4	4.12	1077.220	0.110	2.59	2.59	121.0	4.2		52	84	
3	4.24	1088.775	0.120	2.82	2.82	120.0	4.6		51	85	
2	4.36	1101.487	0.150	3.52	3.52	120.0	5.3		51	85	
1	4.48	1113.148	0.120	2.82	2.82	121.0	4.8		51	85	
FINAL DIFF/AVG.		307.846	0.15201		3.598	121				84	

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Carolina Plating Company, Greenville, South Carolina

RUN	SAMPLING LOCATION	TEST TEAM LEADER
I-1	Napco Scrubber Inlet	C. Sorrell
I-2	Napco Scrubber Inlet	C. Sorrell
I-3	Napco Scrubber Inlet	C. Sorrell

		I-1	I-2	I-3
	RUN DATE	05/15/85	05/16/85	05/16/85
	RUN START TIME	1235	901	1525
	RUN FINISH TIME	1723	1442	2013
	NET SAMPLING POINTS	24	24	24
Theta	NET RUN TIME, MINUTES	288.00	288.00	288.00
Dia	NOZZLE DIAMETER, INCHES	0.375	0.375	0.375
Cp	PITOT TUBE COEFFICIENT	0.840	0.840	0.840
Y	DRY GAS METER CAL. FACTOR	1.005	1.005	1.005
Pbar	BAROMETRIC PRESSURE, IN. HG.	29.17	29.04	29.02
Delta H	AVG. PRESS. DIFFERENTIAL OF ORIFICE METER, IN. H2O	3.802	3.536	3.598
Vm	VOLUME OF METERED GAS SAMPLE DRY ACTUAL CUBIC FEET	311.772	303.053	307.846
tm	DRY GAS METER TEMP., DEG. F	115	113	121
Vm(std)	VOLUME OF METERED GAS SAMPLE @ DRY STD. COND., DSCF*	283.083	274.724	275.082
Vlc	VOLUME OF WATER CATCH IN IMPINGERS & SIL. GEL.,ML	98.0	88.6	84.2
Vw(std)	VOLUME OF WATER VAPOR, SCF*	4.613	4.170	3.963
%H2O	MOISTURE, PERCENT BY VOLUME	1.6	1.5	1.4
Mfd	DRY MOLE FRACTION	0.984	0.985	0.986

(continued next page)

		I-1	I-2	I-3
Md	DRY MOLECULAR WT, LB/LB-MOLE	28.84	28.84	28.84
Ms	WET MOLECULAR WT, LB/LB-MOLE	28.66	28.67	28.68
Ps	GAS STATIC PRESS., IN. H2O	-1.6	-1.6	-1.6
Ps	ABSOLUTE GAS PRESS., IN. HG.	29.05	28.92	28.90
ts	GAS TEMPERATURE, DEG. F	84	79	84
Delta p	AVG VELOCITY HEAD, IN. H2O	0.1666	0.1468	0.1520
vs	FLUE GAS VELOCITY, FT/SEC	23.7	22.2	22.7
A	STACK/DUCT AREA, SQUARE IN.	1,018.0	1,018.0	1,018.0
Qsd	GAS FLOW RATE, DRY SCFM *	9,315	8,773	8,888
Qaw	GAS FLOW RATE, WET ACFM	10,049	9,409	9,620
%I	PERCENT ISOKINETIC	97.1	100.1	98.9
	METHOD 5 RESULTS:			
mg	CATCH, MILLIGRAMS	60.5	38.6	51.3
gr/DSCF	CONCEN., GRAINS PER DSCF*	0.0033	0.0022	0.0029
Lb/Hr	EMISSION RATE, LBS/HOUR	0.26	0.16	0.22
	HEXAVALENT CHROMIUM:			
	CATCH, MILLIGRAMS	(7,200.0)	(3,680.0)	(6,520.0)
	TOTAL CHROMIUM:			
	CATCH, MILLIGRAMS	(14,977.0)	(7,993.0)	(13,345.0)

* 68 Deg. F - 29.92 in. Hg.

( ) = x 10^{-3}

RUN NUMBER	I-1	I-2	I-3	
FLUE GAS TEMPERATURE:				
Degrees Fahrenheit	84	79	84	deg. F
Degrees Centigrade	29	26	29	deg. C
AIR FLOW RATES x million:				
Actual Cubic Meters/hr	0.0171	0.0160	0.0163	acmh
Actual Cubic Feet/hr	0.6029	0.5645	0.5772	acfh
Dry Std. Cubic Meters/hr	0.0158	0.0149	0.0151	dscmh
Dry Std. Cubic Feet/hr	0.5589	0.5264	0.5333	dscfh
PARTICULATE:				
Concentration, mg/dscm	7.548	4.962	6.586	mg/dscm
Concentration, gr/dscf	0.00330	0.00217	0.00288	gr/dscf
Emissions, kg/hr	0.119	0.074	0.099	kg/hr
Emissions, lb/hr	0.263	0.163	0.219	lb/hr
HEXAVALENT CHROMIUM:				
Concentration, mg/dscm	(898.221)	(473.059)	(837.048)	mg/dscm
Concentration, gr/dscf	(0.39251)	(0.20672)	(0.36578)	gr/dscf
Emissions, kg/hr	(14.215)	(7.051)	(12.640)	kg/hr
Emissions, lb/hr	(31.339)	(15.544)	(27.866)	lb/hr
TOTAL CHROMIUM:				
Concentration, mg/dscm	(1,868.425)	(1,027.489)	(1,713.252)	mg/dscm
Concentration, gr/dscf	(0.81648)	(0.44900)	(0.74867)	gr/dscf
Emissions, kg/hr	(29.570)	(15.314)	(25.871)	kg/hr
Emissions, lb/hr	(65.190)	(33.762)	(57.035)	lb/hr

( ) = 10^{-3}

EXAMPLE PARTICULATE TEST CALCULATIONS NO. I-1

Napco Scrubber Inlet

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

$$Vm(std) = 17.64 * Y * Vm * \frac{(Pbar + Delta\ H/13.6)}{(460 + tm)}$$

$$Vm(std) = 17.64 * 1.005 * 311.772 * \frac{(29.17 + 3.802/13.6)}{(460 + 115)} = 283.083 \text{ DSCF}$$

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

$$Vw(std) = 0.04707 * Vlc$$

$$Vw(std) = 0.04707 * 98.0 = 4.613 \text{ SCF}$$

PERCENT MOISTURE, BY VOLUME, AS MEASURED IN FLUE GAS

$$\%H2O = 100 * Vw(std) / (Vw(std) + Vm(std))$$

$$\%H2O = \frac{4.613}{4.613 + 283.083} * 100 = 1.6 \%$$

DRY MOLE FRACTION OF FLUE GAS

$$Mfd = 1 - \%H2O/100$$

$$Mfd = 1 - 1.6/100 = 0.984$$

WET MOLECULAR WEIGHT OF FLUE GAS

$$Ms = (Md * Mfd) + (0.18 * \%H2O)$$

$$Ms = 28.84 * 0.984 + (0.18 * 1.6) = 28.66 \text{ LB/LB-MOLE}$$

ABSOLUTE FLUE GAS PRESSURE

$$Ps = Pbar + Pg / 13.6$$

$$Ps = 29.17 + (-1.6 / 13.6) = 29.05 \text{ IN. HG.}$$

AVERAGE FLUE GAS VELOCITY [Note: (Delta p)avg is square of avg sq. root]

$$vs = 85.49 * Cp * SQRT\left[\frac{(\text{Delta p})avg * (460 + ts)}{Ps * Ms}\right]$$

$$vs = 85.49 * 0.840 * SQRT\left[\frac{0.1666 * (460 + 84)}{29.05 * 28.66}\right] = 23.7 \text{ FT/SEC}$$

DRY VOLUMETRIC FLUE GAS FLOW RATE @ STANDARD CONDITIONS

$$Qsd = \frac{60}{144} * Mfd * vs * A * \frac{Tstd}{ts + 460} * \frac{Ps}{Pstd}$$

$$Qsd = \frac{60}{144} * 0.984 * 23.7 * 1{,}018.0 * \frac{528}{84 + 460} * \frac{29.05}{29.92}$$

$$Qsd = 9{,}315 \text{ SCFM}$$

WET VOLUMETRIC STACK GAS FLOW RATE @ FLUE GAS CONDITIONS

$$Qaw = 60 / 144 * vs * A$$

$$Qaw = 60 / 144 * 23.7 * 1{,}018.0 = 10{,}049 \text{ ACFM}$$

PERCENT ISOKINETIC OF SAMPLING RATE

$$\%I = \frac{Pstd}{Tstd} * \frac{100}{60} * \frac{(ts + 460) * Vm(std)}{Ps * vs * Mfd * Theta * Area\text{-}nozzle,\ sq.ft.}$$

$$\%I = \frac{29.92}{528} * \frac{100}{60} * \frac{(84 + 460) * 283.083}{29.05 * 23.7 * 0.984 * 288.00 * 0.0007670}$$

$$\%I = 97.1 \%$$

GRAINS PER DRY STANDARD CUBIC FOOT

$$gr/DSCF = \frac{7000}{453,592} * \frac{mes}{Vm(std)}$$

$$gr/DSCF = \frac{7000}{453,592} * \frac{60.5}{283.083} = 0.0033 \text{ gr/DSCF}$$

POUNDS PER HOUR

Lb/Hr = 60 / 7000 * gr/DSCF * Qsd

Lb/Hr = 60/7000 * 0.0033 * 9,315 = 0.26 LB/HR

PLANT	Carolina Plating	PROBE LENGTH & TYPE	4' Glass
DATE	5/15/85	NOZZLE I.D.	0.191
SAMPLING LOCATION	Outlet	ASSUMED MOISTURE, %	2
SAMPLE TYPE	M5	SAMPLE BOX NUMBER	
RUN NUMBER	0-1	METER BOX NUMBER	RAC 4
OPERATOR	C. Sorrell	METER ΔH @	1.928
AMBIENT TEMPERATURE		C FACTOR	0.84
BAROMETRIC PRESSURE	29.160	PROBE HEATER SETTING	
STATIC PRESSURE, (P(s))	2.650	HEATER BOX SETTING	
FILTER NUMBER(s)		REFERENCE Δp	
METER CAL FACTOR	1.052		

Trav. Point. No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H20)	Orifice ΔH (in. H20) Desired	Actual	Dry Gas Meter Temp. (Deg. F.)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
NW	0/0	880.867	--	--	--	--	--			--	
NW1	12.0	890.000	1.800	2.17	2.17	98.0	8.1			86	
NW2	24.0	899.000	1.750	2.17	2.17	104.0	8.1			86	
NW3	36.0	907.900	1.630	2.04	2.04	111.0	7.9			86	
NW4	48.0	916.200	1.530	1.92	1.92	112.0	7.5			86	
NW5	60.0	924.600	1.450	1.82	1.82	111.0	7.2		72	86	
NW6	72.0	930.300	0.590	0.74	0.74	109.0	4.5			87	
NW7	84.0	936.500	0.770	0.96	0.96	107.0	5			87	
NW8	96.0	--	1.800	2.23	2.23	105.5	8.5			87	
NW9	108.0	956.000	2.350	2.95	2.95	112.0	10.6			87	
NW10	120.0	966.600	2.450	3.10	3.10	116.5	11			87	
NW11	132.0	977.800	2.600	3.29	3.29	118.0	11.6			87	
NW12	144.0	989.098	2.650	3.35	3.35	114.5	11.5			84	989.098
NE	0/0	989.244	--	--	--	--	--			--	989.244
NE1	12.0	998.700	1.800	2.23	2.23	101.5	8.3			84	
NE2	24.0	1008.500	1.920	2.4	2.4	107.0	9			84	
NE3	36.0	1018.100	2.000	2.5	2.5	108.0	9.2			84	
NE4	48.0	1027.400	1.850	2.31	2.31	107.0	8.8			84	
NE5	60.0	1036.300	1.650	2.07	2.07	110.0	8			84	
NE6	72.0	1042.300	0.650	0.81	0.81	108.5	5			84	
NE7	84.0	1046.800	0.325	0.4	0.4	103.0	3.8			84	
NE8	96.0	1055.900	1.900	2.34	2.34	99.5	9			84	
NE9	108.0	1066.600	2.400	3	3	108.0	11			84	
NE10	120.0	1077.400	2.450	3.08	3.08	110.0	11			84	
NE11	132.0	1088.350	2.450	3.1	3.1	114.5	11			84	
NE12	144.0	1099.073	2.300	2.91	2.91	114.0	10.4			84	
FINAL											0.146
DIFF/AVG.		218.060	1.71668		2.245	108				85	

PLANT	Carolina Plating	PROBE LENGTH & TYPE	4' Glass
DATE	5/16/85	NOZZLE I.D.	0.181
SAMPLING LOCATION	Outlet	ASSUMED MOISTURE, %	2.2
SAMPLE TYPE	M5	SAMPLE BOX NUMBER	
RUN NUMBER	0-2	METER BOX NUMBER	RAC4
OPERATOR	C. Sorrell	METER ΔH @	1.928
AMBIENT TEMPERATURE		C FACTOR	0.84
BAROMETRIC PRESSURE	29.020	PROBE HEATER SETTING	
STATIC PRESSURE, [P(s)]	0.560	HEATER BOX SETTING	
FILTER NUMBER(s)		REFERENCE Δp	
METER CAL FACTOR	1.052		

Trav. Point No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H20)	Orifice ΔH (in. H20) Desired	Orifice ΔH (in. H20) Actual	Dry Gas Meter Temp. (Deg. F)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
NW	0/0	99.598	--	--	--	--	--			--	
NW1	12.0	109.250	2.050	2.44	2.44	92.5	8.2			75	
NW2	24.0	119.050	2.000	2.45	2.45	94.5	8.2			75	
NW3	36.0	129.000	2.000	2.46	2.46	96.5	8.2			75	
NW4	48.0	138.600	2.030	2.51	2.51	97.0	8.4			75	
NW5	60.0	147.800	1.720	2.13	2.13	95.5	7.5			75	
NW6	72.0	153.580	0.660	0.81	0.81	89.5	4.4			75	
NW7	84.0	157.500	0.260	0.32	0.32	88.0	2.3			75	
NW8	96.0	166.500	1.750	2.13	2.13	95.5	7.8			75	
NW9	108.0	176.000	1.900	2.22	2.22	96.0	8.0			75	
NW10	120.0	186.000	2.250	2.78	2.78	100.0	9.5			75	
NW11	132.0	197.000	2.350	2.92	2.92	100.0	9.9		60	75	
NW12	144.0	207.516	2.250	2.80	2.80	100.0	9.5			75	207.516
NE	0/0	207.791	--	--	--	--	--			--	207.791
NE1	12.0	216.000	1.500	1.79	1.79	81.5	6.5			78	
NE2	24.0	225.300	1.850	2.27	2.27	96.0	8			78	
NE3	36.0	234.800	1.900	2.37	2.37	103.5	8.1			78	
NE4	48.0	244.400	1.900	2.39	2.39	108.5	8.1			78	
NE5	60.0	253.000	1.400	1.76	1.76	110.5	6.2		65	78	
NE6	72.0	259.000	0.850	1.07	1.07	110.0	4.7			80	
NE7	84.0	265.200	0.730	0.91	0.91	109.0	4.5			80	
NE8	96.0	274.000	1.650	2.07	2.07	109.5	7.1			80	
NE9	108.0	284.500	2.200	2.77	2.77	112.5	9			80	
NE10	120.0	295.400	2.600	3.3	3.3	116.0	10.9			80	
NE11	132.0	306.800	2.730	3.45	3.45	114.5	11.1			80	
NE12	144.0	318.263	2.780	3.52	3.52	115.0	11.2			80	
FINAL											
DIFF/AVG.		218.390	1.72456		2.24	101				77	
											0.275

PLANT	Carolina Plating	PROBE LENGTH & TYPE	4' Glass
DATE	5/16/85	NOZZLE I.D.	0.181
SAMPLING LOCATION	Outlet	ASSUMED MOISTURE, %	2.2
SAMPLE TYPE	M5	SAMPLE BOX NUMBER	
RUN NUMBER	0-3	METER BOX NUMBER	RAC4
OPERATOR	C. Sorrell	METER ΔH @	1.928
AMBIENT TEMPERATURE		C FACTOR	0.84
BAROMETRIC PRESSURE	28.960	PROBE HEATER SETTING	
STATIC PRESSURE, [P(s)]	0.560	HEATER BOX SETTING	
FILTER NUMBER(s)		REFERENCE Δp	
METER CAL FACTOR	1.052		

Trav. Point. No.	Sample Time (Min.)	Gas Meter Reading (Cu.Ft.)	Velocity Head (in.H20)	Orifice (in. H20) Desired	ΔH Actual	Dry Gas Meter Temp. (Deg. F)	Pump Vac. (in.Hg)	Filter Box Temp. (deg.F)	Imp. Exit Temp. (deg.F)	Stack Temp. (deg.F)	Leak Check
NE	0/0	318.622	--	--	--	--	--			--	
NE1	12.0	328.300	2.000	2.43	2.43	94.0	6.5			82	
NE2	24.0	337.600	1.800	2.25	2.25	109.5	6.3			82	
NE3	36.0	346.800	1.850	2.32	2.32	112.0	6.5			82	
NE4	48.0	355.800	1.650	2.06	2.06	110.0	6.0			82	
NE5	60.0	364.000	1.600	2.00	2.00	109.5	6.0			82	
NE6	72.0	370.600	0.710	0.89	0.89	108.5	4.0		70	82	
NE7	84.0	376.400	0.660	0.82	0.82	104.5	4.0			82	
NE8	96.0	384.700	1.500	1.85	1.85	102.0	5.5			82	
NE9	108.0	394.800	2.150	2.66	2.66	104.5	7.1			82	
NE10	120.0	405.300	2.380	2.97	2.97	110.0	7.9			82	
NE11	132.0	416.200	2.500	3.12	3.12	110.0	8.0			82	
NE12	144.0	427.146	2.580	3.24	3.24	113.0	8.0			82	427.146
NW	0/0	427.272	--	--	--	--	--			--	427.272
NW1	12.0	436.800	1.850	2.29	2.29	103.5	6.1			82	
NW2	24.0	446.500	1.950	2.42	2.42	105.0	6.7		64	82	
NW3	36.0	456.200	1.950	2.41	2.41	102.5	6.7			80	
NW4	48.0	465.600	1.920	2.37	2.37	101.0	6.7			80	
NW5	60.0	474.000	1.450	1.79	1.79	101.0	5.5			80	
NW6	72.0	478.000	0.275	0.34	0.34	95.5	3.1			80	
NW7	84.0	482.200	0.330	0.4	0.4	92.0	3.2			80	
NW8	96.0	490.300	1.450	1.75	1.75	89.0	5.2		65	80	
NW9	108.0	500.000	1.900	2.31	2.31	93.5	6.7			80	
NW10	120.0	510.100	2.200	2.69	2.69	95.0	7.1			80	
NW11	132.0	520.400	2.250	2.75	2.75	95.5	7.1			80	
NW12	144.0	530.861	2.300	2.81	2.81	95.5	7.4			80	
FINAL											
DIFF/AVG.		212.113	1.63260		2.12	102				81	
											0.126

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Carolina Plating Company, Greenville, South Carolina

RUN	SAMPLING LOCATION	TEST TEAM LEADER
O-1	Napco Scrubber Outlet	C. Sorrell
O-2	Napco Scrubber Outlet	C. Sorrell
O-3	Napco Scrubber Outlet	C. Sorrell

		O-1	O-2	O-3
	RUN DATE	05/15/85	05/16/85	05/16/85
	RUN START TIME	1230	838	1517
	RUN FINISH TIME	1724	1419	0
	NET SAMPLING POINTS	24	24	24
Theta	NET RUN TIME, MINUTES	288.00	288.00	288.00
Dia	NOZZLE DIAMETER, INCHES	0.181	0.181	0.181
Cp	PITOT TUBE COEFFICIENT	0.840	0.840	0.840
Y	DRY GAS METER CAL. FACTOR	1.052	1.052	1.052
Pbar	BAROMETRIC PRESSURE, IN. HG.	29.16	29.02	28.96
Delta H	AVG. PRESS. DIFFERENTIAL OF ORIFICE METER, IN. H2O	2.250	2.240	2.120
Vm	VOLUME OF METERED GAS SAMPLE DRY ACTUAL CUBIC FEET	218.060	218.390	212.113
tm	DRY GAS METER TEMP., DEG. F	108	100	102
Vm(std)	VOLUME OF METERED GAS SAMPLE @ DRY STD. COND., DSCF*	208.924	211.210	203.928
Vlc	VOLUME OF WATER CATCH IN IMPINGERS & SIL. GEL.,ML	100.6	98.6	75.0
Vw(std)	VOLUME OF WATER VAPOR, SCF*	4.735	4.641	3.530
%H2O	MOISTURE, PERCENT BY VOLUME	2.2	2.2	1.7
Mfd	DRY MOLE FRACTION	0.978	0.978	0.983

(continued next page)

		O-1	O-2	O-3
Md	DRY MOLECULAR WT, LB/LB-MOLE	28.84	28.84	28.84
Ms	WET MOLECULAR WT, LB/LB-MOLE	28.60	28.60	28.65
Pg	GAS STATIC PRESS., IN. H2O	2.7	0.6	0.6
Ps	ABSOLUTE GAS PRESS., IN. HG.	29.35	29.06	29.00
ts	GAS TEMPERATURE, DEG. F	85	77	81
Delta p	AVG VELOCITY HEAD, IN. H2O	1.7166	1.7245	1.6326
vs	FLUE GAS VELOCITY, FT/SEC	75.8	75.8	74.0
A	STACK/DUCT AREA, SQUARE IN.	354.7	354.7	354.7
Qsd	GAS FLOW RATE, DRY SCFM *	10,410	10,464	10,171
Qaw	GAS FLOW RATE, WET ACFM	11,204	11,202	10,942
%I	PERCENT ISOKINETIC	95.9	96.5	95.8
	METHOD 5 RESULTS:			
mg	CATCH, MILLIGRAMS	15.5	20.4	16.1
gr/DSCF	CONCEN., GRAINS PER DSCF*	0.0011	0.0015	0.0012
Lb/Hr	EMISSION RATE, LBS/HOUR	0.10	0.13	0.11
	HEXAVALENT CHROMIUM:			
	CATCH, MILLIGRAMS	(155.0)	(121.0)	(174.0)
	TOTAL CHROMIUM:			
	CATCH, MILLIGRAMS	(728.0)	(305.0)	(647.0)

* 68 Deg. F - 29.92 in. Hg.

