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EMISSION TEST REPORT

PIEDMONT INDUSTRIAL PLATING COMPANY
STATESVILLE, NORTH CAROLINA

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1.0 INTRODUCTION

During the week of August 18, 1986, Entropy Environmentalists, Inc. conducted an emissions measurement program at Piedmont Industrial Plating Company located in Statesville, North Carolina. The purpose of this program was to evaluate the effect of scrubber water chromic acid concentration on scrubber performance. The data may also be used to support a possible standard for chromium emissions under the National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

The hard plating process at Piedmont Industrial Plating involves two hard chromium plating tanks that share the use of one emissions control scrubber. Comprehensive testing was conducted at the inlet and the outlet of this control device. This source was selected for source sampling for the following reasons:

- The plant is representative of a small-sized job shop that performs hard chromium electroplating. Hard chromium plating is applied to textile machine parts, industrial rolls, and tubing. Based on operating parameters such as current, voltage, plating time, and chromic acid concentration, the plating tanks selected for testing appear to be typical of other hard chromium plating tanks in the electroplating industry.
- The combined surface area of the two tanks in operation during testing is large. They have equal width and depth dimensions of 0.9 meters [m] [3 feet (ft)] wide, and 1.2 m [4 ft] deep. The larger tank is 7.0 m [23 ft] long, and the smaller is 3 m [10 ft] long. A substantial amount of chromic acid mist is evident across the entire surface of the plating baths when they are operated at full capacity. Neither chemical fume suppressants nor plastic balls are used in the plating bath to control misting. These factors will ensure an adequate emission sample to characterize uncontrolled emissions and the performance of the scrubber.
- Both tanks are equipped with double-sided draft hoods that appear to be very effective in directing fumes from the plating tanks to the control device. No visible emissions or fumes were observed escaping the capture systems of either tank during operation.

Hexavalent chromium and total chromium concentrations were measured at the scrubber inlet and outlet. The concentrations of the scrubber recirculation water and of the plating tank solutions were also measured. The chromium concentration of the scrubber recirculation water was increased over the test program to determine the effect that the scrubber water chromium concentration has on the performance capability of packed-bed scrubbers to control chromium emissions. The data will be used as part of the technical basis for developing a regulatory alternative based on the use of packed-bed scrubbers for removing hexavalent chromium from ventilation air at hard chromium plating facilities. Additional testing was conducted concurrent with Method 13-type impinger train testing to determine the applicability of available detector tubes and personnel monitoring equipment as a screening method for chromium emissions.

The emissions testing was performed using U. S. Environmental Protection Agency (EPA) Reference Method 5 procedures and a Method 13-type impinger train*, and the alternative sample preparation and analytical procedures described in Appendix C. Flue gas flow rates, temperature, and moisture content were also measured in conjunction with the chromium testing.

Mr. Randy Strait [Midwest Research Institute (MRI)] monitored process operations throughout the test period. Mr. Dennis Holzschuh (EPA Task Manager of the Emissions Measurement Branch (EMB) and Mr. Al Vervaert of the Industrial Studies Branch (ISB) observed the test program. Mr. Robert Miller (Manager) served as the contact for Piedmont Industrial Plating Company.

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 used for emissions testing 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 Test Results and Example Calculations (Appendix A); Field and Analytical

*43 Federal Register 11984, 3/23/78 (Method 5) and 43 Federal Register 41852, 6/20/80 (Method 13).

Data (Appendix B); Sampling and Analytical Procedures (Appendix C); Calibration and Quality Assurance Data (Appendix D); MRI Process Data (Appendix E); and Test Participants and Observers (Appendix F).

2.0 PROCESS OPERATION

2.1 PROCESS DESCRIPTION

The Piedmont Industrial Plating plant in Statesville, North Carolina, is a job shop that performs hard chromium electroplating of industrial machine parts, industrial rolls, and steel tubing. The plating facility is operated 15 hours per day, 5 days per week, and 50 weeks per year. The facility consists of three plating tanks arranged as shown in Figure 2-1.

All three tanks are typical of other hard chromium plating tanks used in the electroplating industry with regard to size; operating parameters such as current, voltage, and plating time; and chromic acid concentration of the plating bath. During the source test program, only the 23-foot and 10-foot tanks were operated. The chromic acid consumption for the two tanks is about 136 kilograms (300 pounds) per month. The dimensions and operating parameters for these two tanks are presented in Table 2-1.

The 23-foot tank is used to plate long industrial rolls and tubing as well as smaller parts. The tank is equipped with one 6,000- and three 1,000-ampere rectifiers. When industrial rolls or tubing are plated, the 6,000-ampere rectifier is used, and when smaller and different kinds of parts are plated, up to four work stations can be set up in the tank. Three of the work stations are charged with the 1,000-ampere rectifiers, and one work station is charged with the 6,000-ampere rectifier. The 10-foot tank contains up to five work stations, each of which is charged with a separate 1,000-ampere rectifier. During this source test program, the 23-foot and 10-foot tanks were divided into two and five work stations, respectively.

The plating solution used in the tanks is a conventional hard chromium plating solution containing about 240 grams per liter (g/l) (32 ounces per gallon [oz/gal]) of chromic acid and about 2.40 g/l (0.32 oz/gal) of sulfuric acid.

One porous pot made of ceramic was used at work station 7 in the 23-foot tank during six test runs and at work station 1 in the 10-foot tank during four test runs to reduce trivalent chromium contamination of the plating solution. The concentration of trivalent chromium ions

increases to levels that contaminate the plating baths when the surface area of the cathodes plated is substantially larger than the surface area of the anodes. The pots are made of ceramic that contains pores ranging from 0.5 to 1.0 micrometer (0.002 to 0.004 mils) in diameter. Several anodes are placed around the outside and a cathode is placed inside each pot. The anodes and cathode are both formed from lead-antimony alloy. About 9 volts and 300 amperes of direct current are applied to the anodes surrounding each pot. Trivalent chromium ions present in the bath migrate to the anodes where they react with oxygen to form chromic acid. The ceramic material acts as a selective membrane that prevents the hexavalent chromium anions in the bath from flowing to the cathode where they would be reduced and deposited.

2.2 AIR POLLUTION CONTROL

All three tanks are equipped with double-sided draft hoods that are installed along the length of each tank. Each hood contains one continuous slot that is equal to the tank length and 5.08 centimeters (cm) (2.0 inches [in.]) wide. Each slot is reinforced with inserts spaced approximately 30.5 cm (12.0 in.) apart.

All three tanks are ducted together and vented to a fume scrubber located outside of the plant building. The scrubber is a horizontal-flow single packed-bed unit that is equipped with a self-contained recirculation system. The fume scrubber was manufactured by Duall Industries, Inc. (Model No. F-101). Figure 2-2 presents a diagram of the scrubber provided by Duall. The scrubber was purchased as used equipment and was installed at the plant in 1984. Duall personnel inspected the scrubber in July 1986 and made the following recommendations to ensure normal scrubber operating conditions: (1) the angle of the ductwork entry at the inlet transition of the scrubber should be repositioned to direct the gas flow toward the center of the packed bed and to prevent scrubber water from entering the ductwork, (2) the spray nozzles should be cleaned and the nozzle velocity should be upgraded to design specifications, and (3) minor cracks in the scrubber housing should be sealed. The plant corrected these problems before emission testing was performed.

The gas flow rate to the scrubber is 297 actual cubic meters per minute (10,500 actual cubic feet per minute), and the water flow rate is

about 130.5 liters per minute (34.5 gallons per minute). The pressure drop across the scrubber is 0.5 kilopascals (2 inches of water column).

Removal of chromic acid mist from the inlet gas stream is accomplished by reducing the velocity of the entering gas stream to less than 152 meters per minute (500 feet per minute) and spraying it with water. The water is sprayed countercurrent to the flow of the gas stream through six nozzles. The saturated gas stream then passes through a packed bed of polypropylene, spherical-type mass packing that is continuously washed with water. The packed bed is 142.2 cm (56 in.) in height and width and 30.5 cm (12 in.) in depth. The entrained mist and water droplets impinge on the packing and are carried away in the washwater. Behind the packed bed is a two-stage mist elimination section that eliminates any entrained water droplets. The first stage allows larger droplets to settle by gravity to the bottom of the scrubber. The second stage contains a series of vertically-mounted chevron blades made of polyvinyl chloride that change the direction of the gas flow four times at 30° angles, which forces chromium droplets to impinge on the blades. The mist eliminator is not washed down but is inspected frequently. If wetting appears in the mist eliminator section, the packed bed is reconditioned to prevent the breakthrough of droplets.

The scrubber water drains into a sump in the bottom of the scrubber and is recirculated by a 0.75-horsepower pump. A sensor is used to monitor the water level in the sump which contains about 378 liters (100 gallons [gal]) of water. About four times per day, 95 L (25 gal) of clean water are automatically added over the packed bed when the sensor indicates that water is needed to make up for evaporation losses. The scrubber water is drained to the plating tanks approximately once per day to make up for plating solution evaporation losses. The scrubber is then recharged with clean water. Grab samples of the scrubber water that were taken one month before emission testing was conducted showed that the chromic acid concentration of the scrubber water under normal conditions is about 1.5 g/L (0.2 oz/gal).

2.3 PROCESS CONDITIONS DURING TESTING

Many hard chromium plating facilities that use scrubbers recirculate the scrubber water continuously from several hours to several weeks to reduce water consumption and wastewater treatment costs and to recover chromic acid for use as plating solution makeup. Therefore, the purpose of this emissions test was to assess the effect of increasing chromic acid concentrations in the scrubber water on scrubber performance.

The target level scrubber water chromic acid concentrations selected for testing were 0.0, 30, 60, and 120 g/l (0.0, 4, 8, and 16 oz/gal). The target levels of 0.0, 30, and 60 g/l (0.0, 4, and 8 oz/gal) were selected to represent the range of concentrations that would occur under normal operating conditions. The target level of 120 g/l (16 oz/gal) was selected to represent worst case conditions.

Three mass emission test runs were conducted at the inlet and outlet of the scrubber for each of the four target level concentrations. Each test run was conducted for 2 hours. The plant manager spiked the scrubber water with plating solution taken from the 23-foot plating tank at concentrations near the target levels. Grab samples of the scrubber water were taken from the scrubber recirculation sump at the beginning, middle, and end of each test run and analyzed by spectrophotometer at the test site to monitor chromic acid concentrations. The target and actual scrubber water concentrations observed during testing are presented in Table 2-2. The scrubber operated normally throughout the test runs.

The process was operating normally during the tests. Process operating parameters such as the voltage, current, and plating solution temperature were monitored and recorded during each mass emission test run. Also recorded were the current and plating time for each individual job or item being plating during each test run. Data sheets documenting the process parameters that were recorded during each mass emission test run (Nos. I-1 through I-12 and O-1 through O-12) are presented in Appendix E. Data on the average operating parameters recorded are presented in Table 2-3. Because the third tank was not in operation during the test, the ventilation hood for the tank was dampered off to increase the ventilation rate for the 23-foot and 10-foot tanks.

The total amount of current supplied to the work stations 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 2-4. As shown in Table 2-4, the total amount of current supplied to the tanks during emission test runs 1 through 3 ranged from 12,000 to 13,000 ampere-hours. For test runs 4 through 6, the total current values were 30 to 40 percent lower (8,000 to 9,000 ampere-hours) and for test runs 7 through 12 the total current values were 50 to 60 percent lower (5,500 to 6,500 ampere-hours) than the total current values for test runs 1 through 3. The plant manager stated that a typical work load for the two tanks is about 6,000 ampere-hours.

The amount and type of work plated during the emission test runs varied depending on the plant's scheduled work load. For the 23-foot tank, work stations 7 and 10 were operated simultaneously during test runs 1 through 6. For test run 1 at work station 7, one porous pot was used during the first hour of the test run, and one cast iron part was plated during the second hour of the test run. For test runs 2 through 6 at work station 7, one porous pot was used for all five test runs. For test runs 1 through 6 at work station 10, dummy parts were plated because the plant did not have work to plate at this work station. Lease bars for warp knitting machines were used as dummy parts for test runs 1 through 3, and both lease bars and angle iron were used as dummy parts for test runs 4 through 6. Only work station 10 was operated during test runs 7 through 12. One steel tube (about 6.0 m [19.75 ft] in length) was plated during each of these six test runs. Plating was stopped for about 5 minutes in the middle of each test run to rotate the tube.

For the 10-foot tank, five work stations were operated for part or all of the test runs except for test runs 6 and 9. Work station 1 was not operated during test run 6, and work stations 3 and 4 were not operated during test run 9. The work plated during emission testing included steel shafts and gears for engine components and steel pins and latches for packaging machines. Two to four shafts or gears were plated at each work station from 30 minutes to 4 hours. Pins and latches were mounted on plating racks and plated from 15 to 40 minutes. One porous pot was used at work station 1 during test runs 1, 7, 8, and 9.

Grab samples were taken from both plating tanks during each mass emission test run to monitor the chromic acid concentration of the plating solution. The chromic acid concentration of the grab samples is reported in Section 3.3 (Table 3-5). The plating solution in the 23-foot tank was air agitated for test runs 3 through 12 to maintain a uniform chromic acid concentration throughout the plating solution. The plant manager considered air agitation of the plating solution to be normal operating procedure. The tank freeboard space was maintained at about 15 cm (6 in.), which prevented plating solution from splashing into the ventilation hoods.

Sampling at the inlet and outlet was interrupted only once to change test ports except for test run 11, which was interrupted four times. Test run 11 was first interrupted after 3 minutes of testing for 38 minutes to increase the chromic acid concentration of the scrubber water, a second and third time for a total of 12 minutes at the inlet and 8 minutes at the outlet during the first hour of testing, and a fourth time to change test ports between the first and second hour of testing. Test run 11 was not interrupted during the second hour of testing. Port changes at the inlet took from 3 to 8 minutes except for those during test runs 2 and 3, which took 17 and 39 minutes, respectively. Port changes at the outlet took from 2 to 8 minutes.

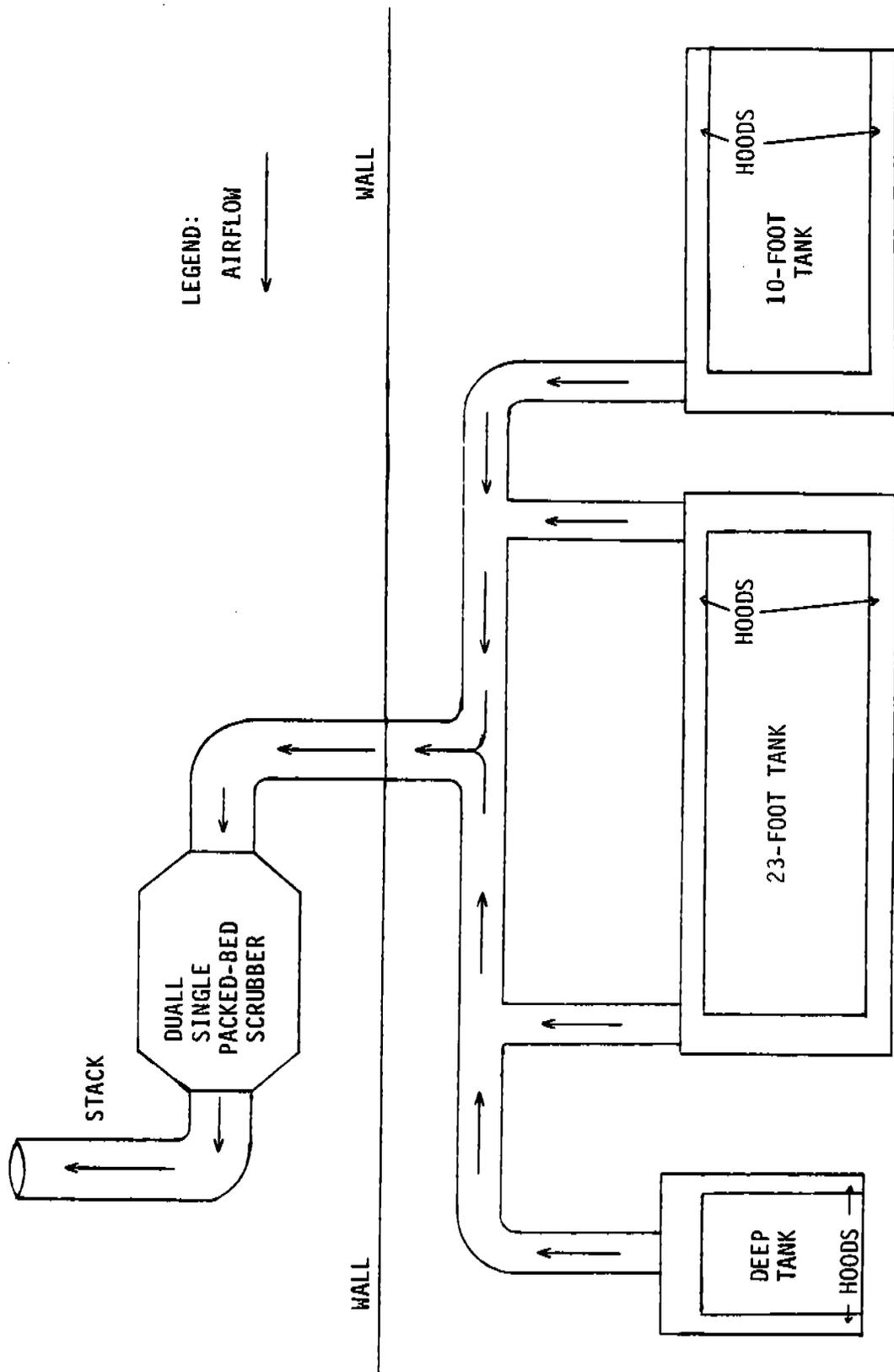


Figure 2-1. Schematic of Piedmont Industrial Plating hard chromium plating operation.

TABLE 2-1. DIMENSIONS AND OPERATING PARAMETERS OF HARD CHROMIUM PLATING TANKS AT PIEDMONT INDUSTRIAL PLATING

Tank	Dimensions (l, w, d) m (ft) ^a	Capacity, \bar{x} (gal)	Voltage, volts ^b	Current, amperes ^{b c}	Method of cooling
23-foot	7.0, 0.9, 1.2 (23.0, 3.0, 4.0)	7,813 (2,064)	12	9,000	Water
10-foot	3.0, 0.9, 1.2 (10.0, 3.0, 4.0)	3,400 (898)	12	5,000	Water

^aL = length, w = width, d = depth.

^bMaximum operating values.

^cA total of four work stations can be used in the 23-foot tank. One of the work stations is charged with a 6,000-ampere rectifier and three of the work stations each are charged with a 1,000-ampere rectifier. A total of five work stations are used in the 10-foot tank. Each work station is charged with separate 1,000-ampere rectifiers.

TABLE 2-2. AVERAGE SCRUBBER WATER CHROMIC ACID
CONCENTRATIONS FOR EACH TEST RUN

Run No. Inlet/outlet	Target concentration, g/l (oz/gal)	Actual concentration, g/l (oz/gal)
I-1/0-1	0.0	1.38 (0.185)
I-2/0-2	0.0	1.73 (0.231)
I-3/0-3	0.0	1.75 (0.234)
I-4/0-4	30.0 (4.0)	25.24 (3.37)
I-5/0-5	30.0 (4.0)	25.54 (3.41)
I-6/0-6	30.0 (4.0)	24.64 (3.29)
I-7/0-7	60.0 (8.0)	50.56 (6.75)
I-8/0-8	60.0 (8.0)	45.24 (6.04)
I-9/0-9	60.0 (8.0)	41.94 (5.60)
I-10/0-10	120.0 (16.0)	78.94 (10.54) ^a
I-11/0-11	120.0 (16.0)	115.19 (15.38)
I-12/0-12	120.0 (16.0)	105.68 (14.11)

^aShortly before the end of this test run plating personnel inadvertently drained the scrubber water into the 23-foot plating tank to makeup for plating solution evaporation losses.

TABLE 2-3. AVERAGE OPERATING PARAMETERS RECORDED DURING EACH MASS EMISSION SOURCE TEST RUN

Test run No. Inlet/Outlet	Tank	Operating voltage, volts	Operating current, amperes	Temperature of plating solution, °C (°F)	Pressure drop of scrubber, kPa (in. w.c.)
I-1/0-1	23-ft	9.2	1,562	57 (134)	0.55 (2.2)
	10-ft	6.6	700	60 (140)	0.55 (2.2)
I-2/0-2	23-ft	9.3	1,622	57 (134)	0.55 (2.2)
	10-ft	6.7	702	60 (140)	0.55 (2.2)
I-3/0-3	23-ft	9.3	1,634	58 (136)	0.55 (2.2)
	10-ft	7.1	720	60 (140)	0.55 (2.2)
I-4/0-4	23-ft	9.7	1,756	58 (137)	0.52 (2.1)
	10-ft	5.6	171	60 (140)	0.52 (2.1)
I-5/0-5	23-ft	9.7	1,800	59 (138)	0.52 (2.1)
	10-ft	5.8	245	60 (140)	0.52 (2.1)
I-6/0-6	23-ft	9.7	1,826	59 (138)	0.52 (2.1)
	10-ft	6.0	275	60 (140)	0.52 (2.1)
I-7/0-7	23-ft	9.0	2,000	57 (135)	0.52 (2.1)
	10-ft	6.0	426	60 (140)	0.52 (2.1)

(continued)

TABLE 2-3. (continued)

Inlet/Outlet	Tank	Operating voltage, volts	Operating current, amperes	Temperature of plating solution, °C (°F)	Pressure drop of scrubber, kPa (in. w.c.)
I-8/0-8	23-ft	8.2	1,946	59 (138)	0.50 (2.0)
	10-ft	7.1	489	60 (140)	0.50 (2.0)
I-9/0-9	23-ft	8.0	2,000	59 (138)	0.50 (2.0)
	10-ft	6.9	378	60 (140)	0.50 (2.0)
I-10/0-10	23-ft	8.0	2,000	58 (136)	0.50 (2.0)
	10-ft	6.9	366	60 (140)	0.50 (2.0)
I-11/0-11	23-ft	8.5	2,000	58 (136)	0.52 (2.1)
	10-ft	6.5	405	60 (140)	0.52 (2.1)
I-12/0-12	23-ft	8.5	2,000	58 (136)	0.50 (2.0)
	10-ft	6.6	415	60 (140)	0.50 (2.0)

TABLE 2-4. TOTAL CURRENT SUPPLIED TO THE TANKS
DURING EACH MASS EMISSION TEST RUN

Test run No. Inlet/Outlet	Tank	Ampere-hours	
		Inlet	Outlet
I-1/0-1	23-ft	6,213	6,213
	10-ft	<u>6,005</u>	<u>6,005</u>
	Total	12,218	12,218
I-2/0-2	23-ft	6,492	6,492
	10-ft	<u>6,731</u>	<u>6,731</u>
	Total	13,223	13,223
I-3/0-3	23-ft	6,524	6,546
	10-ft	<u>6,484</u>	<u>6,501</u>
	Total	13,008	13,047
I-4/0-4	23-ft	7,039	7,115
	10-ft	<u>1,470</u>	<u>1,489</u>
	Total	8,509	8,604
I-5/0-5	23-ft	7,154	7,262
	10-ft	<u>2,253</u>	<u>2,308</u>
	Total	9,407	9,570
I-6/0-6	23-ft	7,312	7,372
	10-ft	<u>1,129</u>	<u>1,119</u>
	Total	8,441	8,491
I-7/0-7	23-ft	3,998	3,996
	10-ft	<u>2,473</u>	<u>2,491</u>
	Total	6,471	6,487
I-8/0-8	23-ft	3,326	3,325
	10-ft	<u>3,106</u>	<u>3,041</u>
	Total	6,432	6,366
I-9/0-9	23-ft	3,996	4,029
	10-ft	<u>1,465</u>	<u>1,445</u>
	Total	5,461	5,474

(continued)

TABLE 2-4. (continued)

Test run No. Inlet/Outlet	Tank	Ampere-hours	
		Inlet	Outlet
I-10/0-10	23-ft	3,897	3,864
	10-ft	<u>2,439</u>	<u>2,444</u>
	Total	6,336	6,308
I-11/0-11	23-ft	3,997	4,030
	10-ft	<u>2,227</u>	<u>2,245</u>
	Total	6,224	6,275
I-12/0-12	23-ft	3,831	3,830
	10-ft	<u>2,827</u>	<u>2,847</u>
	Total	6,658	6,677

3.0 SUMMARY OF RESULTS

Chromium (hexavalent and total) testing using Method 5 procedures and Method 13-type impinger trains was conducted at the inlet and outlet of the packed-bed scrubber controlling the 23-foot and 10-foot plating tanks. This was done at four different scrubber water chromic acid concentrations ranging from 0.22 to 13.3 oz of chromic acid per gallon of water. Table 3.1 summarizes the testing schedule for these tests. In addition, a series of tests were also conducted at the scrubber inlet and outlet to evaluate three alternative screening methods for estimating emissions of chromium from chromium plating operations (see Section 3.5).

In brief, from the results of the impinger train testing, the uncontrolled emissions from the tanks with the scrubber liquor at 0.22 oz/gal averaged 0.23 pounds per hour of hexavalent chromium and 0.26 pounds per hour of total chromium. The controlled emissions with the scrubber water at 0.22 oz/gal averaged 0.00096 pounds per hour of hexavalent chromium and 0.0014 pounds per hour of total chromium. The resulting collection efficiency on a mass emission rate basis was 99.54% for hexavalent chromium and 99.38% for total chromium. The collection efficiency ranged from 99.22% to 99.54% for hexavalent chromium and from 99.16% to 99.38% for total chromium. One of the three potential screening methods evaluated for estimating emissions of chromium from chromium plating operations appears to be promising. This method involves collecting the chromium emissions on a 37-mm Teflon filter using a disposable plastic filter cassette and a portable personnel sampling pump. Further evaluation is recommended in conjunction with impinger train testing to obtain a better estimate of the screening method precision and accuracy.

Discussions detailing all the results obtained are presented in the following sections. Computer printouts of the emission calculations are presented in Appendix A. Original field data sheets and the analytical data are located in Appendix B.

TABLE 3.1. TESTING SCHEDULE FOR PIEDMONT INDUSTRIAL PLATING

Date (1986)	Sample Type	Scrubber Inlet		Scrubber Outlet	
		Run No.	Test Time 24 h clock	Run No.	Test Time 24 h clock
8/19	Cr ⁺⁶ , Total Cr	I-1	0847-1100	0-1	0847-1055
	Cr ⁺⁶ , Total Cr	I-2	1131-1342	0-2	1132-1339
	Cr ⁺⁶ , Total Cr	I-3	1423-1640	0-3	1423-1627
8/20	Cr ⁺⁶ , Total Cr	I-4	1046-1325	0-4	1046-1255
	Cr ⁺⁶ , Total Cr	I-5	1347-1600	0-5	1348-1553
	Cr ⁺⁶ , Total Cr	I-6	1624-1832	0-6	1626-1830
8/21	Cr ⁺⁶ , Total Cr	I-7	1051-1258	0-7	1050-1253
	Cr ⁺⁶ , Total Cr	I-8	1350-1556	0-8	1352-1555
	Cr ⁺⁶ , Total Cr	I-9	1639-1846	0-9	1639-1843
8/22	Cr ⁺⁶ , Total Cr	I-10	0831-1036	0-10	0830-1033
	Cr ⁺⁶ , Total Cr	I-11	1113-1403	0-11	1114-1400
	Cr ⁺⁶ , Total Cr	I-12	1428-1632	0-12	1428-1631

3.1 HEXAVALENT CHROMIUM AND TOTAL CHROMIUM

The chromium emissions tests, along with the determination of the associated flue gas flow rates were conducted at both the scrubber inlet and outlet at four scrubber liquor chromic acid concentrations. The samples were collected using a Method 13-type impinger train with no backup filter. For analysis, a measured portion of each impinger sample was initially filtered for insoluble chromium. It was assumed that all insoluble chromium was in the trivalent state and all soluble chromium was in the hexavalent state. The trivalent chromium was measured using inductively coupled argon plasmography (ICAP). The soluble (hexavalent) chromium in each sample was measured using the diphenylcarbazide colorimetric method as described in the tentative EPA method for hexavalent chromium. Total chromium concentrations for each sample were calculated as the sum of the hexavalent chromium concentration and the trivalent chromium concentration. A complete description 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 results represent the uncontrolled emissions from the 32-foot and 10-foot tanks at Piedmont Industrial Plating Company. Prior to testing, a pitot tube traverse was conducted to determine the amount of flow misalignment. The results demonstrated that the flow was parallel with the duct (with an average flow misalignment angle of 5.5°) in spite of the relatively short, straight runs of duct before and after the sampling location. Since the gas conditions and chromium concentrations at the scrubber inlet should not have been affected by the changing scrubber liquor concentrations (which is confirmed by the data), the discussion of the results will simultaneously address the values for all twelve inlet runs.

Flue Gas Conditions and Isokinetic Sampling Rate - A summary of the flue gas conditions at the scrubber inlet is presented in Table 3.2. The volumetric flow rates were consistent at the inlet and averaged 17,400 actual cubic meters per hour (614,000 actual cubic feet per hour). The flow rate at the inlet was approximately 5% less than the outlet flow rate which is within reasonable measurement error. The flue gas temperature averaged 26°C (78°F), with a moisture content of 2.7 percent. The oxygen, carbon dioxide, and carbon

TABLE 3.2. SUMMARY OF FLUE GAS CONDITIONS

Run No.	Date (1986)	Volumetric Flow Rate				Stack Temperature		Moisture %	O ₂ %	CO ₂ %	Isokinetic %
		Actual ^a		Standard ^b		°C	°F				
		acmh x 10 ³	acfh x 10 ³	dscmh x 10 ³	dscfh x 10 ³						
Scrubber Inlet, 0.22 oz/gal CrO ₃											
I-1	8/19	17.6	622	16.5	583	25	77	2.5	20.9	0.0	98.7
I-2	8/19	17.8	629	16.5	584	26	79	3.0	20.9	0.0	99.0
I-3	8/19	18.0	637	16.7	589	26	79	3.4	20.9	0.0	99.5
Average		17.8	629	16.6	585	26	78	3.0	20.9	0.0	
Scrubber Inlet, 3.36 oz/gal CrO ₃											
I-4	8/20	17.1	603	16.0	566	26	78	2.9	20.9	0.0	100.2
I-5	8/20	17.0	600	15.9	563	25	77	2.9	20.9	0.0	97.7
I-6	8/20	17.1	604	16.1	567	25	77	3.0	20.9	0.0	97.7
Average		17.1	602	16.0	565	25	77	2.9	20.9	0.0	
Scrubber Inlet, 6.13 oz/gal CrO ₃											
I-7	8/21	17.2	608	16.2	574	26	78	2.6	20.9	0.0	98.0
I-8	8/21	17.6	621	16.5	582	28	82	2.5	20.9	0.0	98.3
I-9	8/21	17.5	618	16.4	578	28	83	2.5	20.9	0.0	98.1
Average		17.4	616	16.4	578	27	81	2.5	20.9	0.0	
Scrubber Inlet, 13.3 oz/gal CrO ₃											
I-10	8/22	17.3	612	16.5	583	24	75	2.1	20.9	0.0	97.2
I-11	8/22	17.2	608	16.3	574	26	78	2.5	20.9	0.0	97.1
I-12	8/22	17.1	604	16.1	569	26	79	2.5	20.9	0.0	97.0
Average		17.2	608	16.3	575	25	77	2.4	20.9	0.0	
Scrubber Outlet, 0.22 oz/gal CrO ₃											
O-1	8/19	18.7	660	17.6	621	25	77	2.5	20.9	0.0	100.6
O-2	8/19	18.9	668	17.9	631	26	78	2.0	20.9	0.0	103.6
O-3*	8/19	18.7	662	17.5	617	27	80	2.8	20.9	0.0	102.7
Average		18.8	664	17.8	626	26	78	2.2	20.9	0.0	
Scrubber Outlet, 3.36 oz/gal CrO ₃											
O-4	8/20	18.1	638	17.1	605	26	78	2.0	20.9	0.0	102.1
O-5	8/20	18.5	652	17.5	619	26	78	2.2	20.9	0.0	103.0
O-6	8/20	18.0	634	17.0	601	26	79	2.1	20.9	0.0	103.3
Average		18.2	641	17.2	608	26	78	2.1	20.9	0.0	
Scrubber Outlet, 6.13 oz/gal CrO ₃											
O-7	8/21	18.4	650	17.4	616	26	78	2.7	20.9	0.0	100.0
O-8	8/21	18.3	648	17.4	613	27	81	2.3	20.9	0.0	100.8
O-9	8/21	18.1	639	17.1	605	27	80	2.4	20.9	0.0	101.5
Average		18.3	646	17.3	611	27	80	2.5	20.9	0.0	
Scrubber Outlet, 13.3 oz/gal CrO ₃											
O-10	8/22	18.0	637	17.2	607	26	78	2.2	20.9	0.0	101.1
O-11	8/22	18.1	639	17.1	603	27	80	2.7	20.9	0.0	101.4
O-12	8/22	17.9	632	17.1	605	26	79	1.5	20.9	0.0	101.3
Average		18.0	636	17.1	605	26	79	2.1	20.9	0.0	

^aVolumetric flow rate in actual cubic meters per hour (acmh) and actual cubic feet per hour (acfh) at stack conditions.

^bVolumetric flow rate in dry standard cubic meters per hour (dscmh) and dry standard cubic feet per hour (dscfh).

Results for this run not included in average because heavy rain during run entered stack and may have biased results.

monoxide content was that of ambient air at 20.9, 0.0, and 0.0 percent, respectively. The volumetric flow rate at standard conditions averaged 16,300 dry standard cubic meters per hour (576,000 dry standard cubic feet per hour). Standard conditions are 20°C (68°), 760 mm Hg (29.92 in. Hg), and dry basis. The isokinetic sampling rates were well within the allowable for all twelve sample runs.

Hexavalent Chromium Emissions - The hexavalent chromium emissions for each test run (see Table 3.3) were fairly consistent for eleven out of the twelve runs; however, the results indicate some variation in emissions based on process operation. The results for run I-4 were about 3 times higher than for the other runs, and it is suspected that the nozzle may have contacted the duct wall at some time during the run. Therefore, the results for this run have not been included in any of the averages. The uncontrolled hexavalent chromium emissions averaged 5.5 milligrams per dry standard cubic meter (0.0024 grains per dry standard cubic foot) and 0.091 kilograms per hour (0.199 pounds per hour).

Total Chromium Emissions - The total chromium emissions for each test run also were fairly consistent for eleven of the twelve test runs and averaged about 11% higher than the hexavalent chromium emissions. The uncontrolled emissions averaged 6.16 milligrams per dry standard cubic meter (0.0027 grains per dry standard cubic foot) and 0.100 kilograms per hour (0.221 pounds per hour).

3.1.2 Scrubber Outlet

The scrubber outlet represents the controlled emissions from the 23-foot and 10-foot plating tanks. Since the flue gas conditions did not vary with the changing scrubber water concentrations, the results for all twelve outlet runs are discussed in the following subsection. The chromium emission results at each scrubber water chromic acid concentration are addressed in separate subsections.

TABLE 3.3. SUMMARY OF HEXAVALENT CHROMIUM AND TOTAL CHROMIUM EMISSIONS

Run No.	Date (1986)	Hexavalent Chromium				Total Chromium			
		concentration		mass emissions		concentration		mass emissions	
		mg/dscm	gr/dscf x 10 ⁻³	kg/h x 10 ⁻³	lb/h x 10 ⁻³	mg/dscm	gr/dscf x 10 ⁻³	kg/h x 10 ⁻³	lb/h x 10 ⁻³
Scrubber Inlet, 0.22 oz/gal CrO ₃									
I-1	8/19	4.499	1.966	74.2	163.7	5.156	2.253	85.1	187.6
I-2	8/19	7.065	3.087	116.9	257.6	7.978	3.486	132.0	290.9
I-3	8/19	7.035	3.074	117.4	258.7	8.057	3.521	134.4	296.3
Average		6.20	2.71	103	227	7.07	3.09	117	258
Scrubber Inlet, 3.36 oz/gal CrO ₃									
I-4*	8/20	15.941	6.966	255.4	563.1	18.021	7.875	288.7	636.6
I-5	8/20	5.481	2.395	87.4	192.7	5.992	2.619	95.6	210.7
I-6	8/20	6.421	2.806	103.1	227.2	7.010	3.063	112.5	248.1
Average		5.95	2.60	95.2	210	6.50	2.84	104	229
Scrubber Inlet, 6.13 oz/gal CrO ₃									
I-7	8/21	4.905	2.143	79.7	175.7	5.616	2.454	91.2	201.2
I-8	8/21	4.586	2.004	75.6	166.6	5.000	2.185	82.4	181.7
I-9	8/21	4.379	1.914	71.7	158.1	4.802	2.098	78.6	173.3
Average		4.62	2.02	76.3	167	5.14	2.25	84.1	185
Scrubber Inlet, 13.3 oz/gal CrO ₃									
I-10	8/22	6.065	2.650	100.1	220.8	6.571	2.872	108.5	239.2
I-11	8/22	5.495	2.401	89.4	197.0	6.086	2.660	99.0	218.2
I-12	8/22	4.618	2.018	74.4	164.1	5.118	2.236	82.5	181.9
Average		5.39	2.36	88.0	194	5.93	2.59	96.7	213
Scrubber Outlet, 0.22 oz/gal CrO ₃									
O-1	8/19	0.0217	0.0095	0.381	0.840	0.037	0.016	0.644	1.420
O-2	8/19	0.0275	0.0120	0.491	1.083	0.036	0.016	0.648	1.428
O-3**	8/19	0.1463	0.0639	2.557	5.637	0.158	0.069	2.767	6.101
Average		0.0246	0.0108	0.436	0.962	0.036	0.016	0.646	1.42
Scrubber Outlet, 3.36 oz/gal CrO ₃									
O-4	8/20	0.0233	0.0102	0.400	0.883	0.040	0.017	0.678	1.494
O-5	8/20	0.0276	0.0121	0.484	1.067	0.047	0.021	0.829	1.828
O-6	8/20	0.0253	0.0111	0.431	0.950	0.045	0.020	0.774	1.707
Average		0.0254	0.0111	0.438	0.967	0.044	0.019	0.760	1.68
Scrubber Outlet, 6.13 oz/gal CrO ₃									
O-7	8/21	0.0301	0.0132	0.517	1.139	0.035	0.015	0.594	1.309
O-8	8/21	0.0392	0.0171	0.680	1.500	0.044	0.019	0.769	1.696
O-9	8/21	0.0338	0.0147	0.578	1.274	0.039	0.017	0.672	1.481
Average		0.0344	0.0150	0.592	1.30	0.039	0.017	0.678	1.50
Scrubber Outlet, 13.3 oz/gal CrO ₃									
O-10	8/22	0.0319	0.0140	0.549	1.201/1.210	0.042	0.018	0.713	1.573
O-11	8/22	0.0321	0.0140	0.548	1.208	0.044	0.019	0.755	1.664
O-12	8/22	0.0395	0.0172	0.676	1.490	0.053	0.023	0.905	1.996
Average		0.0345	0.0151	0.591	1.271/1.303	0.046	0.020	0.791	1.74

* Results for this run not included in average; it is suspected that nozzle may have contacted duct wall during testing.

**Results for this run not included in average; heavy rain during run entered stack and may have biased results.

Figure 3-1 presents the ranges for the hexavalent chromium emission measurements made at four levels of scrubber water chromic acid concentrations. [EPA to add explanatory paragraph.]

The average total chromium emissions measured at the outlet were 15% to 74% higher than the average hexavalent chromium emissions measured at the corresponding scrubber water chromic acid concentration. This was in contrast to the total chromium emissions measured at the inlet which averaged about 11% higher than the hexavalent chromium emissions, at all four scrubber water concentrations. [EPA to add explanatory paragraph.]

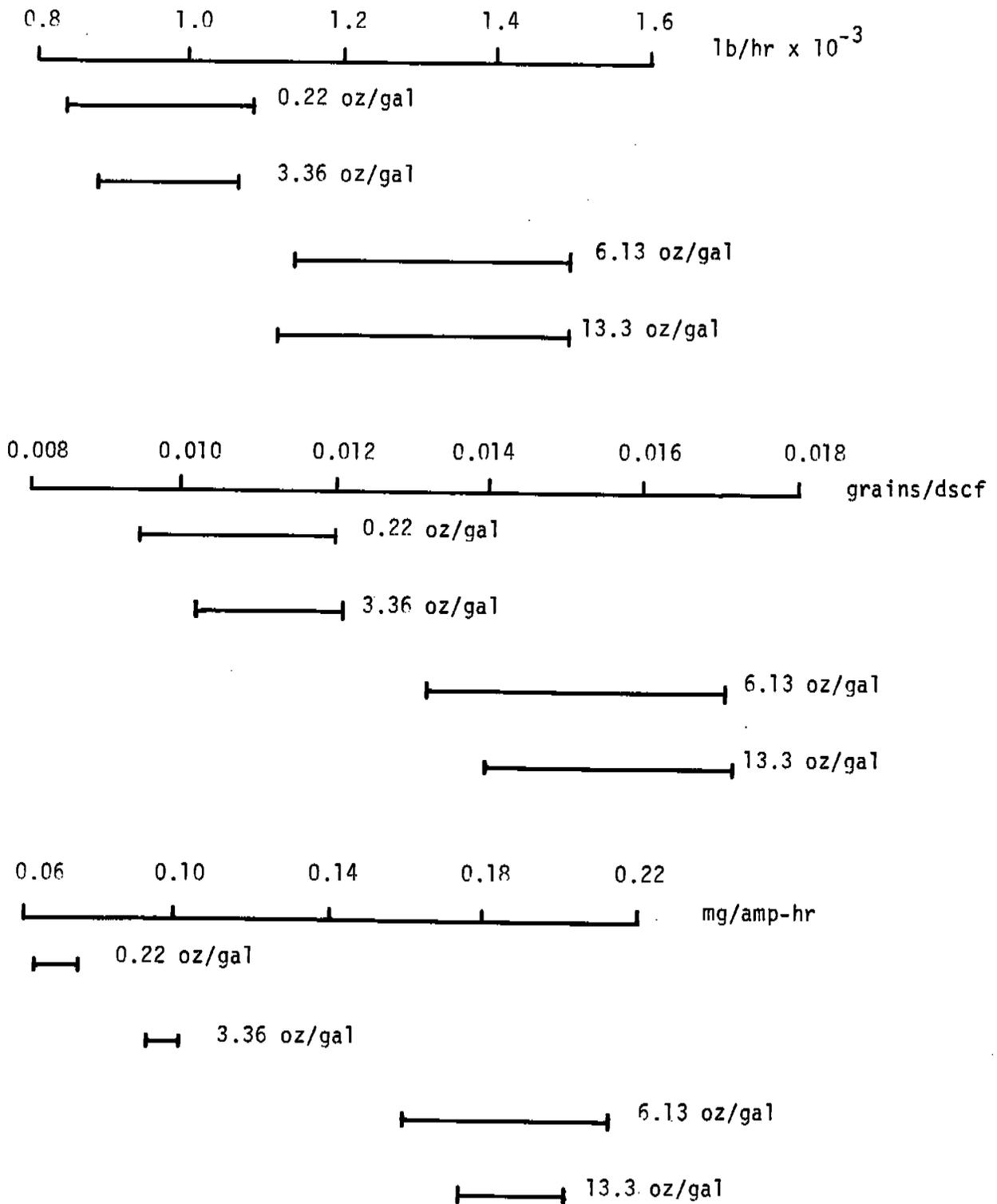


Figure 3-1. Ranges for measurements of hexavalent chromium emissions conducted at four scrubber water chromic acid concentrations for mass emission rate, concentration, and emission rates in units of process rate.

Flue Gas Conditions and Isokinetic Sampling Rate - A summary of the flue gas conditions at the scrubber outlet is presented in Table 3.2. The results from run 0-3 are not included in any of the averages because heavy rain during that run entered the stack and may have biased the results. For subsequent runs, a rain cap was constructed and installed on the stack.

The volumetric flow rate averaged 18,300 actual cubic meters per hour (647,000 actual cubic feet per hour) with a flue gas temperature average of 26°C (78°F) and a moisture content of 2.2 percent. The oxygen, carbon dioxide, and carbon monoxide content was that of ambient air at 20.9, 0.0, and 0.0 percent, respectively. The volumetric flow rate at standard conditions averaged 17,400 dry standard cubic meters per hour (613,000 dry standard cubic feet per hour). Standard conditions are 20°C (68°), 760 mm Hg (29.92 in. Hg), and dry basis. The isokinetic sampling rates were well within the allowable for all twelve sample runs.

Hexavalent and Total Chromium Emissions (Scrubber Liquor at 0.22 oz/gal) - The controlled hexavalent chromium emissions for test runs 0-1 and 0-2 were fairly consistent when compared to the simultaneous inlet runs. The results for run 0-3 were approximately 6 times greater than the other two runs. It is believed that the heavy rains entering the stack during this run may have solubilized chromium on the stack walls, which became re-entrained and biased the results high. Therefore, the results of this run are not included in the averages. Hexavalent chromium emissions for runs 0-1 and 0-2 averaged 0.025 milligrams per dry standard cubic meter (0.00001 grains per dry standard cubic foot) and 0.00044 kilograms per hour (0.00096 pounds per hour).

Controlled total chromium emissions for test runs 0-1 and 0-2 averaged about 48% higher than the hexavalent chromium emissions. The total chromium emissions averaged 0.036 milligrams per dry standard cubic meter (0.000016 grains per dry standard cubic foot) and 0.00065 kilograms per hour (0.0014 pounds per hour).

Hexavalent and Total Chromium Emissions (Scrubber Liquor at 3.36 oz/gal) - The hexavalent chromium emissions were fairly consistent for each of the three test runs (see Table 3.3). They were not significantly different from the hexavalent chromium results with the scrubber liquor chromic acid concentration at 0.22 oz/gal. The controlled hexavalent chromium emissions averaged 0.025

milligrams per dry standard cubic meter (0.00001 grains per dry standard cubic foot) and 0.00044 kilograms per hour (0.00097 pounds per hour).

The total chromium emissions were consistent for each test run and averaged about 74% higher than the hexavalent chromium emissions. The controlled emissions averaged 0.044 milligrams per dry standard cubic meter (0.00019 grains per dry standard cubic foot) and 0.00076 kilograms per hour (0.0017 pounds per hour).

Hexavalent and Total Chromium Emissions (Scrubber Liquor at 6.13 oz/gal) -

The controlled hexavalent chromium emissions for the test runs were fairly consistent from run to run. They averaged about 40% higher than the values measured when the scrubber liquor chromic acid concentration was at 0.22 oz/gal, and averaged 0.034 milligrams per dry standard cubic meter (0.000015 grains per dry standard cubic foot) and 0.00059 kilograms per hour (0.0013 pounds per hour).

The controlled total chromium emissions for each test run were very consistent and averaged about 15% higher than the hexavalent chromium emissions. The total chromium emissions averaged 0.039 milligrams per dry standard cubic meter (0.000017 grains per dry standard cubic foot) and 0.00068 kilograms per hour (0.0015 pounds per hour).

Hexavalent and Total Chromium Emissions (Scrubber Liquor at 13.3 oz/gal) -

The controlled hexavalent chromium emissions for the test runs were fairly consistent from run to run. Overall, they averaged about 40% higher than those measured when the scrubber liquor chromic acid concentration was at 0.22 oz/gal. For the three runs, the hexavalent chromium emission averages were 0.035 milligrams per dry standard cubic meter (0.000015 grains per dry standard cubic foot) and 0.00059 kilograms per hour (0.0013 pounds per hour).

The controlled total chromium emissions for each test run were very consistent and averaged about 37% higher than the hexavalent chromium emissions. The controlled total chromium emissions averaged 0.046 milligrams per dry standard cubic meter (0.000020 grains per dry standard foot) and 0.00079 kilograms per hour (0.0017 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 presented in terms of grams of emissions per hour per square foot of tank surface area and in units of milligrams emissions per amperage input to the plating operation expressed in ampere-hours. To determine the collection efficiency of the scrubber, the mass emission rates in milligrams per hour (uncontrolled emissions and controlled emissions) were used for the calculations.

3.2.1 Emissions in Units of Process Rate

The emissions in terms of units of process rate are expressed in relation to two process parameters, as shown in Table 3.4. The first is milligrams of emissions per hour per amperage input per hour into the plating operation. The second is grams of emissions per hour per square foot of tank surface area. The surface area of the two tanks combined was 99 ft² for all tests.

3.2.2 Scrubber Collection Efficiency

The collection efficiency of the packed-bed scrubber is presented in Table 3.4. It was measured with the scrubber recirculating water or scrubber water at four different chromic acid concentrations to evaluate the effect of increasing the concentration on scrubber efficiency. As is shown in Table 3.4, the collection efficiency did not decrease significantly with scrubber liquor chromic acid concentrations around 10 times the normal concentration at this plant. At a scrubber water concentration of 0.22 oz/gal, the scrubber collection efficiency averaged 99.54 percent by weight for hexavalent chromium and 99.38 percent by weight for total chromium. At a scrubber water concentration of 13.3 oz/gal, the scrubber collection efficiency averaged 99.32 percent by weight for hexavalent chromium and 99.16 percent by weight for total chromium. The collection efficiencies for both hexavalent and total chromium were fairly consistent.

3.3 ANALYSIS OF CHROME PLATING SOLUTIONS AND SCRUBBER LIQUOR

Grab samples of the chrome plating solution were taken from the plating tanks at the middle of each run. Grab samples of the scrubber recirculating water were taken from the scrubber reservoir at the beginning, middle, and end of each test run. A summary of the results for these samples is shown in

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

Run Nos.	Process Rate amp-hr ⁺	Uncontrolled Emissions (Inlet)				Controlled Emissions (Outlet)				Collection Efficiency**	
		hexavalent chromium		total chromium		hexavalent chromium		total chromium		hexavalent chromium %	total chromium %
		mg	g/h	mg	g/h	mg	g/h	mg	g/h		
		amp-hr	ft ² *	amp-hr	ft ² *	amp-hr	ft ² *	amp-hr	ft ² *		
Scrubber Liquor, 0.22 oz/gal											
I.0-1	12.218	12.15	0.75	13.93	0.86	0.0624	0.00384	0.105	0.0065	99.49	99.25
I.0-2	13.223	17.68	1.18	19.97	1.33	0.0743	0.00496	0.098	0.0065	99.58	99.51
I.0-3***	13.028	18.02	1.19	20.63	1.36	0.393	0.0258	0.425	0.0279	97.82	97.94
Avg.	12.720	14.9	0.96	17.0	1.10	0.068	0.0044	0.102	0.0065	99.54	99.38
Scrubber Liquor, 3.36 oz/gal											
I.0-4***	8.556	59.70	2.58	67.48	2.92	0.0935	0.00404	0.158	0.00685	99.84	99.76
I.0-5	9.488	18.42	0.883	20.15	0.97	0.102	0.00489	0.175	0.00837	99.45	99.13
I.0-6	8.466	24.36	1.041	26.58	1.14	0.102	0.00435	0.183	0.00782	99.58	99.31
Avg.	8.980	21.4	0.962	23.4	1.05	0.102	0.00462	0.179	0.00810	99.52	99.22
Scrubber Liquor, 6.13 oz/gal											
I.0-7	6.479	24.60	0.805	28.15	0.921	0.159	0.00522	0.183	0.00600	99.35	99.35
I.0-8	6.399	23.63	0.764	25.75	0.832	0.213	0.00687	0.240	0.00777	99.10	99.07
I.0-9	5.468	26.23	0.724	28.75	0.794	0.211	0.00584	0.246	0.00679	99.19	99.14
Avg.	6.120	24.8	0.764	27.6	0.849	0.194	0.00598	0.223	0.00685	99.22	99.19
Scrubber Liquor, 13.3 oz/gal											
I.0-10	6.322	31.67	1.011	34.32	1.096	0.174	0.00554	0.226	0.00720	99.49	99.34
I.0-11	6.250	28.61	0.903	31.68	1.00	0.175	0.00554	0.242	0.00763	99.39	99.24
I.0-12	6.668	22.32	0.752	24.75	0.833	0.203	0.00683	0.271	0.00914	99.09	98.91
Avg.	6.410	27.5	0.889	30.2	0.976	0.184	0.00597	0.246	0.00799	99.32	99.16

* Emission rate in units of grams per hour per square foot of tank surface (gr/hr/ft²) using tank surface of 99 ft².

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

*** Results for this run not included in average.

+ Average of the inlet and outlet values from Table 2-4.

TABLE 3.5. SUMMARY OF PLATING SOLUTION AND SCRUBBER RECIRCULATING WATER CHROMIC ACID CONCENTRATIONS

Run	Date	Chromic Acid Concentration of Solution (oz/gal)		
		10-Foot Tank	23-Foot Tank	Scrubber Water
I,0-1	8/19	30.30	30.22	0.185
I,0-2	8/19	30.12	30.54	0.231
I,0-3	8/19	29.89	30.94	0.234
Average		30.10	30.57	0.217
I,0-4	8/20	30.60	30.34	3.37
I,0-5	8/20	30.86	30.86	3.41
I,0-6	8/20	31.76	30.47	3.29
Average		31.07	30.56	3.36
I,0-7	8/21	30.70	30.54	6.75
I,0-8	8/21	29.89	30.38	6.04
I,0-9	8/21	26.84	30.22	5.60
Average		29.14	30.38	6.13
I,0-10	8/22	29.32	28.28	10.54*
I,0-11	8/22	30.60	28.54	15.38
I,0-12	8/22	30.60	28.80	14.11
Average		30.17	28.54	13.34

* Scrubber water drained into plating tank toward end of this run.

Table 3.5. There were no significant differences between any of the tank solutions with respect to chromic acid concentration. The table shows the average chromic acid concentration for the scrubber recirculating water for each day of testing. These average values have been used in the discussions of the effect of varying the scrubber water concentration on chromium emissions. Detailed analytical results for all the individual grab samples are presented in Tables 3.6 and 3.7.

3.4 ANALYSIS FOR CHROMIUM IN IMPINGER SAMPLES

The summary of the analytical results for hexavalent and total chromium obtained for each impinger train sample is presented in Table 3.8. The summary of the analytical results for the plating tank and scrubber water grab samples are, as previously stated, presented in Tables 3.6 and 3.7. The results shown in these tables for hexavalent chromium (assumed to be all the soluble chromium) are those obtained by analyzing a measured portion of each sample using the EPA tentative method for hexavalent chromium "Determination of Hexavalent Chromium Emissions from Stationary Sources" (see Appendix C). The results shown for trivalent chromium (assumed to be all the insoluble chromium) were obtained by taking another measured representative portion of the sample, filtering it to catch the insoluble chromium, and analyzing the filter for chromium using inductively-coupled argon plasmography (ICAP). Total catches for hexavalent, trivalent, and total chromium were calculated using the sample volume and concentrations(s) of hexavalent and/or trivalent chromium.

Quality assurance audit samples were analyzed using both the chromium methods; the results are shown in the Quality Assurance Section (5.0). As can be seen in Table 5.2, no bias was present using either of the methods and, thus, the results are considered acceptable.

3.5 SUMMARY OF EVALUATIONS AND RESULTS FOR SCREENING METHOD TESTING

The alternative screening methods evaluated included trains using a personnel sampling pump with either a midget impinger or a 37-mm Teflon filter and gas detector tubes.

The screening method testing using a personnel sampling pump with a midget impinger or 37-mm Teflon filter and cassette was conducted for nominal 30-minute sampling runs concurrent with both the inlet and outlet Method 13-type impinger train runs. The personnel sampling pump runs (using either

TABLE 3.5. SUMMARY OF PLATING SOLUTION AND SCRUBBER RECIRCULATING WATER CHROMIC ACID CONCENTRATIONS

Run	Date	Chromic Acid Concentration of Solution (oz/gal)		
		10-Foot Tank	23-Foot Tank	Scrubber Water
I,0-1	8/19	30.30	30.22	0.185
I,0-2	8/19	30.12	30.54	0.231
I,0-3	8/19	29.89	30.94	0.234
Average		30.10	30.57	0.217
I,0-4	8/20	30.60	30.34	3.37
I,0-5	8/20	30.86	30.86	3.41
I,0-6	8/20	31.76	30.47	3.29
Average		31.07	30.56	3.36
I,0-7	8/21	30.70	30.54	6.75
I,0-8	8/21	29.89	30.38	6.04
I,0-9	8/21	26.84	30.22	5.60
Average		29.14	30.38	6.13
I,0-10	8/22	29.32	28.28	10.54*
I,0-11	8/22	30.60	28.54	15.38
I,0-12	8/22	30.60	28.80	14.11
Average		30.17	28.54	13.34

* Scrubber water drained into plating tank toward end of this run.

TABLE 3.6. ANALYTICAL RESULTS FOR CHROMIUM CONCENTRATION
IN 23-FOOT AND 10-FOOT PLATING TANK GRAB SAMPLES

Run No.	Date (1986)	Chromium Concentration		
		Cr ⁺⁶ g/L	Cr ⁺³ g/L	Total Cr g/L
10-Foot Plating Tank				
1	8/19	118.0	0.003	118.00
2	8/19	117.4	0.001	117.40
3	8/19	116.4	0.011	116.41
4	8/20	119.2	0.007	119.21
5	8/20	120.2	0.002	120.20
6	8/20	123.7	0.006	123.71
7	8/21	119.6	0.001	119.60
8	8/21	116.6	0.001	116.60
9	8/21	104.6	0.002	104.60
10	8/22	114.2	0.002	114.20
11	8/22	119.2	0.007	119.21
12	8/22	119.2	0.001	119.20
23-Foot Plating Tank				
1	8/19	117.7	0.003	117.70
2	8/19	118.9	0.005	118.90
3	8/19	120.5	0.011	120.51
4	8/20	118.2	0.007	118.21
5	8/20	120.2	0.001	120.20
6	8/20	118.7	0.000	118.70
7	8/21	119.0	0.002	119.00
8	8/21	118.3	0.001	118.30
9	8/21	117.7	0.002	117.70
10	8/21	110.2	0.001	110.20
11	8/22	111.2	0.002	111.20
12	8/22	112.2	0.001	112.20

TABLE 3.7. ANALYTICAL RESULTS FOR CHROMIUM CONCENTRATION
IN SCRUBBER RECIRCULATING WATER GRAB SAMPLES

Run #/ Sample #	Date (1986)	Chromium Concentration		
		Cr ⁺⁶ g/L	Cr ⁺³ g/L	Total Cr g/L
1-1	8/19	0.65	0.005	0.66
1-2	8/19	0.68	0.002	0.68
1-3	8/19	0.82	0.002	0.82
2-1	8/19	0.84	0.001	0.84
2-2	8/19	0.89	0.002	0.89
2-3	8/19	0.98	0.003	0.98
3-1	8/19	0.77	0.004	0.77
3-2	8/19	1.03	0.001	1.03
3-3	8/19	0.94	0.001	0.94
4-1	8/20	13.45	0.001	13.45
4-2	8/20	12.78	0.001	12.78
4-3	8/20	13.09	0.004	13.09
5-1	8/20	14.22	0.002	14.22
5-2	8/20	12.47	0.001	12.47
5-3	8/20	13.15	0.002	13.15
6-1	8/20	13.45	0.001	13.45
6-2	8/20	12.14	0.001	12.14
6-3	8/20	12.77	0.001	12.77
7-1	8/21	26.45	0.003	26.46
7-2	8/21	27.82	0.003	27.82
7-3	8/21	24.54	0.003	24.54
8-1	8/21	23.17	0.005	23.17
8-2	8/21	24.33	0.005	24.34
8-3	8/21	23.04	0.005	23.04
9-1	8/21	23.72	0.005	23.72
9-2	8/21	21.67	0.004	21.67
9-3	8/21	19.96	0.007	19.97
10-1	8/22	52.27	0.010	52.28
10-2	8/22	62.38	0.006	62.39
10-3*	8/22	8.34	0.002	8.34
11-1	8/22	57.18	0.005	57.19
11-2	8/22	60.36	0.005	60.37
11-3	8/22	61.95	0.003	61.95
12-1	8/22	53.39	0.006	53.39
12-2	8/22	58.56	0.000	58.56
12-3	8/22	52.78	0.006	52.78

* Scrubber water drained into plating tank prior to time this sample was taken.

TABLE 3.8. ANALYTICAL RESULTS FOR HEXAVALENT AND TRIVALENT CHROMIUM
IN IMPINGER TRAINS

Run No.	Date (1986)	Sample Type	Total Catch Cr +6 (mg)	Total Catch Cr +3 (mg)	Total Catch Total Cr (mg)
Scrubber Inlet					
I-1	8/19	Impinger	11.40	1.66	13.06
I-2	8/19	Impinger	17.99	2.32	20.31
I-3	8/19	Impinger	18.15	2.64	20.79
I-4	8/20	Impinger	39.81	5.20	45.00
I-5	8/20	Impinger	13.28	1.24	14.52
I-6	8/20	Impinger	15.65	1.43	17.09
I-7	8/21	Impinger	12.14	1.77	13.90
I-8	8/21	Impinger	11.56	1.04	12.60
I-9	8/21	Impinger	10.93	1.05	11.99
I-10	8/22	Impinger	15.13	1.26	16.39
I-11	8/22	Impinger	13.49	1.45	14.94
I-12	8/22	Impinger	11.22	1.22	12.44
Scrubber Outlet					
O-1	8/19	Impinger	0.083	0.058	0.141
O-2	8/19	Impinger	0.111	0.035	0.146
O-3	8/19	Impinger	0.571	0.047	0.618
O-4	8/20	Impinger	0.091	0.050	0.141
O-5	8/20	Impinger	0.102	0.072	0.174
O-6	8/20	Impinger	0.091	0.072	0.163
O-7	8/21	Impinger	0.105	0.016	0.121
O-8	8/21	Impinger	0.140	0.018	0.158
O-9	8/21	Impinger	0.120	0.019	0.139
O-10	8/22	Impinger	0.113	0.034	0.147
O-11	8/22	Impinger	0.113	0.043	0.156
O-12	8/22	Impinger	0.140	0.047	0.187

the impinger or filter) were conducted through whichever port at each location was not occupied by the impinger train. Since the Method 13-type impinger train runs were two hours in duration, it was possible to conduct a personnel sampling pump run first with the impinger for 30 minutes and then with the filter for 30 minutes, without interfering with the impinger train run.

Detector tube measurements were made towards the end or directly following each Method 13-type impinger train run, as time allowed. Both the detector tube sample pump and an extra personnel sampling pump were used to draw samples through the detector tubes.

Table 3.9 summarizes the analytical results for hexavalent and trivalent chromium for the samples collected for the screening method tests using a personnel sampling pump. The results for hexavalent chromium (assumed to be all the soluble chromium) were obtained by the EPA draft method for hexavalent chromium. The results for trivalent chromium (assumed to be all the insoluble chromium) were obtained using ICAP to measure the chromium caught in a filtered representative portion of the sample. Trivalent chromium was not analyzed for the filter samples. Total chromium catches were calculated as discussed for Table 3.8.

Table 3.10 presents a summary of the sampling parameters and chromium emission results for each screening method run. Each of the sampling pumps used was calibrated prior to the testing and the calibration values used to calculate the actual flow rate during testing. All filter and impinger runs were approximately 30 minutes in duration; exact sampling times are listed in Table 3.10. The total volume of gas sampled was calculated by multiplying the actual flow rate by the sampling time and correcting to standard conditions (68°F and 29.92 in. Hg) using the barometric pressure and stack gas temperature measured for the corresponding impinger train run. The catch weights of chromium from Table 3.9 were then used to calculate the mass emission values shown in Table 3.10. The following sections discuss the results for each screening method in more detail. Comparative results are presented in Table 3.11.

3.5.1 Detector Tubes

The results for the detector tubes shown in Table 3.11 indicate that they are totally unacceptable as a screening method.

Detector tubes specific for a particular compound or element are used in combination with a hand pump. The pump is designed to pull a precise volume

TABLE 3.9. ANALYTICAL RESULTS FOR HEXAVALENT AND TRIVALENT CHROMIUM
IN SCREENING METHOD SAMPLES

Run No.	Date (1986)	Sample Type	Total Catch Cr ⁺⁶ ug	Total Catch Cr ⁺³ ug**	Total Catch Total Cr ug
Scrubber Inlet					
I-1	8/19	Impinger	398.14	29.075	427.22
I-2	8/19	Impinger	245.39	17.050	262.44
I-3	8/19	Impinger	598.46	42.275	640.74
I-4*	8/20	Impinger	410.66	24.075	434.74
I-5	8/20	Impinger	26.29	2.450	28.74
I-6*	8/20	Impinger	10.02	<0.25	10.02
I-7	8/21	Impinger	570.91	36.125	607.04
I-8	8/21	Impinger	355.57	23.850	379.42
I-9	8/21	Impinger	127.70	6.900	134.60
I-10	8/22	Impinger	175.28	7.850	183.13
I-11	8/22	Impinger	300.48	19.125	319.61
I-12	8/22	Impinger	518.33	32.475	550.81
I-1	8/19	Filter	305.5		
I-2	8/19	Filter	702.9		
I-3	8/19	Filter	653.4		
I-4	8/20	Filter	1,230.3		
I-5*	8/20	Filter	--		
I-6	8/20	Filter	33.3		
I-7	8/21	Filter	282.1		
I-8	8/21	Filter	326.0		
I-9	8/21	Filter	295.1		
I-10	8/22	Filter	571.7		
I-11	8/22	Filter	504.6		
I-12	8/22	Filter	175.0		
Scrubber Outlet					
O-1	8/19	Impinger	0.7	<0.25	0.7
O-2	8/19	Impinger	0.7	0.350	1.05
O-3	8/19	Impinger	11.0	<0.25	11.0
O-4	8/20	Impinger	0.2	0.275	0.48
O-5*	8/20	Impinger	0.3	<0.25	0.3
O-6	8/20	Impinger	1.2	<0.25	1.2
O-7	8/21	Impinger	1.2	<0.25	1.2
O-8	8/21	Impinger	2.5	<0.25	2.5
O-9	8/21	Impinger	3.0	<0.25	3.0
O-10	8/22	Impinger	0.7	<0.25	0.7
O-11	8/22	Impinger	5.8	<0.25	5.8
O-12	8/22	Impinger	1.3	<0.25	1.3
O-1	8/19	Filter	1.66		
O-2	8/19	Filter	3.04		
O-3	8/19	Filter	9.45		
O-4	8/20	Filter	2.26		
O-5	8/20	Filter	1.81		
O-6	8/20	Filter	5.83		
O-7	8/21	Filter	3.81		
O-8	8/21	Filter	4.51		
O-9	8/21	Filter	5.45		
O-10	8/22	Filter	1.68		
O-11	8/22	Filter	2.93		
O-12	8/22	Filter	1.65		

*Runs aborted or not conducted for technical reasons.
**Due to dilution factors, 0.25 ug is the lower detection limit for this analytical method.

TABLE 3.10. SUMMARY OF SAMPLING PARAMETERS AND CHROMIUM EMISSION RESULTS FOR SCREENING METHODS USING PERSONNEL SAMPLING PUMP

Run No.	Date (1986)	Sample Type	Flow Rate L/min	Sampling Time min	Total Vol. Sampled L std	Mass Emissions	
						Cr+6 mg/dscm	Total Cr mg/dscm
Scrubber Inlet							
I-1	8/19	Impinger	0.924	30.0	26.66	14.93	16.02
I-2	8/19	Impinger	0.924	30.0	26.67	9.20	9.84
I-3	8/19	Impinger	0.924	29.5	26.23	22.82	24.43
I-4*	8/20	Impinger	--	--	--	--	--
I-5	8/20	Impinger	0.935	32.0	29.09	0.90	0.99
I-6*	8/20	Impinger	--	--	--	--	--
I-7	8/21	Impinger	0.924	31.0	27.89	20.47	21.77
I-8	8/21	Impinger	0.924	34.0	30.37	11.71	12.49
I-9	8/21	Impinger	0.924	29.5	26.30	4.86	5.12
I-10	8/22	Impinger	0.930	30.0	27.32	6.42	6.70
I-11	8/22	Impinger	0.911	60.6	53.71	5.59	5.95
I-12	8/22	Impinger	0.911	40.0	35.44	14.63	15.54
Scrubber Inlet							
I-1	8/19	Filter	3.646	30.0	105.68	2.89	
I-2	8/19	Filter	3.325	30.0	96.02	7.32	
I-3	8/19	Filter	3.417	27.0	88.82	7.36	
I-4	8/20	Filter	3.458	30.0	100.72	12.22	
I-5*	8/20	Filter	--	--	--	--	
I-6	8/20	Filter	3.602	40.0	140.15	0.24	
I-7	8/21	Filter	3.602	32.0	112.29	2.51	
I-8	8/21	Filter	3.602	35.0	121.91	2.67	
I-9	8/21	Filter	3.602	37.5	128.71	2.29	
I-10	8/22	Filter	2.617	30.0	76.91	7.43	
I-11	8/22	Filter	2.617	35.0	89.23	5.66	
I-12	8/22	Filter	2.477	32.0	77.06	2.27	
Scrubber Outlet							
O-1	8/19	Impinger	0.930	20.0	18.06	0.04	0.04
O-2	8/19	Impinger	0.935	30.0	27.04	0.03	0.04
O-3*	8/19	Impinger	--	--	--	--	--
O-4	8/20	Impinger	0.930	30.0	26.80	0.01	0.02
O-5*	8/20	Impinger	--	--	--	--	--
O-6	8/20	Impinger	0.935	30.0	27.17	0.04	0.04
O-7	8/21	Impinger	0.925	61.0	54.98	0.02	0.02
O-8	8/21	Impinger	0.930	34.0	30.62	0.08	0.08
O-9	8/21	Impinger	0.930	33.0	29.78	0.10	0.10
O-10	8/22	Impinger	0.924	30.0	26.99	0.03	0.03
O-11	8/22	Impinger	0.924	30.0	26.89	0.22	0.22
O-12	8/22	Impinger	0.924	38.5	34.58	0.04	0.04
Scrubber Outlet							
O-1	8/19	Filter	3.670	30.0	106.35	0.02	
O-2	8/19	Filter	3.460	28.0	93.37	0.03	
O-3	8/19	Filter	3.037	33.0	96.30	0.10	
O-4	8/20	Filter	3.347	30.0	97.13	0.02	
O-5	8/20	Filter	3.271	31.0	98.45	0.02	
O-6	8/20	Filter	2.710	40.0	105.05	0.06	
O-7	8/21	Filter	2.929	32.0	91.30	0.04	
O-8	8/21	Filter	2.650	35.0	89.84	0.05	
O-9	8/21	Filter	2.719	36.0	95.02	0.06	
O-10	8/22	Filter	3.602	30.0	105.27	0.02	
O-11	8/22	Filter	3.602	34.5	120.62	0.02	
O-12	8/22	Filter	3.602	32.0	112.08	0.01	

* Runs aborted or not conducted for technical reasons.

TABLE 3.11. COMPARISON OF IMPINGER TRAIN AND SCREENING METHOD RESULTS

Run No.	Impinger Train mg/dscm	Concentration of Hexavalent Chromium and Relative Percent Difference from Impinger Train Value					
		Screening Method					
		Impinger		Filter		Detector Tube	
		mg/dscm	%	mg/dscm	%	mg/m ³	%
Scrubber Inlet							
I-1	4.50	14.93	232	2.89	- 36	1.0	- 78
I-2	7.07	9.20	30	7.32	4	<1.0	>-86
I-3	7.04	22.82	224	7.36	5	*	*
I-4	15.94	*	*	12.22	- 23	1.0	- 94
I-5	5.48	0.90	- 84	*	*	*	*
I-6	6.42	*	*	0.24	- 96	2.0	- 69
I-7	4.90	20.47	317	2.51	- 49	*	*
I-8	4.59	11.71	155	2.67	- 42	0.4	- 91
I-9	4.38	4.86	11	2.29	- 48	0.5	- 89
I-10	6.06	6.42	6	7.43	27	1.0	- 84
I-11	5.50	5.59	2	5.66	3	1.65	- 70
I-12	4.62	14.63	217	2.27	- 51	2.0	- 57
Scrubber Outlet							
O-1	0.022	0.039	79	0.016	- 28	0.1	362
O-2	0.028	0.026	- 6	0.033	18	0.15	445
O-3	0.146	*	*	0.098	- 33	0.1	- 32
O-4	0.023	0.007	- 68	0.023	0	<0.1	>328
O-5	0.028	*	*	0.018	- 33	<0.1	>262
O-6	0.025	0.044	75	0.055	120	<0.1	>295
O-7	0.030	0.022	- 28	0.042	38	0.017	- 44
O-8	0.039	0.082	108	0.050	28	*	*
O-9	0.034	0.101	199	0.057	70	*	*
O-10	0.032	0.026	- 19	0.016	- 50	0.02	- 37
O-11	0.032	0.216	572	0.024	- 24	0.02	- 38
O-12	0.039	0.038	- 5	0.015	- 63	0.03	- 24

*Runs not conducted, aborted, or data not valid (see text).

of gas sample through a detector tube. The compound of interest in the air reacts with the reagent(s) in the tube which affects a color change indicating the concentration of the compound by stain length or depth of coloration. The number of pump strokes is specified for the tube to read in the range of concentrations for which a tube is designed. In some cases, as was done for this testing, the number of strokes may be increased or decreased to test concentrations outside this range.

In general, detector tubes are designed to measure low concentrations of a compound in ambient air. In the case of chromic acid testing, when the sample concentrations drawn through the tubes were in excess of the indicating capacity of the tubes, they often gave an indication representative of a lesser concentration. Determining the exact color of a tube was also a problem. Many times the color was between or lighter than the colors of the color comparison tube. In addition, the color indication band on the chromic acid tubes begins to fade within 15 to 30 minutes of sampling. Therefore, they could not be submitted to a responsible party for confirmation of the results.

To use detector tubes as a screening method, it would be necessary to know the approximate concentration of the gas being measured to be able to gauge the number of pump strokes required to obtain a reading. In many cases, this information would not be readily available. Therefore, numerous tubes would have to be run to bracket the number of pump strokes required. Based on the lack of reproducibility and accuracy shown in this test series, this procedure would be difficult at best. Any variations in process rate during the bracketing would cause additional difficulty.

As the chromic acid concentration of the gas being measured decreases, the number of pump strokes required for an indication increases. Some of the tube readings taken on this test required more than 100 pump strokes. Because of the rate of sample passage through the packing in the tube, the time required for one pump stroke is approximately 10 seconds. This means that 100 pump strokes require about an hour to accomplish. This would easily cause operator fatigue, particularly since it is highly likely that more than one tube reading would be necessary.

Based on the results and experience from this test and additional work by both EPA and EPA contractor personnel (see the EPA memo in Appendix C), the detector tubes are not considered a viable screening technique for this application.

3.5.2 Filter and Personnel Pump Train

The results of sampling with the filter and personnel pump presented in Table 3.11 suggests that this method may be acceptable. Most of the measured values from the filter screening method were within 50% of the impinger train value.

As demonstrated by the data in Table 3.12, almost all of the sample was collected in the nozzle and probe portions of the train. The precision of this screening method would probably improve and be within an acceptable range if one of two modifications was made. The first would involve using the existing train and improving the probe cleaning (sample recovery) technique. The second (and probably better) modification would involve eliminating the probe and using the filter cassette in-stack with only a nozzle in front of it. This method would result in a greater proportion of the catch on the filter and would yield less surface area from which to recover the sample.

This screening method could be used as is, but the precision would probably improve with the addition of one of the above mentioned modifications. In addition, the method can be readily performed by any individual skilled in plant maintenance or laboratory operations.

3.5.3 Impinger and Personnel Pump Train

The results shown in Table 3.11 for the single impinger and the personnel pump train would generally be considered too imprecise to be used as a screening method. The precision of the method could probably be improved by modifying the sampling procedures to include better probe cleaning techniques.

The main reason for the imprecision is probably the same as for the filter train, that most of the sample is collected in the nozzle and probe. Due to the size of the impinger and the fact that it must be maintained in an upright position, it would not be advantageous to remove the probe from the train and sample with the impinger in the stack.

The impinger and personnel pump train as a screening method did not demonstrate any advantage over the filter train. In fact, it would require greater skill to operate and should therefore only be considered a weak alternative to the filter train system.

TABLE 3.12. COMPARISON OF CHROMIUM CATCH ON FILTER VS. IN PROBE RINSE

Run	Percentage of Total Hexavalent Chromium Catch	
	Filter	Probe
I-1-F	0.16%	99.84%
I-2-F	0.56%	99.44%
I-3-F	0.06%	99.94%
I-4-F	0.03%	99.97%
I-5-F	—	—
I-6-F	0.30%	99.70%
I-7-F	0.04%	99.96%
I-8-F	0.03%	99.97%
I-9-F	0.04%	99.96%
I-10-F	0.13%	99.87%
I-11-F	0.32%	99.68%
I-12-F	2.85%	97.15%
Average	0.41%	99.59%
0-1-F	8.76%	91.24%
0-2-F	29.63%	70.37%
0-3-F	9.90%	90.10%
0-4-F	26.17%	73.83%
0-5-F	13.72%	86.28%
0-6-F	7.20%	92.80%
0-7-F	14.63%	85.37%
0-8-F	28.38%	71.62%
0-9-F	11.49%	88.51%
0-10-F	5.62%	94.38%
0-11-F	3.30%	96.70%
0-12-F	5.71%	94.29%
Average	13.71%	86.29%

4.0 SAMPLING LOCATIONS AND TEST METHODS

This section describes the sampling locations and test methods used to characterize emissions from the hard chromium plating tanks at Piedmont Industrial Plating Company in Statesville, North Carolina. Five sampling locations were used in the emissions testing program. At two sampling locations (one at the scrubber inlet and one at the scrubber outlet), emissions testing was conducted for hexavalent and total chromium using a Method-13 type impinger train. Total chromium content was calculated as the sum of the hexavalent and trivalent chromium. At the large and small plating tank locations, grab samples were taken at the middle of each sampling run. Three grab samples per sampling run were collected from the fifth location, the scrubber recirculating water reservoir. All grab samples were analyzed for hexavalent and trivalent chromium concentrations. 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 that follow further describe each sampling location and applicable test methods.

4.1 SCRUBBER INLET (SAMPLING LOCATION A)

Hexavalent chromium and total chromium emissions were measured at the inlet to the scrubber, as shown in Figure 4.2. Two sampling ports were installed 90° apart in the horizontal circular duct (27 inches in diameter). These ports were located 8.8 inches (0.33 duct diameters) upstream of a bend in the duct to the scrubber and 55.2 inches (2.04 duct diameters) downstream from another bend.

For the Method 13-type impinger train testing (refer to Appendix C for further discussion of sampling train and sample analysis procedures), a total of 24 points as per Method 1, were sampled. Each of the 24 points was sampled for 5 minutes for a total of 120 minutes of sampling per run. Each run was performed concurrently with sampling at the scrubber outlet location.

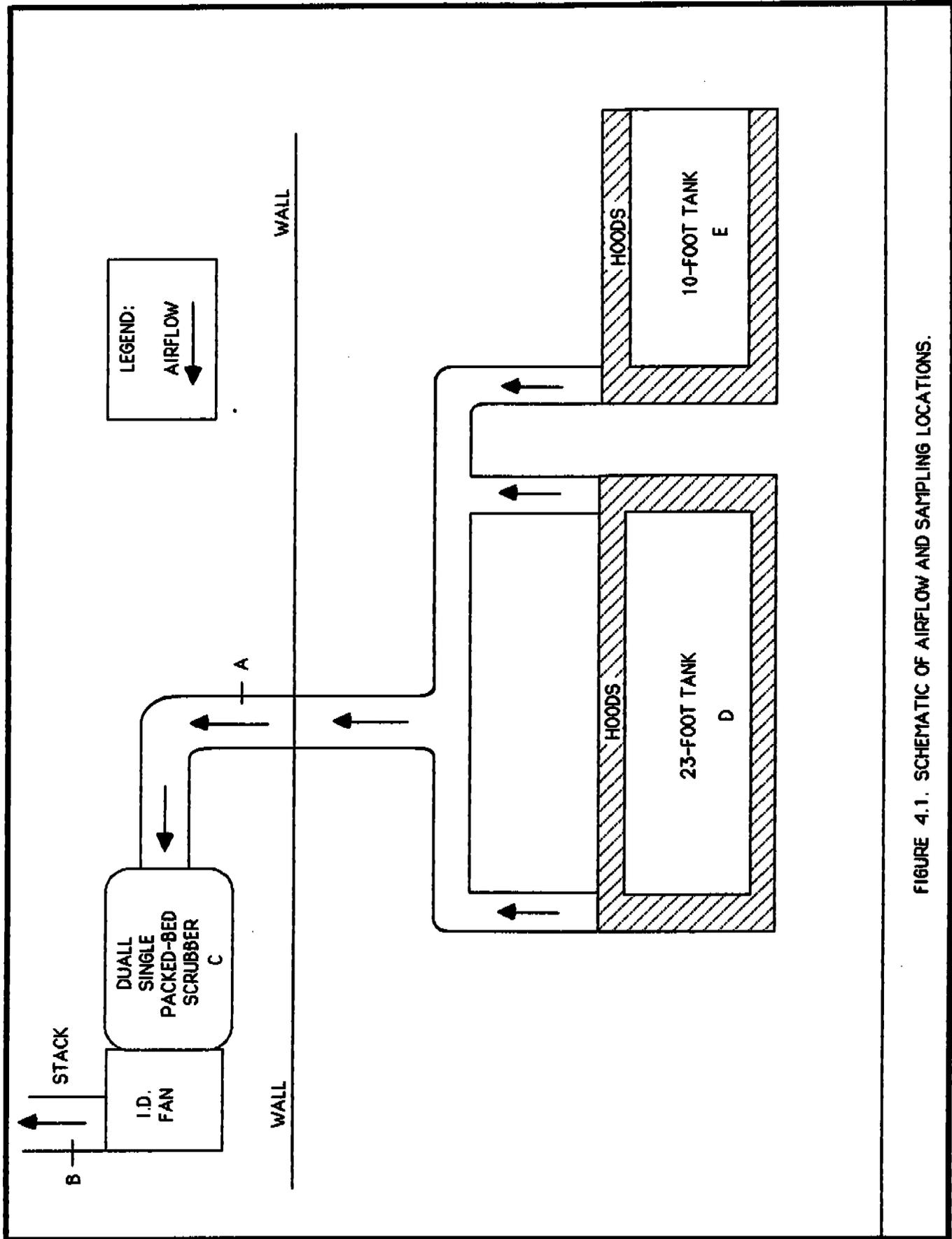


FIGURE 4.1. SCHEMATIC OF AIRFLOW AND SAMPLING LOCATIONS.

TABLE 4.1. SAMPLING PLAN FOR PIEDMONT INDUSTRIAL PLATING COMPANY

Sample Type	Sampling Locations	Number of Samples	Methods*
Standards Setting			
Hexavalent Cr	A & B	12 each	Method 13-Type Impinger Train & Tentative Method for Cr ⁺⁶
Total Cr	A & B	12 each	Method 13-Type Impinger Train & ICP Analysis for Cr ⁺³
Hexavalent & Total Cr	C D E	12 sets of 3 grab 12 grab 12 grab	Tentative EPA Method for Cr ⁺⁶ & ICP for Cr ⁺³
Screening Methods Development			
Hexavalent & Total Cr	A & B	12 each	Personnel Monitoring Pump with Midget Impinger and Tentative EPA Method for Cr ⁺⁶ and ICP for Cr ⁺³
Hexavalent & Total Chromium	A & B	12 each	Personnel Monitoring Pump with Teflon Filter and Tentative EPA Method for Hexavalent Cr ⁺⁶
Chromic Acid	A & B		Detector Tubes

* ICP: Inductively-Coupled Argon Plasmography

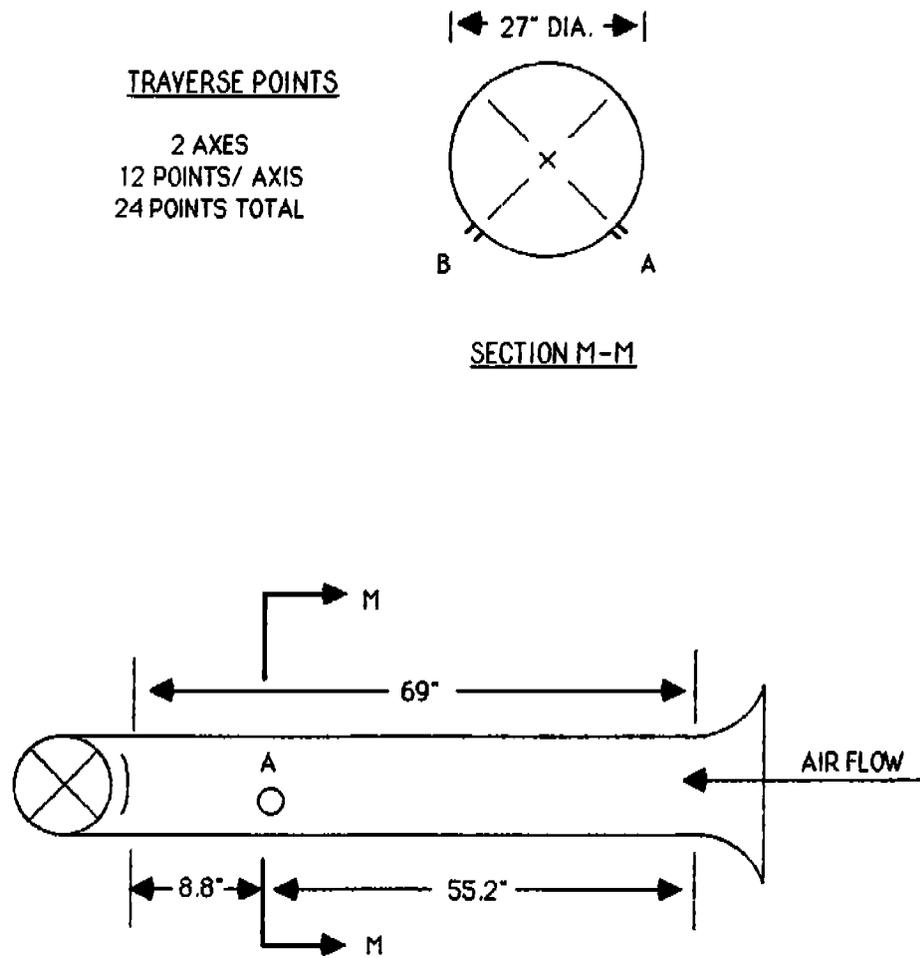


FIGURE 4.2. PIEDMONT INDUSTRIAL PLATING COMPANY: SCRUBBER INLET.