( ) = x 10^{-3}

RUN NUMBER	O-1	O-2	O-3	
FLUE GAS TEMPERATURE:				
Degrees Fahrenheit	85	77	81	deg. F
Degrees Centigrade	29	25	27	deg. C
AIR FLOW RATES x million:				
Actual Cubic Meters/hr	0.0190	0.0190	0.0186	acmh
Actual Cubic Feet/hr	0.6723	0.6721	0.6565	acfh
Dry Std. Cubic Meters/hr	0.0177	0.0178	0.0173	dscmh
Dry Std. Cubic Feet/hr	0.6246	0.6278	0.6103	dscfh
PARTICULATE:				
Concentration, mg/dscm	2.620	3.411	2.788	mg/dscm
Concentration, gr/dscf	0.00114	0.00149	0.00122	gr/dscf
Emissions, kg/hr	0.046	0.061	0.048	kg/hr
Emissions, lb/hr	0.102	0.134	0.106	lb/hr
HEXAVALENT CHROMIUM:				
Concentration, mg/dscm	(26.200)	(20.232)	(30.133)	mg/dscm
Concentration, gr/dscf	(0.01145)	(0.00884)	(0.01317)	gr/dscf
Emissions, kg/hr	(0.463)	(0.360)	(0.521)	kg/hr
Emissions, lb/hr	(1.022)	(0.793)	(1.148)	lb/hr
TOTAL CHROMIUM:				
Concentration, mg/dscm	(123.058)	(50.998)	(112.045)	mg/dscm
Concentration, gr/dscf	(0.05377)	(0.02229)	(0.04896)	gr/dscf
Emissions, kg/hr	(2.176)	(0.907)	(1.936)	kg/hr
Emissions, lb/hr	(4.798)	(1.999)	(4.269)	lb/hr

( ) = 10^{-3}

PARTICULATE FIELD DATA & RESULTS TABULATION

PLANT: Carolina Plating, Greenville, SC

RUN	SAMPLING LOCATION	TEST TEAM LEADER
DIF1	Scrubber Inlet	J. Brown
DIF2	Scrubber Inlet	J. Brown
DIF3	Scrubber Outlet	J. Brown

		DIF1	DIF2	DIF3
	RUN DATE	05/14/85	05/15/85	05/16/85
	RUN START TIME	1230	1915	2015
	RUN FINISH TIME	2130	730	850
	NET SAMPLING POINTS	1	1	1
Theta	NET RUN TIME, MINUTES	485.00	735.00	735.00
Dia	NOZZLE DIAMETER, INCHES	0.600	0.600	0.600
Cp	PITOT TUBE COEFFICIENT	0.840	0.840	0.840
Y	DRY GAS METER CAL. FACTOR	1.000	1.000	1.000
Pbar	BAROMETRIC PRESSURE, IN. HG.	29.17	29.11	28.96
Delta H	AVG. PRESS. DIFFERENTIAL OF ORIFICE METER, IN. H2O	0.250	0.390	3.560
Vm	VOLUME OF METERED GAS SAMPLE DRY ACTUAL CUBIC FEET	1042.280	1954.560	6612.250
tm	DRY GAS METER TEMP., DEG. F	92	82	81
Vm(std)	VOLUME OF METERED GAS SAMPLE @ DRY STD. COND., DSCF*	972.198	1853.613	6300.253
Vlc	VOLUME OF WATER CATCH IN IMPINGERS & SIL. GEL.,ML	314.0	640.0	2314.0
Vw(std)	VOLUME OF WATER VAPOR, SCF*	14.780	30.125	108.920
%H2O	MOISTURE, PERCENT BY VOLUME	1.5	1.6	1.7
Mfd	DRY MOLE FRACTION	0.985	0.984	0.983

(continued next page)

		DIF1	DIF2	DIF3
Md	DRY MOLECULAR WT, LB/LB-MOLE	28.84	28.84	28.84
Ms	WET MOLECULAR WT, LB/LB-MOLE	28.67	28.66	28.65
Ps	GAS STATIC PRESS., IN. H2O	-1.6	-1.6	0.6
Ps	ABSOLUTE GAS PRESS., IN. HG.	29.05	28.99	29.00
ts	GAS TEMPERATURE, DEG. F	92	82	81
Delta p	AVG VELOCITY HEAD, IN. H2O	0.1500	0.1600	1.6000
vs	FLUE GAS VELOCITY, FT/SEC	22.6	23.2	73.3
A	STACK/DUCT AREA, SQUARE IN.	1,018.0	1,018.0	354.7
Qsd	GAS FLOW RATE, DRY SCFM *	8,782	9,136	10,069
Qaw	GAS FLOW RATE, WET ACFM	9,603	9,840	10,832
%I	PERCENT ISOKINETIC	82.1	99.3	106.7
	METHOD 5 RESULTS:			
mg	CATCH, MILLIGRAMS	100.0	147.3	55.2
gr/DSCF	CONCEN., GRAINS PER DSCF*	0.0016	0.0012	0.0001
Lb/Hr	EMISSION RATE, LBS/HOUR	0.12	0.10	0.01
	HEXAVALENT CHROMIUM:			
	CATCH, MILLIGRAMS	(23,099.0)	(29,099.0)	(6,499.0)
	TOTAL CHROMIUM:			
	CATCH, MILLIGRAMS	(31,883.0)	(43,209.0)	(10,090.0)

* 68 Deg. F - 29.92 in. Hg.

( ) = x 10^{-3}

RUN NUMBER	DIF1	DIF2	DIF3	
FLUE GAS TEMPERATURE:				
Degrees Fahrenheit	92	82	81	deg. F
Degrees Centigrade	33	28	27	deg. C
AIR FLOW RATES x million:				
Actual Cubic Meters/hr	0.0163	0.0167	0.0184	acmh
Actual Cubic Feet/hr	0.5762	0.5904	0.6499	acfh
Dry Std. Cubic Meters/hr	0.0149	0.0155	0.0171	dscmh
Dry Std. Cubic Feet/hr	0.5269	0.5482	0.6041	dscfh
PARTICULATE:				
Concentration, mg/dscm	3.633	2.806	0.310	mg/dscm
Concentration, gr/dscf	0.00159	0.00123	0.00014	gr/dscf
Emissions, kg/hr	0.054	0.044	0.005	kg/hr
Emissions, lb/hr	0.119	0.096	0.012	lb/hr
HEXAVALENT CHROMIUM:				
Concentration, mg/dscm	(839.079)	(554.400)	(36.429)	mg/dscm
Concentration, gr/dscf	(0.36667)	(0.24227)	(0.01592)	gr/dscf
Emissions, kg/hr	(12.520)	(8.606)	(0.623)	kg/hr
Emissions, lb/hr	(27.601)	(18.972)	(1.374)	lb/hr
TOTAL CHROMIUM:				
Concentration, mg/dscm	(1,158.160)	(823.227)	(56.558)	mg/dscm
Concentration, gr/dscf	(0.50610)	(0.35974)	(0.02472)	gr/dscf
Emissions, kg/hr	(17.281)	(12.778)	(0.968)	kg/hr
Emissions, lb/hr	(38.097)	(28.172)	(2.133)	lb/hr

( ) = 10^{-3}

TOTAL CHROMIUM ANALYSIS CALCULATION

(A) Sample No.	(B) Total Wt of Sample mg	(C) NAA Results of Cr mg	Cr Analysis of Sample (D) Wt of Sample Analyzed mg	(E) Aliquot Factor	(F) Cr in Sample w/Blank	Cr Analysis of Residue (G) Wt of Residue Analyzed mg	(H) Aliquot Factor	(J) Cr in Sample Residue mg	(K) Cr^{+6} from Filtrate mg	(L) Cr in Sample w/Blank mg	(M) Blank Value mg	(N) Cr in Sample Blank Corrected mg	(P) Cr Conc. mg/g
237	100.0	8.784				Total	1	8.784	23.099	31.883	--	31.883	318.8
221	147.3	14.11				Total	1	14.11	29.099	43.209	--	43.209	293.3
222	55.2	3.591				Total	1	3.591	6.499	10.090	--	10.090	182.8
223	Blank	No Value				Total	1	No Value	----	----	N/A	----	----
224	15.5	0.573				Total	1	0.573	0.155	0.728	--	0.728	47.0
225	20.4	0.184				Total	1	0.184	0.121	0.305	--	0.305	15.0
226	16.1	0.473				Total	1	0.473	0.174	0.647	--	0.647	40.2
227	60.5	7.777				Total	1	7.777	7.200	14.977	--	14.977	247.6
228	38.6	4.313				Total	1	4.313	3.680	7.993	--	7.993	207.1
229	51.3	6.825				Total	1	6.825	6.520	13.345	--	13.345	260.1
230	Blank	No Value				Half	2	No Value	<0.5	----	N/A	----	----
231	Total	0.0006				Half	2	0.001	0.001	0.002	--	0.002	negl
232	Total	0.0004				Half	2	0.001	----	0.001	--	0.001	negl
233	Total	0.002				Half	2	0.004	0.007	0.011	--	0.011	negl
234	Total	0.0006				Half	2	0.001	0.001	0.002	--	0.002	negl
235	Total	0.001				Half	2	0.002	----	0.002	--	0.002	negl
236	Total	0.001				Half	2	0.002	----	0.002	--	0.002	negl

EXPLANATION OF TOTAL CHROMIUM ANALYSIS CALCULATION TABLE

Column

A (Sample Number) - Used to identify samples transferred to RTI and NCSU for hexavalent and total chromium analysis. Samples are identified on the Request for Analysis sheets in Appendix B.

B (Total Weight of Sample in mg) - Given for Method 5 and particle sizing samples (filters and catch or precutter contents). Taken from Particulate Sampling Laboratory Results and Particle Sizing Laboratory Data found in Appendix B.

C (NAA Results for Cr in mg) - Reported results for total chromium in the sample. Taken from computer printout of results found in Appendix B.

D (Weight of Sample Analyzed in mg) - If only a portion of the total sample was taken for NAA, the weight was recorded here. This weight was taken from the Sample Preparation and Analysis Data Form which is transferred with the samples for NAA (found in Appendix B).

E (Aliquot Factor) - The ratio of the total weight of the sample to amount of sample analyzed; should be 1 in all cases.

F (Cr in Sample with Blank in mg) - Total chromium in sample as measured by NAA; blank value, if any, has not been subtracted out. Results are taken from computer printout in Appendix B or Column C of this table.

G (Weight of Residue Analyzed in mg) - In some cases (i.e., Method 5, particle size, and some impinger samples), the hexavalent chromium was first extracted from the sample before it was submitted for NAA. The remainder of the sample following the hexavalent chromium extraction is termed the "residue." This column gives the weight of the residue analyzed and is taken from the Sample Preparation and Analysis Data Form found in Appendix B.

H (Aliquot Factor) - The ratio of the total weight of the sample to the amount of residue analyzed. This number multiplied by the total chromium results yields the total chromium in the sample residue.

J (Cr in Sample Residue in mg) - Total chromium content of the sample residue calculated by multiplying the total chromium results by NAA (column C) times the aliquot factor (column H). Thus, H x C = J.

K (Cr^{+6} in the Filtrate in mg) - Amount of hexavalent chromium in the filtrate extracted from the sample. This value must be added to the total chromium measured by NAA to get the total chromium in the sample. The hexavalent chromium value is taken from the Wet Chemical Analysis Sheets found in Appendix B.

L (Cr in Sample with Blank in mg) - Total chromium in sample; blank value, if any, has not been subtracted out. This value is the sum of the hexavalent chromium in the sample filtrate (column K) and the total chromium in the sample residue (column J). Thus, K + J = L.

M (Blank Value in mg) - Total chromium value for the appropriate sample blank, if any.

N (Cr in Sample, Blank Corrected in mg) - Total chromium in sample with value of sample blank, if any, subtracted out. Thus, L - M = N.

P (Cr Concentration in mg/g) - Chromium concentration in sample calculated by dividing the total chromium content of the sample by the sample weight: N ÷ B = P or N ÷ D = P.

APPENDIX B

FIELD AND ANALYTICAL DATA

PRELIMINARY VELOCITY TRAVERSE

PLANT Carolina Plating
DATE 15 MAY 85
LOCATION Inlet
STACK I.D. 36.0"
BAROMETRIC PRESSURE, in. Hg 29.17
STACK GAUGE PRESSURE, in. H_2O
OPERATORS F. Clay P Schindler

STATIC = −1.6 H_2O

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1-H	.07	85
2-H	.18	85
3-H	.17	85
4-H	.16	85
5-H	.17	85
6-H	.16	85
7-H	.16	85
8-H	.18	85
9-H	.205	85
10-H	.21	85
11-H	.21	85
12-H	.21	85
AVERAGE		

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1-V	.22	85
2-V	.21	85
3-V	.21	85
4-V	.21	85
5-V	.205	85
6-V	.19	85
7-V	.07	85
8-V	.07	85
9-V	.08	85
10-V	.09	85
11-V	.08	85
12-V	.07	85
AVERAGE	.1520	85

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AIR FLOW RATE DETERMINATIONS

Inlet

COMPANY NAME *Carolina Plating* RUN # *5-15-85*

ADDRESS ______ DATE ______

MEASUREMENT LOCATION ______ START-FINISH TIME ______

DUCT DIMENSIONS ______ DUCT AREA (A) ______ $IN.^2$ PERSONNEL ______

BARO. PRESSURE (P_{BAR}) ______ IN. H_G STATIC PRESSURE (P_G) ______ IN. H_2O

PITOT PROBE I.D. ______ PITOT TUBE COEFFICIENT (C_P) ______

Traverse Times

START ______ FINISH ______

POINT #	Δp IN H_2O	TEMP. °F

AVG. ______ $(\sqrt{\Delta p})^2$ ______ T_S

Flue Gas Composition - Sampling & Analysis Data

Sampling Data

PORT/POINT	CO_2 FYRITE	START STOP TIME	BAG #	PUMP #

Analysis Data

TIME OF ANALYSIS	CO_2 READING A	O_2 READING B	% O_2 B-A	%$CO+N_2$ 100-C
AVERAGE		AVERAGE		
	% CO_2		% O_2	%$CO+N_2$

Moisture Data

PORT	TIME	DRY BULB TEMP. F	WET BULB TEMP. F	DIFF.	% H_2O

ABSOLUTE STACK GAS PRESSURE, in. Hg

P_s = (29.17) P_{bar} + [(-1.60) P_g / 13.6] = 29.05 P_s

DRY MOLE FRACTION OF STACK GAS

M_{fd} = 1 - (1.6 %H_2O / 100) = .984 M_{fd}

DRY MOLECULAR WEIGHT OF STACK GAS, lb/lb-mole

M_d = [0.44 (0 %CO_2)] + [0.32 (20.9 %O_2)] + [0.28 (79.1 %N_2 + 0 %CO)] = 28.84 M_d

WET MOLECULAR WEIGHT OF STACK GAS, lb/lb-mole

M_s = (28.84 M_d)(.984 M_{fd}) + 0.18 (1.6 %H_2O) = 28.66 M_s

AVERAGE STACK GAS VELOCITY, ft/sec

v_s = 85.49 (0.84 C_p) $\sqrt{(.1520\ \Delta p_{avg})(85\ t_s + 460) / (29.05\ P_s)(28.66\ M_s)}$ = 22.7 v_s

DRY VOLUMETRIC STACK GAS FLOW RATE, scfm

Q_{sd} = 7.353 (.984 M_{fd})(22.7 v_s)(1018 A)(29.05 P_s) / (85 t_s + 460) = 8893 Q_{sd}

WET VOLUMETRIC STACK GAS FLOW RATE, acfm

Q_{aw} = (60 / 144)(22.7 v_s)(1018 A) = 9607 Q_{aw}

ENTROPY

PRELIMINARY VELOCITY TRAVERSE

PLANT _____
DATE _____
LOCATION _____
STACK I.D. _____
BAROMETRIC PRESSURE, in. Hg _____
STACK GAUGE PRESSURE, in. H_2O _____
OPERATORS _____

SCHEMATIC OF TRAVERSE POINT LAYOUT

NW $T_s = 85$

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F	FLOW ANGLE
1	1.72		0°
2	1.60	2.3	30D°
3	1.80	2.2	45R 90L
4	0.88	2.33	45R 90L
5	1.60	2.15	45R 90L
6	0.01	1.70	0R 90L
7	0.37	1.80	30L 90R
8	2.10	2.65	30L 90R
9	3.20	2.90	45L 90R
10	3.50	2.90	45L 90R
11	3.60	2.60	45L 90R
12	3.50	2.20	45L 90R
AVERAGE			

NE

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F	FLOW ANGLE
1	1.90	2.3	45R 90L
2	1.80	2.4	45R 90L
3	1.80	2.4	45R 90L
4	1.90	2.4	35R 90L
5	1.60	2.2	45R 90L
6	.79	1.75	45R 90L
7	.55	1.0	45L 90L
8	2.2	2.7	45L 90L
9	3.0	2.6	45L 90R
10	3.3	2.5	45L 90L
11	3.20	2.3	45L 90R
12	3.0	2.0	45L 90R
AVERAGE			

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CYCLONIC FLOW FIELD CALCULATION SHEET

Company Name Carolina Platina 8 Date 5-15-85

Address _____ Tester _____

Sampling Location OUTLET Base Test Time —

	Sample Point	Run #				Run #			
		Angle ϕ	Test Time	Δp	cos ϕ ($\sqrt{\Delta p}$)	Angle ϕ	Test Time	Δp	cos ϕ ($\sqrt{\Delta p}$)
NW	1	30	-	1.72	1.1358				
	2	45		1.60	.8911				
	3	45		1.80	.9487				
	4	45		0.88	.6633				
	5	45		1.60	.8944				
	6	0		0.01	0.1				
	7	30		0.37	.5268				
	8	30		2.10	1.255				
	9	45		3.20	1.2649				
	10	45		3.50	1.3229				
	11	45		3.60	1.3416				
	12	45		3.50	1.3229				
NE	1	45		1.90	.9747				
	2	45		1.80	.9487				
	3	45		1.80	.9487				
	4	35		1.90	1.1291				
	5	45		1.60	.8944				
	6	45		.79	.6285				
	7	45		.55	.5244				
	8	45		2.2	1.0488				
	9	45		3.0	1.2247				
	10	45		2.3	1.0724				
	11	45		3.20	1.2649				
	12	45		3.0	1.2247				

Test Time = cos ϕ (Base Time)

Avg. $\Delta p_v = \left(\frac{\Sigma \cos \phi \sqrt{\Delta p}}{n}\right)^2$ .9632 / Average Δp_v _____ / Average Δp_v

ENTROPY ENVIRONMENTALISTS, INC.