4.2 SCRUBBER OUTLET (SAMPLING LOCATION B)

Hexavalent chromium and total chromium emissions were measured at the scrubber outlet as shown in Figure 4.3. Two sampling ports were installed 90° apart in the vertical circular stack (24 inches in diameter). These ports were located 14 inches (0.58 duct diameters) upstream from the stack exit and 56 inches (2.33 duct diameters) downstream from the fan.

For the Method 13-type impinger train testing (refer to Appendix C for further discussion of sampling train and sample analysis procedures), a total of 24 points as per Method 1, were sampled. Each of the 24 points was sampled for 5 minutes for a total of 120 minutes of sampling per run. Each run was performed concurrently with sampling at the scrubber inlet location.

4.3 SCRUBBER RECIRCULATION WATER RESERVOIR (SAMPLING LOCATION C)

During each sampling run, three grab samples of the scrubber recirculation water were taken from the scrubber reservoir (Sampling Location C). The samples were analyzed for hexavalent and trivalent chromium concentrations. The chromium concentration of the scrubber recirculation water was varied prior to each day's testing by transferring a pre-determined volume of plating solution from the plating tanks into the scrubber reservoir. Three simultaneous inlet and outlet emission sampling runs were performed at each of the four scrubber water chromium concentrations.

4.4 PLATING TANK SOLUTIONS (SAMPLING LOCATIONS D AND E)

At the middle of each sampling test run, grab samples of the plating tank solution of both the 23-foot (Sampling Location D) and 10-foot (Sampling Location E) tanks were collected. The samples were analyzed for hexavalent and trivalent chromium concentrations.

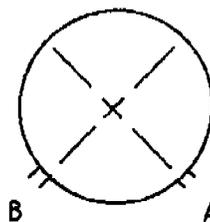
4.5 VELOCITY AND TEMPERATURE

A type S pitot tube and magnehelic gauges were used to measure the gas velocity pressure (ΔP). Velocity pressures were measured at each sampling point across the duct or stack to determine an average value according to the procedures outlined in Method 2. The temperature at each sampling point was measured using a thermocouple and digital readout.

TRAVERSE POINTS

2 AXES
12 POINTS/AXIS
24 POINTS TOTAL

← 24" DIA. →



SECTION M-M

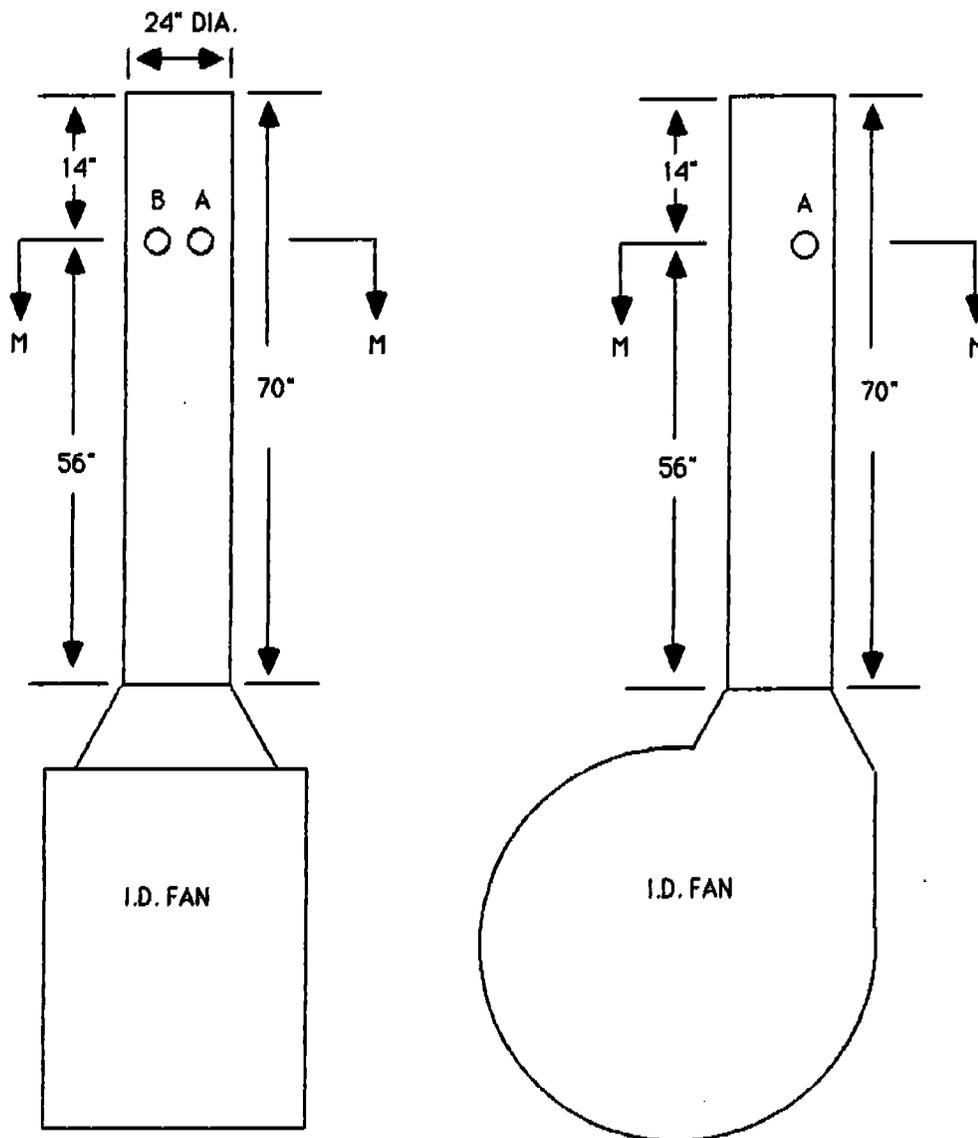


FIGURE 4.3. PIEDMONT INDUSTRIAL PLATING COMPANY: SCRUBBER OUTLET.

4.6 MOLECULAR WEIGHT

The flue gas composition and molecular weight were assumed to be those of ambient air.

4.7 SAMPLING TRAINS

Hexavalent Chromium and Total Chromium - A Method 13-type impinger train was used to capture chromium emissions at Sampling Locations A and B. All tests were conducted isokinetically by traversing the cross-sectional area of the duct or 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. The sampling train consisted of a heated, glass-lined probe, a filter bypass, four impingers (the first two containing 100 ml of 0.1N NaOH each and the fourth containing silica gel). Previous test programs using Method 13-type trains have shown greater than 99% hexavalent and total chromium collection prior to a back half filter. As a result, this test program opted to omit the use of a filter in the sampling train. A deionized water rinse of the nozzle, probe, and first three impingers was made at the end of each test.

Personnel Monitoring Pump - Personnel monitoring pump sampling was performed twice per run concurrent with the impinger train runs. During each 120-minute impinger train sampling run, two 30 to 45 minute personnel monitoring pump sampling runs were performed, one using a midget impinger containing 15 ml of 0.1N NaOH and one using a 37-mm Teflon filter for collecting the chromium emissions. Sampling was conducted at both the inlet (Sampling Location A) and the outlet (Sampling Location B) of the packed-bed scrubber. The sampling trains consisted of a 2-1/2 foot Teflon tube-lined probe, the midget impinger or filter cassette with a Teflon filter, and the personnel sampling pump. The pump was set to sample at 1.0 liter per minute for the impinger runs and 3.5 to 4.0 liters per minute for the filter runs. All samples were analyzed for hexavalent chromium content; midget impinger samples were also analyzed for trivalent chromium content.

Detector Tube Sampling - Detector tube sampling was performed during or immediately following each impinger train run. Samples were collected at both Sampling Locations A and B using a Draeger™ pump and Draeger chromic acid detector tubes following the manufacturer's instructions. In cases where

greater than 200 pump strokes were required to elicit an indication on the detector tube, a personnel sampling pump was used to draw the stack gas through the tube.

4.8 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 assumption was made that all soluble chromium was in the hexavalent state. At the end of each Method 13-type impinger train run, the impinger reagent and train rinsings were combined into one sample which was analyzed for hexavalent chromium content using this method. This method was also used to determine the hexavalent chromium content in the process grab samples and in the personnel monitoring pump samples (impinger and filter samples) that were collected.

4.9 TRIVALENT CHROMIUM CONTENT

Trivalent chromium content was determined using Inductively Coupled Argon Plasmography (ICP) (see Appendix C); the assumption was made that all insoluble chromium was in the trivalent state. Portions of each impinger and each process sample were initially filtered. Then the filters were nitric acid-digested and the digestate was analyzed for chromium by RTI using ICAP. Total chromium contents of the impinger samples, process samples, and midget impinger samples were calculated using the analytical results for hexavalent chromium and trivalent chromium.

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. Two such documents were used in this test program to ensure the collection of acceptable data and to provide a definition of unacceptable data. These documents are: the EPA Quality Assurance Handbook Volume III, EPA-600/4-77-027 and Entropy's "Quality Assurance Program Plan" which has been approved by the U.S. EPA, EMB.

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

- Calibration of field sampling equipment. (Appendix D describes calibration guidelines in more detail.)
- Checks of train configuration and on calculations.
- On-site quality assurance checks such as sampling train, pitot tube, and quality assurance checks of all test equipment prior to use.
- Use of designated analytical equipment and sampling reagents.

Table 5.1 summarizes the on-site audit data sheets for the sampling equipment used for the testing at each sampling location, including deviation limits. In addition to the pre- and post-test calibration audits, a field audit was performed on the meter boxes used for sampling. Entropy used the procedures described in the December 14, 1983 Federal Register (48FR55670). Appendix D includes the audit run data sheets for each dry gas meter used for the testing and audit data sheets for the other sampling equipment.

Audit samples prepared by Entropy were used to check the analytical procedures of the laboratory conducting the hexavalent and trivalent chromium analyses. One of these samples was a hexavalent chromium solution (QA-2). the other sample was prepared by passing a hexavalent chromium solution through the same type of filter used to collect trivalent chromium. This was done to confirm that only trivalent chromium would be collected. Table 5.2

TABLE 5.1. FIELD EQUIPMENT CALIBRATION

Equipment	Reference	Allowable Error	Actual Error	Within Allowable Limits
Scrubber Inlet				
Meter box (N-6)	Wet test meter	$Y \pm 0.03Y$	0.0115	✓
Meter box thermometer	ASTM-3F at ambient temperature	5 °F	1 °F	✓
Impinger thermometer	ASTM-3F at ambient temperature	2 °F	0 °F	✓
Stack thermometer	ASTM-3F at ambient temperature	7 °F	0 °F	✓
Scrubber Outlet				
Meter box (N-8)	Wet test meter	$Y \pm 0.03Y$	0.0137	✓
Meter box thermometer	ASTM-3F at ambient temperature	5 °F	0 °F	✓
Impinger thermometer	ASTM-3F at ambient temperature	2 °F	2 °F	✓
Stack thermometer	ASTM-3F at ambient temperature	7 °F	3 °F	✓

presents the results of these analytical audits; they indicate that the analytical techniques were accurate.

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 5.2. AUDIT REPORT CHROMIUM ANALYSIS

Plant: Piedmont Industrial Plating Task No.: 3505
 Date Samples Received: 8/86 Date Analyzed: 9/86
 Samples Analyzed By: RTI
 Reviewed By: Peter Grohse Date of Review: 9/86

Sample Number	ug/mL Cr ⁺⁶ or Cr	Source of Sample	Analytical Technique	Audit Value	Relative Error, %
QA-1	0.ug Cr on filter	QAD/EEI	ICP	0.0	0.0
QA-2	1.ug/ml Cr ⁺⁶	QAD	ICP	1.03	+3.0
QA-2	1.ug/ml Cr ⁺⁶	QAD	Cr ⁺⁶	1.01	+1.0

APPENDIX A
COMPUTER PRINTOUTS

Nomenclature and Dimensions

- A_s = cross-sectional area of stack, ft²
- A_n = area of sampling nozzle, ft²
- B_{ws} = proportional by volume of water vapor in the gas stream, dimensionless
- C_p = pitot tube coefficient, dimensionless
- $C's$ = concentration of particulate matter in stack gas, g/scf, dry basis
- % CO = percent of carbon monoxide by volume, dry basis
- % CO₂ = percent of carbon dioxide by volume, dry basis
- ΔH = average pressure drop across the orifice meter, in. of H₂O
- I = percent of isokinetic sampling
- L_a = maximum acceptable leakage rate for either a pretest leak or for a leak check following a component change; equal to 0.00057 m³/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less
- M_d = dry molecular weight, lb/lb-mole.
- M_n = total amount of particulate matter collected, mg
- M_s = molecular weight of stack gas (wet basis), lb/lb-mole
- % N₂ = percent of nitrogen by volume, dry basis
- % O₂ = percent of oxygen by volume, dry basis
- ΔP = velocity head of stack gas, in. of H₂O
- P_{bar} = barometric pressure, in.Hg
- P_s = absolute stack gas pressure, in.Hg
- pmr = particulate matter emission rate, lb/h
- Q_s = volumetric flow rate, wet basis, stack conditions
- $Q_{s_{std}}$ = volumetric flow rate, dry basis, standard conditions

(continued)

Nomenclature and Dimensions (continued)

T_m = average temperature of dry gas meter, °R

T_s = average temperature of stack gas, °R

V_{lc} = total volume of liquid collected in impingers and silica gel, ml

V_m = volume of sample through the dry gas meter at meter conditions, ft³

V_{mstd} = volume of gas sample through the dry gas meter at standard conditions, ft³

V_s = stack gas velocity at stack conditions, fps

V_{wstd} = volume of water vapor collected in impingers and silica gel corrected to standard conditions, scf

γ = dry gas meter calibration factor

θ = total sampling time, minutes

Note: Standard conditions = 68°F and 29.92 in.Hg.

Example Calculations for Particulate Emissions

1. Volume of dry gas samples corrected to standard conditions. Note: V_m must be corrected for leakage if any leakage rates exceed L_a .

$$V_{m_{std}} = 17.65 \times V_m \times Y \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m} \right] =$$

2. Volume of water vapor at standard conditions, ft^3 .

$$V_{w_{std}} = 0.04707 V_{1c} =$$

3. Moisture content in stack gas.

$$B_{ws} = \frac{V_{w_{std}}}{V_{m_{std}} + V_{w_{std}}} =$$

4. Dry molecular weight of stack gas.

$$M_d = 0.440 (\% CO_2) + 0.320 (\% O_2) + 0.280 (\% N_2 + \% CO) =$$

5. Molecular weight of stack gas.

$$M_s = M_d (1 - B_{ws}) + 18 B_{ws} =$$

6. Stack velocity at stack conditions, fps .

$$V_s = 85.49 C_p \left(\sqrt{\Delta P} \right) \text{ avg. } \sqrt{\frac{T_s}{P_s M_s}} =$$

7. Stack gas volumetric flow rate at stack conditions, cfm .

$$Q_s = 60 \times V_s \times A_s$$

(continued)

Example Calculations for Particulate Emissions (continued)

8. Dry stack gas volumetric flow rate at standard conditions, cfm.

$$Q_{s_{std}} = 17.65 Q_s \frac{P_s}{T_s} (1 - B_{ws}) =$$

9. Concentration in gr/dscf.

$$C'_s = (0.01543) \frac{M_n}{V_{m_{std}}}$$

10. Particulate mass emission rate, lbs/h.

$$pmr = \frac{C'_s}{7000} Q_{s_{std}} \times 60$$

11. Isokinetic variation.

$$I = \frac{100 T_s}{60 \theta V_s P_s A_n} \left[0.002669 V_c + \frac{V_m}{T_m} Y \left(P_{bar} + \frac{\Delta H}{13.6} \right) \right] =$$

P E I ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

PlantSTEEL HEDDLE
Sampling locationINLET
Test time (start-stop)0227-1145

Date5/24/66
Run number800-1

Sample typeCF+6
Bar. pressure (in-Hg)25.35
Static pressure (in-H₂O)-0.3
Filter number(s)NA
Stack inside dia. (in)32
Pitot tube coeff.0.84
Total H₂O collected (ml)100.0
Percent CO by volume (dry) ...20.8

Leakage (cu-ft)101
Meter calibration factor0.978
Gate interval (min)3.5
Nozzle dia.0.251
Meter box numberFB-11
Number of traverse points24
Percent CO₂ by volume (dry) ...0.0
Percent SO₂ by volume (dry) ...0.0

Sample time (min)	Gas meter reading (cu. ft.)	velocity head (in. H ₂ O)	Orifice drop-acq. (in. H ₂ O)	Stack temp. (deg. F)	Dry gas meter temp. (deg. F)	
					inlet	outlet
0.0	378.740					
7.5	386.400	0.700	1.81	90	84	88
15.0	394.700	0.950	2.50	89	92	88
22.5	403.800	1.050	2.75	93	100	87
30.0	412.800	0.950	2.48	94	105	89
37.5	421.400	0.950	2.55	93	109	92
45.0	430.000	0.900	2.40	94	112	88
52.5	437.700	0.750	2.00	94	115	87
60.0	445.400	0.720	1.95	95	117	101
67.5	453.600	0.720	1.95	95	120	103
75.0	461.000	0.750	2.05	95	121	106
82.5	469.300	0.800	2.20	96	124	106
90.0	476.950	0.720	1.95	96	125	110
97.5	484.500	1.200	3.30	96	125	118
105.0	492.700	1.100	3.00	97	124	117
112.5	504.100	0.900	2.45	97	126	115
120.0	512.100	0.810	2.20	98	128	117
127.5	520.300	0.880	2.40	98	132	118
135.0	528.300	0.800	2.20	98	134	121
142.5	535.900	0.730	2.10	98	135	122
150.0	543.700	0.770	2.15	98	136	127
157.5	551.500	0.790	2.20	100	135	127
165.0	559.400	0.820	2.25	100	136	127
172.5	567.400	0.820	2.25	99	136	127
180.0	575.200	0.820	2.25	99	136	127
187.5	583.545	0.845	2.30	98	136	128

J. F. ...
7/7/66

P E T ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEEDLE
TEST: SIC-1 INLET

TEST DATE: 6/24/81
TEST TIME: 0827-1145

TR	.....	Net size of test orifice	150.0
NR	.....	Net sampling points	24
V	.....	Meter calibration factor	0.979
DR	.....	Sampling nozzle dia (in)	1.051
CF	.....	Pitot tube coefficient	0.940
PR	.....	Average orifice pressure drop (in-H ₂ O)	2.50
VR	.....	Volume of dry gas sampled at meter conditions (scmf) (corrected for leakage)	166.458
TR	.....	Average gas meter temperature (deg F)	114.7
VMEC	.....	Volume of dry gas sampled at standard conditions (scf)	174.150
VLE	.....	Total H ₂ O collected in impingers and slides (ml)	100.0
VE	.....	Volume of water vapor at standard conditions (scf)	4.700
BV	.....	Percent moisture by volume	2.60
FD	.....	moist fraction of dry gas	0.87
POD	.....	Percent O ₂ by volume (dry)	0.000
PC	.....	Percent CO by volume (dry)	20.900
PL	.....	Percent CO ₂ by volume (dry)	0.100
HW	.....	Percent H ₂ by volume (dry)	79.100
W	.....	Molecular weight of dry test gas	28.84

TEST RESULTS

PAGE NO: 1
 RUN NO: 812-1

MWG	.....	Molecular weight - stack gas	25.55
PB	.....	Barometric pressure (in-Hg)	25.05
PBI	.....	Static pressure of stack gas (in-H ₂ O)	-0.301
PS	.....	Stack pressure - absolute (in-Hg)	25.11
TS	.....	Average stack temperature (deg F)	82
VR	.....	Average square root of velocity head (in-H ₂ O)	0.915
VS	.....	Average stack gas velocity (fps)	59.0
AS	.....	Stack area (sq in)	204
Q	.....	Actual stack flow rate (scfm)	18.085
QSTG	.....	Stack flow rate - dry (scfm)	18.075
ISO	.....	Percent isokinetic	95.6
MM	.....	HEXAVALENT CR+6, MG	13.5 ✓
CS	.....	HEXAVALENT CR+6, GR/SCCF	1.17E-02
EME	.....	HEXAVALENT CR+6 Emission rate, lb/hr	0.158
MM	.....	TOTAL CR, MG	13.6 ✓
CS	.....	TOTAL CR, GR/SCCF	1.11E-02
EME	.....	TOTAL CR Emission rate, lb/hr	0.158

J. Fiori

F E I ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

Plant STEEL HEDDLE
Sampling location INLET
Test time (start-stop) 0808-1132

Date 5/25/86
Run number 210-2

Sample type CR-6
Bar. pressure (in-Hg) 29.41
Static pressure (in-H₂O) -0.55
Filter number(s) NP
Stack inside dia. (in) 72
Pitot tube coeff. 0.84
Total H₂O collected (ml) 51.4
Percent O₂ by volume (dry) ... 20.9

Leakage (cu-ft) 0.388
Meter calibration factor 0.978
Data interval (min) 7.5
Nozzle dia. 0.251
Meter box number FB-11
Number of traverse points 24
Percent CO₂ by volume (dry) ... 0
Percent CO by volume (dry) ... 0.0

Sample time (min)	Gas meter reading (cu. ft.)	Velocity head (in. H ₂ O)	Orifice drop-act. (in. H ₂ O)	Stack temp. (deg. F)	
				inlet	outlet
0.0	577.318			87	78
7.5	585.500	0.890	2.30	86	80
15.0	594.100	0.920	2.55	86	85
22.5	602.200	0.830	2.20	86	85
30.0	610.600	0.880	2.35	86	85
37.5	615.000	0.820	2.20	88	85
45.0	625.700	0.830	2.25	88	85
52.5	634.400	0.780	2.10	90	85
60.0	642.300	0.900	2.20	90	85
67.5	650.300	0.840	2.30	90	85
75.0	658.600	0.870	2.40	90	85
82.5	666.700	0.880	2.40	90	85
90.0	674.857	0.890	2.45	90	85
97.5	684.400	1.100	3.05	92	85
105.0	693.100	1.000	2.75	92	85
112.5	701.400	0.920	2.55	92	85
120.0	709.500	0.940	2.60	92	85
127.5	718.200	0.870	2.70	92	85
135.0	726.600	0.940	2.60	92	85
142.5	734.000	0.750	2.01	92	85
150.0	741.100	0.850	1.90	92	85
157.5	748.500	0.720	2.00	92	85
165.0	755.800	0.720	2.00	92	85
172.5	762.300	0.750	2.10	92	85
180.0	769.500	0.750	2.10	92	85
187.5	776.500	0.850	2.30	92	85
195.0	783.500	0.850	2.30	92	85

J. F. Wini
7/7/86

F E I ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEDDLE
TEST: SIC-2 / INTLET

TEST DATE: 6/25/86
TEST TIME: 0808-1132

TT	.....	Net time of test (min)	181.0
NP	.....	Net sampling nocks	24
	.....	Water calibration factor	0.975
DN	.....	Sampling nozzle dia (in)	1.251
CF	.....	Factor tube coefficient	1.941
PM	.....	Average orifice pressure drop (in-H ₂ O)	2.74
VM	.....	Volume of dry gas sampled at meter conditions (scft) (corrected for leakage)	163.119
TM	.....	Average gas meter temperature (deg F)	112.1
VMSTD	.....	Volume of dry gas sampled at standard conditions (scf)	172.326
WV	.....	Total H ₂ O collected in impingers and saline gel (ml)	24.4
WV	.....	Volume of water vapor at standard conditions (scf)	0.831
WV	.....	Percent moisture by volume	0.48
FV	.....	Mole fraction of dry gas	0.98
FO ₂	.....	Percent O ₂ by volume (dry)	0.000
FO	.....	Percent O by volume (dry)	20.900
FO	.....	Percent CO by volume (dry)	0.001
FO	.....	Percent NO by volume (dry)	79.110
FW	.....	Molecular weight dry, stack gas	28.84

TEST RESULTS

PAGE NO: 0
RUN NO: 810-0

MW	.....	Molecular weight - stack gas	28.60
PB	.....	Barometric pressure (in-HG)	29.41
PBI	.....	Static pressure of stack gas (in-H2O)	-3.550
PS	.....	Stack pressure - absolute (in-HG)	25.85
TS	.....	Average stack temperature (deg F)	50
Vn	.....	Average square root of velocity head (in-H2O)	0.933
VS	.....	Average stack gas velocity (fpm)	50.5
AS	.....	Stack area (sq ft)	804
QA	.....	Actual stack flow rate (acfm)	15.049
QSTD	.....	Stack flow rate - std (acfm)	16.509
ISO	.....	Percent isokinetic	94.0
MN	.....	HEXAVALENT CR-6, MG	5.2 ✓
DE	.....	HEXAVALENT CR-6, GR/DSDP	5.202E-04
PMF	.....	HEXAVALENT CR-6 Emission rate, lb/hr	0.074
ML	.....	TOTAL CR, MG	5.4 ✓
DE	.....	TOTAL CR, GR/DSDP	4.862E-04
PMF	.....	TOTAL CR Emission rate, lb/hr	0.089

J. F. Forni

F E I ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

PlantSTEEL HEDDLE
Sampling locationINLET
Test time (start-stop)1245-1633

Date8/25/86
Run number810-3

Sample typeDR+6
Bar. pressure (in-Hg)29.44
Static pressure (in-H₂O)-3.5
Filter number(s)NA
Stack inside dia. (in)32
Pitot tube coeff.0.54
Total H₂O collected (ml)82.1
Percent O₂ by volume (dry) ...20.5

Leakage (cu-ft)297
Meter calibration factor0.975
Data interval (min)7.5
Nozzle dia.0.251
Meter box numberFB-11
Number of traverse points24
Percent O₂ by volume (dry) ...0.0
Percent CO by volume (dry) ...0.0

Sample time (min)	Gas meter reading (cu. ft.)	Velocity head (in. H ₂ O)	Orifice drop-act. (in. H ₂ O)	Stack temp. (deg. F)	Dry gas meter temp. (deg. F)	
					inlet	outlet
0.0	771.075					
7.5	780.400	1.150	3.15	95	121	119
15.0	789.500	1.100	3.00	94	121	117
22.5	798.500	1.050	2.90	95	124	117
30.0	807.000	0.920	2.50	94	125	117
37.5	815.650	0.970	2.70	94	126	117
45.0	823.750	0.850	2.35	95	127	117
52.5	831.300	0.750	2.05	95	129	117
60.0	838.700	0.700	1.95	95	130	117
67.5	846.000	0.700	1.95	95	130	117
75.0	853.400	0.700	1.95	95	130	117
82.5	860.900	0.720	2.00	95	129	117
90.0	868.286	0.720	2.00	95	129	117
97.5	876.300	0.750	2.05	97	124	117
105.0	885.100	0.950	2.70	96	123	116
112.5	893.550	0.950	2.60	98	124	116
120.0	901.750	0.840	2.35	99	124	116
127.5	910.000	0.870	2.35	100	124	114
135.0	917.900	0.820	2.25	99	124	116
142.5	925.500	0.750	2.05	99	123	115
150.0	933.500	0.770	2.10	99	123	115
157.5	941.200	0.850	2.30	99	117	116
165.0	949.500	0.870	2.35	99	117	117
172.5	957.700	0.950	2.30	99	116	117
180.0	965.850	0.750	2.10	99	116	117
187.5	974.000	0.847	2.30	97	114	116

J. F. ...
7/7/86

F E T ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEDDLE
TEST: 800-3 / INLET

TEST DATE: 6/25/86
TEST TIME: 1245-1633

TT	.....	Net time of test (min)	180.0
NP	.....	Net sampling points	24
	.....	Meter calibration factor	0.975
DN	.....	Sampling nozzle dia (in)	0.251
CF	.....	Filter tube coefficient	0.541
PM	.....	Average orifice pressure drop (in-H ₂ O)	2.00
VN	.....	Volume of dry gas sampled at meter conditions (scf) (corrected for leakage)	150.990
TM	.....	Average gas meter temperature (deg F)	119.1
VNSTD	.....	Volume of dry gas sampled at standard conditions (scf)	171.185
VLC	.....	Total H ₂ O collected in impingers and silica gel (ml)	50.1
VWC	.....	Volume of water vapor at standard conditions (scf)	0.854
BWD	.....	Percent moisture by volume	0.12
FRD	.....	Mole fraction of dry gas	0.98
POSD	.....	Percent O ₂ by volume (dry)	0.000
POD	.....	Percent O ₂ by volume (dry)	20.800
PCD	.....	Percent CO by volume (dry)	0.000
PCD	.....	Percent CO by volume (dry)	75.000
NC	.....	molecular weight - dry, clean gas	28.84

TEST RESULTS

PAGE NO: 1
RUN NO: 800-3

MWE	.....	Molecular weight - stack gas	28.60
PB	.....	Barometric pressure (in-Hg)	29.44
PSI	.....	Static pressure of stack gas (in-H2O)	-3.500
PS	.....	Stack pressure - absolute (in-Hg)	29.15
TS	.....	Average stack temperature (deg F)	97
VH	.....	Average square root of velocity head (in-H2O)	0.520
VS	.....	Average stack gas velocity (fps)	59.1
AS	.....	Stack area (sq in)	504
QS	.....	Actual stack flow rate (scfm)	18.033
QSST	.....	Stack flow rate - dry (scfm)	16.367
ISO	.....	Percent isokinetic	94.5
MM	.....	HEXAVALENT CR-6, MG	5.3 ✓
CE	.....	HEXAVALENT CR-6, GR/BBDF	4.9395-04
PM6	.....	HEXAVALENT CR-6 Emission rate, lb/hr	0.059
MA	.....	TOTAL CR, MG	5.3 ✓
CE	.....	TOTAL CR, GR/BBDF	4.7595-04
PM6	.....	TOTAL CR Emission rate, lb/hr	0.057

✓ J. Fiori

PEI ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

PlantSTEEL HEDDLE
Sampling locationOUTLET
Test time (start-stop)0833-1148

Date6/24/55
Run numberSOC-1

Sample typeCR/CR-5
Bar. pressure (in-Hg)09.38
Static pressure (in-H2O)-0.38
Filter number(s)NA
Stack inside dia. (in)22
Filter tube coeff.0.64
Total H2O collected (ml)118.4
Percent O2 by volume (dry)20.9

Leakage (cu/ft)0.000
Meter calibration factor0.921
Data interval (min)7.5
Nozzle dia.0.253
Meter box number57-1
Number of traverse points24
Percent CO2 by volume (dry) ...0.0
Percent CO by volume (dry) ...0.0

Sample time (min)	Gas meter reading (cu. ft.)	Velocity head (in. H2O)	Orifice drop-act. (in. H2O)	Stack temp. (deg. F)	
				inlet	outlet
0.0	645.598			77	85
7.5	651.000	0.550	1.45	75	87
15.0	658.400	0.680	3.00	73	87
22.5	666.000	0.680	3.00	73	87
30.0	673.500	0.680	3.05	73	87
37.5	680.800	0.630	2.85	78	105
45.0	688.200	0.630	2.85	79	105
52.5	696.000	0.650	2.95	80	112
60.0	703.500	0.740	3.35	80	114
67.5	712.400	0.900	4.10	80	117
75.0	721.000	1.050	4.80	81	120
82.5	731.300	1.100	5.05	80	121
90.0	741.114	1.150	5.30	80	122
97.5	751.000	0.850	3.75	80	116
105.0	758.600	0.950	4.35	80	117
112.5	757.800	0.830	4.05	81	120
120.0	775.000	0.830	3.85	81	124
127.5	784.300	0.820	3.80	80	126
135.0	792.800	0.830	3.85	80	127
142.5	801.200	0.790	3.70	80	128
150.0	810.400	0.970	4.55	80	128
157.5	820.000	1.050	4.70	78	128
165.0	830.100	1.200	5.50	80	128
172.5	840.450	1.250	5.85	80	128
180.0	850.750	1.350	5.95	80	121
187.5	861.000	1.350	5.95	80	128

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F E I ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEDDLE
TEST: SCC-1 / OUTLET

TEST DATE: 6/24/66
TEST TIME: 0833-1145

TT	.....	Net time of test (min)	180.0
NF	.....	Net sampling points	24
Y	.....	meter calibration factor	- 0.981
Dn	.....	Sampling nozzle dia (in)	0.253
CF	.....	Pitot tube coefficient	0.840
PM	.....	Average orifice pressure drop (in-H ₂ O)	4.30
Vm	.....	Volume of dry gas sampled at meter conditions (scfd)	205.194
Tm	.....	Average gas meter temperature (deg F)	111.4
VMSF	.....	Volume of dry gas sampled at standard conditions (scf)	184.299
VLE	.....	Total H ₂ O collected in impingers and silica gel (ml)	116.4
VWE	.....	volume of water vapor at standard conditions (scf)	5.573
BWD	.....	Percent moisture by volume	2.94
FND	.....	Mole fraction of dry gas	0.97
PCO2	.....	Percent CO ₂ by volume (dry)	0.000
PO2	.....	Percent O ₂ by volume (dry)	20.800
PO2	.....	Percent O ₂ by volume (dry)	3.000
PN2	.....	Percent N ₂ by volume (dry)	76.199
MO	.....	Molecular weight - dry stack gas	28.54

TEST RESULTS

PMSE NO: 2
RUN NO: 500-1

MWE	.....	Molecular weight - stack gas	29.82
PS	.....	Barometric pressure (in-Hg)	29.75
PSI	.....	Static pressure of stack gas (in-H2O)	-0.350
PE	.....	Stack pressure - absolute (in-Hg)	29.40
TE	.....	Average stack temperature (deg F)	81
VH	.....	Average square root of velocity head (in-H2O)	1.500
VE	.....	Average stack gas velocity (fps)	50.7
AE	.....	Stack area (sq ft)	504
QE	.....	Actual stack flow rate (acfm)	18.114
QESTD	.....	Stack flow rate - dry (scfm)	18.768
ISD	.....	Percent isokinetic	87.7
MA	.....	HEXAVALENT CR+6, MG	0.0 ✓
CE	.....	HEXAVALENT CR+6, GR/SSCF	1.00E-10
PME	.....	HEXAVALENT CR+6 Emission rate, lb/hr	3.1800E-03
MA	.....	TOTAL CR, MG	0.0 ✓
CE	.....	TOTAL CR, GR/SSCF	1.00E-10
PME	.....	TOTAL CR Emission rate, lb/hr	3.1400E-03

J. Fiori

P E I ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

PlantSTEEL HEDDLE
Sampling locationOUTLET
Test time (start-stop)0811-1134

Date6/25/80
Run number300-3

Sample typeDR/CR+6
Bar. pressure (in-HG)29.41
Static pressure (in-H2O)-0.36
Filter number(s)NA
Stack inside dia. (in.)32
Pitot tube coeff.0.84
Total H2O collected (ml)102.8
Percent O2 by volume (dry) ...20.9

Leakage (cu-ft)0.000
Meter calibration factor0.981
Data interval (min)7.5
Nozzle dia.0.250
Meter box numberFT-1
Number of traverse points24
Percent CO2 by volume (dry) ...6.0
Percent CO by volume (dry) ...0.0

Sample time (min)	Gas meter reading (cu. ft.)	Velocity head (in. H2O)	Orifice drop-act. (in. H2O)	Stack temp. (deg. F)	Dry gas meter temp. (deg. F)	
					inlet	outlet
0.0	851.357					
7.5	855.300	0.610	2.65	75	83	82
15.0	865.900	0.710	3.15	75	89	85
22.5	875.500	0.710	3.20	75	100	87
30.0	881.200	0.700	3.15	75	104	91
37.5	888.700	0.660	2.95	74	110	94
45.0	896.200	0.670	3.05	75	111	97
52.5	903.900	0.690	3.15	75	114	100
60.0	912.100	0.780	3.60	75	118	102
67.5	921.000	0.910	4.20	75	118	104
75.0	929.900	1.000	4.60	75	117	105
82.5	939.300	1.050	4.85	76	120	107
90.0	948.975	1.100	5.10	75	121	108
97.5	958.000	0.970	4.50	75	117	110
105.0	967.200	1.000	4.65	76	119	110
112.5	976.000	0.900	4.20	76	122	114
120.0	984.500	0.840	3.90	75	124	114
127.5	993.000	0.840	3.90	75	123	114
135.0	1001.500	0.820	3.85	75	124	114
142.5	1010.700	1.000	4.70	76	125	115
150.0	1020.300	1.100	5.15	75	125	115
157.5	1030.300	1.150	5.40	75	125	115
165.0	1040.500	1.250	5.85	75	125	114
172.5	1050.900	1.300	6.10	75	127	115
180.0	1061.355	1.300	6.10	75	125	115
187.5	1071.950	0.905	4.35	75	125	115

P. E. T. ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEEDLE
TEST: SOC-2 / OUTLET

TEST DATE: 4/25/68
TEST TIME: 0911-1154

TT	.....	Wet time of test (min)	180.0
NF	.....	Net sampling points	24
V	.....	Water calibration factor	0.981
DN	.....	Sampling nozzle dia (in)	0.350
DF	.....	Piston tube coefficient	0.840
PM	.....	Average orifice pressure drop (in-H ₂ O)	4.05
VF	.....	Volume of dry gas sampled at meter conditions (scuf)	205.958
TM	.....	Average gas meter temperature (deg F)	110.7
VNETD	.....	Volume of dry gas sampled at standard conditions (scf)	185.028
VLD	.....	Total H ₂ O collected in impingers and silice gel (ml)	112.8
VWV	.....	Volume of water vapor at standard conditions (scf)	4.575
BWD	.....	Percent moisture by volume	2.45
BFD	.....	Mole fraction of dry gas	0.98
PCDC	.....	Percent CO ₂ by volume (dry)	0.000
PCO	.....	Percent O ₂ by volume (dry)	20.800
PCN	.....	Percent N ₂ by volume (dry)	0.000
PCD	.....	Percent H ₂ by volume (dry)	78.100
MC	.....	molecular weight of dry stack gas	28.84

TEST RESULTS

PAGE NO: 2
 RUN NO: 500-2

MW	.....	Molecular weight - stack gas	28.57
PB	.....	Barometric pressure (in-Hg)	29.41
PSI	.....	Static pressure of stack gas (in-H ₂ O)	-0.360
PE	.....	Stack pressure - absolute (in-Hg)	29.05
TE	.....	Average stack temperature (deg F)	75
Vh	.....	Average square root of velocity head (in-H ₂ O)	0.950
VE	.....	Average stack gas velocity (fps)	54.5
AE	.....	Stack area (sq in)	504
QE	.....	Actual stack flow rate (scfm)	19.009
QESTD	.....	Stack flow rate - dry (scfm)	17.357
ISO	.....	Percent isokinetic	97.1
MN	.....	HEXAVALENT CR+6, MG	0.3 ✓
DE	.....	HEXAVALENT CR+6, GR/DSCF	2.12E-05
PMF	.....	HEXAVALENT CR+6 Emission rate, lb/hr	3.0034E-05
ML	.....	TOTAL CR, MG	0.7 ✓
DE	.....	TOTAL CR, GR/DSCF	2.14E-05
PMF	.....	TOTAL CR Emission rate, lb/hr	3.17E-05

J. Fisti

P E T ASSOCIATES, INC.
EMISSION TEST REPORT

FIELD DATA

PlantSTEEL HEDDLE
Sampling locationOUTLET
Test time (start-stop)1247-1635

Date6/25/66
Run number800-7

Sample typeCR/CR+6
Bar. pressure (in-Hg)29.44
Static pressure (in-H₂O)-0.2c
Filter numbers:N4
Stack inside dia. (in)72
Pitot tube coeff.0.84
Total H₂O collected (ml)9c.8
Percent O₂ by volume (dry) ...20.9

Leakage (cu-ft)0.000
Meter calibration factor0.981
Data interval (min)7.5
Nozzle dia.0.250
Meter box numberFT-1
Number of traverse points24
Percent CO₂ by volume (dry) ...0.0
Percent SO₂ by volume (dry) ...0.0

Sample time (min)	Gas meter reading (cu. ft.)	Velocity head (in. H ₂ O)	Orifice drop-act. (in. H ₂ O)	Stack temp. (deg. F)	Dry gas meter temp. (deg. F)	
					inlet	outlet
0.0	61.501			72	109	108
7.5	70.450	0.950	4.40	72	114	109
15.0	79.650	1.000	4.65	72	118	109
22.5	88.750	0.970	4.50	75	121	109
30.0	97.650	0.910	4.25	75	122	110
37.5	106.200	0.850	3.95	75	122	110
45.0	115.000	0.840	3.90	75	122	110
52.5	123.100	0.790	3.70	74	124	111
60.0	132.200	0.970	4.55	75	125	111
67.5	141.700	1.050	4.90	74	125	112
75.0	152.100	1.250	5.85	74	125	112
82.5	162.700	1.350	6.30	76	125	112
90.0	173.342	1.350	6.30	76	125	112
97.5	181.200	0.700	3.25	75	116	110
105.0	199.050	0.710	3.30	73	117	108
112.5	198.950	0.700	3.25	75	121	109
120.0	204.650	0.680	3.15	74	122	108
127.5	212.200	0.650	3.00	74	122	108
135.0	219.800	0.640	2.95	76	123	107
142.5	228.000	0.680	3.15	75	121	106
150.0	235.900	0.600	3.70	74	120	105
157.5	244.500	0.920	4.15	74	105	98
165.0	253.800	1.050	4.80	74	107	98
172.5	262.500	1.100	5.00	75	115	95
180.0	272.090	1.150	5.30	75	117	95
180.0	211.589	0.908	4.24	74	119	107

P E I ASSOCIATES, INC.
EMISSION TEST REPORT

TEST RESULTS

PLANT: STEEL HEDDLE
TEST: SOC-3 / OUTLET

TEST DATE: 6/25/86
TEST TIME: 1247-1635

TT	.....	Net time of test (min)	160.0
NP	.....	Net sampling points	24
V	.....	Meter calibration factor	0.981
DN	.....	Sampling nozzle dia (in)	0.027
CF	.....	Pitot tube coefficient	0.840
Pm	.....	Average orifice pressure drop (in-H ₂ O)	4.26
VM	.....	Volume of dry gas sampled at meter conditions (cu-ft)	211.859
Tm	.....	Average gas meter temperature (deg F)	120.7
VMSTD	.....	Volume of dry gas sampled at standard conditions (scf)	190.016
VLE	.....	Total H ₂ O collected in impingers and silica gel (ml)	86.8
WV	.....	Volume of water vapor at standard conditions (scf)	4.886
BWC	.....	Percent moisture by volume	2.74
FMD	.....	Mole fraction of dry gas	0.98
POD2	.....	Percent CO ₂ by volume (dry)	0.000
PO1	.....	Percent O ₂ by volume (dry)	20.910
PO3	.....	Percent CO by volume (dry)	0.000
PN2	.....	Percent N ₂ by volume (dry)	78.100
MW	.....	Molecular weight - dry stack gas	28.584

TEST RESULTS

PAGE NO: 2
RUN NO: 800-7

MW	.....	Molecular weight - stack gas	29.58
PB	.....	Barometric pressure (in-Hg)	29.44
PE1	.....	Static pressure of stack gas (in-H2O)	-0.260
PE	.....	Stack pressure - absolute (in-Hg)	29.40
TE	.....	Average stack temperature (deg F)	74
VH	.....	Average square root of velocity head (in-H2O)	0.787
VE	.....	Average stack gas velocity (fps)	54.5
AE	.....	Stack area (sq ft)	8.0
QE	.....	Actual stack flow rate (acfm)	16.071
QSETD	.....	Stack flow rate - dry (acfm)	17.340
ISO	.....	Percent isokinetic	97.4
MN	.....	HEXAVALENT CR+6, ME	0.0 ✓
CE	.....	HEXAVALENT CR+6, GR/250F	0.388E-05
PMR	.....	HEXAVALENT CR+6 Emission rate, lb/yr	1.60388E-03
MN	.....	TOTAL CR, ME	0.0 ✓
CE	.....	TOTAL CR, GR/250F	1.478E-05
PMR	.....	TOTAL CR Emission rate, lb/yr	3.60788E-03

✓
J. F. Trotter

PARTICLE SIZE DISTRIBUTION

MMP:

PEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle ✓ Run no: BIP5-1 ✓
 Sampling Location: Inlet ✓ Date: 6/24/85 ✓
 Sample type: Particle size ✓ Start-stop, Zn: 1205-1340 ✓
 Operator: JP/DS ✓ Barometric pressure, in. Hg: 29.35 ✓
 Filter ID: F-3 ✓ Static pressure, in. H2O: -3.30 ✓
 Meter box ID: .977 ✓ Stack area, Sq in: 802.25 ✓
 Y Factor: 1.34 ✓ Nozzle diameter, in: .197 ✓
 Moisture, %: Pitot tube, Cp: .64 ✓
 Number of sample points: 3 ✓ CO2 percent: 0 ✓
 Sample time, min: 90.60 ✓ O2 percent: 20.9 ✓
 Volume correction, cu-ft: 0 ✓

Sampling time, minutes	Gas meter reading, cfm	Velocity head, in. H2O	Orifice pressure, in. H2O	Stack temp, deg F	Meter temp, deg F		Impactor temp, deg F
					Inlet	Outlet	
0.00 ✓	971.192 ✓	.75 ✓	1.25 ✓	99 ✓	115 ✓	110 ✓	99 ✓
30.00 ✓	991.31 ✓	.75 ✓	1.25 ✓	99 ✓	113 ✓	112 ✓	99 ✓
60.00 ✓	1011.8 ✓	.75 ✓	1.25 ✓	99 ✓	119 ✓	112 ✓	99 ✓
90.6 ✓	1022.262 ✓	.75 ✓	1.25 ✓	99 ✓	119 ✓	112 ✓	99 ✓
90.6	61.07 ✓	.75	1.25	99	117	113	99

J. Fri

PEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: steel Heddle

Run no.: SIP5-1

TI...	Net time of test, min	90.60 ✓
NF...	Net sampling points	3 ✓
Y...	Meter calibration factor	.977 ✓
DN...	Sampling nozzle diameter, in	.197 ✓
CP...	Pitot tube coefficient	.84 ✓
PM...	Avg. orifice pressure, in H2O	1.25 ✓
VM...	Volume of dry gas sampled at meter conditions, cu-ft	61.07 ✓
TM...	Avg. gas meter temp., deg F	115.00 ✓
VMETA...	Volume of dry gas sampled at standard conditions, scf	53.91 ✓
BWD...	Percent moisture by volume	2.34 ✓
MFD...	Mole fraction of dry gas	.9766 ✓
PCO2...	Percent CO2 by volume, dry	0 ✓
PO2...	Percent O2 by volume, dry	20.9 ✓
PN2...	Percent N2 by volume, dry	79.1 ✓
MD...	Dry molecular weight	28.84 ✓
MS...	Stack gas molecular weight	28.58 ✓
PA...	Barometric pressure, in Hg	29.35 ✓
SP...	Static pressure, in H2O	-3.30 ✓
PS...	Stack pressure, in Hg	29.11 ✓
TS...	Avg. stack temperature, deg F	99.00 ✓
TI...	Avg. impactor temp., deg F	99.00 ✓
Vn...	Avg. vent or velocity head	.97 ✓
Vs...	Avg. stack velocity, fms	51.98 ✓
ISO...	Percent isokinetic	102.45 ✓

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7/8/86

***** INPUT DATA *****

1) PART: DIAMETER CLASSICAL AERODYNAMIC
 2) DATE OF TEST: 6/24/86
 3) TIME OF TEST: 1209-1340
 4) LOCATION OF TEST: SCRUBBER INLET
 5) TEST NUMBER 1
 6) TEST TYPE INLET
 7) RUN NUMBER: 61FS-1-FILE NAME: TIR61FS-1.IT
 8) RUN REMARKS:
 10) IMPACTOR TYPE: ANDERSEN GENERIC
 ANDERSEN II WITH GENERIC CAL.

9) WATER VAPOR 2.34%
 CO2 .00% CO .00%
 O2 20.9% N2 78.10%

12) ORIFICE ID (OPTIONAL):
 13) SUBSTRATE MATERIAL: GLASS FIBER

1) GAS METER VEL 80.91 CUBIC FEET
 2) IMPACTOR DELTA P .00 IN. HG.
 3) ORIFICE DELTA P -1.3 INCHES H2O
 4) STACK PRESSURE 17.31 INCHES H2O
 5) BAROMETRIC PRES 29.15 INCHES HG
 6) STACK TEMP 99 DEGREES F
 7) METER TEMP 115 DEGREES F
 8) IMPACTOR TEMP 99 DEGREES F
 9) SAMPLE TIME 90.60 MINUTES
 10) GAS VEL 80.98 FEET/SEC
 11) ORIFICE PRES .00 INCHES HG
 12) NOZILE DIA .197 INCHES
 13) MAX PART DIA 100.0 MICRONS
 14) WATER VOLUME .0 CC
 15) METER FACTOR 1.8770

MASS GAIN OF STAGE 1 15.40 MG
 MASS GAIN OF STAGE 2 .00 MG
 MASS GAIN OF STAGE 3 .00 MG
 MASS GAIN OF STAGE 4 .00 MG
 MASS GAIN OF STAGE 5 .20 MG
 MASS GAIN OF STAGE 6 .00 MG
 MASS GAIN OF STAGE 7 .10 MG
 MASS GAIN OF STAGE 8 .00 MG
 MASS GAIN OF FILTER .30 MG

MASS GAIN OF BLANK SUBSTRATE .00
 MASS GAIN OF BLANK FILTER .00

OK DM
 8/11/86

***** RESULTS *****

TEST NUMBER: 1 RUN NUMBER: BIPS-1

ACTUAL FLOW RATE .555 CFM
 FLOW RATE AT STANDARD CONDITIONS .535 CFM
 PERCENT ISOKINETIC 90.411 %
 VISCOSITY 186.25-066M/CM SEC
 CALCULATED IMPACTOR DELTA P = .51 IN. HG

STAGE	CUMM. CORR.	DP (CLAS AERO)	DP (IMP AERO)	CUM FREQ.	RE. NO.	V*DEU OR-MIE
1	1.017	10.054	10.141	3.1751	45	5.0
2	1.023	5.575	8.955	3.1658	62	7.5
3	1.030	5.916	6.002	3.1625	82	8.5
4	1.044	3.951	4.038	3.1552	103	9.1
5	1.080	2.172	2.277	1.6985	147	10.7
6	1.124	1.053	1.147	1.8725	201	12.7
7	1.210	.652	.734	1.0575	305	15.5
8	1.533	.345	.425	1.2575	521	17.1

STAGE CUT DIAMETERS BASED ON FILE VALUES OF STAGE CONSTANTS

TOTAL MASS CONCENTRATION = 1.12E+01 MG/DF / NORMAL CUBIC METER

SPRINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS) CUMM. CUMM. CUM. MASS DIVIDED

(MICRONS)	(STDDEV)	(PERCENT)	(MG/DRY N.CU. METER)	(MG/DRY N.CU. METER)
.100	- 2.2433	1.24	1.47E-01	2.65E-05
.157	- 2.2415	1.25	1.47E-01	2.66E-05
.251	- 2.2405	1.25	1.48E-01	2.67E-05
.398	- 2.2391	1.26	1.48E-01	2.68E-05
.631	- 2.2377	1.25	1.47E-01	1.95E-01
1.000	- 2.0903	1.83	2.16E-01	3.16E-01
1.585	- 2.0762	1.89	2.24E-01	2.36E-01
2.512	- 2.0540	2.10	2.48E-01	5.12E-01
3.951	- 1.8575	3.16	3.73E-01	3.65E-01
6.017	- 1.8576	3.16	3.73E-01	1.47E-01
10.000	- 1.8565	3.17	3.74E-01	6.85E-01
15.850	- 1.7572	5.94	4.65E-01	5.14E-01
25.120	- 1.5711	5.81	6.85E-01	1.95E+00
39.810	- 1.0497	14.71	1.74E+00	1.22E+01
67.100	1.0559	25.54	1.01E+01	6.13E-01
100.00	1000000	100.00	1.18E-01	0.00E+00
158.50	1000000	100.00	1.15E+01	0.00E+00
251.20	1000000	100.00	1.15E+01	0.00E+00
398.10	1000000	100.00	1.18E-01	0.00E+00
631.00	1000000	100.00	1.18E+01	0.00E+00

**** RESULTS CONTINUED ****

TEST NUMBER: 1 RUN NUMBER: S1P5-1

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON:	.02 MG/DNMS	(1.83 %)
CUM MASS LESS THAN 2.512 MICRON:	.25 MG/DNMS	(2.10 %)
CUM MASS LESS THAN 10.000 MICRON:	.37 MG/DNMS	(3.17 %)
CUM MASS LESS THAN 15.050 MICRON:	.47 MG/DNMS	(3.94 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: $Y = -2.12 + .31X$
MASS MEDIAN DIAMETER: 7075471.350
GEOMETRIC STANDARD DEVIATION: 1494.100
CORRELATION COEFFICIENT: .702

FEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Hebble ✓ Run no: EIPS-1 ✓
 Sampling Date: 6/24/86 ✓
 Location: Inlet ✓ Start-stop, 24h: 1430-1548 ✓
 Sample type: Particle size ✓ Barometric
 Operator: JP/DS ✓ pressure, in. Hg: 29.34 ✓
 Filter ID: Static
 Meter box ID: Fb-3 ✓ pressure, in. H₂O: -3.30 ✓
 Y Factor: .977 ✓ Stack area, Sq in: 802.25 ✓
 Moisture, %: 2.34 ✓ Nozzle diameter, in: .197 ✓
 Number of sample Pitot tube, Co: .84 ✓
 points: 3 ✓ CO₂ percent: 0 ✓
 Sample time, min: 77.50 ✓ O₂ percent: 20.9 ✓
 Volume correction, cu-ft: 0 ✓

Sampling time, minutes	Gas meter reading, cfm	Velocity head, in. H ₂ O	Orifice pressure, in. H ₂ O	Stack temp, deg F	Mixer temp, deg F		Impactor temp, deg F
					Inlet	Outlet	
0.00 ✓	32.48 ✓						
30.00 ✓	55.00 ✓	.75 ✓	1.25 ✓	109 ✓	113 ✓	107 ✓	108 ✓
60.00 ✓	74.4 ✓	.75 ✓	1.25 ✓	108 ✓	115 ✓	109 ✓	109 ✓
77.50 ✓	85.803 ✓	.75 ✓	1.25 ✓	108 ✓	115 ✓	109 ✓	109 ✓
77.5	85.373	.75	1.25	108	115	109	108

J. [Signature]
7/9/86

FEL ASSOCIATES, INC.
 EMISSION TEST REPORT

Run no.: STP5-2

Plant/Stack: Huddle

TT...	Net time of test, min	77.50
NF...	Net sampling points	3
Y...	Meter calibration factor	.977
DN...	Sampling nozzle diameter, in	.197
CP...	Pitot tube coefficient	.84
PM...	Avg. orifice pressure, in H ₂ O	1.25
VH...	Volume of dry gas sampled at meter conditions, cu ft	53.377
TH...	Avg. gas meter temp., deg F	111.67
VNSTD...	Volume of dry gas sampled at standard conditions, scf	47.35
BWD...	Percent moisture by volume	2.34
NFI...	Mole fraction of dry gas	.5765
PCO2...	Percent CO ₂ by volume, dry	0
PO2...	Percent O ₂ by volume, dry	20.9
PN2...	Percent N ₂ by volume, dry	79.1
MD...	Dry molecular weight	28.84
ME...	Stack gas molecular weight	28.58
PB...	Barometric pressure, in Hg	29.34
SP...	Static pressure, in H ₂ O	-5.30
PS...	Stack pressure, in Hg	29.10
TS...	Avg. stack temperature, deg F	108.00
TI...	Avg. impactor temp., deg F	108.00
VH...	Avg. part of velocity head	.57
VS...	Avg. stack velocity, fps	51.40
IEC...	Percent isokinetic	106.10

*****IMPACTOR VERSION: 4.0*****

***** INPUT DATA *****

1) PART. DIAMETER CLASSICAL AERODYNAMIC /
2) DATE OF TEST: 6/24/86 /
3) TIME OF TEST: 1400-1548 /
4) LOCATION OF TEST: SCRUBBER INLET /
5) TEST NUMBER 2 /
6) TEST TYPE INLET /
7) RUN NUMBER: SIPS-2-FILE NAME: T2RSIPS-2.IT /
8) RUN REMARKS:
10) IMPACTOR TYPE: ANDERSEN GENERIC
ANDERSEN: II WITH GENERIC CAL.

9) WATER VAPOR 2.54% /
CO2 .00% / CO .00% /
O2 21.50% / N2 78.10% /
11) ORIFICE ID (OPTIONAL):
13) SUBSTRATE MATERIAL: GLASS FIBER /

1) GAS METER VOL 47.380 / CUBIC FEET
2) IMPACTOR DELTA P .00 / IN. HG.
3) ORIFICE DELTA P -1.07 / INCHES H2O
4) STACK PRESSURE -3.30 / INCHES H2O
5) BAROMETRIC PRES 29.34 / INCHES HG
6) STACK TEMP 108 / DEGREES F
7) METER TEMP 112 / DEGREES F
8) IMPACTOR TEMP 108 / DEGREES F
9) SAMPLE TIME 77.50 / MINUTES
10) AVG GAS VEL 21.40 / FEET/SEC
11) ORIFICE PRES .00 / INCHES HG
12) NOZZLE DIA .197 / INCHES
13) MAX PART DIA 100.0 / MICRONS
14) WATER VOLUME .0 / CC
15) METER FACTOR .8770 /

MASS GAIN OF STAGE 1 8.90 / MG
MASS GAIN OF STAGE 2 .00 MG
MASS GAIN OF STAGE 3 .00 MG
MASS GAIN OF STAGE 4 .00 MG
MASS GAIN OF STAGE 5 .00 MG
MASS GAIN OF STAGE 6 .10 / MG
MASS GAIN OF STAGE 7 .10 / MG
MASS GAIN OF STAGE 8 .00 MG
MASS GAIN OF FILTER .10 / MG

OK DM
8/14/86

MASS GAIN OF BLANK SUBSTRATE .00
MASS GAIN OF BLANK FILTER .00

TEST NUMBER: 1 RUN NUMBER: STPE-2

ACTUAL FLOW RATE .514 CFM
 FLOW RATE AT STANDARD CONDITIONS .542 CFM
 PERCENT ISOKINETIC 94.107 %
 VISCOSITY 182.4E-06GM/CM SEC
 CALCULATED IMPACTOR DELTA P = .56 IN. HG

STAGE	CUMM. CORR.	DF (CLASS AERO)	DF (IMP. AERO)	CUM. FREQ.	RE. NO.	U-500 UM-MIN
1	1.015	9.888	9.957	4.3528	49	5.1
2	1.020	9.713	9.902	4.3418	64	7.8
3	1.001	9.805	9.973	4.3711	84	9.0
4	1.002	9.876	9.964	4.3573	105	9.4
5	1.057	1.047	2.234	4.3078	150	10.6
6	1.171	1.049	1.126	3.2745	233	12.4
7	1.322	.837	.721	2.1801	314	13.8
8	1.338	.335	.411	2.1454	502	12.8

STAGE CUT DIAMETERS BASED ON FILE VALUES OF STAGE CONDUCTANCE

TOTAL GASE CONCENTRATION = 7.82E+00 MG-DRY NORMED CUBIC METERS

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMM. FREQ. (PERCENT)	CUMM. MASS (MG/DRY 1.00 CUM. METER)	DM/DLOG(D)
.100	2.0382	2.13	1.68E-01
.159	2.0267	2.14	1.67E-01
.251	2.0352	2.14	1.68E-01
.398	2.0277	2.15	1.68E-01
.631	2.0242	2.15	1.68E-01
1.000	1.6820	3.13	2.45E-01
1.625	1.7452	4.05	3.15E-01
2.512	1.7171	4.25	3.40E-01
3.981	1.7150	4.32	3.37E-01
6.310	1.7134	4.33	3.39E-01
10.000	1.7115	4.33	3.40E-01
15.850	1.6855	4.47	3.49E-01
25.123	1.5980	5.50	4.30E-01
39.811	1.1592	12.71	9.63E-01
63.100	8.287	60.74	6.31E+00
100.00	100.00	100.00	7.82E+00
158.50	100.00	100.00	7.82E+00
251.20	100.00	100.00	7.82E+00
398.10	100.00	100.00	7.82E+00
631.00	100.00	100.00	7.82E+00

**** RESULTS CONTINUED ****

TEST NUMBER: 2 RUN NUMBER: SIPS-2

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON:	.24	MG/DNMS	(3.13 %)
CUM MASS LESS THAN 2.512 MICRON:	.34	MG/DNMS	(4.35 %)
CUM MASS LESS THAN 10.000 MICRON:	.34	MG/DNMS	(4.35 %)
CUM MASS LESS THAN 15.950 MICRON:	.35	MG/DNMS	(4.47 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: $Y = -1.89 + .25X$
MASS MEDIAN DIAMETER: 41116730.100
GEOMETRIC STANDARD DEVIATION: 10498.112
CORRELATION COEFFICIENT: .923

FEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle Run no: SIPS-3
 Sampling Location: Inlet Date: 6/24/66
 Start-stop: 24h:1643-1803
 Sample type: Particle size Barometric
 Operator: JP/D5 pressure, in. Hg: 29.30
 Filter ID: Static
 Meter box ID: Fb-3 pressure, in. H2O: -3.30
 Y Factor: .977 Stack area, sq in: 802.25
 Moisture, %: 2.34 Nozzle diameter, in: .197
 Number of sample points: 3 Pitot tube, Cf: .84
 Sample time, min: 50.00 CO2 percent: 0
 Volume correction, cu-ft: 0 CO percent: 20.9

Sampling time, minutes	Gas meter reading, cu ft	velocity, in. H2O	Orifice pressure, in. H2O	Stack temp, deg F	Meter temp, deg F		Impaction temp, deg F
					Inlet	Outlet	
0.00	85.853	.72	1.20	105	106	105	105
40.00	129.55	.72	1.20	105	106	101	105
80.00	139.571	.72	1.20	105	106	99	105
50	85.859	.72	1.20	105	107	102	105

J. Simon
7/9/86

(Page 2)

FEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle Run no: SIPS-3

TT... Net time of test, min 50.00

NF... Net sampling points 3

Y... Meter calibration factor .977

DN... Sampling nozzle diameter, in .197

CF... Pitot tube coefficient .84

PM... Avg. orifice pressure, in H2O 1.20

VM... Volume of dry gas sampled at meter conditions, cu-ft 85.859

TM... Avg. gas meter temp., deg F 104.17

VNSTD... Volume of dry gas sampled at standard conditions, scf 48.22

BMS... Percent moisture by volume 2.34

MFD... Mole fraction of dry gas .976

POD... Percent CO2 by volume, dry 0

PO... Percent CO by volume, dry 20.9

MS...	Stack gas molecular weight	28.55
PS...	Barometric pressure, in Hg	29.5
SP...	Static pressure, in H ₂ O	-0.30
PS...	Stack pressure, in Hg	29.06
TS...	Avg. stack temperature, deg F	105.00
TI...	Avg. impactor temp., deg °	105.00
VH...	Avg. Sqrt of velocity head	.85
VS...	Avg. stack velocity, fps	50.26
ISD...	Percent isokinetic	106.55

***** INPUT DATA *****

1) PART. DIAMETER CLASSICAL AERODYNAMIC /
 2) DATE OF TEST: 6/24/86 /
 3) TIME OF TEST: 1643-1803 /
 4) LOCATION OF TEST: SCRUBBER INLET /
 5) TEST NUMBER 3 /
 6) TEST TYPE INLET /
 7) RUN NUMBER: SIPS-3 FILE NAME: TORSIPS-3.IT
 8) RUN REMARKS:
 10) IMPACTOR TYPE: ANDERSEN GENERIC /
 ANDERSEN II WITH GENERIC CAL.

9) WATER VAPOR 2.34% /
 CO2 .00% O2 .00%
 SO2 0.20% NO 79.10%

12) ORIFICE IS (OPTIONAL):
 13) SUBSTRATE MATERIAL: GLASS FIBER /

1) GAS METER VOL 48.220 / CUBIC FEET
 2) IMPACTOR DELTA P .00 / IN. HG.
 3) ORIFICE DELTA P -1.3 / INCHES H2O
 4) STACK PRESSURE -0.30 / INCHES H2O
 5) BAROMETRIC PRES 29.50 / INCHES HG
 6) STACK TEMP 105 / DEGREES F
 7) METER TEMP 104 / DEGREES F
 8) IMPACTOR TEMP 105 / DEGREES F
 9) SAMPLE TIME 80.00 / MINUTES
 10) AVE GAS VEL 50.26 / FEET/SEC
 11) ORIFICE PRES .00 / INCHES HG
 12) NOZZLE DIA .197 / INCHES
 13) MAX PART DIA 100.0 / MICRONS
 14) WATER VOLUME .0 / CC
 15) METER FACTOR .9770

MASS GAIN OF STAGE 1 10.50 / MG
 MASS GAIN OF STAGE 2 .00 / MG
 MASS GAIN OF STAGE 3 .20 / MG
 MASS GAIN OF STAGE 4 .10 / MG
 MASS GAIN OF STAGE 5 .40 / MG
 MASS GAIN OF STAGE 6 .10 / MG
 MASS GAIN OF STAGE 7 .00 / MG
 MASS GAIN OF STAGE 8 .00 / MG
 MASS GAIN OF FILTER .10 / MG

MASS GAIN OF BLANK SUBSTRATE .00
 MASS GAIN OF PLANK FILTER .00

OK DM
 8/14/86

***** RESULTS *****

TEST NUMBER: 3 RUN NUMBER: SIPS-3

ACTUAL FLOW RATE .611 CFM
 FLOW RATE AT STANDARD CONDITIONS .542 CFM
 PERCENT ISOCHINETIC 95.726 %
 VISCOSITY 187.7E-06GM/CM SEC
 CALCULATED IMPACTOR DELTA P = .55 IN. HG

STAGE	CUMM CORR.	DF (CLAS AERO)	DF (IMP AERO)	CUM FREQ.	REL. NO.	V*D50 UM-N/E
1	1.015	9.872	9.965	7.9190	49	5.1
2	1.020	8.721	8.809	7.9102	54	7.7
3	1.031	5.810	5.898	6.1563	84	9.0
4	1.042	3.880	3.967	5.2793	108	9.4
5	1.082	2.151	2.238	1.7715	150	10.5
6	1.170	1.042	1.127	.6945	233	12.3
7	1.280	.638	.702	.9857	315	13.8
8	1.554	.338	.419	.8770	500	12.3

STAGE CUT DIAMETERS BASED ON FILE VALUES OF STAGE CONSTANCE

TOTAL MASS CONCENTRATION = 9.29E+00 MG/DRY NORMAL CUBIC METER

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMM CORR. (CUMM)	CUMM (%)	CUM. MASS (MG DRY N. CU. METER)	DN/LODS
.100	2.3803	.87	8.05E-02	1.92E-03
.150	2.3785	.87	8.09E-02	1.93E-03
.251	2.3768	.87	8.12E-02	1.94E-03
.398	2.3731	.88	8.21E-02	7.05E-03
.631	2.3718	.89	8.23E-02	2.94E-03
1.000	2.3710	.89	8.25E-02	2.93E-02
1.585	2.2790	1.13	1.05E-01	2.49E-01
2.512	1.9696	2.45	2.27E-01	1.17E-00
3.981	1.6072	5.40	5.02E-01	9.74E-01
6.510	1.3299	8.30	5.88E-01	6.32E-01
10.000	1.4039	8.03	7.46E-01	2.02E+00
15.650	1.1011	13.54	1.26E+00	3.28E+00
25.120	.7115	23.84	2.22E+00	7.04E+00
39.810	.0161	50.64	4.71E+00	2.05E+01
63.100	2.3324	89.01	9.20E+00	5.85E+00
100.00	1000000	100.00	9.29E+00	0.00E+00
158.50	1000000	100.00	9.29E+00	0.00E+00
251.20	1000000	100.00	9.29E+00	0.00E+00
398.10	1000000	100.00	9.29E+00	0.00E+00
631.00	1000000	100.00	9.29E+00	0.00E+00

**** RESULTS CONTINUED ****

TEST NUMBER: 1 RUN NUMBER: BIPS-3

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON:	.08 MG/DNMS	(.55 %)
CUM MASS LESS THAN 2.512 MICRON:	.23 MG/DNMS	(2.45 %)
CUM MASS LESS THAN 10.000 MICRON:	.75 MG/DNMS	(5.03 %)
CUM MASS LESS THAN 15.050 MICRON:	1.26 MG/DNMS	(13.54 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE:	$Y = -2.19 + .77X$
MASS MEDIAN DIAMETER:	716.583
GEOMETRIC STANDARD DEVIATION:	20.050
CORRELATION COEFFICIENT:	.995

PEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle ✓ Run no: 80FB-1 ✓
 Sampling Date: 6/24/86 ✓
 Location: Outlet ✓ Start-stop: 24h:1055-1503 ✓
 Sample type: Particle size ✓ Barometric
 Operator: JF/DS ✓ pressure, in. Hg: 29.35 ✓
 Filter ID: Static
 Meter box ID: FB-9 ✓ pressure, in. H2O: -.35 ✓
 Y Factor: .986 ✓ Stack area, Sq in: 802.25 ✓
 Moisture, %: 2.59 ✓ Nozzle diameter, in: .195 ✓
 Number of sample Pitot tube, Co: .84 ✓
 points: 8 ✓ CO2 percent: 0 ✓
 Sample time, min: 240.00 ✓ O2 percent: 20.9 ✓
 Volume cor-
 rection, cu-ft: 0 ✓

Sampling time, minutes	Gas meter reading, cfm	Velocity head, in. H2O	Orifice pressure, in. H2O	Stack temp, deg F	Meter temp, deg °		Impact temp deg
					Inlet	Outlet	
0.00 ✓	476.573 ✓						
30.00 ✓	494.96 ✓	.62 ✓	1.10 ✓	80 ✓	114 ✓	110 ✓	80 ✓
60.00 ✓	520 ✓	.62 ✓	1.10 ✓	80 ✓	124 ✓	112 ✓	80 ✓
90.00 ✓	532.1 ✓	.62 ✓	1.10 ✓	80 ✓	134 ✓	120 ✓	80 ✓
120.00 ✓	550.93 ✓	.62 ✓	1.10 ✓	80 ✓	135 ✓	122 ✓	80 ✓
150.00 ✓	569.7 ✓	.62 ✓	1.10 ✓	80 ✓	138 ✓	125 ✓	80 ✓
180.00 ✓	588.6 ✓	.62 ✓	1.10 ✓	80 ✓	135 ✓	125 ✓	80 ✓
210.00 ✓	606.84 ✓	.62 ✓	1.10 ✓	80 ✓	130 ✓	123 ✓	80 ✓
240.00 ✓	625.724 ✓	.62 ✓	1.10 ✓	80 ✓	132 ✓	122 ✓	80 ✓
240	149.151	.62	1.10	80	130	120	80

FBI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle

Run no.: B08P-1

TT...	Net time of test, min	240.00
NP...	Net sampling points	8
Y...	Meter calibration factor	.986
DN...	Sampling nozzle diameter, in	.195
CP...	Pitot tube coefficient	.84
PM...	Avg. orifice pressure, in H ₂ O	1.10
VH...	Volume of dry gas sampled at meter conditions, cu-ft	149.151
TK...	Avg. gas meter temp., deg F	125.09
VHSTD...	Volume of dry gas sampled at standard conditions, scf	130.55
RWD...	Percent moisture by volume	1.59
MFL...	Mole fraction of dry gas	.6741
PCO2...	Percent CO ₂ by volume, dry	0
PO2...	Percent O ₂ by volume, dry	20.9
PN2...	Percent N ₂ by volume, dry	79.1
MD...	Dry molecular weight	28.84
MS...	Stack gas molecular weight	28.56
PB...	Barometric pressure, in Hg	29.35
SP...	Static pressure, in H ₂ O	-1.05
PS...	Stack pressure, in Hg	29.32
TS...	Avg. stack temperature, deg F	80.00
TI...	Avg. impactor temp., deg F	80.00
VH...	Avg. Bern of velocity head	.79
VS...	Avg. stack velocity, fpm	45.41
ISD...	Percent isokinetic	103.15

*****IMPACTOR VERSION 4.0*****

***** INPUT DATA *****

1) PART, DIAMETER CLASSICAL AERODYNAMIC
 2) DATE OF TEST: 6/24/86
 3) TIME OF TEST: 1055-1503
 4) LOCATION OF TEST: SCRUBBER OUTLET
 5) TEST NUMBER 1
 6) TEST TYPE OUTLET
 7) RUN NUMBER: EDPS-1-FILE NAME: T:RCGFS-1.OT
 8) RUN REMARKS:
 10) IMPACTOR TYPE: ANDERSEN GENERIC
 ANDERSEN II WITH GENERIC DAL.

9) WATER VAPOR 2.57% (KEYBOARD)
 CO2 .00% CO .00%
 EE 20.80% NE 79.10%
 11) DRIFTFIELD (OPTIONAL):
 13) SUBSTRATE MATERIAL: GLASS FIBER

1) INLET FLOW VOL 130.55 CUBIC FEET
 2) IMPACTOR DELTA P .00 IN. HG.
 3) DRIFTFIELD DELTA P -1.1 INCHES H2O
 4) STACK PRESSURE -.35 INCHES H2O
 5) BAROMETRIC PRES 29.35 INCHES HG
 6) STACK TEMP 80 DEGREES F
 7) INLET TEMP 125 DEGREES F
 8) IMPACTOR TEMP 80 DEGREES F
 9) SAMPLE TIME 240.00 MINUTES
 10) AVG GAS VEL 45.41 FEET/SEC
 11) DRIFTFIELD PRES .00 INCHES HG
 12) NOZZLE DIA .195 INCHES
 13) MAX PART DIA 100.0 MICRONS
 14) WATER VOLUME .0 CC
 15) IMPACTOR FACTOR .7850

MASS GAIN OF STAGE 1 7.90 MG
 MASS GAIN OF STAGE 2 .00 MG
 MASS GAIN OF STAGE 3 .10 MG
 MASS GAIN OF STAGE 4 .00 MG
 MASS GAIN OF STAGE 5 .00 MG
 MASS GAIN OF STAGE 6 .00 MG
 MASS GAIN OF STAGE 7 .20 MG
 MASS GAIN OF STAGE 8 .00 MG
 MASS GAIN OF FILTER .00 MG

MASS GAIN OF BLANK SUBSTRATE .00
 MASS GAIN OF BLANK FILTER .00

J. J. J. J.
 8/15/86

***** RESULTS *****

TEST NUMBER: 1 RUN NUMBER: 80FS-1

ACTUAL FLOW RATE .510 CFM
 FLOW RATE AT STANDARD CONDITIONS .476 CFM
 PERCENT ISOKINETIC 90.274 %
 VISCOSITY 181.4E-06GM/CM SEC
 CALCULATED IMPACTOR DELTA P = .40 IN. HG

STAGE	CLIN.	IF	IF	CUM	FEI	V*0.50
	CDRR.	(CLAS AERO)	(IMP AERO)	FREQ.	NO.	UM-M/3
1	1.018	10.640	10.723	4.8766	44	4.6
2	1.018	9.398	9.479	4.8645	58	6.0
3	1.027	6.264	6.346	3.6604	77	8.1
4	1.047	4.187	4.269	3.6484	92	9.2
5	1.071	2.828	2.908	3.6362	137	9.3
6	1.147	1.173	1.215	2.4322	212	11.2
7	1.217	.658	.777	.0241	257	12.6
8	1.260	.377	.481	.0120	486	11.4

STAGE CUT DIAMETERS BASED ON FILE VALUE OF STAGE CONSTANTS

TOTAL MASS CONCENTRATION = 2.57E+00 MG/DRY NORMAL CUBIC METER

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA.	CUMFR	CUMFR	CUM.MASS	DM/DLOGD
(MICRONS)	(STDEV)	(PERCENT)	(MG/DRY N.CU.METER)	
.101	4.0874	.00	6.54E-05	1.85E-04
.107	3.9201	.00	1.15E-04	3.14E-04
.111	3.7857	.01	1.57E-04	5.23E-04
.119	3.6534	.01	3.74E-04	8.62E-04
.131	3.5201	.02	5.37E-04	6.88E-03
1.000	2.5280	1.00	2.57E-02	5.13E-01
1.585	1.6080	5.07	1.30E-01	1.53E-01
2.512	1.7947	3.64	9.33E-02	1.21E-03
3.55	1.7832	3.64	9.38E-02	4.51E-02
5.010	1.7913	3.66	9.40E-02	4.02E-02
10.000	1.5785	4.66	1.20E-01	1.95E-01
15.850	1.3378	9.05	2.32E-01	8.10E-01
25.120	1.3294	15.23	4.75E-01	1.87E-01
35.510	1.117	40.53	1.17E+00	5.85E-00
50.100	1.2417	98.75	2.57E+00	1.98E+00
100.00	1000000	100.00	2.57E+00	0.00E+00
158.50	1000000	100.00	2.57E+00	0.00E+00
251.20	1000000	100.00	2.57E+00	0.00E+00
355.10	1000000	100.00	2.57E+00	0.00E+00
501.00	1000000	100.00	2.57E+00	0.00E+00

**** RESULTS CONTINUED ****

TEST NUMBER: RUN NUMBER: E096-1

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON:	.03 MG/DNMS	(1.00 %)
CUM MASS LESS THAN 2.512 MICRON:	.09 MG/DNMS	(3.04 %)
CUM MASS LESS THAN 10.000 MICRON:	.12 MG/DNMS	(4.66 %)
CUM MASS LESS THAN 15.850 MICRON:	.23 MG/DNMS	(9.05 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: $Y = -2.77 + 1.42X$	
MASS MEDIAN DIAMETER:	70.015
GEOMETRIC STANDARD DEVIATION:	3.067
CORRELATION COEFFICIENT:	.736

FBI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle Run no: 5095-2
 Sampling Date: 6/25/86
 Location: Outlet Start-stop, 24h: 74a-1202
 Sample type: Particulate size Barometric
 Operator: JF/D5 pressure, in. Hg: 29.41
 Filter ID: Static
 Meter box ID: FB-9 pressure, in. H2O: -1.36
 Y Factor: .986 Stack area, sq in: 802.25
 Moisture, %: 2.57 Nozzle diameter, in: .195
 Number of sample points: 9 Pitot tube, sq: .84
 Sample time, min: 238.00 O2 percent: 0
 Volume correction, cu-ft: 0

Sampling time, minutes	Gas meter reading, cfm	velocity head, in. H2O	Orifice pressure, in. H2O	Stack temp., deg F	meter temp., deg F		Impactor temp., deg F
					Inlet	Outlet	
0.00	625.895	.82	1.30	71	80	75	71
30.00	645.40	.82	1.30	71	114	98	71
60.00	655.575	.82	1.30	71	124	107	71
90.00	665.65	.82	1.30	71	130	116	71
120.00	706.208	.73	1.30	76	137	122	71
150.00	726.515	.73	1.30	76	136	125	71
180.00	746.75	.73	1.30	76	137	126	71
210.00	766.86	.73	1.30	76	139	127	71
238.00	785.822	.73	1.30	76	124	112	71
238	159.903	.78	1.30	74	124	112	71

JF
non
7/9/86

PEI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant:Steel Heddle

Run no.:50SP-2

TT...	Net time of test,min	238.00
NF...	Net sampling points	8
Y...	Meter calibration factor	.986
DN...	Sampling nozzle diameter,in	.195
CF...	Pitot tube coefficient	.84
PM...	Avg. orifice pressure,in H ₂ O	1.30
VM...	Volume of dry gas sampled at meter conditions,cu-ft	159.903
Tm...	Avg. gas meter temp.,deg F	118.19
VMSTD...	volume of dry gas sampled at standard conditions, scf	142.01
EMD...	Percent moisture by volume	2.59
MFD...	Mole fraction of dry gas	.9741
PCO ₂ ...	Percent CO ₂ by volume, dry	0
PO ₂ ...	Percent O ₂ by volume, dry	20.9
PNO ₂ ...	Percent NO ₂ by volume, dry	79.1
MD...	Dry molecular weight	28.84
MS...	Stack gas molecular weight	28.56
PB...	Barometric pressure, in Hg	29.41
SP...	Static pressure, in H ₂ O	-1.38
PS...	Stack pressure, in Hg	29.38
TS...	Avg. stack temperature,deg F	73.50
TI...	Avg. impactor temp.,deg F	71.00
VK...	Avg. Error of velocity head	.88
VB...	Avg. stack velocity, fpm	50.39
ISD...	Percent isokinetic	100.53

***** INPUT DATA *****

1)PART. DIAMETER CLASSICAL AERODYNAMIC
 2)DATE OF TEST: 6/25/86
 3)TIME OF TEST: 0746-120Z
 4)LOCATION OF TEST: SCRUBBER OUTLET
 5)TEST NUMBER 2
 6)TEST TYPE OUTLET
 7)RUN NUMBER: SOPS-2-FILE NAME:725SOPS-2.OT
 8)RUN REMARKS:
 10)IMPACTOR TYPE: ANDERSEN GENERIC
 ANDERSEN 11 WITH GENERIC CAL.