AIR FLOW RATE DETERMINATIONS

5/15/85

COMPANY NAME *Carolina Plating* RUN # *Outlet*

ADDRESS *8* DATE

MEASUREMENT LOCATION START-FINISH TIME

DUCT DIMENSIONS DUCT AREA (A) IN.^{2} PERSONNEL

BARO. PRESSURE (P_{BAR}) IN. H_G STATIC PRESSURE (P_G) IN. H_2O

PITOT PROBE I.D. PITOT TUBE COEFFICIENT (C_P)

Traverse Times START		FINISH
POINT #	Δp IN. H_2O	TEMP. °F
AVG.	$(\sqrt{\Delta p})^2$	T_S

Flue Gas Composition — Sampling & Analysis Data

Sampling Data

PORT/POINT	CO_2 FYRITE	START STOP TIME	BAG #	PUMP #

Analysis Data

TIME OF ANALYSIS	CO_2 READING A	O_2 READING B	% O_2 B-A	%CO+N_2 100-C
AVERAGE		AVERAGE		
	% CO_2		% O_2	%CO+N_2

Moisture Data

PORT	TIME	DRY BULB TEMP. F	WET BULB TEMP. F	DIFF.	% H_2O

ABSOLUTE STACK GAS PRESSURE, in. Hg

P_s = (29.17) + [(2.65) / 13.6] = 29.36

DRY MOLE FRACTION OF STACK GAS

M_{fd} = 1 − (2.2 / 100) = .978

DRY MOLECULAR WEIGHT OF STACK GAS, lb/lb-mole

M_d = [0.44 (0)] + [0.32 (20.9)] + [0.28 (79.1 + 0)] = 28.84

WET MOLECULAR WEIGHT OF STACK GAS, lb/lb-mole

M_s = (28.84)(.978) + 0.18 (79.1) = 28.6

AVERAGE STACK GAS VELOCITY, ft/sec

v_s = 85.49 (0.84) $\sqrt{(.9632)(85 + 460) / (29.36)(28.6)}$ = 56.8

DRY VOLUMETRIC STACK GAS FLOW RATE, scfm

Q_{sd} = 7.353 (.978)(56.8)(354.7)(29.36) / (85 + 460) = 7803

WET VOLUMETRIC STACK GAS FLOW RATE, acfm

Q_{aw} = (60 / 144)(56.8)(354.7) = 8391

ENTROPY

DRY MOLECULAR WEIGHT DETERMINATION

PLANT CAROLINA PLATING INC.
DATE 5-14-85
SAMPLING TIME (24-hr CLOCK)
SAMPLING LOCATION INLET
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) INT. BAG
ANALYTICAL METHOD ORSAT
AMBIENT TEMPERATURE 85°F
OPERATOR JWB

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	0	0	0	0	0	0		44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	20.9	20.9	20.9	20.9	21.0	21.0	20.9	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	20.9	0	20.9	0	21.0	21.0	20.9	28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)		79.1		79.1		79.0	79.1	28/100	
								TOTAL	

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ml H_2O = 48 Inlet

FIELD DATA

PLANT Carolina Plating
DATE 15 May 02
SAMPLING LOCATION Inlet
SAMPLE TYPE Cr Part.
RUN NUMBER 1
OPERATOR EClay / P. Schindler
AMBIENT TEMPERATURE 80°F
BAROMETRIC PRESSURE 29.26 29.12
STATIC PRESSURE, (P_g) -1.6
FILTER NUMBER (s)

1 Traverse Twice

PROBE LENGTH AND TYPE 9 ft
NOZZLE I.D. 0.325
ASSUMED MOISTURE, % 32
SAMPLE BOX NUMBER VI I
METER BOX NUMBER BAC 3
METER $\Delta H_@$ 1.930
C FACTOR N/A
PROBE HEATER SETTING 3 J
HEATER BOX SETTING 100°F
REFERENCE Δp N/A

SCHEMATIC OF TRAVERSE POINT LAYOUT

Final Leak Check @ 0.00 @ 15" Hg

READ AND RECORD ALL DATA EVERY 12 MINUTES

Y = 1.005 Pre-test Leak 0.00 @ 15" Hg Start

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0.00 1235	186.505									
1	0.12 1247	199.220	.18	3.89	3.89	80	81	85	6.5		60
2	024 1259	212.850	.20	4.43	4.43	80	104	88	7.5		72
3	036 1311	224.550	.13	2.93	2.93	80	116	96	5.0		64
4	048 1323	236.000	.13	2.93	2.93	82	115	101	5.0		63
5	060 1335	248.235	.15	3.39	3.39	83	117	105	5.5		61
6	112 1347	260.550	.15	3.41	3.41	83	120	108	5.5		60
7	124 1359	273.300	.16	3.65	3.65	83	122	110	6.0		59
8	136 1411	285.700	.18	4.10	4.10	84	122	110	6.5		59
9	148 1423	300.040	.195	4.45	4.45	85	124	112	7.0		60
10	2.00 1435	315.300	.205	4.69	4.69	85	126	113	7.5		60
11	212 1447	329.965	.21	4.82	4.82	85	128	114	7.5		60
12	224 1459	344.630	.215	4.93	4.93	85	128	114	8.0		59
12	2 36 1511	359.410	.21	4.82	4.82	85	128	114	7.75		59
11	2 48 1523	374.100	.21	4.81	4.81	85	127	114	7.75		60
10	3 00 1535	388.500	.20	4.59	4.59	85	128	114	7.5		59
9	3 12 1547	402.250	.18	4.12	4.12	85	127	114	6.5		59
8	3 24 1559	415.775	.175	4.00	4.00	85	125	114	6.5		59
7	3 36 1611	428.700	.16	3.65	3.65	86	125	115	6.0		58
6	348 1623	440.070	.12	2.74	2.74	86	124	114	4.5		58
5	400 1635	451.565	.125	2.84	2.84	86	121	113	4.75		58
4	412 1647	463.675	.115	2.61	2.61	86	121	112	4.5		57
3	424 1659	472.775	.110	2.27	2.27	86	121	112	4.0		57
2	436 1711	486.040	.175	3.97	3.97	86	120	112	6.5		56
1	448 1723	498.277	.14	3.20	3.20	86	121	114	5.0		54

Final 1725 Stop

FIELD DATA

PLANT Carolina Chrome Plating
DATE 16 MAY 85
SAMPLING LOCATION Inlet
SAMPLE TYPE S-S Particulate
RUN NUMBER 3
OPERATOR E. Clay & P. Schlissler
AMBIENT TEMPERATURE 75
BAROMETRIC PRESSURE 29.04
STATIC PRESSURE, (P_g) -1.6
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5' glass
NOZZLE I.D. 0.375
ASSUMED MOISTURE, % 0.5 %
SAMPLE BOX NUMBER
METER BOX NUMBER RAC-7
METER $\Delta H_@$ 1.93
C FACTOR N/A
PROBE HEATER SETTING 333
HEATER BOX SETTING
REFERENCE Δp N/A

SCHEMATIC OF TRAVERSE POINT LAYOUT

Final Leak Rate = 0.00 @ 17.5 "Hg READ AND RECORD ALL DATA EVERY 12 MINUTES Initial Leak Rate = 0.006

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE, °F		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0.00 / 9:01	500.320									
1	012 / 913	511.240	.12	2.71	2.71	75	77	80	9.5		53
2	024 / 925	522.350	.12	2.78	2.78	74	100	85	10.0		62
3	036 / 937	534.035	.13	3.04	3.04	74	112	83	10.5		62
4	048 / 949	546.275	.14	3.33	3.33	75	118	98	11.5		61
5	060 / 1001	558.215	.13	3.12	3.12	75	122	104	10.5		57
6	112 / 1013	570.455	.14	3.38	3.38	75	124	107	11.3		57
7	124 / 1025	582.975	.145	3.50	3.50	76	125	108	11.7		55
8	136 / 1037	596.120	.16	3.87	3.87	76	126	110	13.0		54
9	148 / 1049	609.700	.17	4.12	4.12	76	128	111	14.0		53
10	200 / 1101	623.652	.18	4.36	4.36	77	128	112	15.2		53
11	212 / 1113	637.088	.17	3.89	3.89	78	83	96	14.0		54
12	224 / 1125	650.525	.18	4.23	4.23	81	115	98	15.0		52
12	236 / 1137	664.660	.19	4.52	4.52	81	124	104	16.0		52
11	248 / 1149	678.640	.18	4.31	4.31	81	127	109	15.3		51
10	300 / 1201	692.380	.17	4.09	4.09	81	130	111	14.2		50
9	312 / 1213	705.735	.16	3.86	3.86	81	131	114	13.2		51
8	324 / 1225	718.705	.15	3.61	3.61	82	131	114	12.0		50
7	336 / 1237	730.410	.12	2.89	2.89	82	130	115	9.8		51
6	348 / 1249	741.175	.10	2.40	2.40	83	127	115	8.2		52
5	400 / 1301	752.680	.12	2.87	2.87	83	124	114	9.5		51
4	412 / 1313	765.280	.16	3.83	3.83	83	124	114	13.0		51
3	424 / 1325	779.900	.18	4.35	4.35	80	129	114	15.0		50
2	436 / 1337	795.050	.15	3.62	3.62	81	131	115	12.5		50
1	448 / 1349	803.373	.09	2.18	2.18	80	131	116	7.5		52

FIELD DATA

PLANT Carolina Chrome Plating
DATE 16 MAY 85
SAMPLING LOCATION Inlet
SAMPLE TYPE Sec 5 Particulate
RUN NUMBER 3
OPERATOR E. Clay & P. Schlinder
AMBIENT TEMPERATURE 80
BAROMETRIC PRESSURE 29.92
STATIC PRESSURE, (P_g) -1.6
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5' glass
NOZZLE I.D. .0375
ASSUMED MOISTURE, % 1
SAMPLE BOX NUMBER
METER BOX NUMBER RAC-7
METER $\Delta H_@$ 1.93
C FACTOR N/A
PROBE HEATER SETTING 33
HEATER BOX SETTING
REFERENCE ΔP N/A

SCHEMATIC OF TRAVERSE POINT LAYOUT

Final Leak Rate: 0.00 @ 15.5" Hg READ AND RECORD ALL DATA EVERY 12 MINUTES Initial Leak rate .003 @ 17.5" Hg

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr CLOCK) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_g), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE, °F		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	000 / 1335 PM	805.302									
1	012 / 1337	816.630	.12	2.79	2.79	76	99	102	4.8		62
2	024 / 1349	828.730	.14	3.29	3.29	81	119	105	5.2		68
3	036 / 1401	839.653	.12	2.83	2.83	84	124	109	4.0		66
4	048 / 1413	851.635	.13	3.07	3.07	84	126	111	5.0		62
5	060 / 1425	864.000	.14	3.32	3.32	84	128	113	5.2		60
6	112 / 1437	875.970	.13	3.08	3.08	85	129	114	5.0		58
7	124 / 1449	888.345	.14	3.33	3.33	85	130	115	5.1		56
8	136 / 1501	901.145	.15	3.57	3.57	85	131	116	5.3		56
9	148 / 1513	914.775	.17	4.04	4.04	86	131	117	6.2		57
10	200 / 1525	929.180	.19	4.53	4.53	85	132	117	7.0		55
11	212 / 1537	943.930	.20	4.77	4.77	85	132	117	7.2		53
12	224 / 1549	959.030	.21	5.01	5.01	85	133	117	7.5		54
13	236 / 1601	974.135	.21	4.98	4.98	85	134	118	7.6		55
11	248 / 1613	988.980	.20	4.74	4.74	85	134	118	7.2		55
10	300 / 1625	1003.040	.18	4.27	4.27	85	134	118	6.5		54
9	312 / 1637	1016.725	.17	4.02	4.02	85	132	118	6.0		54
8	324 / 1649	1029.653	.15	3.54	3.54	85	130	118	5.4		55
7	336 / 1701	1042.142	.14	3.30	3.30	85	129	117	5.2		54
6	348 / 1713	1054.115	.13	3.06	3.06	85	128	117	4.8		54
5	400 / 1725	1066.070	.13	3.06	3.06	85	126	116	4.8		53
4	412 / 1737	1077.220	.11	2.59	2.59	84	126	116	4.2		52
3	424 / 1749	1088.775	.12	2.82	2.82	85	125	115	4.6		51
2	436 / 2001	1101.487	.15	3.52	3.52	85	125	115	5.3		51
1	448 / 2013	1113.148	.12	2.82	2.82	85	127	115	4.9		51

T_s 84

B-11

FIELD DATA

PLANT CAROLINA RACING
DATE 5-15-88
SAMPLING LOCATION OUTLET
SAMPLE TYPE M-5
RUN NUMBER 0-1
OPERATOR C. Sorce II
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 29.16
STATIC PRESSURE, (P_s) -2.63
FILTER NUMBER (s)

m_{wD} 28.55
m_{wW} 28.73

PROBE LENGTH AND TYPE A GLASS
NOZZLE I.D. .191 .187 .187
ASSUMED MOISTURE, % 2.0
SAMPLE BOX NUMBER
METER BOX NUMBER RAC N
METER $\Delta H_@$ 1.92
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT 12 min 1 6 9 12

READ AND RECORD ALL DATA EVERY ____ MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE, °F		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0 / 12:30	880.867									
1	12	890.	1.60	2.17	2.17	86	90	86	8.1		
2	24	899.	1.75	2.17	2.17	86	116	92	8.1		
3	36	907.9	1.63	2.04	2.04	86	124	98	7.9		
4	48	916.2	1.53	1.92	1.92	86	122	102	7.5		72
5	60	924.6	1.45	1.82	1.82	86	120	102	7.2		
6	72	930.3	0.94	1.80	1.80	87	116	102	4.5		
7	84	936.5	.80	.96	.96	87	112	102	5.0		
8	96	94	1.80	2.23	2.23	87	110	101	8.5		
9	108	951.	2.35	2.95	2.95	87	122	102	10.6		
10	120	961.6	2.45	3.10	3.10	87	129	104	11.0		
11	132	977.8	2.60	3.29	3.29	87	130	106	11.6		
12	144	989.098	2.65	3.35	3.35	84	124	105	11.5		
							109.9				

B-12

FIELD DATA

PLANT Caselton Plating
DATE 5-16-85
SAMPLING LOCATION outlet
SAMPLE TYPE M5
RUN NUMBER 0-1
OPERATOR C. Sorrell
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 29.16
STATIC PRESSURE, (P_s) 2.65
FILTER NUMBER (s)
leak checks before changing parts

PROBE LENGTH AND TYPE 4' Glass
NOZZLE I.D. .181
ASSUMED MOISTURE, % 2.0
SAMPLE BOX NUMBER
METER BOX NUMBER Rac 4
METER $\Delta H_@$ 1.928
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 12 MINUTES

Y = 1.052

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr CLOCK) / SAMPLING TIME, min	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0 3:00	989.244									
AE 1	12 12	998.7	1.80	2.23	2.23	84	104	99	8.3		
2	24 24	008.5	1.92	2.40	2.40	84	116	98	9.0		
3	36 36	018.10	2.0	2.50	2.50	84	116	100	9.2		
4	48 48	027.4	1.86	2.31	2.31	84	115	99	8.8		
5	60 60	036.3	1.65	2.07	2.07	84	119	101	8.0		
6	72 72	042.3	0.65	.81	.81	84	116	101	5.0		
7	84 84	46.8	0.925	.0240	.0240	84	106	100	3.8		
8	96 96	55.9	1.90	2.34	2.34	84	101	94	9.0		
9	108 108	66.6	2.40	3.00	3.00	84	116	100	11.0		
10	120 120	77.4	2.46	3.08	3.08	84	118	102	11.0		
11	132 132	88.35	2.46	3.10	3.10	84	125	104	11.0		
12	144 144	99.073	2.30	2.91	2.91	84	124	104	10.4		
			1.31022					107.58			
			1.31022	^{2} =	1.716 67572						

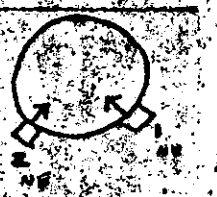
B-13

FIELD DATA

PLANT Carolina Plating
DATE 5-16-85
SAMPLING LOCATION Outlet
SAMPLE TYPE M-5
RUN NUMBER #2
OPERATOR Sorrell
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 29.02
STATIC PRESSURE, (P_s) ~~-0.56~~ -0.56 ok pt 5
FILTER NUMBER (s)

mwd = 28.95
mww = 28.71

PROBE LENGTH AND TYPE 4' glass
NOZZLE I.D. 0.181
ASSUMED MOISTURE, % 2.2
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$ 1.928
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp



SCHEMATIC OF TRAVERSE POINT LAYOUT.

Y = 1.050

READ AND RECORD ALL DATA EVERY 12 MINUTES

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr CLOCK) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0 / 9:38	99.598									
1	12	109.25	2.05	2.44	2.44	75	76	75	8.2		~~ice~~
2	24	119.05	2.00	2.45	2.45	75	103	82	8.2		
3	36	129.	2.00	2.46	2.46	76	104	85	8.2		
4	48	138.6	2.03	2.51	2.51	75	106	87	8.4		
5	60	147.8	1.72	2.13	2.13	75	106	88	7.5		
6	72	153.58	0.676	.81	.81	75	103	88	4.4		
7	84	157.5	0.26	.32	.32	75	93	86	2.3		
8	96	166.5	1.75	2.13	2.13	75	90	86	7.8		
9	108	176.	1.80	2.22	2.22	75	103	88	8.0	}	stay on 9 for 24 min
10	120	186.	2.25	2.78	2.78	75	104	88	9.5		
11	132	197.	2.35	2.92	2.92	75	110	90	9.9		60
12	144	207.516	2.25	2.80	2.80	75	110	90	9.6		

Port 1 NW

FIELD DATA

PLANT Coating Plant
DATE 5-16-95
SAMPLING LOCATION Duct 4
SAMPLE TYPE M-5
RUN NUMBER 02
OPERATOR Sorrell
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 29.02
STATIC PRESSURE, (P_s) -.56
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 4' Glass
NOZZLE I.D. .191
ASSUMED MOISTURE, % 2.2
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$ 1.928
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

Y=1.052

READ AND RECORD ALL DATA EVERY 12 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0 / 1155	207.791									
1	12 /	216.	1.50	1.79	1.79	78	82	81	6.5		
2	24 /	225.3	1.55	2.27	2.27	78	105	87	8.0		
3	36 /	234.9	1.90	2.37	2.37	78	116	91	8.1	250 for 24 min	
4	48 /	244.4	1.90	2.39	2.39	78	121	96	8.1	3	
5	60 /	253.	1.90	1.36	1.76	78	122	99	6.2		65
6	72 /	259.	.85	1.07	1.07	80	120	100	4.7		
7	84 /	265.2	.73	0.91	0.91	80	116	102	4.5		
8	96 /	274.	1.65	2.07	2.07	80	116	103	7.1		
9	108 /	284.5	2.20	2.77	2.77	80	122	103	9.0		
10	120 /	295.4	2.60	3.30	3.30	80	127	105	10.9		
11	132 /	306.8	2.73	3.45	3.45	80	122	107	11.1		
12	144 /	319.263	2.78	3.52	3.52	80	122	108	11.2		
			1.313232		= 1.724556						

Form 2
B-15

1.78 avg Δp

FIELD DATA

PLANT Carolina Plating
DATE 5-16-85
SAMPLING LOCATION Outlet
SAMPLE TYPE M5-3
RUN NUMBER 3
OPERATOR Sorrell
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 28.96
STATIC PRESSURE, (P_s) 0.76
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 4' glass
NOZZLE I.D. .184
ASSUMED MOISTURE, % 2.2
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$ 1.728
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 12 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0 / 1317	319.622									
1	12	328.3	2.00	2.43	2.43	82	95	93	6.5		
2	24	337.6	1.80	2.25	2.25	92	120	99	6.3		
3	36	346.8	1.85	2.32	2.32	82	122	102	6.5		
4	48	355.8	1.65	2.06	2.06	82	118	102	6.0		
5	60	364.	1.60	2.00	2.00	82	117	102	6.0		
6	72	370.16	0.71	0.89	0.89	82	115	102	4.0		70
7	84	376.4	0.66	0.82	0.82	82	108	101	4.0		
8	96	384.7	1.50	1.85	1.85	82	105	99	5.5		
9	108	394.8	2.15	2.66	2.66	92	111	98	7.1		
10	120	405.3	2.38	2.97	2.97	82	120	100	7.9		
11	132	416.2	2.50	3.12	3.12	82	120	100	8.0		
12	144	427.146	2.58	3.24	3.24	82	124	102	8.0		
			1.2771342		= 1.6032605						

B-16

FIELD DATA

PLANT Carbon Plant
DATE 5-16-85
SAMPLING LOCATION Duct
SAMPLE TYPE M5
RUN NUMBER 0-3
OPERATOR Sorrell
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 28.96
STATIC PRESSURE, (P_s) 0.56
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 4' Glass
NOZZLE I.D. 0.181
ASSUMED MOISTURE, % 2.2
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$ 1.928
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 12 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	0	427.272									
1	12	436.4	1.85	2.29	2.29	82	108	99	6.1		
2	24	446.5	1.95	2.42	2.42	82	112	98	6.7		62
3	36	456.2	1.95	2.41	2.41	80	109	96	6.7		60
4	48	465.6	1.92	2.37	2.37	80	107	95	6.7		
5	60	474	1.45	1.79	1.79	80	108	94	5.5		
6	72	478.0	.275	0.34	0.34	80	100	91	3.1		
7	84	482.2	.33	0.40	0.40	80	94	90	3.2		
8	96	490.3	1.45	1.75	1.75	80	90	85	5.2		65
9	108	500.	1.90	2.31	2.31	80	99	88	6.7		
10	120	510.1	2.20	2.69	2.69	80	102	89	7.1		
11	132	520.4	2.25	2.75	2.75	80	103	88	7.1		
12	144	530.861	2.310	2.81	2.81	80	104	87	7.4		

EPA Form 735

B-17

PLANT Carolina Plating

PROCESS INFORMATION

ADDRESS White Horse Rd. Greenville, S.C.