9)WATER VAPOR 2.59%
 CO2 1.00%
 CO 1.00%
 NO2 1.00%
 NO 1.00%

12) ORIFICE ID (OPTIONAL):
 13) SUBSTRATE MATERIAL: GLASS FIBER

10)GAS METER VOL 142.010 CUBIC FEET
 2)IMPACTOR DELTA P .00 IN. HG.
 3)ORIFICE DELTA P -1.0 INCHES H2O
 4)STACK PRESSURE -1.36 INCHES H2O
 5)BAROMETRIC PRES 29.41 INCHES HG
 6)STACK TEMP 74 DEGREES F
 7)METER TEMP 116 DEGREES F
 8)IMPACTOR TEMP 71 DEGREE F
 9)SAMPLE TIME 139.00 MINUTES
 10)AVG GAS VEL 50.39 FEET/SEC
 11)ORIFICE PRES .00 INCHES HG
 12)NOZZLE DIA .195 INCHES
 13)MAX PART DIA 100.0 MICRONS
 14)WATER VOLUME .0 CC
 15)METER FACTOR .9860

MASS GAIN OF STAGE 1 8.70 MG
 MASS GAIN OF STAGE 2 .00 MG
 MASS GAIN OF STAGE 3 .20 MG
 MASS GAIN OF STAGE 4 .00 MG
 MASS GAIN OF STAGE 5 .50 MG
 MASS GAIN OF STAGE 6 .50 MG
 MASS GAIN OF STAGE 7 .00 MG
 MASS GAIN OF STAGE 8 .10 MG
 MASS GAIN OF FILTER .40 MG

MASS GAIN OF BLANK SUBSTRATE .00
 MASS GAIN OF BLANK FILTER .00

J. Fiori

***** RESULTS *****

TEST NUMBER: 2 RUN NUMBER: 5098-2

ACTUAL FLOW RATE .537 CFM
 FLOW RATE AT STANDARD CONDITIONS .530 CFM
 PERCENT ISOKINETIC 89.360 %
 VISCOSITY 179.2E-06GM/CM SEC
 CALCULATED IMPACTOR DELTA P = .50 IN. HG

STAGE	DIFF. CORR.	DP (CLAS AERO)	DP (IMP AERO)	CUM FREQ.	RE. NO.	V+DE. UM-H2O
1	1.016	10.167	10.198	14.723	50	4.3
2	1.018	8.934	9.015	14.713	56	7.2
3	1.027	8.935	6.036	12.752	67	9.3
4	1.041	6.980	4.060	10.792	102	6.3
5	1.073	5.210	2.290	7.8514	123	9.3
6	1.151	3.075	1.153	4.9105	135	11.6
7	1.247	1.881	.735	3.9710	157	12.5
8	1.478	1.353	.429	3.9209	207	14.5

STAGE CUT DIAMETERS BASED ON FILE VALUES OF STAGE CONSTANTS

TOTAL MASS CONCENTRATION = 2.865+00 MG/DRY NORMAL CUBIC METER

SALINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR. (PERCENT)	CUMFR. (PERCENT)	CUM. MASS (MG/DRY N.C.METER)	DM/DLOBF
.100	2.2078	1.36	3.89E-02	8.14E-02
.125	3.0444	2.05	5.84E-02	1.15E-01
.150	4.8509	3.00	8.57E-02	1.57E-01
.175	7.7318	4.17	1.19E-01	2.35E-01
.200	1.16568	4.88	1.39E-01	3.76E-01
1.000	1.7541	4.91	1.40E-01	3.44E-01
1.585	1.5470	6.09	1.74E-01	3.00E-01
2.512	1.3704	6.53	2.43E-01	3.41E-01
3.921	1.2377	10.79	3.02E-01	3.23E-01
6.210	1.1263	15.00	3.71E-01	3.78E-01
10.000	1.0501	14.65	4.19E-01	2.23E-01
15.850	1.0216	15.35	4.38E-01	1.66E-01
25.120	1.0000	15.17	5.15E-01	7.75E-01
39.510	1.0000	22.24	9.21E-01	4.23E+00
63.100	1.0000	24.22	1.69E+00	7.47E+00
100.00	100.000	100.00	2.86E+00	0.00E+00
158.50	100.000	100.00	2.86E+00	0.00E+00
251.20	100.000	100.00	2.86E+00	0.00E+00
395.10	100.000	100.00	2.86E+00	0.00E+00
631.00	100.000	100.00	2.86E+00	0.00E+00

***** RESULTS CONTINUED *****

TEST NUMBER: 2 RUN NUMBER: 80F2-2

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON:	.14	MG/DNMS	(4.91 %)
CUM MASS LESS THAN 2.512 MICRON:	.24	MG/DNMS	(8.57 %)
CUM MASS LESS THAN 10.000 MICRON:	.42	MG/DNMS	(14.68 %)
CUM MASS LESS THAN 15.250 MICRON:	.44	MG/DNMS	(15.35 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: $Y = 1.57 X - .52$	
MASS MEDIAN DIAMETER:	1008.557
GEOMETRIC STANDARD DEVIATION:	80.832
CORRELATION COEFFICIENT:	.971

FBI ASSOCIATES, INC.
EMISSION TEST REPORT

Plant: Steel Heddle Run no: SDF5-3
 Sampling Date: 6/25/86
 Location: Outlet Start-stop, 24h:1217-1655
 Sample type: Particle size Barometric
 Operator: JP/D5 pressure, in. Hg: 29.44
 Filter ID: Static
 Meter box ID: FE-9 pressure, in. H2O: -.26
 Y Factor: .986 Stack area, Sq in: 802.25
 Moisture, %: 2.59 Nozzle diameter, in: .197
 Number of sample points: 9 Pitot tube, Cp: .84
 Sample time, min: 240.10 CO2 percent: 0
 Volume correction, cu-ft: 0

Sampling time, minutes	Gas meter reading, cfm	Velocity head, in. H2O	Orifice pressure, in. H2O	Stack temp, deg F	Meter temp, deg F		Impactor temp, deg F
					Inlet	Outlet	
0.00	785.903	.71	1.46	72	130	125	72
30.00	807.00	.71	1.46	72	138	126	72
60.00	828.35	.71	1.46	72	138	126	72
90.00	849.6	.71	1.46	72	138	126	72
120.00	870.545	.71	1.46	72	138	126	72
150.00	891.9	.84	1.46	75	131	124	72
180.00	913.1	.84	1.46	75	136	122	72
185.00	916.38	.84	1.46	75	135	122	72
210.00	933.9	.84	1.46	75	120	111	72
240.10	954.838	.84	1.46	75	122	111	72
240.1	165.955	.78	1.46	74	132	121	72

✓
J. Fiori
7/9/86

FEI ASSOCIATES, INC.
 EMISSION TEST REPORT

Plant: Steel Heddle

Run no.: 509P-0

TT...	Net time of test, min	240.10
NF...	Net sampling points	9
Y...	Meter calibration factor	.966
DN...	Sampling nozzle diameter, in	.197
CF...	Pitot tube coefficient	.84
PM...	Avg. orifice pressure, in H ₂ O	-1.46
VM...	Volume of dry gas sampled at meter conditions, cu-ft	168.935
TM...	Avg. gas meter temp., deg F	126.67
VMSTL...	Volume of dry gas sampled at standard conditions, scf	148.05
BWC...	Percent moisture by volume	2.59
MFD...	Mole fraction of dry gas	.9741
POD...	Percent O ₂ by volume, dry	0
PO...	Percent O ₂ by volume, dry	20.9
PN...	Percent N ₂ by volume, dry	75.1
MD...	Dry molecular weight	28.64
MS...	Stack gas molecular weight	28.56
PS...	Barometric pressure, in Hg	29.44
SP...	Static pressure, in H ₂ O	-1.26
FS...	Stack pressure, in Hg	29.42
TS...	Avg. stack temperature, deg F	73.67
TI...	Avg. impactor temp., deg F	72.00
WV...	Avg. part of velocity head	.88
VS...	Avg. stack velocity, fps	30.58
ISD...	Percent isokinetic	101.70

***** INPUT DATA *****

1) PART. DIAMETER CLASSICAL AERODYNAMIC
 2) DATE OF TEST: 6/25/66
 3) TIME OF TEST: 1217-1655
 4) LOCATION OF TEST: SCRUBBER OUTLET
 5) TEST NUMBER 3
 6) TEST TYPE OUTLET
 7) RUN NUMBER: SOPS-3-FILE NAME: T3RSOPS-3.OT
 8) RUN REMARKS:
 10) IMPACTOR TYPE: ANDERSEN GENERIC
 ANDERSEN II WITH GENERIC CAL.

9) WATER VAPOUR 2.59%
 CO2 .00% CO .00%
 O2 10.90% N2 79.10%

11) DRIFICE ID (OPTIONAL):
 12) SUBSTRATE MATERIAL: GLASS FIBER

1) GAS METER VOL 148.050 CUBIC FEET
 2) IMPACTOR DELTA P .00 IN. HG.
 3) ORIFICE DELTA P -1.5 INCHES H2O
 4) STAG. PRESSURE -1.26 INCHES H2O
 5) BAROMETRIC PRES 29.44 INCHES HG
 6) STACK TEMP 74 DEGREES F
 7) METER TEMP 107 DEGREES F
 8) IMPACTOR TEMP 72 DEGREE F
 9) SAMPLE TIME 240.10 MINUTES
 10) AVE GAS VEL 50.58 FEET/SEC
 11) DRIFICE PRES .00 INCHES HG
 12) NOZZLE DIA .157 INCHES
 13) MAX PART DIA 100.0 MICRONS
 14) WATER VOLUME .0 CC
 15) METER FACTOR .9860

MASS GAIN OF STAGE 1 4.80 MG
 MASS GAIN OF STAGE 2 .00 MG
 MASS GAIN OF STAGE 3 .00 MG
 MASS GAIN OF STAGE 4 .00 MG
 MASS GAIN OF STAGE 5 .00 MG
 MASS GAIN OF STAGE 6 .00 MG
 MASS GAIN OF STAGE 7 .20 MG
 MASS GAIN OF STAGE 8 .20 MG
 MASS GAIN OF FILTER .40 MG

MASS GAIN OF BLANK SUBSTRATE .00
 MASS GAIN OF BLANK FILTER .00

J. Fri

***** RESULTS *****

TEST NUMBER: 7 RUN NUMBER: 6095-3

ACTUAL FLOW RATE .566 CFM
 FLOW RATE AT STANDARD CONDITIONS .540 CFM
 PERCENT ISOKINETIC 89.772 %
 VISCOSITY 179.5E-06 CM/CM SEC
 CALCULATED IMPACTOR DELTA P = .52 IN. HG

STAGE	CUMUL. COEFF.	DF (CLASS. AERO)	DF (IMP. AERO)	CUM. FREQ.	REL. NO.	WATER Uptake
1	1.015	10.025	10.106	20.772	51	4.8
2	1.018	6.833	8.934	27.754	57	7.1
3	1.028	5.901	5.981	20.703	89	6.5
4	1.041	5.943	4.023	20.686	110	6.9
5	1.074	2.190	2.269	10.669	157	10.0
6	1.100	1.064	1.147	13.777	241	11.7
7	1.250	.655	.732	10.304	223	13.1
8	1.484	.742	.405	6.8890	337	11.9

STAGE DIA DIAMETERS BASED ON FILE VALUES OF STAGE CONSTANTS
 TOTAL MASS CONCENTRATION = 1.58E+00 MG/DRY NORMAL CLETC METER
 SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM. MASS (MG/DRY N. CU. METER)	DM/DROGG
.100	1.9.32	2.78	4.34E-02	5.01E-02
.150	1.7835	3.81	6.21E-02	1.08E-01
.200	1.5937	5.39	8.29E-02	1.41E-01
.300	1.4370	7.84	1.19E-01	1.85E-01
.500	1.2754	10.11	1.60E-01	2.12E-01
1.000	1.1157	13.23	2.09E-01	3.00E-01
1.500	.9171	17.95	2.54E-01	3.88E-01
2.000	.8125	21.12	3.04E-01	5.51E-02
3.000	.6172	20.69	3.17E-01	1.56E-00
4.000	.5157	20.73	3.28E-01	1.18E-07
5.000	.4141	20.78	3.18E-01	4.74E-05
7.500	.3011	21.12	3.34E-01	7.85E-07
10.000	.2032	24.08	3.81E-01	4.85E-01
15.000	.1092	33.33	4.03E-01	2.47E-04
20.000	.7377	96.02	1.30E+00	3.04E-00
100.00	100.00	100.00	1.58E+00	0.00E+00
150.00	100.00	100.00	1.58E+00	0.00E+00
200.00	100.00	100.00	1.58E+00	0.00E+00
300.00	100.00	100.00	1.58E+00	0.00E+00
500.00	100.00	100.00	1.58E+00	0.00E+00

**** RESULTS CONTINUED ****

TEST NUMBER: 2 RUN NUMBER: 5085-3

*** INHALABLE PARTICULATE MATTER ***

CUM MASS LESS THAN 1.000 MICRON: .21 MG/DNMS (13.55 %)
CUM MASS LESS THAN 2.512 MICRON: .33 MG/DNMS (21.11 %)
CUM MASS LESS THAN 10.000 MICRON: .33 MG/DNMS (20.78 %)
CUM MASS LESS THAN 15.850 MICRON: .33 MG/DNMS (21.12 %)
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: $y = -1.14 + .47x$
MASS MEDIAN DIAMETER: 278.535
GEOMETRIC STANDARD DEVIATION: 130.125
CORRELATION COEFFICIENT: .845

APPENDIX B
FIELD DATA SHEETS

ONSITE EQUIPMENT AUDITS AND
PRELIMINARY DATA

Plant Steel Heddle

Date 6/23/86

Sampling location Scrubber Inlet

Inside of far wall to outside of nipple 32.4"

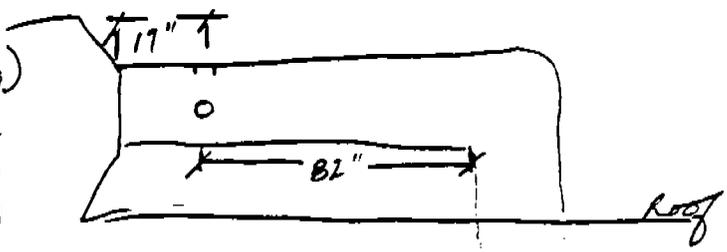
Inside of near wall to outside of nipple (nipple length) 32" (Wall Thickness) 1/4"

Stack I.D. 32"

Nearest upstream disturbance .53 dd

Nearest downstream disturbance 2.6 dd

Calculated by CR/MS

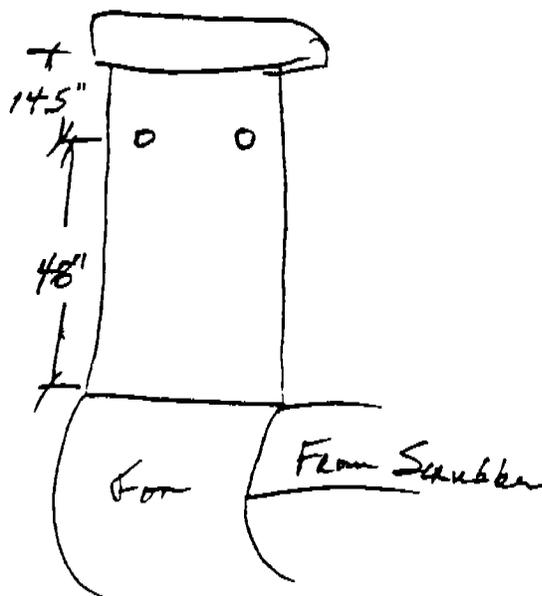


SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	NIPPLE LENGTH	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	.021	32		1/4"	.92
2	.067				2.4
3	.118				4
4	.177				5.9
5	.250				8.25
6	.356				11.64
7	.644				20.86
8	.750				24.25
9	.823				26.59
10	.882				28.5
11	.932				30.1
12	.979				31.58

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

Plant Steel Heddle
 Date 6/23/86
 Sampling location Scrubber Outlet
 Inside of far wall to outside of nipple 32 1/4
 Inside of near wall to outside of nipple (nipple length) 1/4"
 Stack I.D. 32
 Nearest upstream disturbance .45 dd
 Nearest downstream disturbance 1.5 dd
 Calculated by CP



SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	NIPPLE LENGTH	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1		32		1/4"	None on inlet
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

GAS VELOCITY AND VOLUMETRIC FLOW RATE

Plant and City S-70 HADDLE Date 6/27/51
 Sampling Location OUTLET Clock Time 10:00
 Run No. CYCLIC FLOW CHECK Operator JF/S
 Barometric Pressure, in. Hg _____ Static Pressure, in. H₂O _____
 Moisture, % _____ Molecular wt., Dry _____ Pitot Tube, Cp _____
 Stack Dimension, in. Diameter or Side 1 _____ Side 2 _____

FIELD DATA

CALCULATIONS

TRAVERSE POINT NUMBER	ORIENTATION, VELOCITY IN INCHES PER SECOND (in. H ₂ O)	STACK TEMP., °F
1	0	
2	0	
3	+20	
4	+30	
5	+1	
6	+2	
7	-10	
8	-15	
9	-15	
10	-16	
11	-13	
12	-13	
Σ	+20	
1	+15	
2	+13	
3	+8	
4	0	
5	-5	
6	-10	
7	-10	
8	-8	
9	-9	
10	-6	
11	-10	
12	-10	
MIN = -8.50		

+ = Correntia lockhouse

$$M_s = M_0 \times \left(1 - \frac{H_2O}{100}\right) + 18 \left(\frac{H_2O}{100}\right)$$

$$M_s = () \times \left(1 - \frac{ }{100}\right) + 18 \left(\frac{ }{100}\right)$$

$$M_s =$$

$$T_s = \text{°F} \quad \text{°R} = (\text{°F} + 460)$$

$$P_s = P_b + \frac{S.P.}{13.6} = () + \frac{ }{13.6}$$

$$P_s = \text{in. Hg}$$

$$\sqrt{\frac{P_s}{P_s}}$$

$$V_s = 85.49 \times C_p \times \sqrt{\frac{P_s}{P_s} \times \frac{M_s}{M_s}}$$

$$V_s = 85.49 \times () \times () \times \sqrt{\frac{ }{ } }$$

$$V_s = \text{ft/s}$$

$$A_s = \text{ft}^2$$

$$Q_s = V_s \times A_s \times \frac{60 \text{ s}}{\text{min}}$$

$$Q_s = \text{scfm} \times 60$$

$$Q_{s, \text{std}} = Q_s \times 17.647 \times \frac{P_s}{T_s} \times \left(1 - \frac{H_2O}{100}\right)$$

$$Q_{s, \text{std}} = \text{scfm} \times 17.647 \times \frac{ }{ } \times \left(1 - \frac{ }{100}\right)$$

$$Q_{s, \text{std}} = \text{scfm}$$

GAS VELOCITY AND VOLUMETRIC FLOW RATE

Plant and City STEEL MILL Date 6/20/82
 Sampling Location INLET Clock Time 14:23
 Run No. CYCLONE FLOW CHECK Operator JP/DC
 Barometric Pressure, in.Hg _____ Static Pressure, in.H₂O _____
 Moisture, % _____ Molecular wt., Dry _____ Pitot Tube, Cp _____
 Stack Dimension, in. Diameter or Side 1 _____ Side 2 _____

0 ROTATION AT
 NULL READING
 FIELD DATA

CALCULATIONS

TRAVERSE POINT NUMBER	VELOCITY (ft/s) (at P _s at 0% H ₂ O)	STACK TEMP., °F
H-1	-1	
2	0	
3	0	
4	0	
5	0	
6	0	
7	0	
8	-5	
9	-5	
10	0	
11	0	
12	0	
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		

$$M_s = M_o \times \left(1 - \frac{H_2O}{100}\right) + 18 \left(\frac{H_2O}{100}\right)$$

$$M_s = \left(\quad \right) \times \left(1 - \frac{\quad}{100}\right) + 18 \left(\frac{\quad}{100}\right)$$

$$M_s = \quad$$

$$T_s = \quad \text{°F} = \quad \text{°R} = (\text{°F} + 460)$$

$$P_s = P_b + \frac{S \cdot P_s}{13.6} = \left(\quad \right) + \frac{\quad}{13.6}$$

$$P_s = \quad \text{in. Hg}$$

$$\sqrt{\Delta P} = \quad$$

$$V_s = 85.49 \times C_p \times \sqrt{\Delta P} \times \sqrt{\frac{T_s \text{ °F}}{P_s \times P_s}}$$

$$V_s = 85.49 \times \left(\quad \right) \times \left(\quad \right) \times \sqrt{\frac{\quad}{\quad}}$$

$$V_s = \quad \text{ft/s}$$

$$A_s = \quad \text{ft}^2$$

$$Q_s = V_s \times A_s \times \frac{60 \text{ s}}{\text{min}}$$

$$Q_s = \quad \times \quad \times 60$$

$$Q_s = \quad \text{scfm}$$

$$Q_{s, \text{std}} = C_s \times 37.647 \times \frac{P_s}{T_s} \times \left(1 - \frac{H_2O}{100}\right)$$

$$Q_{s, \text{std}} = \quad \times 37.647 \times \frac{\quad}{\quad} \times \left(1 - \frac{\quad}{100}\right)$$

$$Q_{s, \text{std}} = \quad \text{scfm}$$

NEEDLE FINDER DOES NOT WORK WITH PITOT IN VERTICAL POSITION - NEEDLE RUBS SIDE OF FACE.

FIELD AUDIT REPORT: DRY GAS METER
BY CRITICAL ORIFICE

DATE: 6/23/86 CLIENT: USEPA-EMA
 BAROMETRIC PRESSURE (P_{bar}): 29.45 in.Hg METER BOX NO. FB-3
 ORIFICE NO. 8 PRETEST Y: 0.977 $\Delta H\theta$ 1.86 in.H₂O
 ORIFICE K FACTOR: 4.725×10^{-4} AUDITOR: (CP)

Orifice manometer reading ΔH , in.H ₂ O	Dry gas meter reading V_i/V_f , ft ³	Temperatures					Duration of run θ min.
		Ambient		Dry gas meter			
		T_{ai}/T_{af} , °F	Average T_a , °F	Inlet T_{ii}/T_{if} , °F	Outlet T_{oi}/T_{of} , °F	Average T_m , °F	
1.9	957.20	120	115	119	113	116	15:22.17
	969.70	109		118	112		15:36.95

Dry gas meter V_m , ft ³	$V_{m, std}$, ft ³	$V_{m, act}$, ft ³	Audit, Y	Y deviation, %	Audit $\Delta H\theta$, in.H ₂ O	$\Delta H\theta$ Deviation, in.H ₂ O
12.5	11.279	10.80	.958	-2.03 ✓	1.85 ✓	-0.1 ✓

$$V_{m, std} = \frac{17.647(V_m)(P_{bar} + \Delta H/13.6)}{(T_m + 460)} = \text{ft}^3$$

$$V_{m, act} = \frac{1203(\phi)(K)(P_{bar})}{(T_a + 460)^{1/2}} = \text{ft}^3$$

$$\text{Audit Y} = \frac{V_{m, act}}{V_{m, std}} = \text{Y deviation} = \frac{\text{Audit Y} - \text{Pre-test Y}}{\text{Audit Y}} \times 100 =$$

$$\text{Audit } \Delta H\theta = (0.0317)(\Delta H)(P_{bar})(T_m + 460) \left[\frac{\phi}{Y(V_m)(P_{bar} + \Delta H/13.6)} \right]^2 = \text{in.H}_2\text{O}$$

Audit Y must be in the range, pre-test Y ± 0.05 Y.
 Audit $\Delta H\theta$ must be in the range pre-test $\Delta H\theta \pm 0.15$ inches H₂O.

FIELD AUDIT REPORT: DRY GAS METER
BY CRITICAL ORIFICE

DATE: 6/23/86 CLIENT: USEPA-EMB
 BAROMETRIC PRESSURE (P_{bar}): 29.45 in.Hg METER BOX NO. FB-11
 ORIFICE NO. 3 PRETEST Y: .978 ΔH@ 1.16 in.H₂O
 ORIFICE K FACTOR: 5.377x10⁻⁴ AUDITOR: (CB)

Orifice manometer reading ΔH, in.H ₂ O	Dry gas meter reading V _i /V _f , ft ³	Temperatures					Duration of run Ø min.
		Ambient		Dry gas meter			
		T _{ai} /T _{af} , °F	Average T _a , °F	Inlet T _{ii} /T _{if} , °F	Outlet T _{oi} /T _{of} , °F	Average T _m , °F	
1.48	357.60 371.0	122 109	116	125 123	119 128	124	15:09 (15:15) 21

Dry gas meter V _m , ft ³	V _m std', ft ³	V _m act', ft ³	Audit, Y	Y deviation, %	Audit ΔH@, in.H ₂ O	ΔH@ Deviation, in.H ₂ O
13.40	11.969	12.03	1.00	2.7 ✓	1.24	-.08 ✓

$$V_{m\text{std}} = \frac{17.647(V_m)(P_{\text{bar}} + \Delta H/13.6)}{(T_m + 460)} = \text{ft}^3$$

$$V_{m\text{act}} = \frac{1203(\emptyset)(K)(P_{\text{bar}})}{(T_a + 460)^{1/2}} = \text{ft}^3$$

$$\text{Audit } Y = \frac{V_{m\text{act}}}{V_{m\text{std}}} = \text{Y deviation} = \frac{\text{Audit } Y - \text{Pre-test } Y}{\text{Audit } Y} \times 100 =$$

$$\text{Audit } \Delta H@ = (0.0317)(\overset{1.48}{\Delta H})(P_{\text{bar}})(T_m + 460) \left[\frac{\emptyset}{Y(V_m)(P_{\text{bar}} + \Delta H/13.6)} \right]^2 = 1.24 \text{ in.H}_2\text{O}$$

Audit Y must be in the range, pre-test Y ± 0.05 Y.
 Audit ΔH@ must be in the range pre-test ΔH@ ± 0.15 inches H₂O.

THERMOCOUPLE DIGITAL INDICATOR
AUDIT DATA SHEET

Date 6/23/86 Indicator No. FT-1 Operator CB

Test Point No.	Millivolt signal*	Equivalent temperature, °F*	Digital indicator temperature reading, °F	Difference, %
1		0	-2	-
2		200	199	-.15 ✓
3		400	399	.12 ✓
4		600	599	.09 ✓

(92427)

Percent difference must be less than or equal to 0.5%.

Percent difference:

$$\frac{(\text{Equivalent temperature } ^\circ\text{R} - \text{Digital indicator temperature reading } ^\circ\text{R})(100\%)}{(\text{Equivalent temperature } ^\circ\text{R})}$$

Where $^\circ\text{R} = ^\circ\text{F} + 460^\circ\text{F}$

* These values are to be obtained from the calibration data sheet for the calibration device.

THERMOCOUPLE DIGITAL INDICATOR
AUDIT DATA SHEET

Date 6/23/86 Indicator No. 219 Operator SB

Test Point No.	Millivolt signal*	Equivalent temperature, °F*	Digital indicator temperature reading, °F	Difference, %
1	0	0	-1	-
2		200	199	.15
3		400	398	.23
4		600	598	.19

Percent difference must be less than or equal to 0.5%.

Percent difference:

$$\frac{(\text{Equivalent temperature } ^\circ\text{R} - \text{Digital indicator temperature reading } ^\circ\text{R})(100\%)}{(\text{Equivalent temperature } ^\circ\text{R})}$$

Where $^\circ\text{R} = ^\circ\text{F} + 460^\circ\text{F}$

* These values are to be obtained from the calibration data sheet for the calibration device.

FIELD AUDIT REPORT: DRY GAS METER
BY CRITICAL ORIFICE

DATE: 6/23/86
 BAROMETRIC PRESSURE (P_{bar}): 29.45 in. Hg
 ORIFICE NO. 8
 ORIFICE K FACTOR: 4.725×10^{-4}

CLIENT: USEPA-EMB
 METER BOX NO. FT-1
 PRETEST Y: .981 $\Delta H@$ 1.93 in. H₂O
 AUDITOR: (98)

Orifice manometer reading ΔH , in. H ₂ O	Dry gas meter reading V_i/V_f , ft ³	Temperatures					Duration of run \emptyset min.
		Ambient		Dry gas meter			
		T_{ai}/T_{af} , °F	Average T_a , °F	Inlet T_{ii}/T_{if} , °F	Outlet T_{oi}/T_{of} , °F	Average T_m , °F	
1.80	632.5	118	122	122	117	120	15:05.49
	644.6	126		122	118		(15:0915)

Dry gas meter V_m , ft ³	$V_{m_{std}}$, ft ³	$V_{m_{act}}$, ft ³	Audit, Y	Y deviation, %	Audit $\Delta H@$, in. H ₂ O	$\Delta H@$ Deviation, in. H ₂ O
12.1	10.842	10.472	.966	-1.55 ✓	1.80	-0.03 ✓

$$V_{m_{std}} = \frac{17.647(V_m)(P_{bar} + \Delta H/13.6)}{(T_m + 460)} = \text{ft}^3$$

$$V_{m_{act}} = \frac{1203(\emptyset)(K)(P_{bar})}{(T_a + 460)^{1/2}} = \text{ft}^3$$

$$\text{Audit Y} = \frac{V_{m_{act}}}{V_{m_{std}}} = \text{Y deviation} = \frac{\text{Audit Y} - \text{Pre-test Y}}{\text{Audit Y}} \times 100 =$$

$$\text{Audit } \Delta H@ = (0.0317)(\Delta H)(P_{bar})(T_m + 460) \left[\frac{\emptyset}{Y(V_m)(P_{bar} + \Delta H/13.6)} \right]^2 = \text{in. H}_2\text{O}$$

Audit Y must be in the range, pre-test Y ± 0.05 Y.
 Audit $\Delta H@$ must be in the range pre-test $\Delta H@ \pm 0.15$ inches H₂O.

FIELD AUDIT REPORT: DRY GAS METER
BY CRITICAL ORIFICE

DATE: 6/23/86 CLIENT: KSEPA-EMB
 BAROMETRIC PRESSURE (P_{bar}): 29.45 in.Hg METER BOX NO. FB-9
 ORIFICE NO. 3 PRETEST Y: .986 ΔH@ 2.04 in.H₂O
 ORIFICE K FACTOR: 5.377 x 10⁻⁴ AUDITOR: (C)

Orifice manometer reading ΔH, in.H ₂ O	Dry gas meter reading V _i /V _f , ft ³	Temperatures					Duration of run Ø min.
		Ambient		Dry gas meter			
		T _{ai} /T _{af} , °F	Average T _a , °F	Inlet T _{ii} /T _{if} , °F	Outlet T _{oi} /T _{of} , °F	Average T _m , °F	
2.62	455.40	108	109	126	116	121.5	15:20.59 (15:34.3)
	469.50	112		126	118		

Dry gas meter V _m , ft ³	V _m std', ft ³	V _m act', ft ³	Audit, Y	Y deviation, %	Audit ΔH@, in.H ₂ O	ΔH@ Deviation, in.H ₂ O
14.1	12.684	12.253	.966	-2.1 ✓	2.00	-.04 ✓

$$V_{m\text{std}} = \frac{17.647(V_m)(P_{\text{bar}} + \Delta H/13.6)}{(T_m + 460)} = \text{ft}^3$$

$$V_{m\text{act}} = \frac{1203(\overset{15.343}{\emptyset})(\overset{5.377 \times 10^{-4}}{K})(P_{\text{bar}})}{(T_a + 460)^{1/2}} = \text{ft}^3$$

$$\text{Audit } Y = \frac{V_{m\text{act}}}{V_{m\text{std}}} = 0.966 \quad Y \text{ deviation} = \frac{\text{Audit } Y - \text{Pre-test } Y}{\text{Audit } Y} \times 100 =$$

$$\text{Audit } \Delta H@ = (0.0317)(\Delta H)(P_{\text{bar}})(T_m + 460) \left[\frac{\emptyset}{Y(V_m)(P_{\text{bar}} + \Delta H/13.6)} \right]^2 = 2.00 \text{ in.H}_2\text{O}$$

Audit Y must be in the range, pre-test Y ± 0.05 Y.
 Audit ΔH@ must be in the range pre-test ΔH@ ± 0.15 inches H₂O.

ON-SITE AUDIT DATA SHEET

Audit Name: USEPA-EMB

Date: 6/23/96

Auditor: CB

Equipment	Reference	Reference Value	Value Determined	Deviation	Max. Allowable Deviation
Meter box inlet thermo. ^{FB-3} ₋₉ ^{FT-1}	ASTM-3F at ambient temp.	101 103 105 101	98 100 104 101	-30°F ✓ -3°F ✓ -10°F ✓ 0 ✓	5°F
Meter box outlet thermo. ^{FB-3} ₋₉ ^{FT-1}	ASTM-3F at ambient temp.	99 95 100 101	99 100 101 101	0 ✓ -2°F ✓ -10°F ✓ 0 ✓	5°F
Impinger thermometer ^{I-1} _{I-15}	ASTM-3F at ambient temp.	97	95	-2°F ✓	2°F
Stack thermometer #101 or Thermocouple	ASTM-3F at ambient temp.	99 99	93 95	-4°F ✓ -2°F ✓	7°F
	ASTM-3F at stack temp.				See table
Orsat analyzer	% O ₂ in ambient air	20.8%			0.7%
Trip balance	IOLM std. weight		NA		0.5 grams
Barometer	Corrected* NWS value		NA		0.20 in. Hg

Reference temp. °F	32-140	141-273	274-406	407-540	541-673	674-760
Max. deviation °F	7	9	11	13	15	17

* Correction factor:

$$\text{NWS value (in. Hg)} - [\text{Altitude (ft)/1000(ft/in. Hg)}] + 0.74 \text{ in. Hg}^{**}$$

** 0.74 in. Hg is the nominal correction factor for the reference barometer against which the field barometer was calibrated.

If it is not feasible to perform the audit on any piece of equipment, record "N/A" in the space provided for the data.



DRY MOLECULAR WEIGHT DETERMINATION

PLANT Steel Heddle COMMENTS: No. 422
 DATE 6/23/86 TEST NO P-1
 SAMPLING TIME (24 hr CLOCK) ~ 1445-1500
 SAMPLING LOCATION Scrubber Inlet
 SAMPLE TYPE (BAG) INTEGRATED, CONTINUOUS
 ANALYTICAL METHOD Orsat
 AMBIENT TEMPERATURE 105°F
 OPERATOR CB
 ORSAT LEAK CHECKED

RUN GAS	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	44/100	0
O ₂ (NET IS ACTUAL O ₂ READING MINUS ACTUAL CO ₂ READING)	20.5	20.5	20.5	20.5			20.5	32/100	6.56
CO (NET IS ACTUAL CO READING MINUS ACTUAL O ₂ READING)							0	28/100	0
N ₂ (NET IS 100 MINUS ACTUAL CO READING)							79.5	28/100	22.26
TOTAL									28.82

Cr⁺⁶/Cr FIELD DATA SHEETS

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Heddle Sample date 6/24/86
 Sample location Scrubber Inlet Recovery date 6/24/86
 Run number SIC-1 Recovered by CB
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel #4	
Final volume (wt)	611.0	638.3	596.2 ml(g)	Final wt	794.3 g
Initial volume (wt)	585.0	613.8	570.9 ml(g)	Initial wt	750.1 g
Net volume (wt)	26.0	24.5	25.3 ml(g)	Net wt	44.2 g
Description of impinger water	<u>slightly yellow</u>			100	% spent
Total moisture				100.0	g

RECOVERED SAMPLE

Filter container number(s) NA Sealed _____
 Description of particulate on filter NA

Probe rinse container no.	<u>NA</u>	Liquid level marked	<u>-NA</u>
blank container no.	<u>NA</u>	Liquid level marked	<u>NA</u>
Impinger contents container no.	<u>4675-A</u>	Liquid level marked	<u>✓</u>
<u>NaOH</u> blank container no.	<u>4676-A</u>	Liquid level marked	<u>✓</u>

Samples stored and locked _____

Remarks PH check: 10.0 ✓
- sample had yellowish tint; from nozzle/packer time.

LABORATORY CUSTODY

Received by Laura Petal Date 9/3/86

Remarks _____

Particulate sample recovery and integrity data sheet.

EMISSION TESTING FIELD DATA

DI-219
7605
STACK
PAGE 6
IAP I-
501
2002

PLANT & CITY	DATE	SAMPLING LOCATION	SAMPLE TIME
STREETS HERBIVORE (S) 91444444	16/05/86	White	01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

BURN NO.	OPERATOR	BAR. PRESS. (IN. Hg)	STATIC PRESS. (IN. H ₂ O)	FILTER NUMBER(S)	STACK INSIDE DIMEN. (INCHES)	PITOT TUBE NO.	REF. SP.
175224	W. B. RAY	30.33	3.53	13A, 13B, 13C, 13D, 13E, 13F, 13G, 13H, 13I, 13J, 13K, 13L, 13M, 13N, 13O, 13P, 13Q, 13R, 13S, 13T, 13U, 13V, 13W, 13X, 13Y, 13Z	26.3, 25.2	084	13

PROBE LENGTH AND TYPE	NOZZLE NO.	SAMPLE METER NO.	METER FACTOR	LEAK CHECK	METER CAL. FACTOR	STAGE TEMPERATURE (°F)	STAGE TEMPERATURE (°C)	DRY GAS METER INLET (°F)	DRY GAS METER OUTLET (°F)	PUMP VACUUM (IN. Hg)	SAMPLE BOX TEMPERATURE (°F)	RECORD DATA RINS
1002	41113	1466	0.8718	13A, 13B, 13C, 13D, 13E, 13F, 13G, 13H, 13I, 13J, 13K, 13L, 13M, 13N, 13O, 13P, 13Q, 13R, 13S, 13T, 13U, 13V, 13W, 13X, 13Y, 13Z	14.3	0.001	143	0.001	103	2.5	30	13

TRAVELER POINT NUMBER	CLOCK TIME (24 HR CLOCK)	GAS METER READING (V ₁)	VELOCITY HEAD (AP, IN. H ₂ O)	ORIFICE PRESSURE DIFFERENTIAL (IN. H ₂ O)		STAGE TEMPERATURE (°F)	STAGE TEMPERATURE (°C)	DRY GAS METER INLET (°F)	DRY GAS METER OUTLET (°F)	PUMP VACUUM (IN. Hg)	SAMPLE BOX TEMPERATURE (°F)	INDICATOR TEMPERATURE (°F)
				DESIRED	ACTUAL							
0	0808	579.318	0.89	2.31	2.30	89	81	78	2.5	30	68	
1	75	585.6	0.88	2.57	2.58	86	91	82	3.0	25.8	65	
2	150	594.1	0.83	2.2	2.2	86	99	85	2.5	25.0	65	
3	225	602.2	0.84	2.36	2.35	86	103	89	2.5	25.0	65	
4	300	610.6	0.82	2.22	2.2	89	110	93	2.5	24.7	66	
5	375	619.7	0.83	2.25	2.25	88	113	96	2.5	24.6	69	
6	450	626.7	0.80	2.11	2.10	90	116	99	2.5	24.3	68	
7	525	634.4	0.84	2.16	2.2	89	116	102	2.5	22.8	69	
8	600	642.3	0.87	2.29	2.30	89	117	104	2.5	22.6	70	
9	675	650.3	0.87	2.39	2.40	89	119	107	2.5	22.6	69	
10	750	658.6	0.88	2.42	2.40	90	120	109	2.5	22.3	70	
11	825	666.7	0.89	2.44	2.45	90	121	110	2.5	22.5	66	
12	900	674.4	1.0	3.04	3.05	92	123	116	3.0	30.5	63	
1	975	683.1	1.0	2.76	2.25	92	123	116	3.0	23.2	64	
2	1050	701.4	0.92	2.54	2.55	92	123	116	2.5	24.4	65	
3	1125	709.5	0.94	2.60	2.60	92	125	117	2.5	24.6	67	
4	1200	718.2	0.97	2.68	2.70	92	125	117	3.0	24.5	68	
5	1275	726.6	0.94	2.60	2.60	92	125	117	3.0	24.5	68	
6	1350	734.1	0.95	2.68	2.60	92	126	117	2.5	24.8	66	
7	1425	741.1	0.68	1.89	1.80	92	127	117	2.5	25.1	64	
8	1500	748.5	0.72	2.0	2.0	92	128	117	2.5	23.2	64	
9	1575	755.8	0.72	2.0	2.0	92	129	118	2.5	25.1	65	
10	1650	763.3	0.75	2.09	2.10	92	130	119	2.5	24.0	66	
11	1725	770.0	0.825	2.08	2.10	92	131	119	2.5	24.5	67	
12	1800	777.0	0.823	2.08	2.10	92	131	119	2.5	24.5	67	

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Heddle Sample date 6/25/86
 Sample location Scrubber Inlet Recovery date 6/25/86
 Run number SIC-2 Recovered by CB
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel #4	
Final volume (wt)	592.5	615.9	592.7 ml(g)	Final wt	797.3 g
Initial volume (wt)	582.7	592.7	592.7 ml(g)	Initial wt	755.4 g
Net volume (wt)	9.8	23.2	6.5 ml(g)	Net wt	41.9 g
Description of impinger water	<u>slightly Turbid</u>			<u>100</u>	% spent
Total moisture				<u>81.4</u>	g

RECOVERED SAMPLE

Filter container number(s) NA Sealed _____
 Description of particulate on filter NA

Probe rinse container no.	<u>NA</u>	Liquid level marked	_____
_____ blank container no.	<u>NA</u>	Liquid level marked	_____
Impinger contents container no.	<u>4677-A</u>	Liquid level marked	<input checked="" type="checkbox"/>
<u>NaOH</u> blank container no.	<u>4679-A</u>	Liquid level marked	<input checked="" type="checkbox"/>

Samples stored and locked _____
 Remarks _____

LABORATORY CUSTODY

Received by Laura Kottell Date 7/3/86
 Remarks _____

Particulate sample recovery and integrity data sheet.

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Heddle Sample date 6/25/86
 Sample location Scrubber inlet Recovery date 6/25/86
 Run number 2JC-3 Recovered by CB
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel #4	
Final volume (wt)	578.4	643.5	599.9 ml(g)	Final wt	829.9 g
Initial volume (wt)	566.6	626.6	591.8 ml(g)	Initial wt	783.6 g
Net volume (wt)	16.8	16.9	8.1 ml(g)	Net wt	46.3 g
Description of impinger	water - slight yellow color			<u>95</u>	% spent
Total moisture				82.1	g

RECOVERED SAMPLE

Filter container number(s) NA Sealed —
 Description of particulate on filter —

Probe rinse container no.	<u>NA</u>	Liquid level marked	<u>NA</u>
blank container no.	<u>NA</u>	Liquid level marked	<u>NA</u>
Impinger contents container no.	<u>7806-A</u>	Liquid level marked	<input checked="" type="checkbox"/>
<u>NaOH</u> blank container no.	<u>4679-A</u>	Liquid level marked	<input checked="" type="checkbox"/>

Samples stored and locked —

Remarks —

LABORATORY CUSTODY

Received by Laura Bell Date 7/1/86
 Remarks —

Particulate sample recovery and integrity data sheet.

PLANT & CITY: STANLEY, WADSWORTH, OHIO

DATE: 6/24/86

OPERATOR: J. J. ...

STATIC PRESS. (IN. H₂O): 0.33

BAR. PRESS. (IN. Hg): 29.85

W. SAMPLE (IN. H₂O): 1.47

NOZZLE NO.: 1171

PROBE LENGTH AND TYPE: 1171

W. SAMPLE (IN. H₂O): 1.47

NOZZLE NO.: 1171

PROBE LENGTH AND TYPE: 1171

TRAVELER POINT NUMBER	SAMPLING TIME, MIN	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V), %	VELOCITY HEAD (ft), in. H ₂ O	ORIFICE PRESSURE DIFFERENTIAL (IN. H ₂ O)		STACK TEMPERATURE (T), °F	DRY GAS METER INLET TEMPERATURE (T _{in}), °F	DRY GAS METER OUTLET TEMPERATURE (T _{out}), °F	PUMP VACUUM, IN. Hg	SAMPLE-BOX TEMPERATURE, °F	REF. AP
					DESIRED	ACTUAL						
1	0	0833	645.598	0.55	1.47	1.47	77	85	87	2.2	240	66
2	130		658.4	0.68	2.87	3.00	78	89	85	2.05	260	67
3	22.5		666	0.68	3.02	3.05	78	92	90	2.05	255	77
4	30.0		673.5	0.68	3.06	3.05	78	103	91	2.05	254	79
5	37.5		680.8	0.63	2.83	2.85	78	105	93	2.05	260	81
6	45.0		688.2	0.63	2.83	2.85	79	109	95	2.05	255	82
7	52.5		696	0.65	2.94	2.95	80	112	98	2.05	250	67
8	60.0		703.5	0.74	3.36	3.35	80	114	100	2.05	255	65
9	67.5		712.4	0.80	4.10	4.10	80	117	103	3.0	255	65
10	75.0		722	1.05	4.80	4.80	81	120	106	3.0	251	64
11	82.5		731.3	1.10	5.05	5.05	80	121	106	3.05	255	64
12	90.0	1003	741.114	1.15	5.29	5.30	80	122	108	3.05	260	67
5-1	97.5	1018	750	0.86	3.96	3.95	80	116	111	2.05	256	62
2	105.0		758.6	0.95	4.36	4.35	80	117	111	3.0	255	66
3	112.5		767.6	0.88	4.04	4.05	81	120	110	3.0	263	69
4	120.0		776	0.83	3.83	3.85	81	124	117	2.05	260	71
5	127.5		784.3	0.82	3.80	3.80	80	126	114	2.05	252	71
6	135		792.8	0.83	3.86	3.85	80	127	115	2.05	260	73
7	142.5		801.2	0.79	3.68	3.70	80	128	117	2.05	254	70
8	150.0		810.4	0.97	4.53	4.55	80	129	118	3.0	250	70
9	157.5		820.0	1.05	4.92	4.90	79	129	118	3.05	252	72
10	165		830.1	1.20	5.61	5.60	80	129	118	3.05	260	70
11	172.5		840.45	1.25	5.84	5.85	80	130	118	3.05	260	69
12	180.0	1.1.4.8	850.75	1.25	5.84	5.85	80	130	118	3.05	260	69
13	187.5	1.1.4.8	850.75	1.25	5.84	5.85	80	130	118	3.05	260	69

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Heddle Sample date 6/24/86
 Sample location Scrubber Outlet Recovery date 6/24/86
 Run number SOC-1 Recovered by (signature)
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel	
Final volume (wt)	<u>632.1</u>	<u>627.4</u>	<u>695.0</u>	Final wt <u>#4</u>	<u>786.6</u> g
Initial volume (wt)	<u>594.2</u>	<u>603.1</u>	<u>587.5</u>	Initial wt	<u>737.9</u> g
Net volume (wt)	<u>37.9</u>	<u>24.3</u>	<u>7.5</u>	Net wt	<u>48.7</u> g
Description of impinger water	<u>Clear</u>				<u>100</u> % spent

Total moisture 118.4 g

RECOVERED SAMPLE

Filter container number(s) NA Sealed _____
 Description of particulate on filter NA

Probe rinse container no.	<u>NA</u>	Liquid level marked	<u>NA</u>
_____ blank container no.	<u>NA</u>	Liquid level marked	<u>NA</u>
Impinger contents container no.	<u>4677-A</u>	Liquid level marked	<input checked="" type="checkbox"/>
<u>NaOH</u> blank container no.	<u>4676-A</u>	Liquid level marked	<input checked="" type="checkbox"/>

Samples stored and locked _____

Remarks pH checked: 11.0

Probe rinse to container: yellowish color

LABORATORY CUSTODY

Received by (signature) Date 7/3/86
 Remarks _____

Particulate sample recovery and integrity data sheet.