SAMPLING LOCATION Scrubber Controlled Inlet & Outlet

SAMPLE COLLECTED BY JNB, DGB, DH

DATE	RUN - TRAV. POINT	CLOCK TIME	SAMPLE TIME	ΔH	ΔP	POWER SET.	NOZZLE VEL. (FPM)	FILTER TYPE	COMMENTS
5-14-85	SINGLE POINT	12:30		.25	.15	28%	~1310	CLEANED FG THIMBLE	#1 TEST SAMPLE AT INLET
"	"	14:40		→					STOP FOR INLET TRAVERSE
"	"	15:35		"	"	"	"	"	RESTART
"	"	21:30	8 HR 5 MIN	"	"	"	"	"	FINISH
5-15-85	"	19:15		.35	.16	33%	~1400	"	#2 SAMPLE RUN AT INLET
5-16-85	"	07:30	12 HR 16 M	.43	"	"	"	"	
5-16-85	"	20:15		3.52	1.60	60%	~4400	"	#3 SAMPLE RUN AT OUTLET
5-17-85	"	08:50	12 HR 15 M	3.60	"	"	"	"	

SAMPLE ID LOG
CAROLINA PLATING INC.
GREENVILLE, S.C. MAY 14TH, 1985

SAMPLE #	TEST POINT	DESCRIPTION
AB		ACETONE BLANK
WB		DI H_2O BLANK
DIF-1	INLET	THIMBLE FILTER RUN (FILTER & WASH)
CP-O-1 ACE	OUTLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
CP-I-1 ACE	INLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
DIF-2		THIMBLE FILTER RUN (FILTER & WASH)
CP-O-2 ACE	OUTLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
CP-I-2 ACE	INLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
CP-O-3 ACE	OUTLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
CP-I-3 ACE	INLET	FRONT HALF ACETONE WASH
" H_2O	"	" " H_2O "
" BH	"	BACK HALF H_2O RINSE
" F	"	FILTER
FILTER BLANKS		3 FIBER GLASS FILTERS
DIF-3	OUTLET	THIMBLE FILTER RUN (FILTER & WASH)

FIELD TEST FILTERS

FILTER TARES		TOTAL WT.	FILTER CATCH
NO.	WT. (G)		
000155	.3096 ✓		
000156	.3038 ✓		
000157	.3140 ✓		
000158	.3220 ✓		
000159	.3133 ✓		
000160	.3152 ✓		
000161	.3142 ✓		
000162	.3108 ✓		
000163	.3236 ✓		
000164	.3178 ✓		
000165	.3135 ✓		
000166	.3095 ✓		
000167	.3155 ✓		
000168	.3110 ✓		
000169	.3159 ✓		
000170	.3112 ✓		
000171	.3073 ✓		
000172	.3073 ✓		
000173	.3079 ✓		
000174	.3089 ✓		
000175	.3090 ✓		
000176	.3089 ✓		
000177	.3105 ✓		
000178	.3112 ✓		
000179	.3140 ✓		
000180	.3119 ✓		

ANALYTICAL DATA

PLANT CAROLINA PLATING

DATE 5-15-85

SAMPLING LOCATION INLET

SAMPLE TYPE M-5

RUN NUMBER CP-I-1

SAMPLE BOX NUMBER _____

CLEAN-UP MAN JWR

COMMENTS:

FRONT HALF

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

FILTER NUMBER 000185

LABORATORY RESULTS

CONTAINER _____ _____ mg

CONTAINER _____ _____ mg

FRONT HALF SUBTOTAL _____ mg

BACK HALF

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

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

CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	270	ml
INITIAL VOLUME	200	ml
NET VOLUME	70	ml

SILICA GEL

FINAL WEIGHT	694.6	g	_____	g	_____	g
INITIAL WEIGHT	666.6	g	_____	g	_____	g
NET WEIGHT	28.0	g	_____	g	_____	g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT CAROLINA PLATING

DATE 5-16-85

SAMPLING LOCATION INLET

SAMPLE TYPE M-5

RUN NUMBER CP I-2

SAMPLE BOX NUMBER _____

CLEAN-UP MAN _____

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

FILTER NUMBER 000158 — CONTAINER _____ _____ mg

_____ _____

_____ _____

FRONT HALF SUBTOTAL _____ mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	241 ml		
INITIAL VOLUME	200 ml		
NET VOLUME	41 ml		

SILICA GEL

FINAL WEIGHT	698.6 g	_____ g	_____ g
INITIAL WEIGHT	651.0 g	_____ g	_____ g
NET WEIGHT	47.6 g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Carolina Plating

DATE 5-16-85

SAMPLING LOCATION Inlet

SAMPLE TYPE M-5

RUN NUMBER CP-I-3

SAMPLE BOX NUMBER _____

CLEAN-UP MAN JWB

COMMENTS:

FRONT HALF

LABORATORY RESULTS

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

CONTAINER _____ _____ mg

FILTER NUMBER 000159 _____

CONTAINER _____ _____ mg

FRONT HALF SUBTOTAL _____ mg

BACK HALF

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

CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

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

CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	256 ml		
INITIAL VOLUME	200 ml		
NET VOLUME	56 ml		

SILICA GEL

FINAL WEIGHT	678.7 g	_____ g	_____ g
INITIAL WEIGHT	649.5 g	_____ g	_____ g
NET WEIGHT	29.2 g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT CAROLINA PLATING

DATE 5-15-85

SAMPLING LOCATION OUTLET

SAMPLE TYPE M-5

RUN NUMBER CP-O-1

SAMPLE BOX NUMBER _____

CLEAN-UP MAN JWB

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

FILTER NUMBER 000156 _____ — CONTAINER _____ _____ mg

_____ _____

_____ _____

FRONT HALF SUBTOTAL _____ mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	273 ml		
INITIAL VOLUME	200 ml		
NET VOLUME	73 ml		

SILICA GEL

FINAL WEIGHT	692.4 g	_____ g	_____ g
INITIAL WEIGHT	665.8 g	_____ g	_____ g
NET WEIGHT	27.6 g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Carolina Plating

DATE 5-16-85

SAMPLING LOCATION Outlet

SAMPLE TYPE M-5

RUN NUMBER CP-O-2

SAMPLE BOX NUMBER _____

CLEAN-UP MAN JWB

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

FILTER NUMBER 00015T _____ — CONTAINER _____ _____ mg

_____ _____

_____ _____

FRONT HALF SUBTOTAL _____ mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	254 ml		
INITIAL VOLUME	200 ml		
NET VOLUME	54 ml		

SILICA GEL

FINAL WEIGHT	_____ g	705.3 g	_____ g
INITIAL WEIGHT	~~_____~~ g	660.7 g	_____ g
NET WEIGHT	_____ g	44.6 g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT CAROLINA PLATING

DATE 5-16-85

SAMPLING LOCATION OUTLET

SAMPLE TYPE M-5

RUN NUMBER CP-O-3

SAMPLE BOX NUMBER _____

CLEAN-UP MAN JWB

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

FILTER NUMBER 000160 — CONTAINER _____ _____ mg

_____ _____

_____ _____

FRONT HALF SUBTOTAL _____ mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

ETHER-CHLOROFORM EXTRACTION _____ mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER _____ _____ mg

BACK HALF SUBTOTAL _____ mg

TOTAL WEIGHT _____ mg

MOISTURE

IMPINGERS

FINAL VOLUME	242 ml		
INITIAL VOLUME	200 ml		
NET VOLUME	42 ml		

SILICA GEL

FINAL WEIGHT	710.0 g	_____ g	_____ g
INITIAL WEIGHT	677.0 g	_____ g	_____ g
NET WEIGHT	33.0 g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Sampling Location INLET

Date Received 5/22/85 Date Analyzed 5/31/85 Reagent Box(es) _____

Run Number	CPI1	CPI2	CPI3
Run Date	5/15	5/16	5/16

SUMMARY OF PARTICULATE ANALYSES

Sum of Particulate, mg.	366.1	361.5	365.3
Total Filter Tare mg.	304.6	322.0	313.3
Blank Residue, mg.	(500 ml) 1.0	(425 ml) 0.9	(350 ml) 0.7
TOTAL PARTICULATE CATCH, mg.	60.5	38.6	51.3

ANALYSIS OF MOISTURE CATCH

Reagent 1 (H_2O):			
Final Weight, g.	270	241	255
Tared Weight, g.	200.0	200	200
Water Catch, g.	70	41	55
Reagent 2 ( ):			
Final Weight, g.	–	–	–
Tared Weight, g.	–	–	–
Water Catch, g.	–	–	–
CONDENSED WATER, g.	70	41	55
Silica Gel:			
Final Weight, g.	694.6	698.6	678.7
Tared Weight, g.	666.6	651.0	649.5
ABSORBED WATER, g.	28.0	47.6	29.2
TOTAL WATER COLLECTED, g.	98.0	88.6	84.2

Blank Beaker # 395
Final wt. mg. 121790.3
Tare wt. mg. 121789.9
Residue, mg. 0.4
Volume, ml. 200
Concen., mg/ml. .002

— Legend —
✓ = Final Weight
L = Loose Particulate
F = Filter D = Dish
R = Rinse P = Pan

Notes and Comments
COMB. RINSE = COMBINED FRONT HALF H_2O RINSE AND ACETONE RINSE
* WEIGHT OF WATER RINSE ONLY

LABORATORY SAMPLE WEIGHT CALCULATIONS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Run Number	CPI1	CPI2	CPI3
Run Date	5/15	5/16	5/16
Sample ID/Container #	FILTER-1	FILTER-2B	FILTER-10
Tare Wt., g.	74.8490 74.8489 74.5345	74.1475 74.1469 73.8200	77.1704 77.1702 76.8479
SAMPLE WT., g.	.3144	.3269	.3223
Sample ID/Container #	COMB. RINSE-389	COMB. RINSE-390	COMB. RINSE-391
Tare Wt., g.	130.9367 130.9364 *130.8872 130.8847	134.0950 134.0946 *134.0613 134.0600	133.6796 133.6793 *133.6399 133.6363
SAMPLE WT., g.	.0517	.0346	.0430
Sample ID/Container #			
Tare Wt., g.			
SAMPLE WT., g.			
Sample ID/Container #	BKR 395 ACETONE BLANK	BKR 124-A H_2O BLANK	BKR 123AA BACKHALF I-2 BOILDOWN
Tare Wt., g.	121.7903 121.7899	170.4246 170.4246	185.2184 185.2183 185.2189 185.2100
SAMPLE WT., g.	.0004	.0000	.0083

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Sampling Location

Date Received 5/22/85 Date Analyzed 5/31/85 Reagent Box(es)

Run Number	CP01	CP02	CP03
Run Date	5/15	5/16	5/16

SUMMARY OF PARTICULATE ANALYSES

Sum of Particulate, mg.	319.9	335.0	331.8
Total Filter Tare mg.	303.8	314.0	315.2
Blank Residue, mg.	(275 ml) 0.6	(300 ml) 0.6	(225 ml) 0.5
TOTAL PARTICULATE CATCH, mg.	15.5	20.4	16.1

ANALYSIS OF MOISTURE CATCH

Reagent 1 (H_2O):			
Final Weight, g.	273	254	242
Tared Weight, g.	200	200	200
Water Catch, g.	73	54	42
Reagent 2 ( ):			
Final Weight, g.	-	-	-
Tared Weight, g.	-	-	-
Water Catch, g.	-	-	-
CONDENSED WATER, g.	73	54	42
Silica Gel:			
Final Weight, g.	692.4	705.3	710.0
Tared Weight, g.	664.8	660.7	677.0
ABSORBED WATER, g.	27.6	44.6	33.0
TOTAL WATER COLLECTED, g.	100.6	98.6	750

Blank Beaker # 395

Final wt. mg. 121790.3

Tare wt. mg. 121789.9

Residue, mg. 0.4

Volume, ml. 200

Concen., mg/ml. .002

--- Legend ---

✓ = Final Weight

L = Loose Particulate

F = Filter D = Dish

R = Rinse P = Pan

Notes and Comments

COMB. RINSE = COMBINED FRONT HALF H_2O RINSE AND ACETONE RINSE

* WEIGHT OF WATER RINSE ONLY

LABORATORY SAMPLE WEIGHT CALCULATIONS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Run Number	CP01	CP02	CP03
Run Date	5/15	5/16	5/16
Sample ID/Container #	FILTER- UC18	FILTER- 7A	FILTER- 4
Tare Wt., g.	73.2322 73.2322 72.9272	68.5601 68.5599 68.2440	65.4501 65.4500 65.1327
SAMPLE WT., g.	.3050	.3159	.3173
Sample ID/Container #	COMB. RINSE-392	COMB. RINSE-393	COMB. RINSE-394
Tare Wt., g.	124.1917 124.1906 *124.1799 124.1757	119.7715 119.7710 *119.7567 119.7519	122.4152 122.4152 *122.4030 122.4007
SAMPLE WT., g.	.0149	.0191	.0145
Sample ID/Container #			
Tare Wt., g.			
SAMPLE WT., g.			
Sample ID/Container #		BKR 123X BACKHALF 0-2 BOILDOWN	
Tare Wt., g.		185.7347 185.7345 185.7292	
SAMPLE WT., g.		.0053	

PARTICULATE SAMPLING LABORATORY RESULTS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Sampling Location

Date Received 5/22/85 Date Analyzed 5/31/85 Reagent Box(es)

Run Number	DIF1	DIF2	DIF3
Run Date			

SUMMARY OF PARTICULATE ANALYSES

	DIF1	DIF2	DIF3
Sum of Particulate, mg.	2770.3	26675	2455.3
Total Filter Tare mg.	2669.8	2519.6	2399.7
Blank Residue, mg.	(240 ml) 0.5	(300 ml) 0.6	(200 ml) 0.4
TOTAL PARTICULATE CATCH, mg.	100.0	147.3	55.2

ANALYSIS OF MOISTURE CATCH

	DIF1	DIF2	DIF3
Reagent 1 ( ):			
Final Weight, g.			
Tared Weight, g.			
Water Catch, g.			
Reagent 2 ( ):			
Final Weight, g.			
Tared Weight, g.			
Water Catch, g.			
CONDENSED WATER, g.			
Silica Gel:			
Final Weight, g.			
Tared Weight, g.			
ABSORBED WATER, g.			
TOTAL WATER COLLECTED, g.			

Blank Beaker # 395

Final wt. mg. 121790.3

Tare wt. mg. 121789.9

Residue, mg. 0.4

Volume, ml. 200

Concen., mg/ml. .002

--- Legend ---

✓ = Final Weight

L = Loose Particulate

F = Filter D = Dish

R = Rinse P = Pan

Notes and Comments

LABORATORY SAMPLE WEIGHT CALCULATIONS

Plant Name CAROLINA PLATING EEI Ref. # 3018

Run Number / Run Date	DIF1	DIF2	DIF3
Sample ID/Container #	THIMBLE-396	THIMBLE-398	THIMBLE-401
Tare Wt., g.	122.8646 ✓122.8609 122.8626 120.1253	126.6168 ✓126.6145 126.6158 124.0574	✓129.8997 129.8999 127.4681
SAMPLE WT., g.	2.7356	2.5571	2.4316
Sample ID/Container #	T.RINSE-397	T.RINSE-399	T.RINSE-404
Tare Wt., g.	120.3154 ✓120.3154 120.3163 120.2807	✓120.3651 120.3653 120.3681 120.2547	✓120.5072 120.5072 120.5081 120.4835
SAMPLE WT., g.	.0347	.1104	.0237
Sample ID/Container #			
Tare Wt., g.			
SAMPLE WT., g.			
Sample ID/Container #			
Tare Wt., g.			
SAMPLE WT., g.			

ENTROPY
ENVIRONMENTALISTS INC

POST OFFICE BOX 12291
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27709-2291
919-781-3550

REQUEST FOR ANALYSIS

REFERENCE ~~PURCHASE~~ ORDER # 3018 JOB NAME: EMB 3018

LABORATORY: RTI ATT. BILL GUTKNECKT OR PETER GROHSE

DATE SAMPLES WERE TRANSMITTED: 6/4/85 EXPECTED DATE OF RESULTS:

SAMPLE MATRIX:

TYPE OF ANALYSIS REQUESTED: Cr^{+6} AND PREPARE FOR NAA

SAMPLE #	RUN # ID	SAMPLE ID	BASIS	
C-220	DIF1	THIMBLE & RINSE - INLET	100 MG	~~TOTAL~~ CONCENTRATE µg
C-221	DIF2	THIMBLE & RINSE - INLET	150 MG	Total µg
C-222	DIF3	THIMBLE & RINSE - OUTLET	50 MG	" µg
C-223	—	THIMBLE BLANK		"
C-224	CP-O-1	FILTER & RINSE - OUTLET	15 MG	" µg
C-225	CP-O-2	FILTER & RINSE - OUTLET	20 MG	" µg
C-226	CP-O-3	FILTER & RINSE - OUTLET	15 MG	" µg
C-227	CP-I-1	FILTER & RINSE - INLET	60 MG	" µg
C-228	CP-I-2	FILTER & RINSE - INLET	40 MG	" µg
C-229	CP-I-3	FILTER & RINSE - INLET	50 MG	" µg
C-230	—	FILTER & ACETONE BLANK		" µg

SUBMITTED BY:

REQUEST FOR ANALYSIS

URCHASE
RDER # 3018

PAGE 2 OF 2

SAMPLE #	RUN ID	SAMPLE ID	
C-231	CP-O-1	IMPINGER REAGENT - OUTLET	Concentrate to 50 ml — half for total, half for NMM
C-232	CP-O-3	IMPINGER REAGENT - OUTLET	Concentrate to 50 ml — half for Cr⁺⁶, half for NM
C-233	CP-I-1	IMPINGER REAGENT - INLET	ll as above.
C-234	CP-I-3	IMPINGER REAGENT - INLET	ll as above
C-235	CP-O-2	impinger - outlet	—— hold
C-236	CP-I-2	impinger - inlet	—— hold

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 6-4-85 DATE ANALYZED 6-14 to 6-17-85

ANALYST: D. Hardison CLIENT: ENTROPY

ANALYTE: HEXAVALENT Cr^{+6}

RTI #	CLIENT #	SAMPLE CONCENTRATION Total µg	µg/g	µg/mL
C-221		29100		
222		6500		
223		62		
224		155		
225		121		
226		174		
227		7200		
228		3680		
229		6520		
230		<0.5		
231		0.8		
232		<0.5		
233		7.0		
234		<0.5		
235		NO ANALYSIS		
236		NO ANALYSIS		
237		23100		
238		29.0		
76		149		