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Huddle Sample date 6/25/86
 Sample location Sample Outlet Recovery date 6/25/86
 Run number 502-2 Recovered by CB
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel #4
Final volume (wt)	614.7	614.6	601.7 ml(g)	Final wt <u>795.6</u> g
Initial volume (wt)	587.3	594.7	593.5 ml(g)	Initial wt <u>748.3</u> g
Net volume (wt)	27.4	19.9	8.2 ml(g)	Net wt <u>47.3</u> g
Description of impinger water	<u>clean</u>			<u>100</u> % spent
Total moisture				<u>102.8</u> g

RECOVERED SAMPLE

Filter container number(s) NA Sealed _____
 Description of particulate on filter NA

Probe rinse container no.	<u>NA</u>	Liquid level marked	_____
_____ blank container no.	<u>NA</u>	Liquid level marked	_____
Impinger contents container no.	<u>4680-A</u>	Liquid level marked	<input checked="" type="checkbox"/>
<u>NaOH</u> blank container no.	<u>4679-A</u>	Liquid level marked	<input checked="" type="checkbox"/>

Samples stored and locked _____
 Remarks _____

LABORATORY CUSTODY

Received by Laura Roberts Date 7/13/86
 Remarks _____

Particulate sample recovery and integrity data sheet.

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PLANT & CITY												DATE												SAMPLING LOCATION												SAMPLE TYPE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				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PROB. LENGTH AND TYPE												NO. 1												NO. 2												E FACTOR												K FACTOR												PUMP VACUUM, IN. HG												TEMP. IN. °F												TEMP. 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°F																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						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								4898.5												4907.												4915.												4923.5												4932.												4940.												4948.5												4957.												4965.												4973.5												4982.												4990.5												4998.5												5007.												5015.												5023.5												5032.												5040.												5048.5												5057.												5065.												5073.5												5082.												5090.5												5098.5												5107.												5115.												5123.5												5132.												5140.												5148.5												5157.												5165.												5173.5												5182.												5190.5												5198.5												5207.												5215.												5223.5												5232.												5240.												5248.5												5257.												5265.												5273.5												5282.												5290.5												5298.5												5307.												5315.												5323.5												5332.												5340.												5348.5												5357.												5365.												5373.5												5382.												5390.5												5398.5												5407.												5415.												5423.5												5432.												5440.												5448.5												5457.												5465.												5473.5												5482.												5490.5												5498.5												5507.												5515.												5523.5												5532.												5540.												5548.5												5557.												5565.												5573.5												5582.												5590.5												5598.5												5607.												5615.												5623.5												5632.												5640.												5648.5												5657.												5665.												5673.5												5682.												5690.5												5698.5												5707.												5715.												5723.5												5732.												5740.												5748.5												5757.												5765.												5773.5												5782.												5790.5												5798.5												5807.												5815.												5823.5												5832.												5840.												5848.5												5857.												5865.												5873.5												5882.												5890.5												5898.5												5907.												5915.												5923.5												5932.												5940.												5948.5												5957.												5965.												5973.5												5982.												5990.5												5998.5												6007.												6015.												6023.5												6032.												6040.												6048.5												6057.												6065.												6073.5												6082.												6090.5												6098.5												6107.												6115.												6123.5												6132.												6140.												6148.5												6157.												6165.												6173.5												6182.												6190.5												6198.5												6207.												6215.												6223.5												6232.												6240.												6248.5												6257.												6265.												6273.5												6282.												6290.5												6298.5												6307.												6315.												6323.5												6332.												6340.												6348.5												6357.												6365.												6373.5												6382.												6390.5												6398.5												6407.												6415.												6423.5												6432.												6440.												6448.5												6457.												6465.												6473.5												6482.												6490.5												6498.5												6507.												6515.												6523.5												6532.												6540.												6548.5												6557.												6565.												6573.5												6582.												6590.5												6598.5												6607.												6615.												6623.5												6632.												6640.												6648.5												6657.												6665.												6673.5												6682.												6690.5												6698.5												6707.												6715.												6723.5												6732.												6740.												6748.5											

Cr+6/TOTAL Cr SAMPLE RECOVERY AND INTEGRITY DATA SHEET

Plant Steel Noodle Sample date 6/25/86
 Sample location Scraper Outlet Recovery date 6/25/86
 Run number 500-3 Recovered by CP
 Filter number(s) NA

MOISTURE

Impingers	#1	#2	#3	Silica gel #4	
Final volume (wt)	618.6	628.1	595.6 ml(g)	Final wt	830.2 g
Initial volume (wt)	596.6	605.9	590.3 ml(g)	Initial wt	787.9 g
Net volume (wt)	22.0	22.2	5.3 ml(g)	Net wt	47.3 g
Description of impinger water	<u>clear</u>				90 % spent
Total moisture				<u>96.8</u>	g

RECOVERED SAMPLE

Filter container number(s) NA Sealed —
 Description of particulate on filter —

Probe rinse container no.	<u>NA</u>	Liquid level marked	<u>—</u>
blank container no.	<u>NA</u>	Liquid level marked	<u>—</u>
Impinger contents container no.	<u>4807-A</u>	Liquid level marked	<u>—</u>
blank container no.	<u>4679-A</u>	Liquid level marked	<u>✓</u>

Samples stored and locked —
 Remarks —

LABORATORY CUSTODY

Received by L. K. Little Date 7/13/86
 Remarks —

Particulate sample recovery and integrity data sheet.

PARTICLE SIZE DISTRIBUTION
(Gravimetric)

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant STEEL HEDDLE Sample date 6/24/86
 Sample location INLET Recovery date 6/24/86
 Run number SIPS-1 Recovered by CB

RECOVERY SAMPLE

Cyclone particulate container number NA Liquid level marked _____
 Cyclone and nozzle rinse container number NA Liquid level marked _____
 Nozzle (or inlet chamber) rinse container number 4681A Liquid level marked
 Acetone blank container number 4674A Liquid level marked

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	<u>A019</u>	<u>4681 B</u>	<input checked="" type="checkbox"/>	<u>no load</u>
1	<u>AM62</u>		<input checked="" type="checkbox"/>	<u>no load</u>
2	<u>A027</u>		<input checked="" type="checkbox"/>	<u>no load</u>
3	<u>AM96</u>		<input checked="" type="checkbox"/>	<u>inlet data - com</u>
4	<u>A049</u>		<input checked="" type="checkbox"/>	<u>"</u>
5	<u>AM44</u>		<input checked="" type="checkbox"/>	<u>"</u>
6	<u>AP25</u>		<input checked="" type="checkbox"/>	<u>"</u>
7	<u>AM66</u>		<input checked="" type="checkbox"/>	<u>light "</u>
Backup	<u>A237</u>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<u>no visible load</u>

Samples stored and locked

Remarks ~~FILTER F~~ FILTER BLANK SET - 4674 B
- Nozzle / lining some → yellowish tint

LABORATORY CUSTODY

Received by Laura Katalic Date 6/24/86

Remarks _____

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant Steel Heddle Sample date 6/24/86
 Sample location Scrubber Inlet Recovery date 6/24/86
 Run number SIPS-2 Recovered by (93)

RECOVERY SAMPLE

Cyclone particulate container number _____ Liquid level marked _____
 Cyclone and nozzle rinse container number _____ Liquid level marked _____
 Nozzle (or inlet chamber) rinse container number 4677-A Liquid level marked
 Acetone blank container number 4674-A Liquid level marked

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	<u>A097</u>	<u>4679-C</u>	<input checked="" type="checkbox"/>	<u>no sample (lost)</u>
1	<u>A082</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
2	<u>A095</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
3	<u>AP04</u>		<input checked="" type="checkbox"/>	<u>very light</u>
4	<u>AR91</u>		<input checked="" type="checkbox"/>	<u>even; dots</u>
5	<u>A010</u>		<input checked="" type="checkbox"/>	<u>" "</u>
6	<u>AS61</u>		<input checked="" type="checkbox"/>	<u>" "</u>
7	<u>A028</u>		<input checked="" type="checkbox"/>	<u>lighter; dots</u>
Backup	<u>A-258</u>		<input checked="" type="checkbox"/>	<u>no sample (lost)</u>

Samples stored and locked _____

Remarks _____

LABORATORY CUSTODY

Received by John R. ... Date 7/3/86

Remarks _____

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant Stack Heddle Sample date 6/24/86
 Sample location Scrubber Inlet Recovery date 6/25/86
 Run number SIP8-3 Recovered by CB

RECOVERY SAMPLE

Cyclone particulate container number NA Liquid level marked —
 Cyclone and nozzle rinse container number NA Liquid level marked —
 Nozzle (or inlet chamber) rinse container number 4808-A Liquid level marked ✓
 Acetone blank container number 4674-A Liquid level marked ✓

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	Am-11	4808-A	✓	No visible load
1	Am 46	↓	✓	" " "
2	AMP 01		✓	Basely visible
3	AN-60		✓	visible
4	AM-69		✓	even; dist. dots
5	AO-20		✓	" " "
6	AO-65		✓	" " "
7	AO-00		✓	very light
Backup	A245		✓	no visible load

Samples stored and locked ✓

Remarks Yellowish tint in sample/coming down.

LABORATORY CUSTODY

Received by Laura R. Bell Date 7/3/86
 Remarks _____

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant STEEL HEDDLE Sample date 6/24/86
 Sample location OUTLET Recovery date 6/24/86
 Run number 50PS-1 Recovered by CP

RECOVERY SAMPLE

Cyclone particulate container number NA Liquid level marked _____
 Cyclone and nozzle rinse container number NA Liquid level marked _____
 Nozzle (inlet chamber) rinse container number 4682A Liquid level marked _____
 Acetone blank container number 4694 A Liquid level marked

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	<u>1-003</u>	<u>4682 B</u>	<input checked="" type="checkbox"/>	<u>no visible lead</u>
1	<u>A004</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
2	<u>AM27</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
3	<u>AM52</u>		<input checked="" type="checkbox"/>	<u>very light</u>
4	<u>AP23</u>		<input checked="" type="checkbox"/>	<u>Even; dirt dots.</u>
5	<u>AM72</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
6	<u>A065</u>		<input checked="" type="checkbox"/>	<u>lighter; " "</u>
7	<u>AM34</u>		<input checked="" type="checkbox"/>	<u>" " "</u>
Backup	<u>A066</u>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<u>no visible lead</u>

Samples stored and locked

Remarks Acetone rinse -> clean

LABORATORY CUSTODY

Received by Alexis Katselis Date 7/3/86

Remarks _____

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant Steel Huddle Sample date 6/25/86
 Sample location Scrubber Outlet Recovery date 6/25/86
 Run number 50PS-2 Recovered by CB

RECOVERY SAMPLE

Cyclone particulate container number NA Liquid level marked —
 Cyclone and nozzle rinse container number NA Liquid level marked —
 Nozzle (or inlet chamber) rinse container number 4700-A Liquid level marked ✓
 Acetone blank container number 4674-A Liquid level marked ✓

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	<u>A045</u>	<u>4700-B</u>	<u>✓</u>	<u>None available</u>
1	<u>A046</u>		<u>✓</u>	<u>" "</u>
2	<u>A521</u>		<u>✓</u>	<u>" "</u>
3	<u>A000</u>		<u>✓</u>	<u>Available; dist. date (light)</u>
4	<u>A541</u>		<u>✓</u>	<u>even; " (heavy)</u>
5	<u>A026</u>		<u>✓</u>	<u>" " "</u>
6	<u>A045</u>		<u>✓</u>	<u>very light date</u>
7	<u>A022</u>		<u>✓</u>	<u>" " "</u>
Backup	<u>A239</u>		<u>✓</u>	<u>none available</u>

Samples stored and locked ✓

Remarks _____

LABORATORY CUSTODY

Received by Lane Reilly Date 7/3/86

Remarks _____

ANDERSEN IMPACTOR RECOVERY AND INTEGRITY SHEET

Plant Steel Huddle Sample date 6/25/86
 Sample location Scrubber Outlet Recovery date 6/25/86
 Run number 5095-3 Recovered by (93)

RECOVERY SAMPLE

Cyclone particulate container number Liquid level marked
 Cyclone and nozzle rinse container number Liquid level marked
 Nozzle (or inlet chamber) rinse container number 4605-A Liquid level marked ✓
 Acetone blank container number 4674-A Liquid level marked 4674-A ✓

Filters

Stage	Filter number	Container number	Container sealed	Comments
0	<u>A016</u>	<u>4605-B</u>	<u> / </u>	<u>no load</u>
1	<u>A054</u>	<u> / </u>	<u> / </u>	<u>" "</u>
2	<u>A011</u>		<u> / </u>	<u>" "</u>
3	<u>A058</u>		<u> / </u>	<u>" "</u>
4	<u>A099</u>		<u> / </u>	<u>even load</u>
5	<u>A052</u>		<u> / </u>	<u>" "</u>
6	<u>A047</u>		<u> / </u>	<u>light</u>
7	<u>A056</u>		<u> / </u>	<u>" "</u>
Backup	<u>A253</u>	<u> / </u>	<u> / </u>	<u> </u>

Samples stored and locked

Remarks

LABORATORY CUSTODY

Received by Lynn Rodde Date 7/3/86

Remarks

APPENDIX C
LABORATORY DATA SHEETS



PEI Associates, Inc. LABORATORY REPORT FORM

Sample type: Stack samples

Client: US EPA EMB
Steel Heddle Company

Project no: 3615-22
Requisition: 9496
Received: 7/3/86
Sampled by: PEI
Reported: 8/20/86

attn:

Lab No.	Run Number	Fraction	Chromium (VI),mg	Total Chromium,mg
FT 338	SIC-1	liquid	13.3	12.6
FT 339	SIC-2	liquid	5.84	5.43
FT 340	SIC-3	liquid	5.48*	5.28
FT 341	SOC-1	liquid	0.265	0.261
FT 342	SOC-2	liquid	0.276	0.263*
FT 343	SOC-3	liquid	0.293	0.299
FT 344	blank SIC-1, SOC-1	liquid	<0.006**	<0.020 **
FT 345	blank SIC-2,3 SOC-2,3	liquid	<0.006**	<0.020 **

*Spike recovery was 100.3% for chromium (VI) and 92.3% for total chromium

** Based on largest volume used for the samples

Submitted by: *Ida Bennett*

PEI Associates, Inc.
11499 Chester Road
Cincinnati, Ohio 45246
(513)-782-4700

T.M.



PEI Associates, Inc. LABORATORY REPORT FORM

Sample type: Particle size samples

Client: US EPA EMB

Steel Heddle Company

Project no: 3615-22
 Requisition: 9496
 Received: 7/3/86
 Sampled by: PEI
 Reported: 8/20/86

attn:

Lab Number	Run No.	Stage No.	Chromium (VI),ug	Total Chromium,ug
FT 268,278,288	SIPS 1-3	0	1.1	11.5
FT 269,279,289		1	1.5	13.8
FT 270,280,290		2	4.4	19.2
FT 271,281,291		3	13.7	29.5
FT 272,282,292		4	55.9	84.0
FT 273,283,293		5	32.6	54.1
FT 274,284,294		6	1.2	12.5
FT 275,285,295		7	0.5	11.2
FT 276,286,296		back-up	1.1	18.0*
FT 277,287,297		acetones	840*	1810
FT 298,308,318	SOPS 1-3	0	1.6	13.1
FT 299,309,319		1	1.7	11.7
FT 300,310,320		2	7.0	19.8
FT 301,311,321		3	26.3	44.6
FT 302,312,322		4	86.1	117
FT 303,313,323		5	25.3	51.1
FT 304,314,324		6	1.6	17.0
FT 305,315,325		7	1.0	12.1
FT 306,316,326		back-up	1.7	12.3
FT 307,317,327		acetones	1.4	27.1*
FT 308,318,328	Blank	0,2,4,6	0.9	11.0
FT 332,333,334		1,3,5,7	0.8	11.6
FT 336**		back-up	0.5 **	6.6**
FT 337		acetone	0.6	<2.0
Extraction		-	<0.4	<2.0

*Spike recovery 105.8% for chromium VI and 85.5% and 89.4% for total chromium
 SAMPLES NOT BLANK CORRECTED

** Blank values must be multiplied by 3

Submitted by:

Ada Bennett

PEI Associates, Inc.
 11499 Chester Road
 Cincinnati, Ohio 45246
 (513)-782-4700



PEI Associates, Inc. LABORATORY REPORT FORM

Sample type: *PROCESS* samples

Client: US EPA EMB

Steel Heddle Company

Project no: 3615-22
 Requisition: 9504
 Received: 7/3/86
 Sampled by: PEI
 Reported: 8/20/86

attn:

Lab No.	Run Number	Fraction	Chromium (VI)mg/l	Total Chromium,mg/l
FT 433	SIPS-1 tank 1	liquid	92000*	97200
FT 434	SIC-1 tank 1	liquid	97400	98600
FT 435	SIC-2 tank 1	liquid	88900	96200
FT 436	SIC-3 tank 1	liquid	90300	98600
FT 437	SIPS-1 tank 2	liquid	101900	106800
FT 438	SIC-1 tank 2	liquid	95400	103600
FT 439	SIC-2 tank 2	liquid	97400	103400
FT 440	SIC-3 tank 2	liquid	99100	104400*
FT 441	SIPS-1 tank 4	liquid	83800	92900
FT 442	SIC-1 tank 4	liquid	82700	91100
FT 443	SIC-2 tank 4	liquid	78700	87300
FT 444	SIC-3 tank 4	liquid	81700	90300
FT 445	SIPS-1 scrubber	liquid	16.3, 11.9	11.1, 10.2
FT 446	SIC-1 scrubber	liquid	6.63, 8.48	7.99, 7.80
FT 447	SIC-2 scrubber	liquid	5.33, 6.97	6.74, 6.38
FT 448	SIC-3 scrubber	liquid	7.45	7.53

*Spike recovery was 96.2% for chromium (VI) and 92.8% for total chromium

Submitted by: *Ida Bennett*

PEI Associates, Inc.
 11499 Chester Road
 Cincinnati, Ohio 45246
 (513)-782-4700

T.A.N.

Particle Size Distribution
(Gravimetric)

METHOD 5 BLANK ANALYTICAL DATA

Plant Steel Heddle Co.
 Sample location _____
 Relative humidity of laboratory 50%
 Density of acetone (ρa) 0.7899 g/ml

Blank type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone		
Filter		

Acetone blank container No. 4674A Lab No. 7T337 ✓
 Acetone blank volume (Va) 244 ml
 Date and time of wt 7/16/86 8:40 Gross wt 98799.0 mg
 Date and time of wt 7/16/86 4:58 Gross wt 98799.5 mg
 Average Gross wt 98799.2 mg
 Tare wt 98796.3 mg ✓
 Weight of blank (ma) 7.9 mg

$$Ca = \frac{(ma)}{(Va)(\rho a)} = \frac{(7.9)}{(244)(0.7899)} = 0.0010 \text{ mg/g} \quad \star$$

Note: In no case should a blank residue greater than 0.01 mg/g or 0.001% of the blank weight be subtracted from the sample weight.

Filter blank container No. _____ Lab No. _____
 Filter blank No. _____
 Date and time of wt _____ Gross wt _____ mg
 Date and time of wt _____ Gross wt _____ mg
 Average gross wt _____ mg
 Tare wt _____ mg
 Difference _____ mg

Note: Difference must be less than ±5 mg or 2% of total sample weight, whichever is greater.

Remarks A 0.01 (2% maximum allowable amount) will be used in all calculations

Signature of analyst Lenora Stephens
 Signature of reviewer Ed Muller

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant Steel Heddle Co. Run No. Blank

Sample location _____

Relative humidity 50%

Density of acetone (pa) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4674A Lab No. 77337 ✓

Acetone rinse volume (Vaw) 2.44 ml - ✓

Acetone blank residue concentration (Ca) 0.01 mg/g

Wa = Ca Vaw pa = (0.01) (2.44) (0.7899) = 1.93 mg - ✓

Date and time of wt 7/16/86 3⁰⁰ P Gross wt 98799.0 mg - ✓

Date and time of wt 7/16/86 4⁰⁵ P Gross wt 98799.5 mg - ✓

Average Gross wt 98799.2 mg ✓

Tare wt 98797.3 mg - ✓

Less acetone blank wt (Wa) 1.9 mg - ✓

Weight of particulate in acetone rinse 6.0 mg - ✓

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AS-37</u>	<u>77338</u>	<u>159.7</u> ✓	<u>159.6</u> ✓	<u>0.1</u> ✓
1	<u>AP-37</u>	<u>329</u>	<u>164.2</u> ✓	<u>164.1</u> ✓	<u>0.1</u> ✓
2	<u>AS-19</u>	<u>330</u>	<u>162.4</u> ✓	<u>161.9</u> ✓	<u>0.5</u> ✓
3	<u>AS-49</u>	<u>331</u>	<u>163.0</u> ✓	<u>162.6</u> ✓	<u>0.4</u> ✓
4	<u>AM-35</u>	<u>332</u>	<u>144.1</u> ✓	<u>143.7</u> ✓	<u>0.4</u> ✓
5	<u>AP-90</u>	<u>333</u>	<u>142.3</u> ✓	<u>142.5</u> ✓	<u>-0.2</u> ✓
6	<u>AP-85</u>	<u>334</u>	<u>142.7</u> ✓	<u>142.5</u> ✓	<u>0</u> ✓
7	<u>AP-06</u>	<u>335</u>	<u>149.3</u> ✓	<u>149.3</u> ✓	<u>0</u> ✓
Backup	<u>A-294</u>	<u>336</u>	<u>220.2</u> ✓	<u>219.6</u> ✓	<u>0.6</u> ✓

Weight of particulate in acetone rinse 6.0 ✓

Total 8.1 ✓

Signature of analyst Stephen Stephens

Signature of reviewer Ken Miller T.N.

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant Steel Heddle Co. Run No. 31PS-1

Sample location _____

Relative humidity 50%

Density of acetone (ρ_a) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4681A Lab No. 97277

Acetone rinse volume (V_{aw}) 124 ml

Acetone blank residue concentration (C_a) 0.01 mg/g

$W_a = C_a V_{aw} \rho_a = (0.01) (124) (0.7899) = 0.98$ mg ✓

Date and time of wt 7/11/86 3:00 P Gross wt 100632.5 mg ✓

Date and time of wt 7/14/86 10:20 P Gross wt 100632.0 mg ✓

Average Gross wt 100632.2 mg ✓

Tare wt 100616.0 mg ✓

Less acetone blank wt (W_a) 1.0 mg ✓

Weight of particulate in acetone rinse 15.2 mg ✓

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AO-19</u>	<u>97268</u>	<u>167.6</u> ✓	<u>167.4</u> ✓	<u>0.2</u> ✓
1	<u>AM-62</u>	<u>269</u>	<u>143.4</u> ✓	<u>143.5</u> ✓	<u>-0.1</u> ✓
2	<u>PL-27</u>	<u>270</u>	<u>168.3</u> ✓	<u>168.6</u> ✓	<u>-0.3</u> ✓
3	<u>PA-96</u>	<u>271</u>	<u>141.3</u> ✓	<u>141.4</u> ✓	<u>-0.1</u> ✓
4	<u>PC-49</u>	<u>272</u>	<u>165.1</u> ✓	<u>164.9</u> ✓	<u>0.2</u> ✓
5	<u>PN-44</u>	<u>273</u>	<u>143.4</u> ✓	<u>143.6</u> ✓	<u>-0.2</u> ✓
6	<u>PP-25</u>	<u>274</u>	<u>165.6</u> ✓	<u>165.5</u> ✓	<u>0.1</u> ✓
7	<u>PT-66</u>	<u>275</u>	<u>144.5</u> ✓	<u>144.4</u> ✓	<u>0.1</u> ✓
Backup	<u>P-234</u>	<u>276</u>	<u>218.4</u> ✓	<u>218.2</u> ✓	<u>0.2</u> ✓

Weight of particulate in acetone rinse 15.2

Total 15.9 ✓

Signature of analyst James Stephens

Signature of reviewer R. P. Miller 7/9/86

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant Steel Heddies Co. Run No. STPS-2

Sample location _____

Relative humidity 50%

Density of acetone (pa) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4699A Lab No. 77287

Acetone rinse volume (Vaw) 38 ml

Acetone blank residue concentration (Ca) 0.01 mg/g

$W_a = C_a V_{aw} p_a = (0.01) (38) (0.7899) = 0.30$ mg

Date and time of wt 7/1/86 3⁵⁵P Gross wt 95850.1 mg

Date and time of wt 7/1/86 10²⁰P Gross wt 95849.8 mg

Average Gross wt 95850.0 mg

Tare wt 95841.3 mg

Less acetone blank wt (W_a) 0.3 mg

Weight of particulate in acetone rinse 8.4 mg

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	AC-97	77278	167.8	167.3	0.5
1	AC-32	279	149.2	149.2	0
2	AC-95	280	168.2	168.2	0
3	AP-07	281	145.9	145.9	0
4	AR-41	282	159.6	159.6	0
5	AD-10	283	149.3	149.2	0.1
6	AS-61	284	159.7	159.6	0.1
7	AC-28	285	149.3	149.3	0
Backup	A-258	286	219.2	219.0	0.2

Weight of particulate in acetone rinse 5.4

Total 9.3

Signature of analyst [Signature]

Signature of reviewer [Signature]

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant STEEL HEDDLE CO. Run No. SIRS-3

Sample location _____

Relative humidity 50%

Density of acetone (pa) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4808A Lab No. 77297

Acetone rinse volume (Vaw) 72 ml

Acetone blank residue concentration (Ca) 0.01 mg/g

Wa = Ca Vaw pa = (0.01) (72) (0.7899) = 0.57 mg

Date and time of wt 7/11/86 3³⁰P Gross wt 102103.5 mg

Date and time of wt 7/11/86 10²⁰P Gross wt 102103.4 mg

Average Gross wt 102103.4 mg

Tare wt 102092.4 mg

Less acetone blank wt (Wa) 0.6 mg

Weight of particulate in acetone rinse 10.4 mg

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AM-11</u>	<u>77288</u>	<u>161.8</u>	<u>161.7</u>	<u>0.1</u>
1	<u>AM-46</u>	<u>289</u>	<u>143.4</u>	<u>143.5</u>	<u>-0.1</u>
2	<u>AM-01</u>	<u>290</u>	<u>157.7</u>	<u>157.5</u>	<u>0.2</u>
3	<u>AM-60</u>	<u>291</u>	<u>142.7</u>	<u>142.6</u>	<u>0.1</u>
4	<u>AM-09</u>	<u>292</u>	<u>160.9</u>	<u>160.5</u>	<u>0.4</u>
5	<u>AM-20</u>	<u>293</u>	<u>148.7</u>	<u>148.6</u>	<u>0.1</u>
6	<u>AM-65</u>	<u>294</u>	<u>167.4</u>	<u>167.4</u>	<u>0</u>
7	<u>AM-60</u>	<u>295</u>	<u>145.8</u>	<u>146.0</u>	<u>-0.2</u>
Backup	<u>A-245</u>	<u>296</u>	<u>219.0</u>	<u>218.9</u>	<u>0.1</u>

Weight of particulate in acetone rinse 10.4

Total 11.2

Signature of analyst [Signature]

Signature of reviewer [Signature]

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant Steel Heddle Co. Run No. 90PS-1

Sample location _____

Relative humidity 50%

Density of acetone (pa) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4682A Lab No. 77307

Acetone rinse volume (Vaw) 80 ml ✓

Acetone blank residue concentration (Ca) 0.01 mg/g ✓

Wa = Ca Vaw pa = (0.01) (80) (0.7899) = 0.63 mg ✓

Date and time of wt 7/11/86 3⁵⁵ Gross wt 1126.0.8 mg ✓

Date and time of wt 7/14/86 10²⁰ Gross wt 1126.0.8 mg ✓

Average Gross wt 1126.0.9 mg ✓

Tare wt 11252.3 mg ✓

Less acetone blank wt (Wa) 0.6 mg ✓

Weight of particulate in acetone rinse 7.9 mg ✓

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AP-03</u>	<u>77298</u>	<u>161.4</u> ✓	<u>161.4</u> ✓	<u>0</u>
1	<u>AP-04</u>	<u>299</u>	<u>150.6</u> ✓	<u>150.8</u> ✓	<u>-0.2</u>
2	<u>AP-27</u>	<u>300</u>	<u>151.3</u> ✓	<u>151.2</u> ✓	<u>0.1</u>
3	<u>AP-52</u>	<u>301</u>	<u>143.4</u> ✓	<u>143.4</u> ✓	<u>0</u>
4	<u>AP-23</u>	<u>302</u>	<u>159.2</u> ✓	<u>159.2</u> ✓	<u>0</u>
5	<u>AP-72</u>	<u>303</u>	<u>144.0</u> ✓	<u>144.0</u> ✓	<u>0.1</u>
6	<u>AP-65</u>	<u>304</u>	<u>128.4</u> ✓	<u>128.2</u> ✓	<u>0.2</u>
7	<u>AP-34</u>	<u>305</u>	<u>144.8</u> ✓	<u>144.8</u> ✓	<u>0.1</u>
Backup	<u>A-066</u>	<u>306</u>	<u>214.2</u> ✓	<u>214.2</u> ✓	<u>0</u>

Weight of particulate in acetone rinse 7.9 mg ✓

Total 8.4 mg ✓

Signature of analyst _____

Signature of reviewer Lu Mader _____

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant STEEL HEADLINE Co. Run No. 3730-2

Sample location _____

Relative humidity 50%

Density of acetone (ρ_a) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4710A Lab No. 77317

Acetone rinse volume (V_{aw}) 6.9 ml - ✓

Acetone blank residue concentration (C_a) 0.01 mg/g

$W_a = C_a V_{aw} \rho_a = (0.01) (6.9) (0.7899) = 0.55$ mg - ✓

Date and time of wt 7/1/86 3⁰⁰ Gross wt 103622.5 mg - ✓

Date and time of wt 7/1/86 10²⁰ Gross wt 103622.5 mg - ✓

Average Gross wt 103622.5 mg ✓

Tare wt 103613.2 mg - ✓

Less acetone blank wt (W_a) 0.6 mg ✓

Weight of particulate in acetone rinse 2.7 mg

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AD-45</u>	<u>77308</u>	<u>116.4</u> ✓	<u>116.4</u> ✓	<u>0</u> ✓
1	<u>AN-46</u>	<u>309</u>	<u>142.0</u> ✓	<u>142.1</u> ✓	<u>-0.1</u> ✓
2	<u>AS-41</u>	<u>310</u>	<u>141.8</u> ✓	<u>141.6</u> ✓	<u>0.2</u> ✓
3	<u>AN-00</u>	<u>311</u>	<u>145.6</u> ✓	<u>145.4</u> ✓	<u>0.2</u> ✓
4	<u>AS-41</u>	<u>312</u>	<u>159.9</u> ✓	<u>159.6</u> ✓	<u>0.3</u> ✓
5	<u>AN-26</u>	<u>313</u>	<u>140.7</u> ✓	<u>140.4</u> ✓	<u>0.3</u> ✓
6	<u>AD-45</u>	<u>314</u>	<u>163.5</u> ✓	<u>164.0</u> ✓	<u>-0.2</u> ✓
7	<u>AN-22</u>	<u>315</u>	<u>140.4</u> ✓	<u>140.3</u> ✓	<u>0.1</u> ✓
Backup	<u>A-239</u>	<u>316</u>	<u>218.8</u> ✓	<u>218.4</u> ✓	<u>0.4</u> ✓

Weight of particulate in acetone rinse 8.7

Total 11.2 ✓

Signature of analyst [Signature]

Signature of reviewer [Signature]

ANDERSEN IMPACTOR ANALYTICAL DATA

Plant Steel Heddle Co. Run No. SORS-3

Sample location _____

Relative humidity 50%

Density of acetone (pa) 0.7899

Sample type	Sample identifiable	Liquid level at mark and/or container sealed
Acetone rinse	✓	✓
filter(s)	✓	✓

Acetone rinse container no. 4805A Lab No. 7T327

Acetone rinse volume (Vaw) 6.2 ml ✓

Acetone blank residue concentration (Ca) 0.01 mg/g ✓

Wa = Ca Vaw pa = (0.01) (6.2) (0.7899) = 0.49 mg ✓

Date and time of wt 7/11/86 3:45 Gross wt 1012.97.0 mg ✓

Date and time of wt 7/11/86 10:30 Gross wt 1012.96.9 mg ✓

Average Gross wt 1012.97.0 mg ✓

Tare wt 1012.91.9 mg ✓

Less acetone blank wt (Wa) 0.5 mg ✓

Weight of particulate in acetone rinse 2.6 mg ✓

Filters

Stage	Filter No.	Lab No.	Gross, mg	Tare, mg	Net, mg
0	<u>AO-15</u>	<u>7T313</u>	<u>128.3</u> ✓	<u>128.4</u> ✓	<u>-0.1</u> ✓
1	<u>AN-54</u>	<u>319</u>	<u>141.7</u> ✓	<u>141.8</u> ✓	<u>-0.1</u> ✓
2	<u>AO-11</u>	<u>320</u>	<u>127.1</u> ✓	<u>127.4</u> ✓	<u>-0.3</u> ✓
3	<u>AN-58</u>	<u>321</u>	<u>141.6</u> ✓	<u>141.7</u> ✓	<u>-0.1</u> ✓
4	<u>AO-99</u>	<u>322</u>	<u>127.8</u> ✓	<u>128.0</u> ✓	<u>-0.2</u> ✓
5	<u>AN-52</u>	<u>323</u>	<u>140.8</u> ✓	<u>140.6</u> ✓	<u>0.2</u> ✓
6	<u>AS-47</u>	<u>324</u>	<u>159.4</u> ✓	<u>159.4</u> ✓	<u>0.0</u> ✓
7	<u>AN-56</u>	<u>325</u>	<u>141.2</u> ✓	<u>141.2</u> ✓	<u>0.0</u> ✓
Backup	<u>A-2.53</u>	<u>326</u>	<u>218.8</u> ✓	<u>218.4</u> ✓	<u>0.4</u> ✓

Weight of particulate in acetone rinse 2.6 ✓

Total 5.8 ✓

Signature of analyst [Signature]

Signature of reviewer T.S.W.



APPENDIX D
SAMPLE AND ANALYTICAL PROCEDURES

DETERMINATION OF Cr⁺⁶ AND TOTAL Cr EMISSIONS

The following sample and analytical procedures were used during this test program. Sampling procedures generally followed those described in EPA Test Method 13B.* The sample train used at both the scrubber inlet and outlet test locations was assembled by PEI personnel and consisted of the following items:

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 gas temperature of approximately 121°C (250°F) at the exit end during sampling.

Pitot tube - Type-S pitot tube that meets all geometric standards. It was attached to the probe to monitor stack gas velocity.

Thermocouple - Type-K thermocouple capable of measuring stack gas temperatures within 2 percent. It was attached to the probe.

Draft gauge - An inclined manometer made by Dwyer with a range of 0 to 10 in.H₂O.

Impingers - For impingers connected in series with glass ball joints. The second impinger was of the Greenburg-Smith design. The first, third, fourth, and fifth impingers were also of the Greenburg-Smith design, but modified by replacing the tip with a ½-in. i.d. glass tube extending to ½ in. from the bottom of the flask.

Metering system - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5°F, dry gas meter with 2 percent accuracy, and related equipment to maintain an isokinetic sampling rate and to determine sampling volume. The dry gas meter is made by Rockwell and the fiber vane pump is made by Gast.

Barometer - Aneroid type to measure atmospheric pressures to within ±2.5 mmHg (±0.1 in.Hg).

* 40 CFR 60, Appendix A, Reference Method 13B, July 1985.

Sampling Procedures

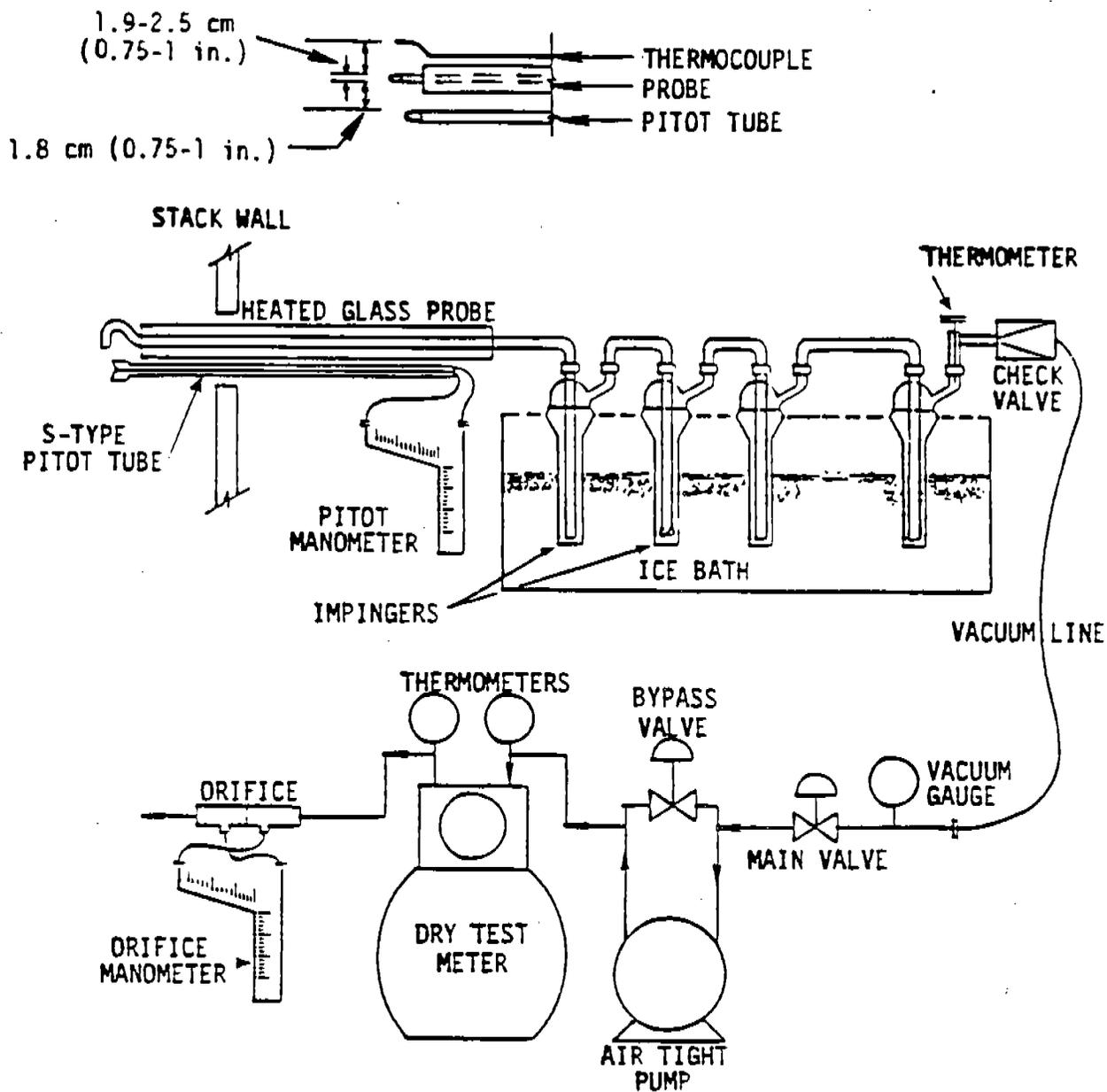
Prior to departure, all glassware used in this study was washed with acid to minimize the potential for contamination. One hundred ml of 0.1 N NaOH was placed in each of the first three impingers; 300 g of silica gel was added to the fourth impinger. The train was set up with the probe as shown in Figure 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 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 and at the conclusion of each test run. The check was made by blowing into the impact opening of the pitot tube until 3 or more inches of water is recorded on the manometer and then capping the impact opening and holding it for 15 seconds to assure it is leak free. The static pressure side of the pitot tube was leak checked using the same procedure, except suction will be used to obtain the 3-in.H₂O manometer reading. Crushed ice was placed around the impingers to keep the temperature of the gases leaving the last impinger at 20°C (68°F) or less.

During sampling, stack gas and sampling train data were recorded at each sampling point and when significant changes in stack flow conditions occur. Isokinetic sampling rates were set throughout the sampling period with the aid of a programmable calculator.

Sampling Recovery Procedures

The sampling trains were moved carefully from the test sites to the designated cleanup/recovery area located in the wastewater treatment building.



IMPINGER CONTENTS

1. 100 ml 0.1 N NaOH
2. 100 ml 0.1 N NaOH
3. 100 ml 0.1 N NaOH
4. 200 g SILICA GEL

Figure D-1. Cr⁺⁶/Total Cr sampling train.

Each impinger was weighed after each test to determine the amount of moisture present. Sample fractions were recovered as follows:

Container No. 1 - All sample exposed surfaces prior to the first impinger (nozzle and probe) were rinsed with 0.1 N NaOH and brushed with a nylon brush. After they are weighed, the contents of each impinger were placed in this container and the impingers and connecting glassware rinsed with 0.1 N NaOH. This rinse was also placed in the container. The container was then sealed, labeled, and packed for shipment.

Container No. 2 - A minimum of 200 ml of 0.1 N NaOH was taken during each test for blank analysis.

The silica gel from the fourth impinger was weighed, and this value was recorded with other pertinent data on the Sample Recovery and Integrity Data Sheet.