Figure 1. Sample Preparation and Analysis Data Form

Sample No.[a]	Particulate Sample				Solid Process Sample		Liquid Process Samples			Sample Weight µg of Cr^{+6} i	Results by NAA µg of Cr[j]
	Filter/Rinse[b]		Impinger[c]		Weight of Sample, mg[d]	Sample Concentration[e]	Initial Volume[f]	Final Volume[g]	Aliquot[h]		
	Residue	Filtrate	Volume	Aliquot							
C-221 through C-230	Total ↓				300 µg						
C-231			590	295[k]	small 10 µg						
C-232			420	210[k]							
C-233			470	235[k]							
C-234			420	210[k]	0 µg						
C-235			— [L]	Total							
C-236			— [L]	Total							
C-237	Total										
C-238					residue from 1.0076 g	29.0 µg/g				"no" Cr^{+6} in residue	
(QA-22) C-239									0.2 mL of ampule G-9	10 µg	
(QA-23) C-240									4.5 mL of C-217	450 µg	

[a] Sample number marked on sample vial or sample container.
[b] Mark whether the particulate sample is a sample residue or filtrate sample aliquot.
[c] Record exact volume impinger sample after concentrate and indicate that the sample is 2.0 ml aliquot.
[d] The weight in mg of the process sample analyzed will be recorded by NAA personnel.
[e] Concentration of process sample in terms of µg/g of Cr^{+6} for process sample when the NAA facility is to weigh sample.
[f] Record initial volume of liquid sample if liquid sample is concentrated.
[g] Record final volume of liquid sample if liquid sample is concentrated.
[h] Indicate that the sample is a 2.0 ml aliquot of a liquid process sample.
[i] Total mass of hexavalent chromium in sample vial in µg.
[j] Analytical results by NAA in terms of µg of Cr per sample vial.
K concentrated to less than 2 mL
L dry - residue extracted with nitric acid

Legend: < - Below Minimum Detectable limit > - Over Instrument analytical range * - Nonreportable constituent
"No value" - No data value present "Fit fail" - Curve fit failure

Value	Constituent	Value	Constituent	Value	Constituent	Value	Constituent	Value	Constituent
CRS # 221	CO221	85/ 8/23 @ 11:13:43 by NAA002 (JPL)				Multipliers: 1.627E+00			(1)
No Value Cd		1.411E+04 Cr		No Value Ni					
CRS # 222	CO222	85/ 8/23 @ 11:13:53 by NAA002 (JPL)				Multipliers: 1.627E+00			(2)
No Value Cd		3.591E+03 Cr		No Value Ni					
CRS # 223	CO223	85/ 8/23 @ 11:15: 3 by NAA002 (JPL)				Multipliers: 1.351E+00			(3)
No Value Cd		No Value Cr		No Value Ni					
CRS # 224	CO224	85/ 8/23 @ 11:14: 3 by NAA002 (JPL)				Multipliers: 1.627E+00			(4)
No Value Cd		5.736E+02 Cr		No Value Ni					
CRS # 225	CO225	85/ 8/23 @ 11:15:53 by NAA002 (JPL)				Multipliers: 1.216E+00			(5)
No Value Cd		1.843E+02 Cr		No Value Ni					
CRS # 226	CO226	85/ 8/23 @ 11:17:53 by NAA002 (JPL)				Multipliers: 1.012E+00			(6)
No Value Cd		4.730E+02 Cr		No Value Ni					
CRS # 227	CO227	85/ 8/23 @ 11:18: 3 by NAA002 (JPL)				Multipliers: 1.012E+00			(7)
No Value Cd		7.777E+03 Cr		No Value Ni					
CRS # 228	CO228	85/ 8/23 @ 11:16:43 by NAA002 (JPL)				Multipliers: 1.013E+00			(8)
No Value Cd		4.313E+03 Cr		No Value Ni					
CRS # 229	CO229	85/ 8/23 @ 11:12:33 by NAA002 (JPL)				Multipliers: 1.056E+00			(9)
No Value Cd		6.825E+03 Cr		No Value Ni					
CRS # 230	CO230	85/ 8/23 @ 11:12:43 by NAA002 (JPL)				Multipliers: 1.056E+00			(10)
No Value Cd		No Value Cr		No Value Ni					
CRS # 296	CO296	85/ 8/23 @ 11:14:53 by NAA002 (JPL)				Multipliers: 1.627E+00			(11)
No Value Cd		> 4.990E+05 Cr		1.825E+04 Ni					
CRS # 297	CO297	85/ 8/23 @ 11:12:53 by NAA002 (JPL)				Multipliers: 1.056E+00			(12)
No Value Cd		> 7.294E+05 Cr		No Value Ni					
CRS # 298	CO298	85/ 8/23 @ 11:11:43 by NAA002 (JPL)				Multipliers: 1.025E+00			(13)
No Value Cd		> 3.497E+05 Cr		No Value Ni					
CRS # 299	CO299	85/ 8/23 @ 11:14:23 by NAA002 (JPL)				Multipliers: 1.627E+00			(14)
No Value Cd		> 6.048E+05 Cr		3.493E+04 Ni					
CRS # 300	CO300	85/ 8/23 @ 11:11:53 by NAA002 (JPL)				Multipliers: 1.025E+00			(15)
No Value Cd		8.019E+04 Cr		No Value Ni					
CRS # 301	CO301	85/ 8/23 @ 11:16:53 by NAA002 (JPL)				Multipliers: 1.013E+00			(16)
No Value Cd		> 1.213E+05 Cr		No Value Ni					

Legend: < - Below Minimum Detectable limit > - Over Instrument analytical range * - Nonreportable constituent
"No value" - No data value present "Fit fail" - Curve fit failure

Value	Constituent	Value	Constituent	Value	Constituent	Value	Constituent	Value	Constituent
CR5 # 231	C0231	85/ 9/ 4 a	14:23:28	by NAA002 (JPL)	Multiplier:	1.401E+00			(1)
No Value	Cd	5.533E-01	Cr	No Value	Ni				
CR5 # 232	C0232	85/ 9/ 4 a	14:25: 8	by NAA002 (JPL)	Multiplier:	1.191E+00			(2)
No Value	Cd	3.912E-01	Cr	No Value	Ni				
CR5 # 233	C0233	85/ 9/ 4 a	14:23:38	by NAA002 (JPL)	Multiplier:	1.401E+00			(3)
No Value	Cd	1.926E+00	Cr	No Value	Ni				
CR5 # 234	C0234	85/ 9/ 4 a	14:23:48	by NAA002 (JPL)	Multiplier:	1.401E+00			(4)
No Value	Cd	6.195E-01	Cr	No Value	Ni				
CR5 # 235	C0235	85/ 9/ 4 a	14:22:38	by NAA002 (JPL)	Multiplier:	1.044E+00			(5)
No Value	Cd	1.068E+00	Cr	No Value	Ni				
CR5 # 236	C0236	85/ 9/ 4 a	14:19:28	by NAA002 (JPL)	Multiplier:	1.023E+00			(6)
No Value	Cd	1.320E+00	Cr	No Value	Ni				
CR5 # 237	C0237	85/ 9/ 4 a	14:20:48	by NAA002 (JPL)	Multiplier:	1.410E+00			(7)
No Value	Cd	8.784E+03	Cr	No Value	Ni				
CR5 # 238	C0238	85/ 9/ 4 a	14:17:38	by NAA002 (JPL)	Multiplier:	1.097E+00			(8)
No Value	Cd	8.899E+04	Cr	6.467E+02	Ni				
CR5 # 239	C0239	85/ 9/ 4 a	14:19:58	by NAA002 (JPL)	Multiplier:	1.424E+00			(9)
No Value	Cd	1.088E+01	Cr	No Value	Ni				
CR5 # 240	C0240	85/ 9/ 4 a	14:21:48	by NAA002 (JPL)	Multiplier:	1.046E+00			(10)
No Value	Cd	4.125E+02	Cr	No Value	Ni				
CR5 # 241	C0241	85/ 9/ 4 a	14:22:48	by NAA002 (JPL)	Multiplier:	1.100E+00			(11)
No Value	Cd	9.201E+00	Cr	No Value	Ni				
CR5 # 242	C0242	85/ 9/ 4 a	14:21:58	by NAA002 (JPL)	Multiplier:	1.046E+00			(12)
No Value	Cd	1.327E+01	Cr	No Value	Ni				
CR5 # 243	C0243	85/ 9/ 4 a	14:19:18	by NAA002 (JPL)	Multiplier:	1.023E+00			(13)
No Value	Cd	1.874E+01	Cr	5.824E+01	Ni				
CR5 # 244	C0244	85/ 9/ 4 a	14:17: 8	by NAA002 (JPL)	Multiplier:	1.000E+00			(14)
No Value	Cd	1.565E+01	Cr	9.645E+01	Ni				
CR5 # 245	C0245	85/ 9/ 4 a	14:26:38	by NAA002 (JPL)	Multiplier:	1.940E+00			(15)
No Value	Cd	2.344E+01	Cr	No Value	Ni				
CR5 # 246	C0246	85/ 9/ 4 a	14:17:18	by NAA002 (JPL)	Multiplier:	1.000E+00			(16)
No Value	Cd	1.827E+01	Cr	No Value	Ni				

APPENDIX C

SAMPLING AND ANALYTICAL PROCEDURES

DETERMINATION OF TOTAL PARTICULATE EMISSIONS

All particulate samples were collected using an EPA Method 5 sampling train, and Method 5 sampling procedures, as described in the Federal Register*.

SAMPLING APPARATUS

The particulate sampling train used in these tests met design specifications established by the EPA. The sampling apparatus, which was assembled by Entropy personnel, consisted of the following:

Nozzle - Stainless steel (316) with sharp, tapered leading edge and accurately measured round opening.

Probe - Borosilicate glass with a heating system capable of maintaining a minimum gas temperature of 121°C (250°F) at the exit end during sampling.

Pitot Tube - A type S pitot tube that met all geometric standards was attached to a probe to monitor stack gas velocity pressure.

Temperature Gauge - A Palmer bimetallic coil thermometer was used to monitor stack gas temperature.

Filter Holder - The filter holder was made of Pyrex glass, with heating system capable of maintaining a filter temperature of approximately 121°C (250°F).

Filter - A 79-mm (3-in.) diameter glass fiber filter (Reeve Angel) was used.

Draft Gauge - The draft was measured with an inclined manometer.

Impingers - Four Greenburg-Smith design impingers were connected in series. The first, third, and fourth impingers were modified by removing the tip and extending the tube to within 1.3 cm (0.5 in.) of the bottom of the flask.

Metering System - The RAC metering system consisted of a vacuum gauge, a leak-free pump, thermometers capable of measuring temperature to within 1.5°C (5°F), a calibrated dry gas meter, and related equipment, to maintain an isokinetic sampling rate and to determine sample volume.

*40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

Barometer - An aneroid type barometer was used to measure atmospheric pressures to 0.3 kPa (0.1 in. Hg).

SAMPLING PROCEDURES

After the sampling site and minimum number of traverse points were selected, the stack pressure, temperature, moisture, and range of velocity head were measured according to procedures described in the Federal Register.*

Approximately 200 grams of silica gel was weighed and placed in a sealed impinger prior to each test. Glass fiber filters were desiccated for at least 24 hours to a constant weight and weighed to the nearest 0.1 mg on an analytical balance. One hundred (100) milliliters of deionized-distilled water was placed in each of the first two impingers; the third impinger was initially empty; and the fourth impinger containing the silica gel was placed next in series. The train was set up as shown in Figure D-1. The sampling train was leak-checked at the sampling site prior to each test run by plugging the inlet to the nozzle and pulling a 50 kPa (15 in. Hg) vacuum, and at the conclusion of the test by plugging the inlet to the nozzle and pulling a vacuum equal to the highest vacuum reached during the test run.

The pitot tube and lines were leak-checked at the test site prior to each test run and at the conclusion of each test run. The check was made by blowing into the impact opening of the pitot tube until 7.6 cm (3 in.) or more of water was recorded on the inclined manometer and then capping the impact opening and holding it for 15 seconds to assure it was leak-free. The same procedure was used to leak-check the static pressure side of the pitot tube, except suction was used to obtain the 7.6 cm (3 in.) H_2O manometer reading. Crushed ice was placed around the impingers to ensure that the temperature of the gases leaving the last impinger was at 20°C (68°F) or less.

*40 CFR 60, Appendix A, Methods 1, 2, 3, and 4, July 1, 1980.

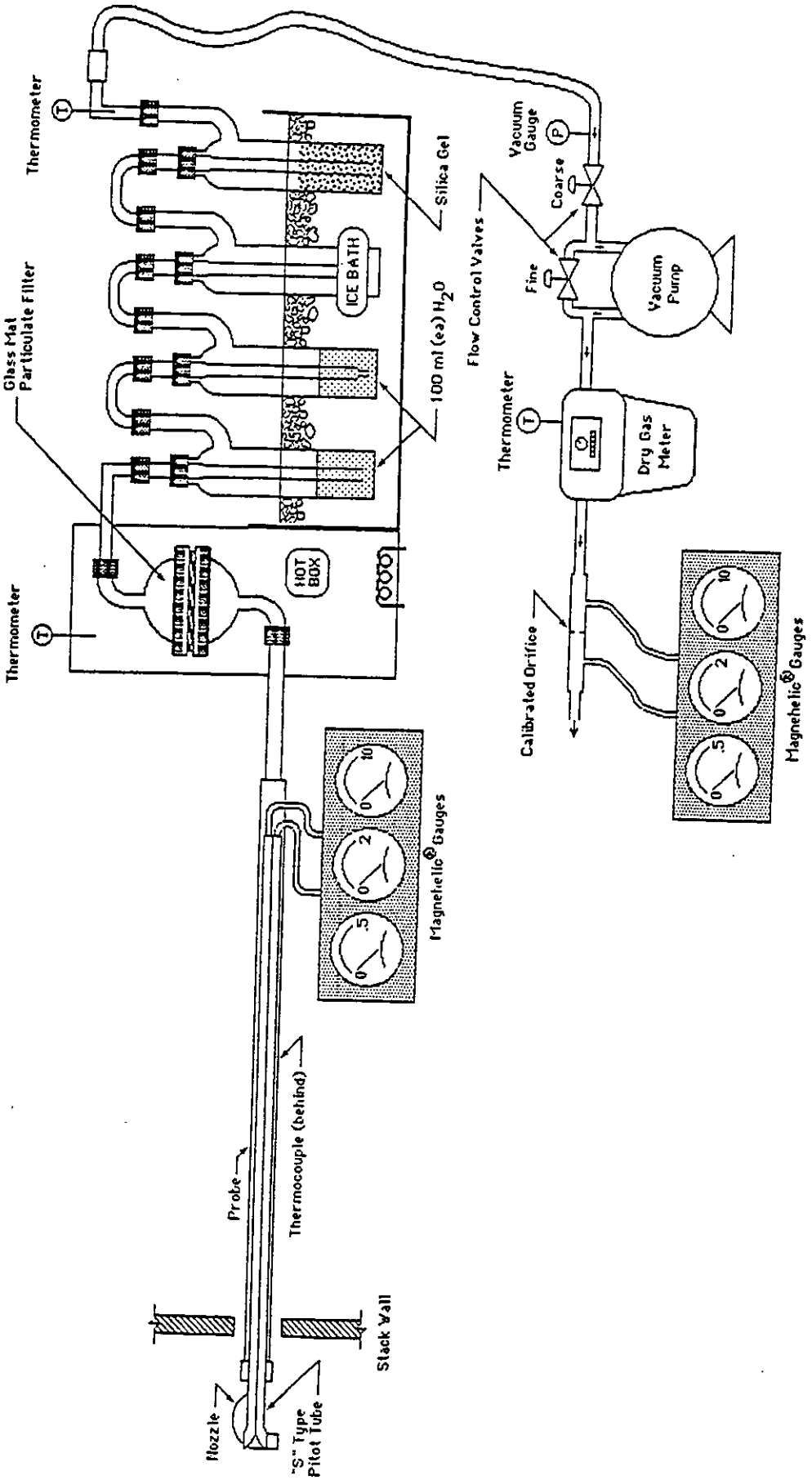


Figure C-1. Method 5 sample train.

During the sampling, stack gas and sampling train data were recorded at each sampling point and whenever significant changes in stack flow conditions occurred. Isokinetic sampling rates were set throughout the sampling period with the aid of a nomograph or calculator. All sampling data were recorded on the field data sheets.

SAMPLE RECOVERY PROCEDURES

The sampling train was carefully moved from the test site to the cleanup area. The volume of water from the first three impingers was measured, and the silica gel from the fourth impinger was weighed to the nearest 0.1 gram. Sample fractions were recovered as follows:

Container No. 1 - The filter was removed from its holder and placed in a petri dish and sealed.

Container No. 2 - Loose particulate and acetone washings from all sample-exposed surfaces prior to the filter were placed in a glass jar, sealed, and labeled. Particulate was removed from the probe with the aid of a brush and acetone rinsing. The liquid level was marked after the container was sealed.

Container No. 3 - The sample-exposed surfaces prior to the filter were also washed with distilled water. These washings were placed in a glass jar, sealed, and labeled. The liquid level was marked after the container was sealed.

Container No. 4 - A minimum of 200 ml of acetone was taken for the blank analysis. The blank was obtained and treated in a manner similar to the acetone washing.

Container No. 5 - After being measured, distilled water in the impinger section of the sampling train was placed in a glass or polyethylene container. The impingers and connecting glassware were rinsed with distilled H_2O and this rinse was added to the container for shipment to the laboratory.

Container No. 6 - A minimum of 200 ml of distilled water was taken for the blank analysis. The blank was obtained and treated in a manner similar to the water rinse.

Container No. 7 - An unused glass fiber filter was taken for blank analysis.

Data was recorded on the appropriate sample recovery and laboratory data sheets.

ANALYTICAL PROCEDURES

The following procedures were used and followed the methods described in the Federal Register*.

Container No. 1 - The filter and any loose particulate matter from this sample container were placed into a tared glass weighing dish, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container No. 2 - The acetone washings were transferred to a tared beaker, evaporated to dryness at ambient temperature and pressure, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container No. 3 - The water washings were transferred to a tared beaker, evaporated to dryness in an oven, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container No. 4 - The acetone blank was transferred to a tared beaker and evaporated to dryness at ambient temperature and pressure. The blank was then desiccated for 24 hours to a constant weight and weighed to the nearest 0.1 mg.

Container No. 5 - The impinger contents were marked with the sample run number and saved for chromium analysis.

Container No. 6 - The distilled water blank was saved for chromium analysis.

Container No. 7 - The unused glass fiber filter was treated in an identical manner as the filter in Container No. 1.

The term "constant weight" referred to above means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater between two consecutive readings, with no less than 6 hours of desiccation between weighings. All analytical data were recorded on the analytical data sheets.

*40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

DETERMINATION OF HEXAVALENT CHROMIUM EMISSIONS
"DRAFT METHOD"

Particulate samples collected using the EPA Method 5 sampling train and Method 5 sampling procedures* were analyzed for hexavalent chromium using the tentative method "Determination of Hexavalent Chromium Emissions from Stationary Sources" (dated December 13, 1984) by digesting in an alkaline solution and assaying with the diphenylcarbazide colorimetric method.

SAMPLING APPARATUS

The sampling train used in these tests were the same as for the particulate (Method 5) tests. These trains met design specifications established by the U. S. EPA and were assembled by Entropy personnel.

SAMPLING PROCEDURES

The sampling procedures were performed according to Method 5. All sampling data were recorded on the field data sheets.

SAMPLE RECOVERY PROCEDURES

Sample recovery was done according to Method 5. Data was recorded on the appropriate sample recovery and laboratory data sheets.

SAMPLE AND REAGENT PREPARATION

Samples for analysis and reagents were prepared as described in the following subsections.

Reagents

All reagents conformed to the specifications established by the Committee on Analytical Reagents of the American Chemical Society. In all cases, the water used was deionized and distilled and met the ASTM specifications for

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*40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

type 2 reagent - ASTM Test Method D 1193-77. Solutions were made as follows:

Digestion Solution - 20.0 g of NaOH and 30.0 g anhydrous Na_2CO_3 were dissolved in water in a 1-liter volumetric flask, and this solution diluted to the mark. It was stored in a tightly capped polyethylene bottle and was prepared fresh monthly.

Potassium Dichromate Stock Solution - 141.4 mg of analytical reagent grade $K_2Cr_2O_7$ was dissolved in water, and this solution diluted to 1 liter (1 ml = 50 µg Cr^{+6}).

Potassium Dichromate Standard Solution - 10.00 ml of $K_2Cr_2O_7$ stock solution was diluted to 100 ml (1 ml = 5 µg Cr^{+6}) with water.

Sulfuric Acid - A ten percent (v/v) solution was made by diluting 10 ml H_2SO_4 to 100 ml in water.

Acetone - Same as Method 5.

Diphenylcarbazide Solution - 250 mg of 1, 5-diphenylcarbizide was dissolved in 50 ml acetone and stored in a brown bottle. The solution was discarded whenever it became discolored.

Sample Preparation

To prevent the possibility of sample deterioration, all samples were protected from extreme heat, were kept dry, and were analyzed within one month of collection. Sample preparation involved digestion and filtration. The contents of Container No. 2 (the acetone probe rinse) was placed in a 250 ml beaker and evaporated to dryness. Following this, the contents of Container No. 1 (with the filter cut into small pieces) was added to the beaker; digestion solution (40 ml) was added and the beaker covered with a watch glass. Using a hot plate, this solution was heated to near boiling with constant stirring for 30 minutes; it was not allowed to evaporate to dryness.

The solution was then cooled and transferred quantitatively to the filtration apparatus with water. This apparatus consists of a vacuum unit constructed of plastic or glass which accommodates a 47 mm diameter, 3.0 µm pore size Teflon filter. The solution was filtered and transferred quantitatively to a 100 ml volumetric flask which was then filled to the mark with water.

To serve as a blank, a representative amount of acetone and a blank Method 5 filter were prepared in the same manner as the sample described above.

The spent silica gel (in Container No. 3) was weighed to the nearest 0.5 g using a balance.

SAMPLE ANALYSIS

Analysis of the samples involved four basic elements: (1) color development and measurement, (2) a check for matrix results on the Cr^{+6} results, (3) calibration of the spectrophotometer, and (4) calculation of the results.

Color Development and Measurement

An aliquot of the prepared sample 50 ml or smaller was transferred to a 100 ml volumetric flask and diluted with sufficient water to bring the volume to approximately 80 ml. The pH was adjusted to 2 $\pm$ 0.5 with 10 percent H_2SO_4, 2.0 ml of diphenylcarbazide solution was added, and this solution diluted to volume with water. The solution then stood about 10 minutes for color development. For each set of samples analyzed, an identical aliquot of reagent blank solution was treated in the same way.

To measure, a portion of the sample was transferred to a 1-cm absorption cell, and the absorbance read at the optimum wavelength as determined during spectrophotometer calibration. After each sample measurement, the reagent blank absorbance reading, if any, was subtracted to obtain a net reading. If the absorbance of the sample exceeded the absorbance of the 100 µg Cr^{+6} standard as determined during calibration, the sample and the reagent blank were diluted with equal volumes of water.

Check for Matrix Effects on the Cr^{+6} Results

Since the analysis for Cr^{+6} by colorimetry is sensitive to the chemical composition of the sample (matrix effects), at least one sample from each source was checked using the method of additions as follows:

Two equal volume aliquots of the same sample solution were taken; each contained between 30 and 50 µg of Cr^{+6} (less if that was not possible). One of the aliquots was spiked with an aliquot of standard solution containing 30 to 50 µg of Cr^{+6}. Then both the spiked and unspiked sample aliquots were readied for measurement as described in the previous section.

The Cr^{+6} mass, C_s, in µg in the aliquot of the unspiked sample solution was then calculated using the following equation:

$$C_s = C_a \frac{A_s}{A_t - A_s} \qquad \text{Equation C-1}$$

Where:

C_a = Cr^{+6} in the standard solution, µg.

A_s = Absorbance of the unspiked sample solution.

A_t = Absorbance of the spiked sample solution.

Volume corrections were not required since the solutions as analyzed were made to the same final volume. When the results of the method of additions procedure used on the single source sample did not agree within 10 percent of the value obtained by the routine spectrophotometric analysis, all samples from the source were reanalyzed using the method of additions procedure.

SPECTROPHOTOMETER CALIBRATION

Calibration of the spectrophotometer involved two basic sets of operations and these are described below.

Optimum Wavelength Determination

Every 6 months, the wavelength scale of the spectrophotometer was calibrated using an energy source with an intense line emission or a series of glass filters spanning the measuring range of the spectrophotometer. The spectrophotometer was checked to see that the wavelength scale read within ±5 nm at all calibration points. After confirming that the wavelength scale of

the spectrophotometer was in proper calibration, 540 nm was used as the optimum wavelength for the measurement of the absorbance of the standards and samples.

In some cases, a scanning procedure was employed to determine the proper measuring wavelength. For both the blank and a 50 µg Cr^{+6} standard solution, the spectrum was scanned between 530 and 550 nm. The optimum wavelength was chosen as the wavelength at which the maximum difference in absorbance between the standard and the blank occurred.

Spectrophotometer Calibration

To calculate the spectrophotometer calibration factor, 0.0 ml, 1 ml, 2 ml, 5 ml, 10 ml, 15 ml, and 20 ml of the working standard solution (1 ml = 5 µg Cr^{+6}) were added to a series of seven 100-ml volumetric flasks. These calibration standards were analyzed as described in the section on color development and measurement. The calibration procedure was repeated on each day that samples were analyzed. The spectrophotometer calibration factor, K_c, was calculated using the following equation:

$$K_c = 5 \quad \frac{A_1 + 2A_2 + 5A_3 + 10A_4 + 15A_5 + 20A_6}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + A_6^2}$$

Equation C-2

Where:

K_c = Calibration factor.

A_1 = Absorbance of the 5 µg Cr^{+6} standard.

A_2 = Absorbance of the 10 µg Cr^{+6} standard.

A_3 = Absorbance of the 25 µg Cr^{+6} standard.

A_4 = Absorbance of the 50 µg Cr^{+6} standard.

A_5 = Absorbance of the 75 µg Cr^{+6} standard.

A_6 = Absorbance of the 100 µg Cr^{+6} standard.

Spectrophotometer Calibration Quality Control

The absorbance value obtained for each standard was multiplied by the K_c factor (least squares slope) to determine the distance each calibration point was from the theoretical calibration line. To maintain quality control, it was assured that these concentration values did not differ from the actual concentrations (i.e., 5, 10, 25, 50, 75, and 100 μg Cr^{+6}) by more than 7 percent (to be determined) for five of the six standards.

EMISSION CALCULATIONS

All emission calculations were done retaining at least one extra decimal figure beyond that of the acquired data. Figures were rounded off after final calculations.

Total Cr^{+6} in Sample

The total μg Cr^{+6} in each sample, m, was calculated as follows:

$$m = \frac{100\ K_c\ AF}{v_a} \qquad \text{Equation C-3}$$

Where:

100 = Volume in ml of total sample.

A = Absorbance of sample.

F = Dilution factor (required only if sample dilution was needed to reduce the absorbance into the range of calibration.)

v_a = Volume in ml of aliquot analyzed.

Average Dry Gas Meter Temperature and Average Orifice Pressure Drop

The average dry gas meter temperature and average orifice pressure drop was calculated as described in Method 5.

Dry Gas Volume, Volume of Water Vapor, Moisture Content

The dry gas volume, volume of water vapor, and moisture content was calculated as described in Method 5.

Cr^{+6} Emission Concentration

The Cr^{+6} concentration in the stack gas, C_s (g/dscm), dry basis, corrected to standard conditions was calculated as follows:

$$C_s = (10^{-6} g/\mu g)\ (m/V_{m(std)}) \qquad \text{Equation C-4}$$

Isokinetic Variation, Acceptable Results

Isokinetic variation and acceptable results were calculated as described in Method 5.

DETERMINATION OF TOTAL CHROMIUM CONTENT
"DRAFT METHOD"

Particulate samples collected using the EPA Method 5 sampling train and Method 5 sampling procedures* or particle sizing equipment (see section on Determination of Particle Size Distribution) were prepared and analyzed for total chromium content using Neutron Activation Analysis (NAA). This was done following the procedures in the "EPA Protocol for Emissions Sampling for Both Hexavalent and Total Chromium," dated February 22, 1985.**

SAMPLING APPARATUS

The sampling train used in these tests were the same as for the Method 5 tests. No sample-exposed stainless steel or chrome-plated equipment was used with the exception of the sample nozzle. In some cases, paper filters were used for particulate testing or particle size testing. These trains met design specifications established by the U. S. EPA and were assembled by Entropy personnel.

SAMPLING PROCEDURES

The sampling procedures were performed according to Method 5 (or according to the particle size determination sampling procedures). All sampling data were recorded on the field data sheets.

SAMPLE RECOVERY PROCEDURES

Following sample recovery, all samples were kept dry, protected from extreme heat, and analyzed within one month of collection.

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*40 CFR 60, Appendix A, Reference Method 5, July 1, 1980.

**For Chromium Screening Study ESED No. 85/02 and 85/02a, U. S. Environmental Protection Agency, Emission Measurement Branch, Research Triangle Park, North Carolina.

SAMPLE PREPARATION

In all cases, samples collected using EPA Method 5 were analyzed first for hexavalent chromium content (as described in the previous section) and then for total chromium content. Most of the process samples collected were also treated in this manner. The exception to this was in respect to the solid process samples; in this case, the sample was made homogeneous and then representative portions were taken quantitatively and used separately in the analyses for hexavalent chromium and total chromium content.

All samples prepared for NAA were put into suitable sample vials which had been properly prepared. Procedures for this are described below. The subsections which follow describe the sample and blank preparation procedures used for the various categories of sample states.

Sample Preparation Apparatus

No chrome-plated or stainless steel equipment was used. The following items were also required:

Analytical Balance - To determine weight of material submitted for total chromium analysis to within 0.1 mg.

Polyethylene Sample Vials - Five (5) ml size to contain samples submitted for total chromium.

Teflon Spatula - To assist in sample transfer.

Teflon Gloves - To be used for sample handling.

Preparation of Sample Vials

For use in the analytical phase, sample vials were prepared in the following manner. All vials were initially cleaned with soap and water, rinsed with tap water, soaked for 48 hours in a rinse solution of 1 to 1 (v/v) water and concentrated nitric acid, and finally rinsed with deionized-distilled water. After the vials dried, each was marked on both sides with the appropriate sample identification number using a permanent pen (water

insoluble). All sample identification numbers, volumes, and weights were recorded on the Sample Preparation and Analysis Data Forms.

Preparation and Analysis for Method 5 Samples

Initially, the entire sample was analyzed for hexavalent chromium by the EPA Cr^{+6} Method described in the previous section. The sample residue (particulate filter, filtration filter and insoluble materials) for each run was then transferred to a separate cleaned and marked sample vial. For samples with 2 to 10 grams of material, multiple 5 ml vials (least possible number) were used. For samples with greater than 10 grams of material, a portion of the filter catch (approximately 4-5 grams) were taken, weighed to the nearest 0.1 mg, and transferred to a sample vial. For one sample run at each emission test location, a 2.0 ml aliquot of the filtrate from the hexavalent chromium analysis was transferred to a cleaned and marked vial.

The sample blank consisted of the blank residue, including the acetone blank (the volume of the acetone blank being approximately equal to the average of the acetone rinse volume); a blank particulate filter; and a solution filtration filter that had been prepared in the same manner as the field samples. This was transferred to a separate cleaned/marked sample vial.

All samples were analyzed for total chromium in terms of µg of total chromium per sample vial.

Preparation and Analysis for Liquid Process Samples

Initially, a representative portion of the liquid process sample was analyzed for hexavalent chromium by the EPA Cr^{+6} method. For total chromium analysis, a separate representative sample (2.0 ml aliquot) that contained greater than 1 µg/ml of total chromium was transferred to a sample vial for analysis. When the liquid sample was below 1 µg/ml concentration, a

representative sample was concentrated and then a 2.0 ml aliquot transferred to a sample vial for analysis. Representative portions were taken according to EPA Method 160.2 (EPA-600/4-79-020, March 1974). No sample blank was required.

Preparation and Analysis for Solid Process Samples

A representative sample of solid process samples was first taken and analyzed for hexavalent chromium by the EPA Cr^{+6} Method. A separate representative sample was taken for total chromium analyis. Two procedures were followed in preparing these samples for total chromium analysis: (1) a representative sample not exceeding the volume of the 5.0 ml sample vial and containing 5 to 100 µg of Cr^{+6} was taken and weighed to the nearest 0.1 mg, or (2) a representative sample (about 10 to 20 grams) was taken and placed in a marked and cleaned polyethylene container, then the exact sample fraction and weight analyzed was selected and performed by the NAA staff. The concentration of the process material in terms of µg/g of hexavalent chromium was included on the sample log to provide the NAA staff with the information necessary to make the proper sample size selection. When the sample concentration was unknown, the second procedure was followed. An estimate of sample concentration was then determined by NAA prior to the actual sample analysis.

For samples that completely passed through a 200 mesh screen, a representative portion was obtained by thoroughly mixing the entire sample. For samples with material greater than 200 mesh, the sample was initially screened and then all materials that did not pass through the screen were ground, using a technique that would not provide chromium contamination, until all material passed through the screen. The sample was then thoroughly mixed and a representative sample taken. No sample blank was required.

For sludge process samples, the entire sample was thoroughly mixed and then a representative portion was taken.

Procedures to Reduce NAA Time

For all samples that were placed in sample vials, an estimate of the mass of chromium was included on the sample log to provide the NAA facility with the information necessary to select the proper sample irradiation time and strength. When possible, all samples were added to the sample vials in amounts that ensured the mass of chromium per sample was between 10 µg and 5,000 µg. When the total chromium value was not known, samples were prepared so that each sample vial contained between 5 µg and 100 µg of hexavalent chromium. These procedures were followed to allow all known value samples to be irradiated at the same time and strength.

When the sample concentration was unknown or possibly could have exceeded 5,000 µg of total chromium, such was noted on the sample log sheet. A preliminary run on the material was then made to estimate the sample concentration.

When liquid process sample or the 2.0 ml aliquot of the filtrate from the hexavalent analysis were below the 10 µg of total chromium value, total mass of chromium was recorded on the data sheet to allow these samples to be irradiated separately for a longer time and to allow for the selection of a lower concentration standard.

Quality Assurance Sample Analysis

With every set of 15 samples submitted for NAA, one audit sample was submitted to check the analytical technique.

SAMPLE ANALYSIS

Sample analysis for total chromium content was done using Neutron Activation Analysis (NAA) and was conducted by the Department of Nuclear

Engineering at North Carolina State University in Raleigh. In brief, NAA is based on the determination of the number and energy of gamma and/or x-rays emitted by radioisotopes produced in a sample matrix by neutron irradiation. Quantitative analysis is obtained by comparing the x- or gamma-rays of the sample with the number determined for a standard that has been subjected to the identical irradiation.

The samples (prepared as described) were heat-sealed in the 25 ml polyethylene vials. Chromium standards were similarly sealed in identical vials. Sets of samples and standards were irradiated for a predetermined neutron fluence. They were then allowed to radiate for a minimum of 10 days prior to analysis to eliminate possible inference from sodium and cobalt which have short half-lives. After this time, samples and standards were counted on a solid state detector connected to a multichannel analyzer.

Results were reported for samples in terms of total g of chromium for the sample.

CALCULATIONS

Particulate and chromium emissions and concentrations were calculated as described below.

Emission Calculations for Particulate and Hexavalent Chromium

Particulate and hexavalent chromium emissions were calculated as described in the EPA Cr^{+6} Method (see previous section).

Emission Calculations for Total Chromium

The total chromium emissions, C_s (µg/dscm), were calculated as follows:

$$C_s = (m_r - m_b) + (m_h) / V_{m(std)} \qquad \text{Equation C-5}$$

Where:

C_s = Stack gas concentration, g/dscm.

m_r = Mass of Cr in each particulate residue sample, µg.

m_b = Mass of Cr in each particulate residue blank, µg.

m_h = Mass of Cr in filtrate solution (Cr^{+6}) minus blank, µg.

$V_{m(std)}$ = Volume of gas sampled, corrected to standard conditons, dscm.

Note: In some cases, the mass of Cr was calculated separately, for the filter/rinse sample and impinger contents sample, or the masses of both samples and both blanks were added to obtain the total concentration.

Calculation of Chromium in Solid Process Samples

The chromium concentration in solid process samples, C_o (µg/g), was calculated as follows:

$$C_o = (m_s - m_b)/wt \qquad \text{Equation C-6}$$

Where:

C_o = Concentration of chromium in process sample, µg/g.

m_s = Mass of Cr in process sample, µg.

m_b = Mass of Cr in blank sample (if applicable), µg.

wt = Weight of sample analyzed, g.

Calculation of Chromium in Liquid Process Samples

The chromium concentration in liquid process samples, C_l (µg/ml), was calculated as follows:

$$C_l = (m_s/2)\ (V_f/V_i) \qquad \text{Equation C-7}$$

Where:

C_l = Concentration of chromium in liquid sample, µg/ml.

m_s = Mass of Cr in liquid process sample, µg.

2 = 2.0 ml aliquot analyzed.

V_f = Final volume if a sample is concentrated, ml.

V_i = Initial volume of sample concentrated, ml.

DETERMINATION OF PARTICULATE EMISSIONS USING THE MEDIUM SAMPLE VOLUME SCREENING TECHNIQUE

Particulate emissions were estimated using the medium volume screening technique. This particulate screening technique is similar to the sampling and analytical procedures of EPA Method 17. The major differences are itemized below. The system sampling train:

(1) can sample at a rate of six times Method 17;

(2) can be easily operated by one person at a reduced cost;

(3) requires less experience to operate than the Method 17 sampling train;

(4) monitors the flow rate of the sampling system at stack conditions;

(5) does not have a flow totalizing system (dry gas meter);

(6) does not condense out the water vapor or determine moisture content; and

(7) can traverse the stack, but is generally operated at a single point of average velocity.

The screening technique is still undergoing methods evaluation, but is hoped to have a reproducibility of about twice that of Methods 5 or 17 ($\pm$ 20%).

SAMPLING APPARATUS

The sampling apparatus, which was assembled by EPA personnel, consisted of the following (see Figure C-2):

Nozzle - Stainless steel (316) with sharp, tapered leading edge and accurately measured round opening.

Probe - A stainless steel (or other suitable material) probe extension is used after the filter, which also contains the orificemeter.

Pitot Tube - A type S pitot tube meeting the geometric standards of Method 2* was used to measure stack gas velocity pressure.

*40 CFR 60, Appendix A, Reference Method 2, July 1, 1980.

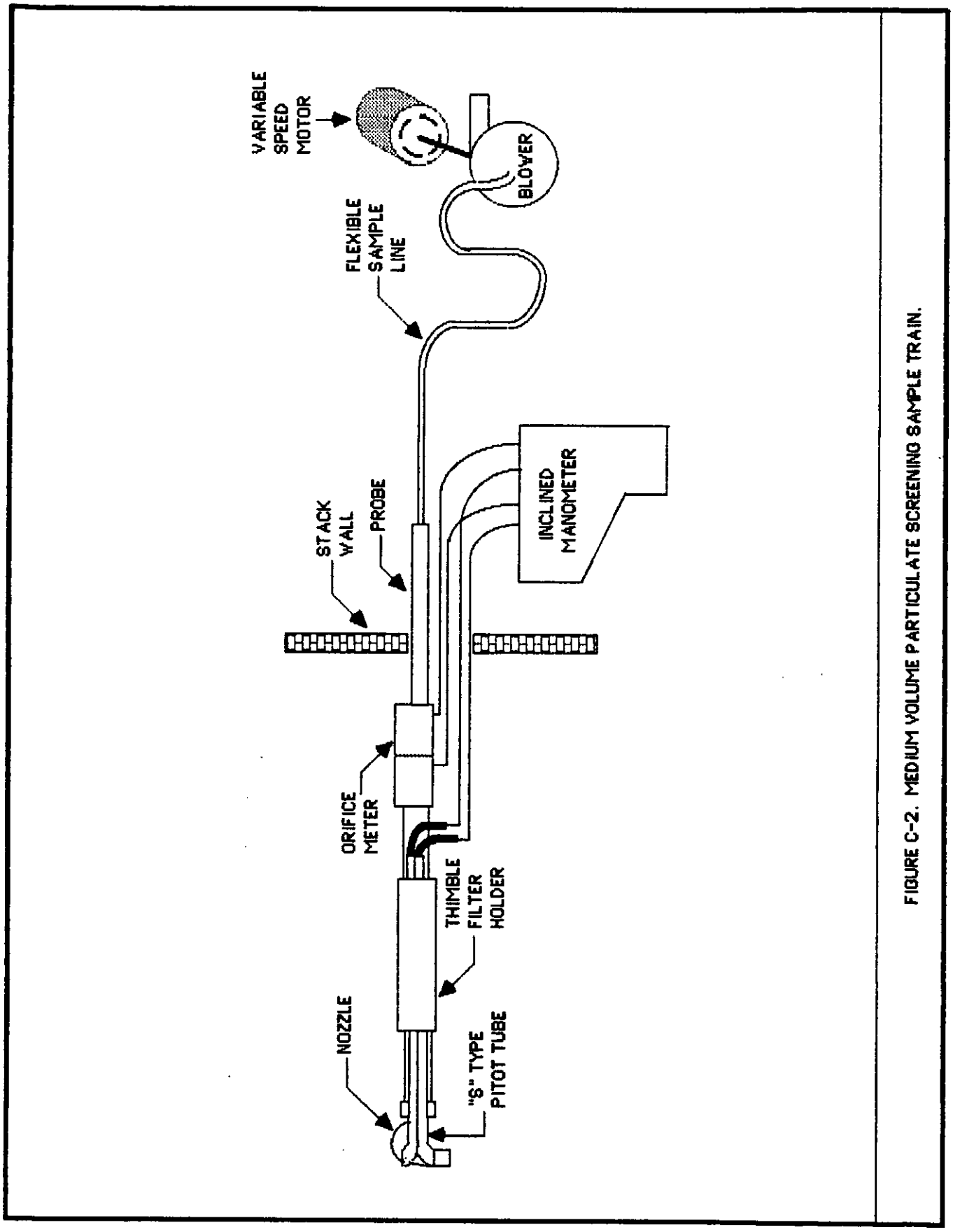


FIGURE C-2. MEDIUM VOLUME PARTICULATE SCREENING SAMPLE TRAIN.