Sample Analysis - Hexavalent Chromium

Each sample (including blanks) was analyzed for Cr⁺⁶ using analytical methodology recently developed by EPA. A copy of the draft method entitled "Determination of Hexavalent Chromium Emissions From Stationary Sources" is contained in Appendix G of this report. Procedures generally follow those described in EPA Method 3060.*

Prior to analysis, the volume of the impinger solutions was measured and an aliquot from Container 1 was filtered through Teflon to remove any solids present in the sample. The Teflon filter was cut into small pieces and placed in a 250-ml beaker. Twenty-five ml of NaOH/Na₂CO₃ digestion solution was added to the beaker. The beaker was covered with a watch glass and heated to near boiling on a hot plate. The solution was stirred constantly for 30 minutes, and was not allowed to evaporate to dryness.

* Test Methods for Evaluating Solid Waste. U.S. EPA SW-846, 2nd Edition. July 1982, Method 3060.

The solution was cooled and filtered through a 47-mm Teflon filter. The beaker was rinsed with deionized, distilled (DI) water, which was then filtered. The filtrate was transferred quantitatively from the filter flask to a 100-ml volumetric flask, and then brought to volume with DI water. Blank filter samples were digested and prepared in a similar manner.

A 50-ml or smaller aliquot of the prepared sample was transferred to a volumetric flask. A 2 percent volume-to-volume ratio of diphenylcarbazide solution was added. The solution was allowed to stand for about 10 minutes for color development. A portion of the sample was transferred to a 1-cm absorption cell, which was placed in the spectrophotometer. A Bausch and Lomb 100 spectrophotometer was used for this analysis. The absorbance was then measured at the optimum wavelength using the blank solution as a zero reference.

Sample Analysis--Total Chromium

The filtrates from the impinger contents (Container No. 1) were analyzed for total Cr using preparation procedures described in EPA Method 3050.* Inductively Coupled Argon Plasma (ICP) spectroscopy techniques were used for sample analysis.

* Test Methods for Evaluating Solid Waste. U.S. EPA SW-846, 2nd Edition. July 1982, Method 3050.

DETERMINATION OF PARTICLE SIZE DISTRIBUTION

The following procedures were used to determine particle size distribution of Cr⁺⁶ and total Cr. The sampling train was assembled by PEI personnel and consisted of the following items:

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

Metering system - Vacuum gauge, Gast fiber-vane leak-free pump, thermometers capable of measuring temperatures to within 5°F, Rockwell dry-gas meter with 2 percent accuracy, and related equipment to maintain an isokinetic sampling rate and to determine sample volume.

Condenser - Moisture removal device capable of maintaining a temperature less than 20°C (68°F); it will be immersed in an ice water bath.

Impactor - An Andersen Mark III impactor with eight stages and a backup filter.

Barometer - Aneroid type to measure atmospheric pressures to ± 0.1 in.Hg.

Sampling Procedures--

Two points (one in each sample traverse) representing the average gas velocity and temperature in each duct were selected as the sampling points.

The Andersen mark III impactor was assembled by alternating the stage plates, collection media, flat crossbars, and Inconel spacer rings needed to provide eight cut sizes. The collection substrates were Reeve Angel 934 AH glass-fiber filters that were heated in a 204°C (400°F) oven for 1 or 2 hours, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg on an analytical balance.

The sampling train was assembled as shown in Figure D-2. It was leak checked at the sampling site prior to each test run by plugging the inlet to the impactor and pulling a 10-in.Hg vacuum. When the desired vacuum was reached, the leakage rate was checked at the dry gas meter for 1 minute. If the leak rate was 0.02 ft³/min, the sampling train was used to obtain the samples. Excessive leaks were corrected prior to sampling. The impactor was then placed at the selected sampling point(s). Sampling times ranged between 75 and 90 minutes at the inlet location and 240 minutes at the outlet. A post-test leak check was performed to avoid the possibility of dislodging the particles on individual stages.

During sampling, stack gas and sampling train data were recorded at designated intervals depending on the length of the run. The isokinetic sampling rate was set initially, and constant cut-point characteristics were maintained throughout the sampling period.

Sampling Recovery Procedures--

After each test was completed, the impactors were removed from the probe and carefully moved to the designated cleanup area; the impactors were kept in an upright position. All pertinent data were recorded on the Impactor Recovery and Integrity Data Sheets.

Mark III:

Container No. 1 - The nozzle and inlet chamber were brushed and rinsed with acetone to remove particulate into a polyethylene container. After the container was sealed and labeled, the liquid level was marked.

Container Nos. 2 through 10 - Each filter was removed from its stage and carefully placed in a petri dish. Loose particulate from the bottom side of the previous stage plate, the Inconel spacer, flat crossbar, and top side of the plate directly under the filter were brushed into the same petri dish as the respective filter. Each petri dish was sealed and labeled.

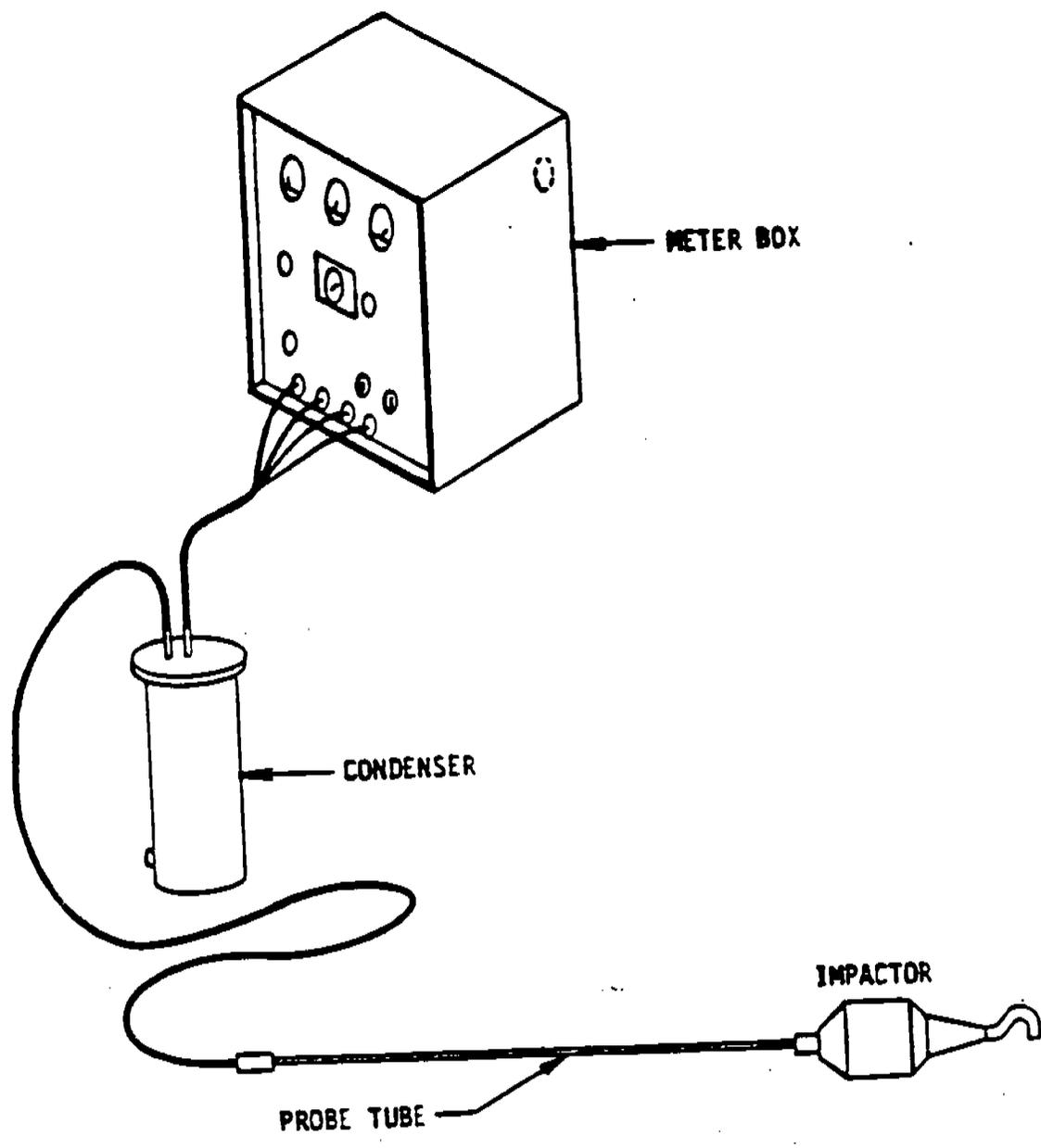


Figure D-2. Andersen Mark III impactor sampling train.

Gravimetric Analysis--

Filters - Each glass fiber filter was desiccated in its respective sample container for 24 hours to a constant weight and weighed to the nearest 0.1 mg on an analytical balance.

Acetone rinse - The volume of each acetone rinse was measured and transferred to a tared beaker. The sample was evaporated to dryness at ambient temperature and pressure, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

The term "constant weight" means a difference of no more than 0.2 mg or 1 percent of total weight less tare weight (whichever is greater) between two consecutive weighings, with no less than 6 hours of desiccation between weighings.

Data Reduction--

For each test, size distribution curves were established representing the total weight percent of particulate matter smaller than the indicated aerodynamic particle diameter in micrometers (μm). Each data point was plotted by computer and indicates both the 50 percent effective cut-size of each impactor stage and the cumulative weight percent of material collected in subsequent stages. Inhalable ($<10 \mu\text{m}$) and fine ($<2.5 \mu\text{m}$) size fractions are also reported.

Cut-points for the eight Mark III impactor stages were calculated by computer programs contained in "A Computer-Based Cascade Impactor Data Reduction System" (CIDRS) developed for EPA by Southern Research Institute (SRI).^{*} All

^{*} Southern Research Institute. A Computer-Based Cascade Impactor Data Reduction System. Prepared for U.S. Environmental Protection Agency under Contract No. 68-022-131, Revised March 1980.

particle size results are based on a particle density of 1 g/cm³. Data reduction and intermediate results calculations for the impactors were performed by the CIDRS programs, with moisture contents obtained from the Method 13B tests.

Cr⁺⁶ and Total Cr Analysis by Particle Size Fraction

Upon completion of the gravimetric analysis, samples from each location were composited by stage cutpoint into a single inlet and outlet sample. The following procedures were used to determine Cr⁺⁶ and total Cr by size fraction.

Hexavalent Cr

After the gravimetric analysis was completed, the Andersen run samples were prepped for Cr⁺⁶ by use of the alkaline digestion method (No. 3060 SW846). The filters in the inlet runs were combined by stages and cut into small pieces and placed in beakers. The filters in the outlet runs were treated in the same manner. The acetone rinses were combined by adding a small amount of acetone to the beakers and scraping the residue with a Teflon spatula and rinsing it into a beaker. The acetone evaporated off, leaving the combined residues. The blank Andersen filters were combined by taking three filters with small spacing between the filter rings and combining them in a beaker, and combining three filters with large spacing between filter rings in another beaker. The backup filter and blank acetone rinse were analyzed individually and then prepped in the same manner as the other Andersen samples. After the digestion was completed, the contents of the beaker was filtered using a 47-mm, 3.0- μ m pore size Teflon filter. The filtrate was quantitatively transferred to a 100-ml volumetric flask and diluted to the mark with Type I H₂O. The Teflon filter and Andersen filters

were saved for digestion for total Cr. The Cr⁺⁶ concent of the filtrate was determined using the colorimetric method (Method 7196 SW846).

The volume of the impinger solutions was measured and then an aliquot was filtered using a 47-mm, 3.0- μ m pore size Teflon filter. The filter and solids were digested using the alkaline digestion method with the final volume being 100 ml. The filtrate and alkaline extracts were then analyzed for Cr⁺⁶ using the colorimetric method.

The process samples were treated in the same manner as the impinger solutions with the exception that the total volume was not measured.

Total Cr

The total Cr content of the Andersen filters was determined by means of digesting the filters and residue from the alkaline digestion using the acid digestion for sludges (Method 3050 SW846) and a final volume of 100 ml. The filters and residue from the alkaline digestion of the impinger solution solids and process sample solids were digested in the same manner. The digestates were analyzed for Cr using a Perkin Elmer Model Plasma II Inductively Coupled Plasma Emission Spectrometer. The instrument was calibrated and the calibration was checked using reference solution obtained from the EPA (ICAP-19 Concentrate 1 WP1083). The samples were analyzed with spiked samples, and 10 percent of the calibrations were checked. The filtrates from the impinger contents and process samples were analyzed in the same manner.

DETERMINATION OF Cr⁺⁶ AND TOTAL Cr CONTENT OF PROCESS SAMPLES

Process samples (scrubber water and plating tank solution) were collected approximately 4 times during each Cr⁺⁶/total Cr test. Scrubber water was collected from the holding tank located in the plating operations building. Plating tank solutions were collected individually from each operational tank using a ladle. All samples were placed in polyethylene containers. Analytical procedures for Cr⁺ and total Cr followed those procedures previously described for the actual emission samples.



APPENDIX E
EQUIPMENT CALIBRATION PROCEDURES AND RESULTS

CALIBRATION PROCEDURES AND RESULTS*

All of the equipment used for these tests was calibrated according to the procedures outlined in Maintenance, Calibration, and Operation of Isokinetic Source-Sampling Equipment.*

NOZZLE DIAMETER

The nozzles were calibrated by making three separate measurements with different inside diameters and calculating the average. If a deviation of more than 0.004 inch was found, the nozzle was either discarded or reamed out and remeasured. A micrometer was used for measuring. These calibration data are shown in Figure E-1.

PITOT TUBE CALIBRATION

The pitot tubes used in sampling were constructed by PEI Associates, Inc., and met all requirements of EPA Method 2.** Therefore, a baseline coefficient of 0.84 was assigned to each pitot tube. Figures E-2 and E-3 present the alignment requirements of Method 2, and Figures E-4a through E-4c present actual calibration and inspection data of the pitot tubes used during the test program.

* Office of Air Programs Publication No. APTD-0576.

** 40 CFR 60, Appendix A, Reference Method 2, July 1985.

Date 6/23/86

Calibrated by QB

Nozzle identification number	D ₁ , in.	D ₂ , in.	D ₃ , in.	ΔD, in.	D _{avg}
Inlet #4-112	.252	.250	.251	.002	.251
Outlet #4-119	.255	.254	.251	.004	.253
<hr/>					
<i>Part. Size</i> Inlet #3-118	0.197	0.197	0.197	0.0	0.197
Outlet #3-104	0.195	0.196	0.195	0.001	0.195

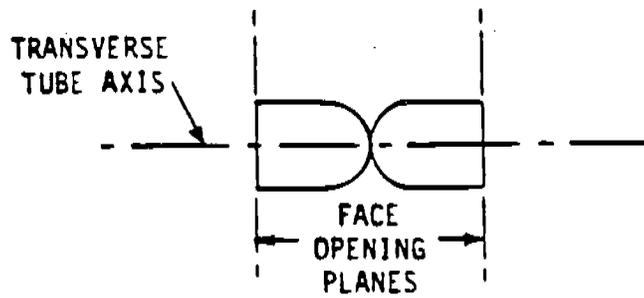
where:

D_{1,2,3} = nozzle diameter measured on a different diameter, in.
Tolerance = measure within 0.001 in.

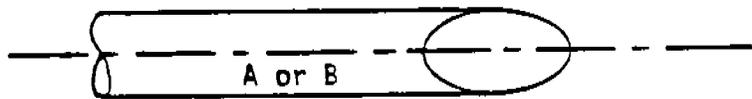
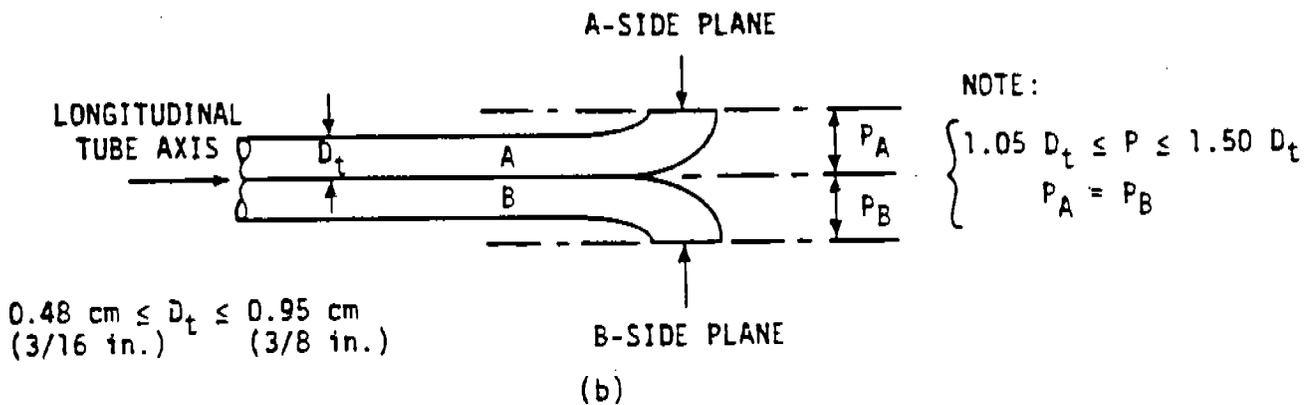
ΔD = maximum difference in any two measurements, in.
Tolerance = 0.004 in.

D_{avg} = average of D₁, D₂, and D₃.

Figure E-1. Nozzle calibration data.



(a) ENDVIEW



(c)

Figure E-2. Properly constructed Type S pitot tube, shown in: (a) end view; face opening planes perpendicular to transverse axis; (b) top view; face opening planes parallel to longitudinal axis; (c) side view; both legs of equal length and centerlines coincident, when viewed from both sides. Baseline coefficient values of 0.84 may be assigned to pitot tubes constructed this way.

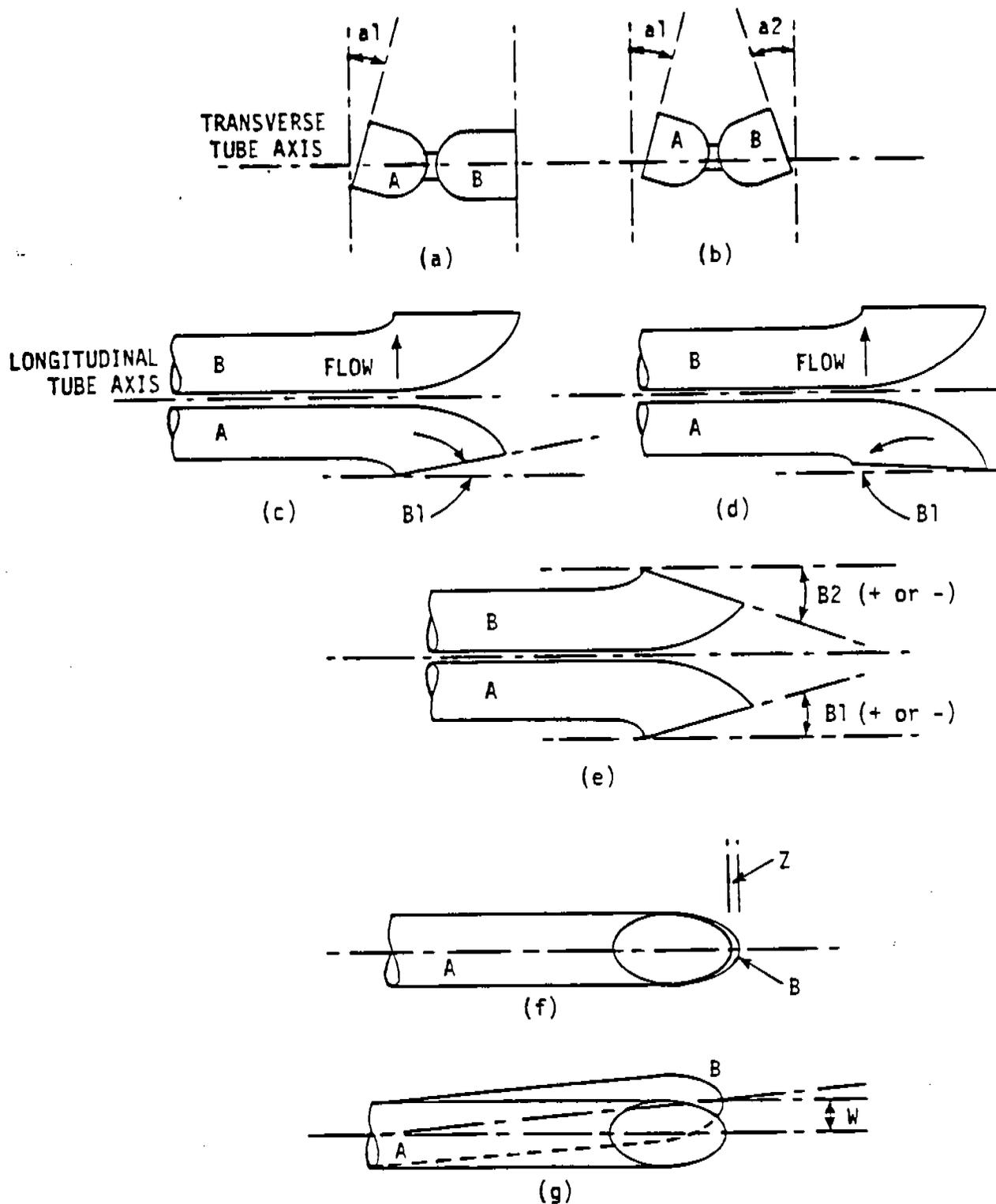


Figure E-3. Types of face-opening misalignment that can result from field use or improper construction of Type S pitot tubes. These will not affect C_p so long as a_1 and $a_2 < 10^\circ$, B_1 and $B_2 < 5^\circ$, $z < 0.32$ (1/8 in.) and $w < 0.08$ cm (1/32 in.).

Pitot Tube No. 242 Date 12-30-85 Inspector G. Howard
3'

α_1 Degrees	α_2 Degrees	β_1 Degrees	β_2 Degrees
10	10	10	20
<10°	<10°	<5°	<5°

D_t Inches	P Inches	1.05 D_t Inches	1.50 D_t Inches
.376	.985	.395	.564
$0.185 \leq P_t < 0.380$	-	-	-

γ Degrees	ϕ Degrees	$P_{\sin(\gamma)}$ Inches	$P_{\sin(\phi)}$ Inches
0°	0°		
-	-	<0.125	<0.03125

P_1 Inches	P_2 Inches	$|P_1 - P_2|$ Inches	Meet specifications
.493	.490	.003	✓
$1.05 D_t < P_1 < 1.50 D_t$	$1.05 D_t < P_2 < 1.50 D_t$	≤ 0.010	

Lower line in each table is limits for meeting specifications.

Figure E-4a. Pitot tube inspection data sheet.

Pitot Tube No. 504 Date 12-30-85 Inspector G Howard
3'

α_1 Degrees	α_2 Degrees	β_1 Degrees	β_2 Degrees
0°	0°	1°	0°
<10°	<10°	<5°	<5°

D_t Inches	P Inches	1.05 D_t Inches	1.50 D_t Inches
.375	1.000	.394	.563
$0.185 \leq P_t < 0.380$	-	-	-

γ Degrees	ϕ Degrees	$P \sin(\gamma)$ Inches	$P \sin(\phi)$ Inches
0°	0°	0.000	0.000
-	-	<0.125	<0.03125

P_1 Inches	P_2 Inches	$|P_1 - P_2|$ Inches	Meet specifications
.501	.499	.001	✓
$1.05 D_t < P_1 < 1.50 D_t$	$1.05 D_t < P_2 < 1.50 D_t$	≤ 0.010	

Lower line in each table is limits for meeting specifications.

Figure E-4b. Pitot tube inspection data sheet.

Pitot Tube No. 015 Date 12-30-85 Inspector G Howard
H

α_1 Degrees	α_2 Degrees	β_1 Degrees	β_2 Degrees
1°	3°	0°	1°
<10°	<10°	<5°	<5°

D_t Inches	P Inches	1.05 D_t Inches	1.50 D_t Inches
375	858		
$0.185 \leq P_t < 0.380$	-	-	-

γ Degrees	ϕ Degrees	$P_{\sin(\gamma)}$ Inches	$P_{\sin(\phi)}$ Inches
1°	0°	0.175	0.000
-	-	<0.125	<0.03125

P_1 Inches	P_2 Inches	$|P_1 - P_2|$ Inches	Meet specifications
430	429	0.01	✓
$1.05 D_t < P_1 < 1.50 D_t$	$1.05 D_t < P_2 < 1.50 D_t$	≤ 0.010	

Lower line in each table is limits for meeting specifications.

Figure E-4c. Pitot tube inspection data sheet.

DRY GAS METER AND ORIFICE METER

Figure E-5 was the setup used for the initial and post-test calibration. A wet-test meter with a 2-cubic-feet-per-minute capacity and ± 1 percent accuracy was used. The pump was run for approximately 15 minutes at an orifice manometer setting of 0.5 in.H₂O to heat up the pump and wet the interior surface of the wet-test meter. The information in Figure E-6 (example calculation sheet) was gathered for the initial calibration; the ratio of accuracy of the wet-test meter to the dry-test meter and the $\Delta H\theta$ were then calculated.

POST-TEST METER CALIBRATION CHECK

A post-test meter calibration check was made on the meter box used during the test to check its accuracy against its last calibration check. This post-test calibration must be within ± 5 percent of the initial calibration. The initial calibration was performed as described in APTD-0576. The same method was used for the post-test calibration as was used for the initial calibration. Three calibration runs were made with the average orifice setting obtained during the test series and with the vacuum set at the maximum value obtained during the test series. After the post-test calibration check was run, all three runs were within the ± 5 percent range allowed according to EPA Method 5.* The initial and post-test meter box calibration data are presented in Figures E-7a through E-7h.

STACK THERMOCOUPLES

The thermocouples were calibrated by comparison against an ASTM-3F thermometer at approximately 32°F, ambient temperature, 100°F, and 500°F.

* 40 CFR 60, Appendix A, Reference Method 2, July 1985.

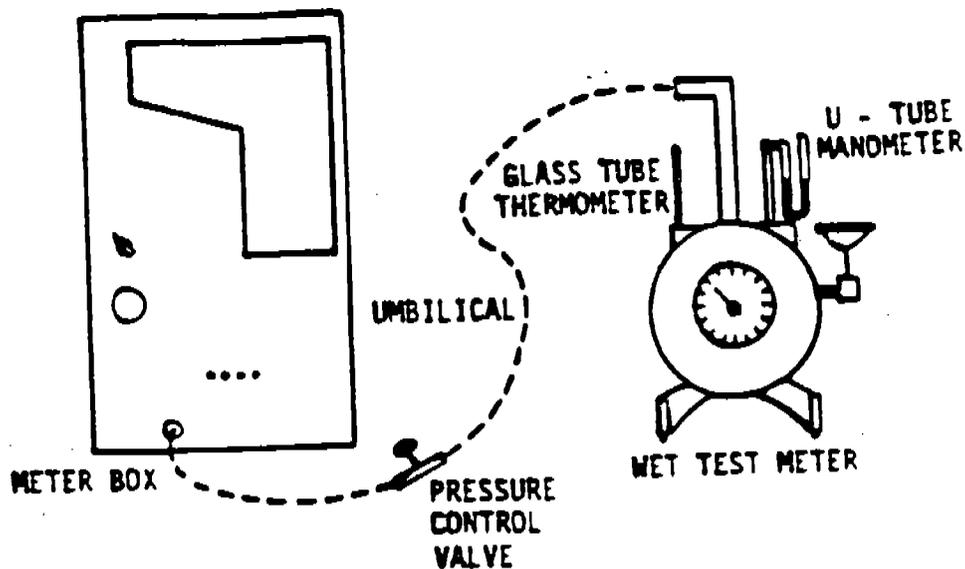


Figure E-5. Calibration setup.

DATE _____ METER BOX NO. _____
 BAROMETRIC PRESSURE, P_b = _____ in. Hg. DRY GAS METER NO. _____

Orifice manometer setting ΔH in. H ₂ O	Gas volume wet test meter V_w ft ³	Gas volume dry gas meter V_d ft ³	Wet test				Time s. min	γ	AME
			meter t_w °F	Inlet t_{di} °F	Outlet t_{do} °F	Average t_d °F			
0.5	5								
1.0	5								
1.5	10								
2.0	10								
3.0	10								
4.0	10								

Average _____

AH	$\frac{\Delta H}{13.6}$	γ	AME
0.5	0.0368		
1.0	0.0737		
1.5	0.110		
2.0	0.147		
3.0	0.221		
4.0	0.294		

γ = Ratio of accuracy of wet test meter to dry test meter. Tolerance = ± 0.01
 AME = Orifice of pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in H₂. Tolerance = ± 0.15 .

Figure E-6. Calibration data sheet.

DATE: 2-26-86 METER BOX NO. FT-1
 CALIBRATOR: G. Howard BAROMETRIC PRESSURE (P_b) 28.96 in. Hg

Leak Checks:

Positive (minimum 5 in. H₂O): ✓ @ 8.3" H₂O
 Negative (within 3 in. Hg of absolute): 0.000 cfm. 27.0 in. Hg
 *Not to exceed 0.005 cfm.

Orifice manometer setting ΔH in H ₂ O	Volume wet test meter V _w ft ³	Volume dry gas meter V _d ft ³	Temperatures				Duration of test P min	Vacuum setting in Hg	γ	ΔHE in H ₂ O
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _i °F	Outlet T _o °F	Average T _d °F				
0.5	5.0	811.773	70.5	83	80	81.5	12 ³³ / ₆₀	10.0	.9804	1.792
		816.772	70.5	84	74					
1.0	12.0	818.859	70.5	83	79	81.5	21 ²⁹ / ₆₀	10.0	.9800	1.823
		831.326	70.5	86	78					
1.5	12.0	831.863	70.5	86	77	81.5	17 ²⁹ / ₆₀	10.0	.9783	1.811
		844.330	70.5	88	78					
2.0	14.01	845.862	70.5	85	78	83.75	17 ⁴⁷ / ₆₀	10.0	.9821	1.825
		860.410	70.5	92	80					
3.0	10.0	861.108	70.5	86	79	84.75	10 ²⁵ / ₆₀	10.0	.9828	1.842
		871.477	70.5	93	81					
4.0	10.0	933.015	70.0	92	83	87.75	9 ⁷ / ₆₀	10.0	.9816	1.87
		943.439	70.0	93	83					
Average									.981	1.83

γ must not deviate by more than ±0.02 γ.
 ΔHE must not deviate by more than 0.15 in H₂O.

ΔH	γ	ΔHE
	$\frac{(V_w)(P_b)(T_d + 460)}{(V_d)(P_b + \Delta H/13.6)(T_w + 460)}$	$(0.0317)(\Delta H) \left[\frac{(T_w + 460)(P)^2}{(V_w)} \right]$
0.5	$\frac{(5.0)(28.96)(541.5)}{(5.199)(28.997)(530.5)}$	$(0.0317)(0.5) \left[\frac{(530.5)(12.55)^2}{5.2} \right]$
1.0	$\frac{(12.0)(28.96)(541.5)}{(12.467)(29.034)(530.5)}$	$(0.0317)(1.0) \left[\frac{(530.5)(21.42)^2}{12.0} \right]$
1.5	$\frac{(12.0)(28.96)(541.5)}{(12.467)(29.070)(530.5)}$	$(0.0317)(1.5) \left[\frac{(530.5)(17.42)^2}{12.0} \right]$
2.0	$\frac{(14.01)(28.96)(543.75)}{(14.548)(29.107)(530.5)}$	$(0.0317)(2.0) \left[\frac{(530.5)(17.78)^2}{14.61} \right]$
3.0	$\frac{(10.0)(28.96)(544.75)}{(10.369)(29.180)(530.5)}$	$(0.0317)(3.0) \left[\frac{(530.5)(10.42)^2}{10.0} \right]$
4.0	$\frac{(10.0)(28.96)(547.75)}{(10.424)(29.25)(530.5)}$	$(0.0317)(4.0) \left[\frac{(530.5)(9.12)^2}{10.0} \right]$

Figure E-7a. Particulate sampling meter box initial calibration.

DATE: 7-8-86
 BAROMETRIC PRESSURE (P_{bar}): 29.62 in. Hg
 PLANT: Able Mach. Co / Steel Heddle
 PROJECT MANAGER: C. Bruffon

METER BOX NO. FT-1
 PRETEST Y: .981 ΔH@: 1.83
 PROJECT NO. 3615-22
 CALIBRATOR: J. Neese

Orifice manometer setting * ΔH in. H ₂ O	Wet test meter volume V _w ft ³	Dry gas meter volume V _d ft ³	Temperatures				Vacuum setting ** in. Hg	Duration of run Ø min	Y	ΔH@
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _{di} °F	Outlet T _{di} °F	Average T _d °F				
3.0	10.0	813.405	71	92	76	84.25	5	10: ²¹ / ₆₀	.994	1.78
		823.637	71	92	77					
3.0	10.0	823.637	71	92	77	85	5	10: ²² / ₆₀	.993	1.79
		833.898	71	93	78					
3.0	26.0	833.898	71	93	78	86	5	26: ⁵⁷ / ₆₀	.993	1.78
		860.633	71	93	80					
Post-test average***									.993	1.78

Y	ΔH@
$\left(\frac{V_w}{V_d} \right) \left(\frac{P_{bar}}{P_{bar} + \Delta H / 13.6} \right) \left(\frac{T_d + 460}{T_w + 460} \right)$	$\frac{(0.0317)(\Delta H)}{(P_{bar})(T_d + 460)} \left[\frac{(T_w + 460)(\emptyset)}{V_w} \right]^2$
$\left(\frac{10}{10.232} \right) \left(\frac{29.62}{29.84} \right) \left(\frac{544.25}{531} \right)$	$\frac{(0.0317)(3.0)}{(29.62)(544.25)} \left[\frac{(531)(10.35)}{10} \right]^2$
$\left(\frac{10}{10.261} \right) \left(\frac{29.62}{29.84} \right) \left(\frac{545}{531} \right)$	$\frac{(0.0317)(3.0)}{(29.62)(545)} \left[\frac{(531)(10.37)}{10} \right]^2$
$\left(\frac{26}{26.735} \right) \left(\frac{29.62}{29.84} \right) \left(\frac{546}{531} \right)$	$\frac{(0.0317)(3.0)}{(29.62)(546)} \left[\frac{(531)(26.95)}{26} \right]^2$

- *To be the average ΔH used during the test series.
- **To be the highest vacuum used during the test series.
- ***Post-test Y must be within the range, pre-test Y ±0.05Y
 Post-test ΔH@ must be within the range, pre-test ΔH@ ±0.15

Figure E-7b. Particulate sampling meter box post-test calibration.

DATE: 12-4-95

METER BOX NO. FB-11

CALIBRATOR: J. NEESE

BAROMETRIC PRESSURE (P_b) 29.76 in. Hg

Leak Checks:

Positive (minimum 5 in. H₂O):

Negative (within 3 in. Hg of absolute): .000 cfm 27.0 in. Hg

*Not to exceed 0.00% cfm.

Orifice manometer setting ΔH in H ₂ O	Volume wet test meter V _w ft ³	Volume dry gas meter V _d ft ³	Temperatures				Duration of test P min	Vacuum setting in Hg	γ	ΔH ₀ in H ₂ O
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _i °F	Outlet T _o °F	Average T _d °F				
0.5	6	39.414	68.5	80	76	78.25	12.22	10	.985	1.17
		45.612	68.5	81	76					
1.0	10	46.012	68.5	81	76	78.75	14.43	10	.980	1.20
		56.387	68.5	82	76					
1.5	10	56.918	68.5	82	76	79.25	11.42	10	.977	1.13
		67.319	68.5	83	76					
2.0	10	67.714	68.5	83	76	80	10.11	10	.976	1.14
		78.131	68.5	84	77					
3.0	10	78.516	68.5	84	77	80.75	8.23	10	.975	1.16
		88.928	68.5	85	77					
4.0	10	89.364	68.5	85	77	81	7.16	10	.977	1.16
		99.743	68.5	85	77					
Average								.978	1.16	

γ must not deviate by more than +0.02 γ.
ΔH₀ must not deviate by more than 0.15 in H₂O.

ΔH	γ		ΔH ₀	
	$\frac{(V_w)(P_b)(T_d + 460)}{(V_d)(P_b + \Delta H/13.6)(T_w + 460)}$	$\frac{(0.0317)(\Delta H)}{(P_b)(T_d + 460)}$	$\frac{(T_w + 460)(P_b)^2}{(V_w)}$	$\frac{(1528.5)(\Delta H)^2}{(10)}$
0.5	$\frac{(6)(29.76)(538.25)}{(6.198)(29.80)(538.5)}$	$\frac{(0.0317)(0.5)}{(29.76)(538.25)}$	$\frac{(528.5)(12.37)^2}{6}$	
1.0	$\frac{(10)(29.76)(538.75)}{(10.375)(29.83)(528.5)}$	$\frac{(0.0317)(1.0)}{(29.76)(538.75)}$	$\frac{(528.5)(14.72)^2}{10}$	
1.5	$\frac{(10)(29.76)(539.25)}{(10.40)(29.87)(528.5)}$	$\frac{(0.0317)(1.5)}{(29.76)(539.25)}$	$\frac{(528.5)(11.7)^2}{10}$	
2.0	$\frac{(10)(29.76)(540)}{(10.417)(29.91)(528.5)}$	$\frac{(0.0317)(2.0)}{(29.76)(540)}$	$\frac{(528.5)(10.18)^2}{10}$	
3.0	$\frac{(10)(29.76)(540.75)}{(10.412)(29.98)(528.5)}$	$\frac{(0.0317)(3.0)}{(29.76)(540.75)}$	$\frac{(528.5)(8.38)^2}{10}$	
4.0	$\frac{(10)(29.76)(541)}{(10.379)(30.05)(528.5)}$	$\frac{(0.0317)(4.0)}{(29.76)(541)}$	$\frac{(528.5)(7.27)^2}{10}$	

Figure E-7c. Particulate sampling meter box initial calibration.

DATE: 7-8-86
 BAROMETRIC PRESSURE (P_{bar}): 29.62 in. Hg
 PLANT: Steel Heddle / Able Mach. Co
 PROJECT MANAGER: C. Bruffen

METER BOX NO. FB-11
 PRETEST Y: 978 ΔH@: 1.16
 PROJECT NO. 3615-22
 CALIBRATOR: J. Noose

Orifice manometer setting * ΔH in. H ₂ O	Wet test meter volume V _w ft ³	Dry gas meter volume V _d ft ³	Temperatures				Vacuum setting ** in. Hg	Duration of run θ min	γ	ΔH@
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _{di} °F	Outlet T _{di} °F	Average T _d °F				
2.5	12	262.939	71	94	76	85.5	8.5	10: ⁴⁶ / ₆₀	.974	1.11
		275.417	71	94	78					
2.5	19	275.417	71	94	78	87	8.5	17: ⁰⁴ / ₆₀	.968	1.11
		295.512	71	96	80					
2.5	10	295.512	71	96	80	88.5	8.5	9: ⁰⁰ / ₆₀	.999	1.11
		305.793	71	96	82					
Post-test average***									.980	1.11

		ΔH@	
$(\frac{V_w}{V_d}) (P_{bar}) (T_d + 460)$	$(0.0317) (\Delta H)$	$(T_w + 460) (\theta)$	2
$(V_d) (P_{bar} + \Delta H / 13.6) (T_w + 460)$	$(P_{bar}) (T_d + 460)$	$(\frac{V_w}{V_d})$	
$(12) (29.62) (545.5)$	$(0.0317) (2.5)$	$(531) (10.77)$	2
$(12.578) (29.80) (531)$	$(29.62) (545.5)$	(12)	
$(19) (29.62) (547)$	$(0.0317) (2.5)$	$(531) (17.07)$	2
$(20.095) (29.80) (531)$	$(29.62) (547)$	(19)	
$(10) (29.62) (548.5)$	$(0.0317) (2.5)$	$(531) (9.0)$	2
$(10.281) (29.80) (531)$	$(29.62) (548.5)$	(10)	

- *To be the average ΔH used during the test series.
- **To be the highest vacuum used during the test series.
- ***Post-test γ must be within the range, pre-test γ ±0.05γ
 Post-test ΔH@ must be within the range, pre-test ΔH@ ±0.15

Figure E-7d. Particulate sampling meter box post-test calibration.

DATE: 12-27-85
 CALIBRATOR: J. Neese

METER BOX NO. FB-9
 BAROMETRIC PRESSURE (P_b) 29.41 in. Hg

Leak Checks:

Positive (minimum 5 in. H₂O): ✓
 Negative (within 3 in. Hg of absolute): .001 cfm 27.0 in. Hg
 *Not to exceed 0.005 cfm.

Orifice manometer setting ΔH in H ₂ O	Volume wet test meter V _w ft ³	Volume dry gas meter V _d ft ³	Temperatures				Duration of test θ min	Vacuum setting in Hg	γ	ΔH ₀ in H ₂ O
			Wet test meter T _w °F	Dry gas meter						
			Inlet T ₁ °F	Outlet T ₀ °F	Average T _d °F					
0.5	5	76.328	73	95	86	90.5	13.24		984	2.03
		81.571	73	95	86					
1.0	11	81.854	73	95	86	90.75	21.14		984	2.07
		93.377	73	96	86					
1.5	10	93.812	73	96	86	91.95	15.27		986	1.99
		104.274	73	98	87					
2.0	10	104.535	73	98	87	92.75	13.26		987	2.00
		114.994	73	99	87					
3.0	10	115.325	73	99	87	93.5	11.08		988	2.06
		125.758	73	100	88					
4.0	10	126.152	73	100	88	94	9.42		989	2.08
		136.561	73	100	88					
Average								986	2.04	

γ must not deviate by more than ±0.02 γ.
 ΔH₀ must not deviate by more than 0.15 in H₂O.

ΔH	γ		ΔH ₀	
	$\frac{(V_w)(P_b)(T_d + 460)}{(V_d)(P_b + \Delta H/13.6)(T_w + 460)}$	$\frac{(0.0317)(\Delta H)}{(P_b)(T_d + 460)}$	$\frac{(T_w + 460)(\theta)^2}{(V_w)}$	$\frac{(533)(\theta)^2}{(V_w)}$
0.5	$\frac{(5)(29.41)(530.5)}{(5.243)(29.45)(533)}$	$\frac{(0.0317)(0.5)}{(29.41)(550.5)}$	$\frac{(533)(13.48)^2}{5}$	$\frac{(533)(13.48)^2}{5}$
1.0	$\frac{(11)(29.41)(550.75)}{(11.523)(29.48)(533)}$	$\frac{(0.0317)(1.0)}{(29.41)(550.75)}$	$\frac{(533)(21.33)^2}{11}$	$\frac{(533)(21.33)^2}{11}$
1.5	$\frac{(10)(29.41)(551.75)}{(10.412)(29.52)(533)}$	$\frac{(0.0317)(1.5)}{(29.41)(551.75)}$	$\frac{(533)(15.45)^2}{10}$	$\frac{(533)(15.45)^2}{10}$
2.0	$\frac{(10)(29.41)(552.75)}{(10.459)(29.56)(533)}$	$\frac{(0.0317)(2.0)}{(29.41)(552.75)}$	$\frac{(533)(13.43)^2}{10}$	$\frac{(533)(13.43)^2}{10}$
3.0	$\frac{(10)(29.41)(553.5)}{(10.433)(29.63)(533)}$	$\frac{(0.0317)(3.0)}{(29.41)(553.5)}$	$\frac{(533)(11.13)^2}{10}$	$\frac{(533)(11.13)^2}{10}$
4.0	$\frac{(10)(29.41)(554)}{(10.409)(29.70)(533)}$	$\frac{(0.0317)(4.0)}{(29.41)(554)}$	$\frac{(533)(9.7)^2}{10}$	$\frac{(533)(9.7)^2}{10}$

Figure E-7e. Particulate sampling meter box initial calibration.