Filter Holder - The filter holder was made of stainless steel and was inserted into the stack as part of the probe assembly.

Filter - A Schleicher & Schuell (30 mm x 100 mm) fiberglass thimble filter was used.

Draft Gauge - The draft was measured with an inclined manometer.

Metering System - The metering system consisted of a leak-free blower with a variable speed motor, a calibrated in-stack orifice, an inclined manometer, and related equipment. No flow totalizer (dry gas meter) or condensor is used in this sampling system.

Barometer - An anenoid type barometer was used to measure atmospheric pressures to 0.3 kPa (0.1 in. Hg).

SAMPLING PROCEDURES

The sampling sites were identified (see Chapter 4) and a single sampling point selected at a point of average velocity.

The glass fiber thimbles were conditioned using acid, desiccated for at least 24 hours to a constant weight, and then weighed to the nearest 0.1 mg on an analytical balance.

The sampling train was set up as shown in Figure C-2. It was leak-checked at the sampling site prior to each test run by plugging the inlet to the nozzle and observing the orificemeter.

Prior to testing, the "K" factor ($\Delta H = K\Delta_p$) was calculated based on the calibration data and preliminary stack data. To start the test, the nozzle was placed at the preselected point, the blower turned on, and the proper sampling rate set based on the measured Δ_p multiplied by the "K" factor.

At the beginning and end of the sampling period (which was on the order of 5 to 10 hours to obtain the high volume sample), stack gas and sampling train data were recorded on the field data sheet. This data consisted of the following items:

- Date and time
- ΔH
- ΔP
- Power setting for the variable speed motor on the pump
- Nozzle velocity, fpm
- Comments

Data concerning barometric pressure, stack gas temperature, and stack gas moisture for each run were taken from Method 5 runs performed at the same sampling locations on the same days.

Sample Train Calibration

Prior to sampling, an in-stack orifice calibration was performed. This type of calibration uses a calibrated dry gas meter placed in the line between the orifice meter and the blower. The volume of gas passing through the orifice meter is measured at a particular pressure drop (ΔH) across the orifice and a corresponding vacuum at a certain temperature and pressure. This information is then used to calculate the orifice meter calibration factor (K_m) for a representative set of ΔH's. The ΔH and orifice meter calibration factor (K_m) during sampling can then later be used to calculate the flow rate and volume of gas passing through the train. The calibration data sheet can be found in Appendix E.

SAMPLE RECOVERY PROCEDURES

The sampling train was carefully moved from the test site to the cleanup area. Sample fractions were recovered as follows:

Container No. 1 - The thimble filter was removed from its holder and placed in a glass jar. Loose particulate and acetone washings from all sample-exposed surfaces prior to the filter were added to the filter in the glass jar. The jar was sealed, labeled, and the liquid level was marked.

Container No. 2 - A minimum of 200 ml of acetone was taken for the blank analysis. The blank was obtained and treated in a manner similar to the acetone washing.

Container No. 3 - An unused glass fiber thimble filter was taken for blank analysis.

Data were recorded on the appropriate sample recovery and laboratory data sheets.

ANALYTICAL PROCEDURES

The following analytical procedures were used.

Container No. 1 - The contents were transferred to a tared beaker, evaporated to dryness at ambient temperature and pressure, desiccated, and then weighed to the nearest 0.1 mg until a constant weight was obtained.

Container No. 2 - The acetone blank was transferred to a tared beaker and evaporated to dryness at ambient temperature and pressure and weighed to the nearest 0.1 mg until a constant weight was obtained. These data were used to blank correct the sample.

Container No. 3 - The unused glass fiber thimble filter was treated in an identical manner as the filter in Container No. 1. These data were used as a quality control check and were not used to blank correct the field samples.

The term "constant weight" referred to above means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater between two consecutive readings, with no less than 6 hours of desiccation between weighings. All analytical data were recorded on analytical data sheets (see Appendix B).

APPENDIX D

CALIBRATION DATA

RAC-4

4/17/85

Orifice Setting	.5	.5	1	1	2	2	4	4	6	6	8	8
Cubic Ft Wet	5	5	5	5	10	10	10	10	10	10	10	10
① P BAR	29.98	29.98	29.98	29.98	29.99	29.99	29.99	29.99	29.30	29.30	29.30	29.30
T ave. +460	537	544	550	556	561	564	565	571	574	576	577	578
Ft. Dry Finish	596.165	601.087	605.882	610.739	620.649	630.546	640.597	650.550	660.565	670.614	680.583	690.639
Ft. Dry Start	591.358	596.168	601.087	605.882	610.739	620.649	630.546	640.597	650.550	660.565	670.614	680.583
⑤ C	.0368	.0368	.0737	.0737	.147	.147	.294	.294	.431	.431	.588	.588
⑥ Ft. Difference	4.815	4.919	4.795	4.857	9.910	9.897	10.051	9.953	10.015	10.049	9.969	10.056
③ BAR + C	30.0168	30.0168	30.0537	30.0537	30.137	30.137	30.294	30.294	29.731	29.731	29.888	29.888
T wet +460	536	536	536	536	536	536	536	536	536	536	536	536
② Y	1.039	1.030	1.067	1.065	1.051	1.058	1.039	1.060	1.054	1.054	1.059	1.05
Inlet T. Dry	78	90	98	104	109	115	120	122	126	127	128	130
Outlet T Dry	76	78	82	87	92	93	95	100	101	105	106	106
T ave.	77	84	90	96	101	104	105	111	114	116	117	118
T wet	76	76	76	76	76	76	76	76	76	76	76	76
⑦ T wet +460	536	536	536	536	536	536	536	536	536	536	536	536
⑧ Time	12.25	12.40	8.90	9.05	13.30	13.25	9.55	9.50	7.90	7.95	6.90	6.86
⑨ Ft. Wet	5	5	5	5	10	10	10	10	10	10	10	10
⑩ X	.01585	.01585	.0317	.0317	.0634	.0634	.1268	.1268	.1902	.1902	.2536	.253
⑪ P BAR	29.98	29.98	29.98	29.98	29.99	29.99	29.99	29.99	29.30	29.30	29.30	29.30
⑫ Out T dry +460	536	538	542	547	552	553	555	560	561	565	571	571
ΔH ④	1.701	1.736	1.776	1.819	1.946	1.928	1.996	1.957	2.014	2.086	2.073	2.04
Rec. Y	1.052											
Avg. ΔH ④	1.928											

$$Y = \frac{① \cdot ② \cdot ③}{④ \cdot ⑤ \cdot ⑥} \qquad \Delta H_{④} = \frac{⑩}{⑪ \cdot ⑫} \times \left(\frac{⑦ \cdot ⑧}{⑨}\right)^2$$

Check list - meter and pump box - particulate

Date 4-17-85 Box No. RAS-4 Meter No. _____

Pump ✓

Pump oil ✓

Clean quick connects ✓ Valves ✓

Manometers ✓

Dry test meter ✓

Thermometers ✓

Lights ✓ Buzzer _____

Electrical check - Amphenol ✓ 110 V. recept. ✓

Variac ✓

Vacuum gauge ✓

Leak check at 27" Hg. - Leakage = 0 CFM

Remarks _____

Initial each item when checked and write in any remarks.

Calibration - Orifice Std. Meter

Date _____ Box No. _____ Meter No. _____ P_b _____

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d avg.	Time t
0.5	5						
1.0	5						
2.0	10						
4.0	10						
6.0	10						
8.0	10						

Calculate Y & $\Delta H@$ at man. of 2.0

$$CF_w = \frac{P_b\,(T_b \text{ avg.} + 460)}{CF_b\,(P_b + 0.147)\,(T_w + 460)}$$

$$Y = \frac{(\quad + 460)}{(\quad + 0.147)\,(\quad + 460)} =$$

$$\Delta H@ = \frac{0.0634}{(T_w + 460)\,t^2} \cdot \frac{P_b\,(OT_d + 460)}{CF_w} \cdot \frac{(\quad + 460)}{(\quad + 460)} =$$

Tolerances

$$Y = 0.99 - \frac{1.00}{1.84} - 1.01$$

$$\Delta H@ = 1.6 - 2.1$$

RAC-T

4/18/85

Orifice Setting	.5	.5	1	1	2	2	4	4	6	6	8	8
① Cubic Ft. Wet	5	5	5	5	10	10	10	10	10	10	10	10
② P_{BAR}	30.04	30.04	30.04	30.04	30.04	30.04	30.04	30.05	30.05	30.05	30.05	30.05
③ T_{AVG} + 460	534	542	554	555	558	563	567	567	568	569	571	573
Ft. Dry Finish	53.120	58.185	63.332	68.544	78.795	89.216	99.732	110.177	120.717	131.253	141.868	152.314
Ft. Dry Start	52.125	53.120	58.185	63.332	68.544	78.795	89.216	99.732	110.177	120.717	131.253	141.868
C	.0368	.0368	.0737	.0737	.147	.147	.294	.294	.431	.431	.588	.588
④ Ft. Difference	4.995	5.065	5.147	5.212	10.251	10.421	10.516	10.445	10.540	10.536	10.615	10.448
⑤ P_{BAR} + C	30.0768	30.0768	30.1137	30.1137	30.187	30.187	30.334	30.335	30.481	30.481	30.638	30.638
⑥ Twet + 460	532	532	532	532	532	532	532	532	532	532	532	532
Y	1.003	1.004	1.009	.998	1.018	1.011	1.004	1.011	.999	1.001	.992	1.011
Inlet T. Dry	72	84	94	100	104	108	112	112	113	114	115	115
Outlet T. Dry	76	80	84	89	92	97	101	101	102	104	106	110
T Ave.	74	82	89	95	98	103	fpn	fpn	108	109	110	113
T wet	72	72	72	72	72	72	72	72	72	72	72	72
⑦ Twet + 460	532	532	532	532	532	532	532	532	532	532	532	532
⑧ Time	12.55	12.70	9.30	9.30	13.40	13.40	9.20	9.75	7.95	8.00	6.95	7.00
⑨ Ft. Wet	5	5	5	5	10	10	10	10	10	10	10	10
⑩ X	.01585	.01585	.0317	.0317	.0634	.0634	.1268	.1268	.1902	.1902	.2536	.2536
⑪ P_{BAR}	30.04	30.04	30.04	30.04	30.04	30.04	30.04	30.05	30.05	30.05	30.05	30.05
⑫ Out T dry + 460	534	542	549	555	558	563	567	567	568	569	571	573
ΔH ②	1.762	1.777	1.882	1.862	1.922	1.900	1.882	2.000	1.993	2.015	2.021	2.043
Ave. Y	1.005											
Ave. ΔH ②	1.930											

$$Y = \frac{① \cdot ② \cdot ③}{④ \cdot ⑤ \cdot ⑥}$$

$$\Delta H_② = \frac{⑩}{⑪ \cdot ⑫} \times \left(\frac{⑦ \cdot ⑧}{⑨}\right)^2$$

Check list - meter and pump box - particulate

Date 4-18-85 Box No. RAC-7 Meter No. _____

Pump ✓

Pump oil ✓

Clean quick connects ✓ Valves ✓

Manometers ✓

Dry test meter ✓

Thermometers ✓

Lights ✓ Buzzer _____

Electrical check - Amphenol ✓ 110 V recept. ✓

Variac ✓

Vacuum gauge ✓

Leak check at 27" Hg. - Leakage = 0 CFM

Remarks _____

Initial each item when checked and write in any remarks.

Calibration - Orifice and Meter

Date _____ Box No. _____ Meter No. _____ P_b _____

Man. Orifice	CF_w	CF_d	T_w	IT_d	ΣT_d	T_d avg.	Time t
0.5	5						
1.0	5						
2.0	10						
4.0	10						
6.0	10						
8.0	10						

Calculate Y & $\Delta H_@$ at man. of 2.0

$$Y = \frac{CF_w P_b (T_b \text{ avg.} + 460)}{CF_b (P_b + 0.147) (T_w + 460)}$$

$$Y = \frac{\quad + 460)}{(\quad + 0.147) (\quad + 460)} = \quad$$

$$\Delta H_@ = \frac{0.0634}{P_b} \frac{(T_w + 460) t}{(OT_d + 460)} - CF_w \quad ^2$$

$$\Delta H_@ = \frac{0.0634}{\quad} \frac{(\quad + 460) \quad}{(\quad + 460)} - \quad ^2 =$$

Tolerances

$$Y = 0.99 - 1.00 - 1.01$$

$$\Delta H_@ = 1.6 - 1.84 - 2.1$$

RAC-8

4-19-85

Orifice Setting	.5	.5	1	1	2	2	4	4	6	6	8	8
① Cubic Ft Wet	5	5	5	5	10	10	10	10	10	10	10	10
② P_{BAR}	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
③ Tave. +460	537	540	545	549	554	559	563	567	570	571	572	572
Cft. Dry Finish	646.266	651.390	656.595	661.830	672.189	682.603	693.119	703.659	714.174	724.734	735.174	745.594
Cft. Dry Start	641.125	646.266	651.390	656.595	661.830	672.189	682.603	693.119	703.659	714.174	724.734	735.174
C	.0368	.0368	.0737	.0737	.147	.147	.294	.294	.431	.431	.588	.588
④ Ft. Difference	5.140	5.125	5.205	5.235	10.359	10.414	10.516	10.540	10.515	10.560	10.440	10.420
⑤ P_{BAR} + C	29.9368	29.9368	29.9737	29.9737	30.047	30.047	30.194	30.194	30.331	30.331	30.488	30.488
⑥ Twet+460	536	536	536	536	536	536	536	536	536	536	536	536
Y	.9734	.9817	.9743	.9759	.9929	.9966	.9891	.9939	.9970	.9945	1.002	1.004
Inlet-T Dry	78	82	87	92	98	104	108	113	116	116	117	117
Outlet-T Dry	76	78	83	86	90	94	98	101	104	106	107	107
T Ave.	77	80	85	89	94	99	103	107	110	111	112	112
Twet	76	76	76	76	76	76	76	76	76	76	76	76
⑦ Twet+460	536	536	536	536	536	536	536	536	536	536	536	536
⑧ Time	13.90	13.75	9.30	9.30	13.50	13.55	9.60	9.60	7.95	8.00	6.90	6.95
⑨ Ft. Wet	5	5	5	5	10	10	10	10	10	10	10	10
⑩ X	.01585	.01585	.0317	.0317	.0634	.0634	.1268	.1268	.1902	.1902	.2536	.2536
⑪ P BAR	29.9	29.8	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9
⑫ Out Tdry+460	536	538	543	546	550	554	558	561	564	566	567	567
ΔH ③	2.196	2.141	1.941	1.930	2.019	2.019	2.012	2.001	2.048	2.066	2.046	2.076
Ave. Y	.9896											
Ave. ΔH ③	2.041											

$$Y = \frac{① \cdot ② \cdot ③}{④ \cdot ⑤ \cdot ⑥}$$

$$\Delta H_{③} = \frac{⑩}{⑪ \cdot ⑫} \times \left(\frac{⑦ \cdot ⑧}{⑨}\right)^2$$

Check list - meter and pump box - particulate

Date 4-19-85 Box No. RAC-8 Meter No. _____

Pump ✓

Pump oil ✓

Clean quick connects ✓ Valves ✓

Manometers ✓

Dry test meter ✓

Thermometers ✓

Lights ✓ Buzzer _____

Electrical check - Amphenol ✓ 110 V recept. ✓

Variac ✓

Vacuum gauge ✓

Leak check at 27" Hg. - Leakage = 0 CFM

Remarks _____

Initial each item when checked and write in any remarks.

Calibration - Orifice and Meter

Date _____ Box No. _____ Meter No. _____ P_b _____

Man. Orifice	CF_w	CF_d	T_w	IT_d	ΔT_d	T_d avg.	Time t
0.5	5						
1.0	5						
2.0	10						
4.0	10						
6.0	10						
8.0	10						

Calculate Y & $\Delta H_@$ at man. of 2.0

$$Y = \frac{CF_w \, P_b \, (T_b \text{ avg.} + 460)}{CF_b \, (P_b + 0.147) \, (T_w + 460)}$$

$$Y = \frac{\quad}{(\quad + 0.147)\,(\quad + 460)} = \quad$$

$$\Delta H_@ = \frac{0.0634}{P_b \, (\Delta T_d + 460)} \left(\frac{(T_w + 460)\, t}{CF_w} \right)^2$$

$$\Delta H_@ = \frac{0.0634}{(\quad + 460)} \left(\frac{(\quad + 460)}{\quad} \right)^2 = \quad$$

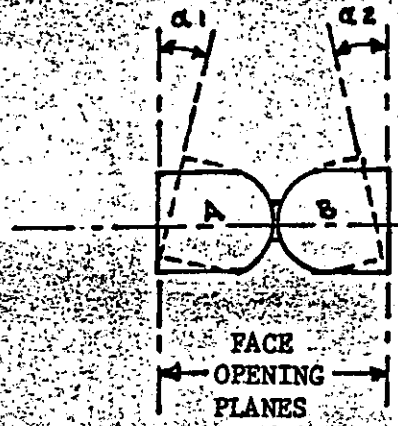
Tolerances

$Y = 0.99 - 1.00 - 1.01$

$\Delta H_@ = 1.6 - 1.84 - 2.1$

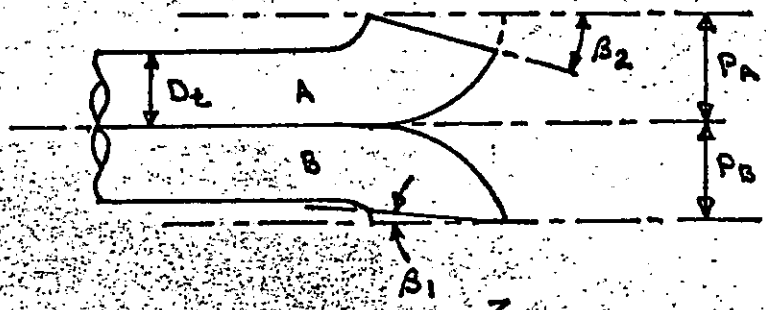
S-TYPE PITOT GEOMETRIC CALIBRATION

PITOT IDENTIFICATION CP - OUTLET
DATE 5-3-85
CALIBRATED BY JWB



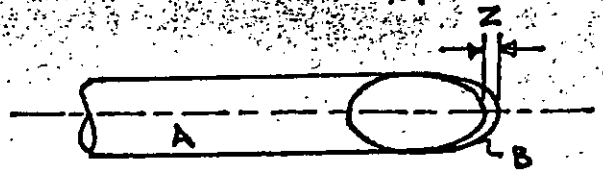
TRANSVERSE TUBE AXIS

α_1 & $\alpha_2 < 10°$

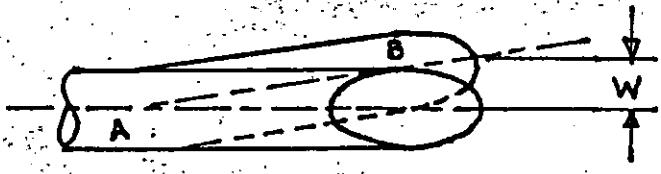


LONGITUDINAL TUBE AXIS

$1.05\ D_t \leq P \leq 1.50\ D_t$
$P_A = P_B$
β_1 & $\beta_2 < 5°$



$Z < 1/8''$ (0.32 cm)



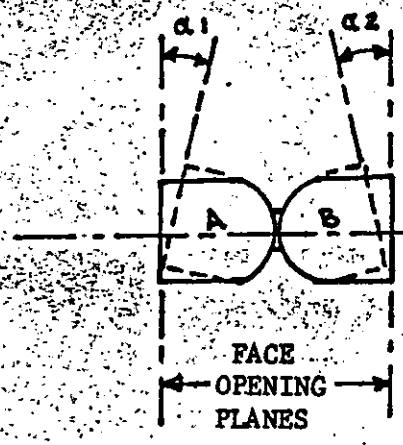
$W < 1/8''$ (0.32 cm)

MEASURED VALUES

	α_1	α_2	β_1	β_2	P_A	P_B	Z	W
AIM	0	4°	0	2°	1.33	1.33	.20	.10
IN SPEC.	✓	✓	✓	✓	✓	✓	✓	✓
OUT SPEC.								

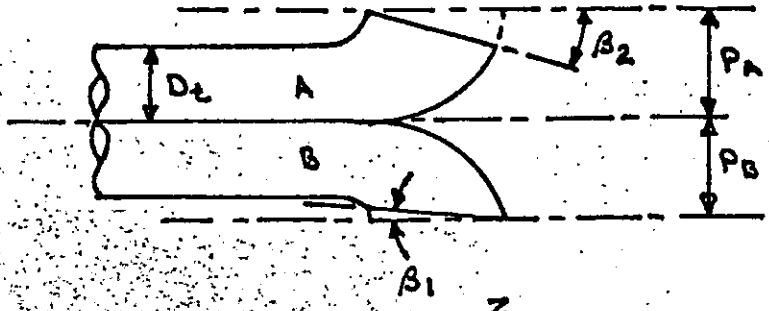
S-TYPE PITOT GEOMETRIC CALIBRATION

PITOT IDENTIFICATION C P - INLET
DATE 5-3-85
CALIBRATED BY JWB



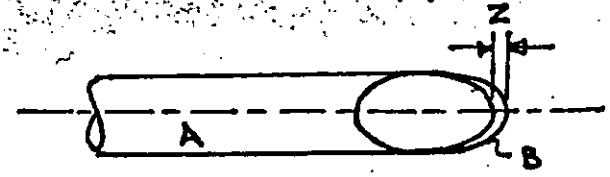
TRANSVERSE TUBE AXIS

α_1 & $\alpha_2 < 10°$

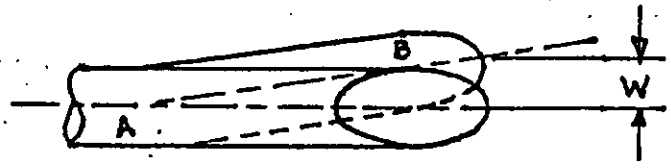


LONGITUDINAL TUBE AXIS

$1.05\ D_t \leq P \leq 1.50\ D_t$
$P_A = P_B$
β_1 & $\beta_2 < 5°$



$Z < 1/8"$ (0.32 cm)



$W < 1/8"$ (0.32 cm)

MEASURED VALUES

	α_1	α_2	β_1	β_2	P_A	P_B	Z	W
VALUE	3°	0°	0°	0°	1.11	1.13	.16	0
IN SPEC.	✓	✓	✓	✓	✓	✓	✓	✓
OUT SPEC.								

IN-STACK ORIFICE CALIBRATION

Run No: 1 Ambient Temp. 78 °F

Date: 3-27-85 Nozzle Iden.: DIF -0.6" DIA 7/16" ORIFICE

Barometric Pressure: 29.81"

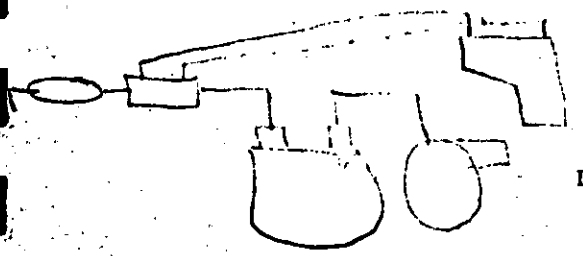
Time (min.)	Gas Meter Vol. (cu. ft.)	Gas Meter Temp. (°F) IN/ST.	Gas Meter Temp. (°F) OUT/FIN.	Δh (in. H_2O)	T_m (°F)	VAC (in. Hg)	K_m
5	56994.0 56979.0 15.0	78	78	0.5	78	0	5.37
5	57015.5 56994.0 21.5	78	78	1.0	78	0.5	5.49
5	57047.0 57015.5 31.5	78	78	2.0	78	0.75	5.71
5	57086.5 57047.0 39.5	78	78	3.0	78	1.50	5.93
5	57137.0 57086.5 50.5	78	78	5.0	78	2.25	5.95
5	57198.0 57137.0 61.0	78	78	7.0	78	3.0	6.16

Notes: CALIBRATED WITH FIBERGLASS THIMBLE INSTALLED

$$K_m = \frac{T}{t} \times \frac{V_d P_d}{T_d} \sqrt{\frac{T_m M}{\Delta h P_m}}$$

Average K_m = 5.77

WHERE: t = Time - minutes
V_d = Gas Meter Volume - dry
P_d = Gas Meter Pressure (Typically P_b)
T_d = Gas Meter Temperature + 460
T_m = Orifice Meter Temperature + 460
P_m = P_b - VAC
M = Gas Molecular Weight (Air-28.96)



$$\Delta H = 782.502 \left(\frac{C_p}{K_m}\right)^2 D_N^4 \times \Delta P$$

APPENDIX E

MRI PROCESS DATA

TEST #1

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/15/85 PAGE: 1 of 3

TEST START TIME--inlet: 1235
outlet: 1230

TEST END TIME--inlet: 1723
outlet: 1724

Time (24-h clock)	Tank No.	Tempera-ture, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1215	1	129	5.6	700	852576	• Scrubber liquid is purged 3-4 times/day.
	2	130	9.0	2,900	852574	
	3	130	12.0	2,400	852571-3	• Temperature guage for tank No. 2 is 8 ft. from the observer. 130°F is estimate.
	7	134	7.2	4,000	852498	
1230	1	129	5.4	700	852576	
	2	130	9.0	2,900	852574	
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	
1245	1	129	5.4	700	852576	
	2	—	—	—	—	→ OFF AT 1240.
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	
1300	1	129	5.4	700	852576	
	2	—	—	—	—	→ OFF
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	
1315	1	129	5.4	700	852576	
	2	130	8.0	1,600	852594	→ START AT 1305
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	

TEST # 1

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/15/85 PAGE: 2 of 3

TEST START TIME--inlet: 1235
outlet: 1230

TEST END TIME--inlet: 1723
outlet: 1724

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1330	1					→ OFF AT 1325
	2	130	8.0	1,600	852594	
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	
1345	1					→ OFF
	2	130	8.0	1,600	852594	
	3	130	12.0	2,400	852571-3	
	7	134	7.2	4,000	852498	
1415	1					→ OFF
	2	130	8.0	1,600	852594	
	3	131	12.0	2,400	852571-3	
	7					→ OFF AT 1355
1445	1					→ OFF
	2					→ OFF AT 145
	3	131	12.0	2,400	852571-3	
	7	134	7.8	4,300	852542	→ START AT 1420
1515	1	129	8.1	500	852589	→ START AT 1505
	2	130	10.0	5,700	852595	→ START AT 1445
	3	132	12.0	2,400	852571-3	
	7	134	7.8	4,300	852542	

TEST #1

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/15/85 PAGE: 3 of 3

TEST START TIME--inlet: 1235
outlet: 1230

TEST END TIME--inlet: 1723
outlet: 1724

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1530	1	129	7.7	500	852589	
	2	130	10.0	5,700	852595	
	3	132	12.0	2,400	852571-3	
	7	134	7.8	4,300	852542	
1600	1	129	7.4	500	852589	
	2	130	10.0	5,700	852595	
	3	132	12.0	2,400	852571-3	
	7	134	7.8	4,400	852542	
1630	1	129	7.3	500	852589	
	2					→ OFF AT 1600
	3	132	12.0	2,400	852571-3	• Purging scrubber liquid into tank No. 1.
	7	134	7.8	4,300	852542	
1700	1	129	7.3	500	852589	
	2					→ OFF
	3	132	12.0	2,400	852571-3	
	7	134	7.8	4,300	852542	
1730	1	129	7.2	500	852589	
	2					→ OFF
	3	132	12.1	2,400	852571-3	
	7	134	7.8	4,400	852542	

TEST # 2

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 1 of 3

TEST START TIME--inlet: 0901
outlet: 0838

TEST END TIME--inlet: 1442
outlet: 1419

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
0840	1	129	6.3	1,200	852592	
	2					→ OFF
	3					→ OFF
	7	133	7.9	3,700	852593	
0900	1	129	6.3	1,200	852592	
	2					→ OFF
	3					→ OFF
	7	134	7.9	3,700	852593	
0915	1	129	6.3	1,200	852592	→ OFF AT 915
	2					→ OFF
	3					→ OFF
	7	134	7.9	3,700	852593	
0935	1	129	6.8	1,300	852592	→ START AT 935
	2					→ OFF
	3					→ OFF
	7	134	7.9	3,700	852593	→ OFF AT 935
1000	1	129	6.7	1,300	852592	
	2					→ OFF
	3					→ OFF
	7					→ OFF

TEST # 2

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 2 of 3

TEST START TIME--inlet: 0901
outlet: 0838

TEST END TIME--inlet: 1442
outlet: 1419

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1030	1	129	6.6	1,300	852592	→ OFF AT 1035
	2	→				OFF
	3	→				OFF
	7	→				OFF
1100	1	129	6.9	1,200	852592	→ START AT 1050
	2	→				OFF
	3	→				OFF
	7	133	--	5,200	852593	• Tank No. 7 was blocked during changeover. Values are estimates.
1145	1	129	6.8	1,200	852592	• TEST WAS INTERRUPTED AT 1102 TO 1145 DUE TO LOW PRODUCTION RATE
	2	130	10.1	7,400	852559-2	→ START AT 1105
	3	→				OFF
	7	133	9.3	3,400	852593	
1200	1	→				OFF AT 1150
	2	130	10.3	7,600	852559-2	
	3	→				OFF
	7	→				OFF AT 1150
1230	1	→				OFF
	2	130	10.2	7,600	852559-2	
	3	128	10.8	5,000	852470	→ START AT 1205
	7	133	9.5	5,400	852593	→ START AT 1220

TEST #2

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 3 of 3

TEST START TIME--inlet: 0901
outlet: 0838

TEST END TIME--inlet: 1442
outlet: 1419

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1300	1					→ OFF
	2	130	10.2	7,500	852559-2	
	3	129	10.8	5,000	852470	
	7	134	9.5	5,400	852593	
1330	1					→ OFF
	2	130	10.1	7,400	852559-2	
	3	131	10.8	5,000	852470	
	7	134	9.5	5,400	852593	
1400	1					→ OFF - ABOUT TO LOAD
	2	130	10.2	7,500	852559-2	
	3	132	10.8	5,100	852470	
	7					→ OFF AT 1330
1430	1	130	7.5	2,500	852514	→ START AT 1355
	2	130	10.0	7,400	852559-2	
	3	132	10.7	5,100	852470	
	7	134	8.4	4,800	852593	→ START AT 1405
1500	1	130	7.4	2,500	852514	
	2	130	10.0	7,300	852559-2	
	3	132	10.7	5,200	852470	
	7	134	8.6	4,700	852593	

TEST #3

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 1 of 3

TEST START TIME--inlet: 1525
outlet: 1517

TEST END TIME--inlet: 2013
outlet: 1955

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1540	1	132	7.3	2,500	852514	
	2	130	10.0	7,300	852559-2	
	3	132	10.1	5,000	852470	
	7	134	8.6	4,700	852593	
1605	1	133	7.3	2,500	852514	
	2	130	10.0	7,300	852559-2	
	3	132	10.1	5,100	852470	
	7	134	8.6	4,700	852593	
1630	1	134	7.2	2,400	852514	
	2	130	10.0	7,300	852559-2	
	3	132	10.1	5,100	852470	
	7	→	→	→	→	OFF AT 1605
1700	1	134	7.2	2,400	852514	
	2	130	10.0	7,400	852559-2	
	3	132	10.1	5,100	852470	
	7	→	→	→	→	OFF
1730	1	134	7.2	2,400	852514	
	2	→	→	→	→	OFF AT 1705
	3	132	10.1	5,100	852470	
	7	→	→	→	→	OFF

TEST #3

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 2 of 3

TEST START TIME--inlet: 1525
outlet: 1517

TEST END TIME--inlet: 2013
outlet: 1955

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
1800	1	134	7.2	2,400	852514	
	2	130	10.0	4,500	852536	→ START AT 1730
	3	132	10.1	5,100	852470	
	7	133	7.2	2,600	852564	→ START AT 1730
1830	1	134	7.1	2,400	852514	
	2	130	10.0	4,600	852536	
	3	132	10.1	5,100	852470	
	7	133	7.2	2,600	852564	
1900	1	134	7.1	2,400	852514	
	2	130	10.4	4,700	852536	
	3	132	10.1	5,100	852470	
	7	134	7.2	2,600	852564	
1930	1	134	7.2	2,400	852514	
	2	130	10.0	4,600	852536	
	3	132	10.1	5,100	852470	
	7	133	7.2	2,600	852564	
2000	1	134	7.2	2,400	852514	
	2	130	10.0	4,600	852536	
	3	132	10.1	5,100	852470	
	7	134	7.2	2,600	852564	

TEST #3

SOURCE SAMPLING PROGRAM
Process Data Sheet

PLACE: Carolina Plating DATE: 5/16/85 PAGE: 3 of 3

TEST START TIME--inlet: 1525
outlet: 1517

TEST END TIME--inlet: 2013
outlet: 1955

Time (24-h clock)	Tank No.	Temperature, °F	Operating voltage, volts	Operating current, amperes	Job No.	Notes
2015 (test end)	1	134	7.1	2,400	852514	
	2	130	10.0	4,600	852536	
	3	132	10.1	5,100	852470	
	7	134	7.2	2,600	852564	
	1					
	2					
	3					
	7					
	1					
	2					
	3					
	7					
	1					
	2					
	3					
	7					
	1					
	2					
	3					
	7					

SOURCE SAMPLING PROGRAM
Job Descriptions

PLACE: Carolina Plating DATE: 5/15

Job No.	Dimensions, in. x in. (circ. x length)	Surface area, $in.^2$	Current required, amps	Tank No.	Plate time, h (in-out)
852498	20 x 130	2,600	4,000	7	5 (0855-1355)
852576	5 x 47.5	237.5	700	1	75 min (1210-1325)
852574	21.8 x 81	1,767	2,800	2	70 min (1130-1240)
852571-3	1 Feeder	--	2,500	3	12 (0930-2130)
852594	16 x 69.25	1,112	1,800	2	70 min (1305-1415)
852542	37.2 x 58	2,160	4,400	7	14
852595	32.3 x 123	3,984	6,000	2	70 min (1445-1600)
852589	Bearing surface	--	500	1	all night
8525592	39.2 x 144	5652	6,000	2	8 (1735-0135)

SOURCE SAMPLING PROGRAM
Job Descriptions

PLACE: Carolina Plating DATE: 5/16

Job No.	Dimensions, in. x in. (circ. x length)	Surface area, $in.^2$	Current required, amps	Tank No.	Plate time, h (in-out)
852593	20.4 x 89.5	1,826	3,600	7	2 (0735-0935)
852592	8 x 64.5	516	1,100	1	1 (0815-0915)
852592	8 x 64.5	516	1,300	1	1 (0935-1035)
852593	31.4 x 109	3,424.9	5,200	7	70 min (1040-1150)
852592	8 x 64.5	516	1,200	1	1 (1050-1150)
852559-2	39.2 x 144	5,652	7,200	2	6 (1105-1705)
852470	54.9 x 60	3,294	4,900	3	24 (1205-1205)
852593	32.4 x 111	3,606	5,400	7	70 min (1220-1330)
852514	26.8 x 45	1,206	2,500	1	12 (1355-0155)
852593	21.2 x 111	23,533	4,800	7	2 (1405-1605)
852564	50.2 x 24	1,205	2,500	7	10 (1730-0330)
852536	37.5 x 77	2,894	4,400	2	18 (1730-1130)

TEST NO. 1--AMPERE-HOUR CALCULATIONS

Clock time	Time interval, min		Current, amperes	Ampere-hours	
	Inlet	Outlet		Inlet	Outlet
1230					
	10	15	10,000	1,670	2,500
1245					
	15	15	7,100	1,780	1,780
1300					
	15	15	7,100	1,780	1,780
1315					
	15	15	8,700	2,180	2,180
1330					
	15	15	8,000	2,000	2,000
1345					
	30	30	8,000	4,000	4,000
1415					
	30	30	4,000	2,000	2,000
1445					
	30	30	6,700	3,350	3,350
1515					
	15	15	12,900	3,220	3,220
1530					
	30	30	12,900	6,450	6,450
1600					
	30	30	13,000	6,500	6,500
1630					
	30	30	7,200	3,600	3,600
1700					
	23	24	7,200	2,760	2,880
TOTAL				41,290	42,240

$\frac{41,290 \text{ amps}}{4.8 \text{ hrs}} = 8,602 \text{ amps/hr}$

$\frac{42,240 \text{ amps}}{4.9 \text{ hrs}} = 8,620 \text{ amps/hr}$

TEST NO. 2--AMPERE-HOUR CALCULATIONS

Clock time	Time interval, min		Current, amperes	Ampere-hours	
	Inlet	Outlet		Inlet	Outlet
0840					
	0	22	4,900	0	1,800
0900					
	14	15	4,900	1,140	1,220
0915					
	20	20	4,900	1,630	1,630
0935					
	25	25	5,000	2,100	2,100
1000					
	30	30	1,300	650	650
1030					
	30	30	1,300	650	650
1100					
	2	2	6,400	210	210
1145					
	15	15	12,000	3,000	3,000
1200					
	30	30	7,600	3,800	3,800
1230					
	30	30	18,000	9,000	9,000
1300					
	30	30	17,900	8,950	8,950
1330					
	30	30	17,800	8,900	8,900
1400					
	30	19	12,600	6,300	3,990
1430					
	12	0	19,800	3,960	0
TOTAL	297	298		50,290	45,900

$\frac{50,290 \text{ amps}}{4.967 \text{ hrs}} = 10,126 \text{ amps/hr}$

$\frac{45,900 \text{ amps}}{4.967 \text{ hrs}} = 9,242 \text{ amps/hr}$

TEST NO. 3--AMPERE-HOUR CALCULATIONS

Clock time	Time interval, min		Current, amperes	Ampere-hours	
	Inlet	Outlet		Inlet	Outlet
1500					
	15	23	19,700	4,920	7,550
1540					
	25	25	19,500	8,120	8,120
1605					
	25	25	19,600	8,170	8,170
1630					
	30	30	14,800	7,400	7,400
1700					
	30	30	14,900	7,450	7,450
1730					
	30	30	7,500	3,750	3,750
1800					
	30	30	14,600	7,300	7,300
1830					
	30	30	14,700	7,350	7,350
1900					
	30	30	14,800	7,400	7,400
1930					
	30	25	14,700	7,350	6,120
2000					
	13	0	14,700	3,180	0
TOTAL				72,390	70,610

$\frac{72,390 \text{ amps}}{4.8 \text{ hrs}} = 15,081 \text{ amps/hr}$

$\frac{70,610 \text{ amps}}{4.63 \text{ hrs.}} = 15,240 \text{ amps/hr}$

APPENDIX F

TEST PARTICIPANTS AND OBSERVERS

TEST PARTICIPANTS AND OBSERVERS

Name	Organization	Responsibility
Dan Bivens	EPA, Emission Measurement Branch	Team Leader/EPA Task Manager
Frank Clay	EPA, Emission Measurement Branch	Inlet Meter Box/Data Reduction
Peter Schindler	EPA, Emission Measurement Branch	Inlet Technician
Candace Sorrell	EPA, Emission Measurement Branch	Outlet Meter Box
Dennis Holzschuh	EPA, Emission Measurement Branch	Outlet Technician
John Brown	EPA, Emission Measurement Branch	Cleanup/Equipment/Medium Volume Train
Barb Dutletsky	Midwest Research Institute	Process Operation Observer
Al Vervaert	EPA, Industrial Studies Branch	EPA Task Manager