DATE: 7-9-86
 BAROMETRIC PRESSURE (P_{bar}): 29.39 in. Hg
 PLANT: Steel Huddle/Able Mach. Co.
 PROJECT MANAGER: C. Bruffey

METER BOX NO. FR-9
 PRETEST Y: .986 ΔH@: 2.04
 PROJECT NO. 3615-22
 CALIBRATOR: J. Nease

Orifice manometer setting * ΔH in. H ₂ O	Wet test meter volume V _w ft ³	Dry gas meter volume V _d ft ³	Temperatures				Vacuum setting ** in. Hg	Duration of run θ min	γ	ΔH@
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _{di} °F	Outlet T _{di} °F	Average T _d °F				
1.3	10.0	218.338	71	99	86	92.5	4	16.24/60	.977	1.92
		228.954	71	99	86					
1.3	11.0	228.954	71	99	86	92.5	4	18.05/60	.977	1.93
		240.633	71	99	86					
1.3	10.0	240.633	71	99	86	92.5	4	16.29/60	.977	1.94
		251.244	71	99	86					
Post-test average***									.977	1.93

γ	ΔH@
$\left(\frac{V_w}{V_d} \right) (P_{bar}) (T_d + 460)$	$(0.0317) (\Delta H) \left[\frac{(T_w + 460) (\theta)}{V_w} \right]^2$
$(V_d) (P_{bar} + \Delta H/13.6) (T_w + 460)$	$(P_{bar}) (T_d + 460) \left[\frac{V_w}{V_w} \right]$
$\left(\frac{10}{10.616} \right) (29.39) (552.5)$	$(.0317) (1.3) \left[\frac{(531) (16.4)}{10} \right]^2$
$(10.616) (29.49) (531)$	$(29.39) (552.5) \left[\frac{10}{10} \right]$
$\left(\frac{11}{11.679} \right) (29.39) (552.5)$	$(.0317) (1.3) \left[\frac{(531) (18.08)}{11} \right]^2$
$(11.679) (29.49) (531)$	$(29.39) (552.5) \left[\frac{11}{11} \right]$
$\left(\frac{10}{10.611} \right) (29.39) (552.5)$	$(.0317) (1.3) \left[\frac{(531) (16.48)}{10} \right]^2$
$(10.611) (29.49) (531)$	$(29.39) (552.5) \left[\frac{10}{10} \right]$

- *To be the average ΔH used during the test series.
- **To be the highest vacuum used during the test series.
- ***Post-test γ must be within the range, pre-test γ ±0.05γ
 Post-test ΔH@ must be within the range, pre-test ΔH@ ±0.15

Figure E-7f. Particulate sampling meter box post-test calibration.

DATE: 12-26-85

METER BOX NO. FR-3

CALIBRATOR: J. Neese

BAROMETRIC PRESSURE (P_b) 29.30 in. Hg

Leak Checks:

Positive (minimum 5 in. H₂O):

Negative (within 3 in. Hg of absolute): ✓ 0.02 cfm 28.0 in. Hg

*Not to exceed 0.005 cfm.

Orifice manometer setting ΔH in H ₂ O	Volume wet test meter V _w ft ³	Volume dry gas meter V _d ft ³	Temperatures				Duration of test θ min	Vacuum setting in Hg	γ	ΔHP in H ₂ O
			Wet test meter T _w °F	Dry gas meter						
				Inlet T _i °F	Outlet T _o °F	Average T _d °F				
0.5	5	585.837	70.5	80	74	77.25	12 ³³ / ₆₀	10	.975	1.79
		591.032	70.5	81	74					
1.0	10	591.332	70.5	81	74	79.5	18 ⁰⁶ / ₆₀	10	.974	1.85
		601.744	70.5	85	78					
1.5	10	602.023	70.5	85	78	82.25	14 ⁴² / ₆₀	10	.978	1.82
		612.436	70.5	87	79					
2.0	10	612.716	70.5	87	79	83.5	12 ⁵³ / ₆₀	10	.979	1.86
		623.123	70.5	89	79					
3.0	10	623.458	70.5	89	79	84.5	10 ⁴¹ / ₆₀	10	.982	1.91
		633.836	70.5	90	80					
4.0	10	634.137	70.5	90	80	85	9 ¹⁸ / ₆₀	10	.973	1.93
		644.591	70.5	90	80					
Average								.977	1.86	

γ must not deviate by more than +0.02 γ.
ΔHP must not deviate by more than 0.15 in H₂O.

ΔH	γ		ΔHP	
	$\frac{(V_w)}{(V_d)} \left(\frac{P_b}{P_b + \Delta H/13.6} \right) (T_d + 460)$	$\frac{(T_w + 460)(\theta)^2}{(V_w)}$	$(0.0317) (\Delta H)$	$\frac{(T_w + 460)(\theta)^2}{(V_w)}$
0.5	$\frac{5}{5.186} \left(\frac{29.30}{29.34} \right) (537.25)$	$\frac{(530.5)(12.55)^2}{5}$	$(0.0317)(0.5)$	$\frac{(530.5)(12.55)^2}{5}$
	$\frac{5}{5.186} \left(\frac{29.30}{29.34} \right) (530.5)$	$\frac{(530.5)(12.55)^2}{5}$	$(0.0317)(0.5)$	$\frac{(530.5)(12.55)^2}{5}$
1.0	$\frac{10}{10.412} \left(\frac{29.30}{29.37} \right) (539.5)$	$\frac{(530.5)(18.1)^2}{10}$	$(0.0317)(1.0)$	$\frac{(530.5)(18.1)^2}{10}$
	$\frac{10}{10.412} \left(\frac{29.30}{29.37} \right) (530.5)$	$\frac{(530.5)(18.1)^2}{10}$	$(0.0317)(1.0)$	$\frac{(530.5)(18.1)^2}{10}$
1.5	$\frac{10}{10.413} \left(\frac{29.30}{29.41} \right) (542.25)$	$\frac{(530.5)(14.7)^2}{10}$	$(0.0317)(1.5)$	$\frac{(530.5)(14.7)^2}{10}$
	$\frac{10}{10.413} \left(\frac{29.30}{29.41} \right) (530.5)$	$\frac{(530.5)(14.7)^2}{10}$	$(0.0317)(1.5)$	$\frac{(530.5)(14.7)^2}{10}$
2.0	$\frac{10}{10.407} \left(\frac{29.30}{29.45} \right) (543.5)$	$\frac{(530.5)(12.85)^2}{10}$	$(0.0317)(2.0)$	$\frac{(530.5)(12.85)^2}{10}$
	$\frac{10}{10.407} \left(\frac{29.30}{29.45} \right) (530.5)$	$\frac{(530.5)(12.85)^2}{10}$	$(0.0317)(2.0)$	$\frac{(530.5)(12.85)^2}{10}$
3.0	$\frac{10}{10.379} \left(\frac{29.30}{29.52} \right) (544.5)$	$\frac{(530.5)(10.68)^2}{10}$	$(0.0317)(3.0)$	$\frac{(530.5)(10.68)^2}{10}$
	$\frac{10}{10.379} \left(\frac{29.30}{29.52} \right) (530.5)$	$\frac{(530.5)(10.68)^2}{10}$	$(0.0317)(3.0)$	$\frac{(530.5)(10.68)^2}{10}$
4.0	$\frac{10}{10.454} \left(\frac{29.30}{29.59} \right) (545)$	$\frac{(530.5)(9.3)^2}{10}$	$(0.0317)(4.0)$	$\frac{(530.5)(9.3)^2}{10}$
	$\frac{10}{10.454} \left(\frac{29.30}{29.59} \right) (530.5)$	$\frac{(530.5)(9.3)^2}{10}$	$(0.0317)(4.0)$	$\frac{(530.5)(9.3)^2}{10}$

Figure E-7g. Particulate sampling meter box initial calibration.

DATE: 7-9-86
 BAROMETRIC PRESSURE (P_{bar}): 29.39 in. Hg
 PLANT: Steel Heddle / Able Mch. Co.
 PROJECT MANAGER: C. Bruffey

METER BOX NO. FB-3
 PRETEST γ : 977 $\Delta H\theta$: 1.86
 PROJECT NO. 3615-22
 CALIBRATOR: J. Neese

Orifice manometer setting * ΔH in. H ₂ O	Wet test meter volume V_w ft ³	Dry gas meter volume V_d ft ³	Temperatures				Vacuum setting ** in. Hg	Duration of run θ min	γ	$\Delta H\theta$
			Wet test meter T_w °F	Dry gas meter						
				Inlet T_{di} °F	Outlet T_{di} °F	Average T_d °F				
1.5	10.0	509.813	71	86	74	81	3	14: ³⁸ / ₆₀	.955	1.80
		520.438	71	88	76					
1.5	10.0	520.438	71	88	76	82.5	3	14: ⁴⁴ / ₆₀	.955	1.82
		531.100	71	89	77					
1.5	12.0	531.100	71	89	77	83.5	3	17: ⁴⁰ / ₆₀	.956	1.82
		543.899	71	89	79					
Post-test average***									.955	1.81

γ	$\Delta H\theta$
$(\frac{V_w}{V_d})(\frac{P_{bar}}{P_{bar} + \Delta H/13.6})(\frac{T_d + 460}{T_w + 460})$	$(0.0317)(\Delta H) \left[\frac{(T_w + 460)(\theta)}{V_w} \right]^2$
$(10)(29.39)(541)$	$(.0317)(1.5) \left[\frac{(531)(14.63)}{10} \right]^2$
$(10.625)(29.50)(531)$	$(.0317)(1.5) \left[\frac{(531)(14.73)}{10} \right]^2$
$(12)(29.39)(543.5)$	$(.0317)(1.5) \left[\frac{(531)(17.67)}{12} \right]^2$
$(12.799)(29.50)(531)$	

- *To be the average ΔH used during the test series.
- **To be the highest vacuum used during the test series.
- ***Post-test γ must be within the range, pre-test $\gamma \pm 0.05\gamma$
 Post-test $\Delta H\theta$ must be within the range, pre-test $\Delta H\theta \pm 0.15$

Figure E-7h. Particulate sampling meter box post-test calibration.

The thermocouples read within 1.5 percent of the reference thermometer value throughout the entire range when expressed in degrees Rankine. The thermocouples were checked at ambient temperature at the test sites to verify the calibration. Calibration data are presented in Figures E-8a through E-8c.

DIGITAL INDICATOR FOR THERMOCOUPLE READOUT

Each digital indicator was calibrated by feeding a series of millivolt signals to the input, and comparing the indicator reading with the reading the signal should have generated. Error did not exceed 0.5 percent when the temperatures were expressed in degrees Rankine. Calibration data are shown in Figure E-9a and E-9b.

DRY GAS THERMOMETERS AND IMPINGER THERMOCOUPLES

The dry gas thermometers were calibrated by comparison against an ASTM-3F thermometer at approximately 32°F, at ambient temperature, and at approximately 110°F. The thermometers agreed within 5°F of the reference thermometer. The impinger thermocouples were checked in similar manner at approximately 32°F and at ambient temperature and agreed within 2°F. The thermometers and thermocouples were checked at ambient temperature prior to the test series to verify calibration. Calibration data are included in Figures E-10a through E-10c and E-11a and E-11b.

BALANCE

The Mettler electronic balance was calibrated by comparison with Class-S standard weights and agreed within 0.5 g. A calibration is also performed yearly by the manufacturer. Calibration data are shown in Figures E-12 and E-13.

Date: 12/31/85 Thermocouple No.: 101
 Calibrator: G Thross Reference: ASTM-3F
 Range: 32 → 452

Reference point No.	Source,*	Reference thermometer temperature, °F	Thermocouple temperature, °F	Difference, %**
1	2	77	77	0
2	1	32	33	.12
3	3	210	211	.15
4	4	452	454	.22

- *Source: 1) Ice Bath
 2) Ambient
 3) Water Bath
 4) Oil Bath

**Percent difference

$$\frac{\text{Reference temp. } ^\circ\text{R} - \text{thermocouple temp. } ^\circ\text{R}}{(\text{Reference temp. } ^\circ\text{R})} \times 100\%$$

where $^\circ\text{R} = ^\circ\text{F} + 460$

Each percent difference must be less than or equal to 1.5%.

Figure E-8a. Thermocouple calibration data sheet.

Date: 12/30/85 Thermocouple No.: 412
 Calibrator: G. Truss Reference: ASTM-3E
 Range: 33 → 470

Reference point No.	Source,*	Reference thermometer temperature, °F	Thermocouple temperature, °F	Difference, %**
1	2	76	76	0
2	1	33	34	1.2
3	3	210	212	0.3
4	4	468	469	0.1

- *Source: 1) Ice Bath
 2) Ambient
 3) Water Bath
 4) Oil Bath

**Percent difference

$$\frac{\text{Reference temp. } ^\circ\text{R} - \text{thermocouple temp. } ^\circ\text{R}}{(\text{Reference temp. } ^\circ\text{R})} \times 100\%$$

where $^\circ\text{R} = ^\circ\text{F} + 460$

Each percent difference must be less than or equal to 1.5%.

Figure E-8b. Thermocouple calibration data sheet.

Date: 12/30/85 Thermocouple No.: 409
 Calibrator: GThress Reference: ASTM-3E
 Range: 33-490

Reference point No.	Source,*	Reference thermometer temperature, °F	Thermocouple temperature, °F	Difference, %**
1	2	81	81	0
2	1	33	33	0
3	3	210	211	.15
4	4	490	491	.10

- *Source: 1) Ice Bath
 2) Ambient
 3) Water Bath
 4) Oil Bath

**Percent difference

$$\frac{\text{Reference temp. } ^\circ\text{R} - \text{thermocouple temp. } ^\circ\text{R}}{(\text{Reference temp. } ^\circ\text{R})} \times 100\%$$

where $^\circ\text{R} = ^\circ\text{F} + 460$

Each percent difference must be less than or equal to 1.5%.

Figure E-8c. Thermocouple calibration data sheet.

DATE: 10-22-85 INDICATOR NO: FT-1
 OPERATOR: J. H. Stensland SERIAL NO: ST03
 CALIBRATION DEVICE NO: 2 MANUFACTURER: Omega

TEST POINT NO	MILLIVOLT SIGNAL	EQUIVALENT TEMPERATURE, deg. F	DIGITAL INDICATOR TEMPERATURE READING, deg. F	DIFFERENCE %
1	-0.692	0	-1	0.22
2	1.520	100	101	0.18
3	3.819	200	201	0.15
4	6.092	300	301	0.13
5	8.314	400	399	0.12
6	10.560	500	501	0.10
7	22.251	1000	1001	0.07
8	29.315	1300	1300	0.00
9	36.166	1600	1599	0.05
10	42.732	1900	1899	0.04

Percent difference must be less than or equal to 0.5%

Percent difference:

$$\frac{(\text{Equivalent temperature, deg. R} - \text{Digital indicator temperature, deg. R})(100\%)}{(\text{Equivalent temperature, deg. R})}$$

Where, deg. R = deg. F + 460

Figure E-9a. Thermocouple digital indicator calibration data sheet.

DATE: 9-14-85 INDICATOR NO: 219
 OPERATOR: G. Inness SERIAL NO: 9450243-10
 CALIBRATION DEVICE NO: #1 MANUFACTURER: Newport

TEST POINT NO#	MILLIVOLT SIGNAL	EQUIVALENT TEMPERATURE, deg. F	DIGITAL INDICATOR TEMPERATURE READING, deg. F	DIFFERENCE %
1	-0.692	0	0	0
2	1.520	100	99	-.17
3	3.819	200	201	.15
4	6.092	300	301	.13
5	8.314	400	399	-.11
6	10.560	500	500	0
7	22.251	1000	1002	.13
8	29.315	1300	1303	.17
9	36.166	1600	1604	.19
10	42.732	1900	1904	.17

Percent difference must be less than or equal to 0.5%

Percent difference:

$$\frac{(\text{Equivalent temperature, deg. R} - \text{Digital indicator temperature, deg. R})}{(\text{Equivalent temperature, deg. R})} \times 100\%$$

(Equivalent temperature, deg. R)

Where, deg. R = deg. F + 460

Figure E-9b. Thermocouple digital indicator calibration data sheet.

Date: 8-19-85

Meter Box No.: FT-1

Calibrator: J. Neese

Reference: ASTM-3F

Inlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F**
1	2	70	70	0
2	1	32	33	1
3	3	200	198	2

Outlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F**
1	2	70	72	2
2	1	32	33	1
3	3	200	200	0

*Source: 1) Ice bath
2) Ambient
3) Water bath

**Difference must be less than or equal to ±5°F.

Figure E-10a. Dry gas thermometer calibration data sheet.

Date: 12-4-85

Meter Box No.: FB-11

Calibrator: J. Noese

Reference: ASTM-3F

Inlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F
1	2	70	70	0
2	1	32	32	0
3	3	186	184	2

Outlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F
1	2	70	72	2
2	1	32	33	1
3	3	186	184	2

- *Source: 1) Ice bath
2) Ambient
3) Water bath

**Difference must be less than or equal to $\pm 5^{\circ}\text{F}$.

Figure E-10b. Dry gas thermometer calibration data sheet.

Date: 12-26-85

Meter Box No.: FB-9

Calibrator: J. Noese

Reference: ASTM-3F

Inlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F
1	2	71	73	2
2	1	32	35	3
3	3	170	169	1

Outlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F
1	2	71	69	2
2	1	32	33	1
3	3	170	168	2

- *Source: 1) Ice bath
2) Ambient
3) Water bath

**Difference must be less than or equal to $\pm 5^{\circ}\text{F}$.

Figure E-10c. Dry gas thermometer calibration data sheet.

Date: 12-26-85

Meter Box No.: FB-3

Calibrator: J. Neese

Reference: ASTM-3F

Inlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F**
1	2	72	70	2
2	1	32	32	0
3	3	188	188	0

Outlet

Reference point No.	Source *	Reference thermometer temperature, °F	Dry gas thermometer temperature, °F	Difference, °F**
1	2	72	71	1
2	1	32	32	0
3	3	188	189	1

*Source: 1) Ice bath
2) Ambient
3) Water bath

**Difference must be less than or equal to +5°F.

Figure E-10d. Dry gas thermometer calibration data sheet.

Date: 1-14 86 Thermocouple No: I-15
 Calibrator: J Neese Reference: ASTM-3F

Reference point No.	Source'	Reference thermometer temperature deg. F	Thermocouple temperature deg. F	Difference deg. F''
1	1	74	73	1
2	2	33	34	1

'Source: 1) Ambient
 2) Ice bath

''Difference must be less than 2 deg. F at both points

Figure E-11a. Impinger thermocouple calibration data sheet.

Date: 9-17-85

Thermocouple No.: I-1

Calibrator: QJTA

Reference: ASTM-3F

Range: _____

Reference point No.	Source,*	Reference thermometer temperature, °F	Thermocouple temperature, °F	Difference, %**
1	2	76	74	0.37
2	1	37	35	0.40
3	3	196	197	0.15
4	4	381	384	0.36

- *Source: 1) Ice Bath
2) Ambient
3) Water Bath
4) Oil Bath

**Percent difference

$$\frac{\text{Reference temp. } ^\circ\text{R} - \text{thermocouple temp. } ^\circ\text{R}}{(\text{Reference temp. } ^\circ\text{R})} \times 100\%$$

where $^\circ\text{R} = ^\circ\text{F} + 460$

Each percent difference must be less than or equal to 1.5%.

Figure E-11b. Thermocouple calibration data sheet.

Balance No.	Date	Calibrator	Mass determined for					
			5 g	Error	50 g	Error	100 g	Error
194	3/25/86	<i>C. Howard</i>	5.1	0.1	49.8	0.2	99.9	0.1
196	3/25/86	<i>C. Howard</i>	5.2	0.2	50.0	0.0	99.9	0.1
198	3/25/86	<i>C. Howard</i>	5.0	0.0	49.8	0.2	99.7	0.3
396	3/25/86	<i>C. Howard</i>	5.0	0.0	50.0	0.0	99.9	0.1
Mettler	3/28/86	J. Neese	5.0	0.0	50.0	0.0	100.0	0.0

Error must not exceed 0.5 grams at each point.

Figure E-12. Trip balance calibration data sheet.

WEIGHT TRACEABILITY CERTIFICATE

TO: PEI Associates
11499 Chester Rd
Cinc. Ohio 45246

The balances listed below have been serviced by our representative
on 10-17-85

This is to certify that the test weights used are traceable to the
National Bureau of Standards.

	Analytical	Precision
Mettler identification number of test weights used:	<u>13</u>	<u>155</u>
Mettler calibration date of test weights used:	<u>5-14-85</u>	<u>1-16-85</u>
National Bureau of Standards test number:	<u>737/0670-45</u>	<u>737/0670-46</u>

Model and serial number of balances serviced:

H35AR # 679025
HL 32 # 758667
H31 # 614363
H35AR # 668020
PC 4400 # C26340

PC 4400 # 743985
PE AD-2 # 65920

Gerry Hunt
Mettler Service Representative

10-17-85
Date of Issue

METTLER

Mettler Instrument Corporation
Box 71, Hightstown, NJ 08520
(609) 448-3000

Figure E-13. Weight traceability certificate.

BAROMETER

The field barometer was calibrated to within 0.1 in.Hg of an NBS-traceable mercury-in-glass barometer before the test series. It was checked against the reference after the test series to determine if it read within 0.2 in.Hg. The barometer read within the allowable limits each time. Calibration data are included in Figure E-14.

ORSAT ANALYZER

The Orsat analyzer was calibrated before the test series by determining the percentage of oxygen, carbon monoxide, and carbon dioxide in a calibrated gas containing known percentages of each. The analyzer read within 0.5 percent of the known value for the gas. Calibration data are shown in Figures E-15a through E-15c.

BAROMETER NO.	406	407	407	406			
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PRETEST
 GTE 5463
 P4G 5456
 EMB 3615.22

BAROMETER READING	29.53	29.89	30.08	29.97			
REFERENCE BAROMETER READING	29.53	29.89	30.08	29.99			
DIFFERENCE*	0.00	0.01	0.00	0.02			
DATE	6/19/86	6/16/86	6/19/86	6/20/86			
CALIBRATOR	Ph	Ph	Ph	J. Neese			

406

BAROMETER READING	29.97	30.05		29.91			
REFERENCE BAROMETER READING	29.99	30.08		29.92			
DIFFERENCE**	.02	.03		.01			
DATE	6-20-86	6-17-86		7/5/86			
CALIBRATOR	J. Neese	J. Neese		(CB)			

*Barometer is adjusted so that difference does not exceed 0.05 in. Hg.
 **Barometer is not adjusted. If difference exceed 0.10 in. Hg, inform project manager immediately.

Figure E-14. Barometer calibration log.



APPENDIX F
PROJECT PARTICIPANTS AND SAMPLE LOG

TABLE F-1. PROJECT PARTICIPANTS

Name	Title	Responsibility
C. Bruffey	PEI Project Manager	Coordinated test activity; liaison with EPA, MRI, and plant personnel; calculations; Cr ⁶ /total Cr and particle size recovery; process sample collection.
J. Prohaska	PEI Test Engineer	Site leader for scrubber inlet and outlet tests; assisted with cleanup/recovery of samples.
D. Scheffel	Environmental Scientist	Assisted with all tests at scrubber inlet and outlet.
F. Clay	Task Manager U.S. EPA-EMB	Coordinated test activity. Onsite data reduction and calculations.
R. Strait	MRI-NSPS Contractor	Monitored process operation and coordinated test activity.
R. Banker	MRI-NSPS Contractor	Monitored process operation and coordinated test activity.

TABLE F-2. SAMPLE LOG

Date (1986)	Activity
Sunday 6/22	Test crew and equipment travel to Greenville, SC
Monday 6/23	Equipment and site setup; conducted all preliminary measurements and equipment audits. Sample trains and impactors setup.
Tuesday 6/24	Conducted one Method 13B test at each location. Conducted one particle size run at outlet and three at inlet. Collected process samples.
Wednesday 6/25	Conducted two Method 13B tests at each location. Conducted two particle size tests at outlet location. Collected process samples. All samples were recovered, equipment packed, and test crew departs plant.



APPENDIX G

DRAFT TEST METHOD FOR HEXAVALENT CHROMIUM
EMISSIONS FROM STATIONARY SOURCES

Method - Determination of Hexavalent Chromium
Emissions from Stationary Sources

1. Applicability and Principle.

1.1 Applicability. This method applies to the determination of hexavalent chromium (Cr^{+6}) emissions from specified stationary sources only.

1.2 Principle. Particulate emissions are collected from the source by use of Method 5 (Appendix A, 40 CFR Part 60). The collected samples are digested in an alkaline solution and analyzed by the diphenylcarbazide colorimetric method.

2. Range, Sensitivity, Precision, and Interferences.

2.1 Range. A straight line response curve was obtained in the range $5 \mu\text{g Cr}^{+6}/100 \text{ ml}$ to $250 \mu\text{g Cr}^{+6}/100 \text{ ml}$. For a minimum analytical accuracy of ± 10 percent, the lower limit of the range is $50 \mu\text{g}/100 \text{ ml}$. The upper limit can be extended by appropriate dilution.

2.2 Sensitivity. A minimum detection limit of $1 \mu\text{g Cr}^{+6}/100 \text{ ml}$ has been observed.

2.3 Precision. The overall precision for sample collection and analysis for Cr^{+6} was tested at a ferrochrome smelter, a chemical plant, and a refractory brick plant. Replicate Method 5 filters with both high and low particulate loadings were analyzed. The relative standard deviation was 4.4, 8.3, and 13.3 percent, respectively.

2.4 Interference. Very large quantities of iron, molybdenum, vanadium, and mercury can interfere with the analysis. No interference was observed at the sources listed in Section 2.3.

3. Apparatus.

3.1 Sampling Train. Same as Method 5, Section 2.1.

3.2 Sample Recovery. Same as Method 5, Section 2.2.

3.3 Analysis. The following equipment is needed.

3.3.1 Beakers. Borosilicate, 250 ml, with watchglass covers.

3.3.2 Filtration Apparatus. Vacuum unit with 47 mm diameter,

3.0 μ pore size Teflon filters.

3.3.3 Volumetric Flasks. 100 ml and other appropriate volumes.

3.3.4 Hot Plate.

3.3.5 Pipettes. Assorted sizes, as needed.

3.3.6 Spectrophotometer. To measure absorbance at 540 nm.

4. Reagents.

4.1 Sampling. Same as Method 5, Section 3.1.

4.2 Sample Recovery. Same as Method 5, Section 3.2.

4.3 Analysis. The following reagents are required.

4.3.1 Sodium Carbonate. Na_2CO_3 , anhydrous, analytical reagent grade.

4.3.2 Sodium Hydroxide. NaOH , analytical reagent grade.

4.3.3 Potassium Dichromate. $\text{K}_2\text{Cr}_2\text{O}_7$, analytical reagent grade.

4.3.4 Water. Deionized distilled, meeting American Society for Testing and Materials (ASTM) specifications for type 3 reagent - ASTM Test Method D 1193-77 (incorporated by reference - see § 61.18). If high concentrations of organic matter are not expected to be present, the analyst may eliminate the KMnO_4 test for oxidizable organic matter.

4.3.5 Digestion Solution. Dissolve 20.0 g NaOH and 30.0 g Na₂CO₃ in deionized distilled water in a 1-liter volumetric flask and dilute to the mark. Store the solution in a tightly capped polyethylene bottle and prepare fresh monthly.

4.3.6 Potassium Dichromate Stock Solution. Dissolve 141.4 mg of dried K₂Cr₂O₇ in deionized distilled water and dilute to 1 liter (1 ml = 50 µg Cr⁺⁶).

4.3.7 Potassium Dichromate Standard Solution. Dilute 10.00 ml K₂Cr₂O₇ stock solution to 100 ml (1 ml = 5 µg Cr⁺⁶) with deionized distilled water.

4.3.8 Sulfuric Acid, 10 Percent (v/v). Dilute 10 ml of reagent grade H₂SO₄ to 100 ml in deionized distilled water.

4.3.9 Diphenylcarbazide Solution. Dissolve 250 mg of 1, 5-diphenylcarbazide in 50 ml acetone. Store in a brown bottle. Discard when the solution becomes discolored.

4.3.10 Acetone. Same as Method 5, Section 3.2.

5. Procedure.

5.1 Sampling. Same as Method 5, Section 4.1.

5.2 Sample Recovery. Same as Method 5, Section 4.2.

5.3 Preservation. Tests with the source samples described in Section 2.3 demonstrated that Cr⁺⁶ is stable in particulate form. Nevertheless, all samples should be protected from extreme heat, and should be analyzed within 1 month of collection.

5.4 Sample Digestion and Preparation. Place the contents of Container Number 1 (the filter) and Container Number 2 (the acetone probe rinse) in a 250 ml beaker. Evaporate to dryness. Add 40 ml of digestion solution (Section 4.2.5). Cover the beaker with the watchglass and heat to near boiling on a hot plate with constant stirring for 30 minutes. Do not allow the solution to evaporate to dryness.

Cool the solution and transfer it quantitatively to the filtration apparatus with deionized distilled water. Filter the solution through the 47 mm Teflon filter. Transfer the filtrate from the filter flask quantitatively to a 100 ml volumetric flask. Fill to the mark with deionized, distilled water.

5.5 Reagent Blank Preparation. Place a 47 mm diameter filter in a 100 ml beaker. Proceed as in Section 5.4.

5.6 Silica Gel Weighing. Weigh the spent silica gel (Container Number 3) or silica gel plus impinger to the nearest 0.5 g using a balance. This step may be conducted in the field.

5.7 Analysis.

5.7.1 Color Development and Measurement. Transfer 50 ml aliquot of the prepared sample to a 100 ml volumetric flask. Add 2.0 ml of diphenylcarbazide solution. Adjust the pH to 2 ± 0.5 with 10 percent H_2SO_4 and dilute to volume with deionized distilled water. Allow the solution to stand about 10 minutes for color development. Transfer a portion of the sample to a 1-cm absorption cell and measure the absorbance at the optimum wavelength (Section 6.2.1), using the blank solution as a zero reference.

Dilute the sample and the blank with equal volumes of deionized distilled water if the absorbance exceeds A_4 , the absorbance of the 250 $\mu\text{g Cr}^{+6}$ standard as determined in Section 6.2.2. Use deionized, distilled water to zero the instrument.

5.7.2 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), the analyst shall check at least one sample from each source using the method of additions as follows:

Add or spike an equal volume of standard solution to an aliquot of the sample solution, then measure the absorbance of the resulting solution and the absorbance of an aliquot of unspiked sample.

Next, calculate the Cr^{+6} concentration C_s , in $\mu\text{g/ml}$ of the sample solution by using the following equation:

$$C_s = C_a \frac{A_s}{A_t - A_s} \quad \text{Eq. G-1}$$

Where:

C_a = Cr^{+6} concentration of the standard solution g/ml.

A_s = Absorbance of the sample solution.

A_t = Absorbance of the spiked sample solution.

Volume corrections will not be required if the solutions as analyzed have been made to the same final volume. Therefore, C_s and C_a represent Cr^{+6}

concentrations before dilutions. If the results of the method of additions procedure used on the single source sample do not agree to within 5 percent of the value obtained by the routine spectrophotometric analysis, then reanalyze all samples from the source using this method of additions procedure.

6. Calibration.

6.1 Sampling Train. Perform all of the calibrations described in Method 5, Section 5.

6.2 Spectrophotometer Calibration.

6.2.1 Optimum Wavelength Determination. Calibrate the wavelength scale of the spectrophotometer every 6 months. The calibration may be accomplished by using an energy source with an intense line emission such as a mercury lamp, or by using a series of glass filters spanning the measuring range of the spectrophotometer. Calibration materials are available commercially and from the National Bureau of Standards. Specific details on the use of such materials should be supplied by the vendor; general information about calibration techniques can be obtained from general reference books on analytical chemistry. The wavelength scale of the spectrophotometer must read correctly within ± 5 nm at all calibration points; otherwise, the spectrophotometer shall be repaired and recalibrated. Once the wavelength scale of the spectrophotometer is in proper calibration, use 540 nm as the optimum wavelength for the measurement of the absorbance of the standards and samples.

Alternatively, a scanning procedure may be employed to determine the proper measuring wavelength. If the instrument is a double-beam spectrophotometer, scan the spectrum between 530 and 550 nm using a 250 µg Cr⁺⁶ standard solution in the sample cell and a blank solution in the reference cell. If a peak does not occur, the spectrophotometer is malfunctioning and should be repaired. When a peak is obtained within the 530 to 550 nm range, the wavelength at which this peak occurs shall be the optimum wavelength for the measurement of absorbance of both the standards and the samples. For a single-beam spectrophotometer, follow the scanning procedure described above, except that the blank and standard solutions shall be scanned separately. The optimum wavelength shall be the wavelength at which the maximum difference in absorbance between the standard and the blank occurs.

6.2.2 Determination of Spectrophotometer Calibration Factor K_C . Add 0.0 ml, 10 ml, 20 ml, 30 ml, and 50 ml of the working standard solution (1 ml = 5 µg Cr⁺⁶) to a series of five 100-ml volumetric flasks. Analyze these calibration standards as in Section 5.7.1. This calibration procedure must be repeated on each day that samples are analyzed. Calculate the spectrophotometer calibration factor as follows:

$$K_C = 100 \frac{\frac{A_1}{2} + \frac{2A_2}{2} + \frac{3A_3}{2} + \frac{4A_4}{2}}{A_1 + A_2 + A_3 + A_4} \quad \text{Eq. G-2}$$

Where:

K_C = Calibration factor.

A_1 = Absorbance of the 50 Cr^{+6} standard.

A_2 = Absorbance of the 100 Cr^{+6} standard.

A_3 = Absorbance of the 150 Cr^{+6} standard.

A_4 = Absorbance of the 250 Cr^{+6} standard.

7. Emission Calculations.

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

7.1 Total Cr^{+6} in Sample. Calculate m , the total μg Cr^{+6} in each sample, as follows:

$$m = K_C 2AF$$

Eq. G-3

Where:

2 = Factor to correct 50 ml aliquot analyzed to 100 ml 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).

7.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop. Same as Method 5, Section 6.2.

7.3 Dry Gas Volume, Volume of Water Vapor, Moisture Content. Same as Method 5, Sections 6.3, 6.4, and 6.5, respectively.

7.4 Cr⁺⁶ Emission Concentration. Calculate c_s (g/dscm), the Cr⁺⁶ concentration in the stack gas, dry basis, corrected to standard conditions, as follows:

$$c_s = (0.001 \text{ g/mg})(m/V_m(\text{std})) \quad \text{Eq. G-4}$$

7.5 Isokinetic Variation, Acceptable Results. Same as Method 5, Sections 6.11 and 6.12, respectively.

8. Bibliography.

1. Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency. SW-846, 2nd Edition. July 1982.
2. Cox, X.B., R.W. Linton, F.E. Butler. Determination of Chromium Speciation in Environmental Particles - A Multitechnique Study of Ferrochrome Smelter Dust. Accepted for publication in Environmental Science and Technology.
3. Same as Method 5, Citations 2 to 5 and 7 of Section 7.

ACID DIGESTION OF SLUDGES1.0 Scope and Application

1.1 Method 3050 is an acid digestion procedure used to prepare sludge-type and soil samples for analysis by flame or furnace atomic absorption spectroscopy (AAS) or by inductively coupled argon plasma spectroscopy (ICP). Samples prepared by Method 3050 may be analyzed by AAS or ICP for the following metals:

Antimony	Lead ✓
Arsenic	Nickel
Barium	Selenium ✓
Beryllium	Silver ✓
Cadmium ✓	Thallium
Chromium	Zinc
Copper	

1.2 Method 3050 may also be applicable to the analysis of other metals in sludge-type samples. However, prior to using this method for other metals, it must be evaluated using the specific metal and matrix.

2.0 Summary of Method

2.1 A dried and pulverized sample is digested in nitric acid and hydrogen peroxide. The digestate is then refluxed with either nitric acid or hydrochloric acid. Hydrochloric acid is used as the final reflux acid for the furnace analysis of Sb or the flame analysis of Sb, Ba, Be, Cd, Cr, Cu, Pb, Ni, and Zn. Nitric acid is employed as the final reflux acid for the furnace analysis of As, Ba, Be, Cd, Cr, Cu, Pb, Ni, Se, Ag, Tl, and Zn or the flame analysis of Ag and Tl.

3.0 Interferences

3.1 Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed to aid in determining whether Method 3050 is applicable to a given waste. Nondestructive techniques such as neutron activation analysis may also be helpful in evaluating the applicability of this digestion method.

4.0 Apparatus and Materials

- 4.1 125-ml conical Phillips' beakers.
- 4.2 Watch glasses.

Revised 4/84

7.3 After the second reflux step has been completed and the sample has cooled, add 2 ml of Type II water and 3 ml of 30% hydrogen peroxide (H_2O_2). Return the beaker to the hot plate for warming to start the peroxide reaction. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides, and cool the beaker.

7.4 Continue to add 30% H_2O_2 in 1-ml aliquots with warming until the effervescence is minimal or until the general sample appearance is unchanged. (NOTE: Do not add more than a total of 10 ml 30% H_2O_2 .)

7.5 If the sample is being prepared for the furnace analysis of Ag and Sb or direct aspiration analysis of Ag, Sb, Ba, Be, Cd, Cr, Cu, Pb, Ni, Tl, and Zn, add 5 ml of 1:1 HCl and 10 ml of Type II water, return the covered beaker to the hot plate, and heat for an additional 10 min. After cooling, filter through Whatman No. 42 filter paper (or equivalent) and dilute to 100 ml with Type II water (or centrifuge the sample). The diluted sample has an approximate acid concentration of 2.5% (v/v) HCl and 0.5% (v/v) HNO_3 and is now ready for analysis.

7.6 If the sample is being prepared for the furnace analysis of As, Ba, Be, Cd, Cr, Cu, Pb, Ni, Se, Tl, and Zn, continue heating the acid-peroxide digestate until the volume has been reduced to approximately 2 ml, add 10 ml of Type II water, and warm the mixture. After cooling, filter through Whatman No. 42 filter paper (or equivalent) and dilute to 100 ml with Type II water (or centrifuge the sample). The diluted digestate solution contains approximately 2% (v/v) HNO_3 . For analysis, withdraw aliquots of appropriate volume, add any required reagent or matrix modifier, and analyze by method of standard additions.

8.0 Quality Control

8.1 For each group of samples processed, procedural blanks (Type II water and reagents) should be carried throughout the entire sample-preparation and analytical process. These blanks will be useful in determining if samples are being contaminated.

8.2 Duplicate samples should be processed on a routine basis. Duplicate samples will be used to determine precision. The sample load will dictate the frequency, but 10% is recommended.

8.3 Spiked samples or standard reference materials should be employed to determine accuracy. A spiked sample should be included with each group of samples processed and whenever a new sample matrix is being analyzed.

8.4 The concentration of all calibration standards should be verified against a quality control check sample obtained from an outside source.

8.5 The method of standard addition shall be used for the analysis of all EP extracts and whenever a new sample matrix is being analyzed.

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4.3 Drying ovens that can be maintained at 30° C.

4.4 Thermometer that covers range of 0° to 200° C.

4.5 Whatman No. 42 filter paper or equivalent.

5.0 Reagents

5.1 ASTM Type II water (ASTM D1193): Water should be monitored for impurities.

5.2 Concentrated nitric acid: Acid should be analyzed to determine level of impurities. If impurities are detected, all analyses should be blank corrected.

5.3 Concentrated hydrochloric acid: Acid should be analyzed to determine level of impurities. If impurities are detected, all analyses should be blank corrected.

5.4 Hydrogen peroxide (30%): Oxidant should be analyzed to determine level of impurities. If impurities are detected, all analyses should be blank corrected.

6.0 Sample Collection, Preservation, and Handling

6.1 All samples must have been collected using a sampling plan that addresses the considerations discussed in Section One of this manual.

6.2 All sample containers must be prewashed with detergents, acids, and distilled deionized water. Plastic and glass containers are both suitable.

6.3 Nonaqueous samples shall be refrigerated when possible, and analyzed as soon as possible.

7.0 Procedure

7.1 Weigh and transfer to a 125-ml conical Phillips' beaker a 1.0-g portion of sample which has been dried at 60° C, pulverized, and thoroughly mixed.

7.2 Add 10 ml of 1:1 nitric acid (HNO_3), mix the slurry, and cover with a watch glass. Heat the sample at 95° C and reflux for 10 min. Allow the sample to cool, add 5 ml of conc. HNO_3 , replace the watch glass, and reflux for 30 min. Do not allow the volume to be reduced to less than 5 ml while maintaining a covering of solution over the bottom of the beaker.

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APPENDIX H
PROCESS DATA MONITORED DURING TESTS

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.
 INLET: SIC-1; OUTLET: SOC-1
 TANK 1

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:27	08:33					
08:35	08:35	8	2	1,000	133	33
08:40	08:40	<u>5</u>	<u>5</u>	1,000	<u>83</u>	<u>83</u>
Subtotal		13	7		216	116
08:54	08:54					
09:05	09:05	11	11	1,500	275	275
09:15	09:15	10	10	1,500	250	250
09:25	09:25	10	10	1,500	250	250
09:35	09:35	10	10	1,400	233	233
09:45	09:45	10	10	1,500	250	250
09:54	09:54	<u>9</u>	<u>9</u>	1,500	<u>225</u>	<u>225</u>
Subtotal		60	60		1,483	1,483
10:17	10:18					
10:25	10:25	8	7	3,000	400	350
10:35	10:35	10	10	2,750	458	458
10:45	10:45	10	10	3,000	500	500
10:55	10:55	10	10	2,900	483	483
11:05	11:05	10	10	2,900	483	483
11:14	11:14	<u>9</u>	<u>9</u>	2,900	<u>435</u>	<u>435</u>
Subtotal		57	56		2,759	2,709
11:25	11:25					
11:35	11:35	10	10	2,900	483	483
11:45	11:45	10	10	2,800	467	467
	11:48	<u>0</u>	<u>3</u>	2,800	<u>0</u>	<u>140</u>
Subtotal		20	23		950	1,090
TOTAL		150	146		5,408	5,398

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-1; OUTLET: SOC-1
 TANK NO. 2

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:27						
08:30		<u>3</u>	<u>0</u>	1,300	<u>65</u>	<u>0</u>
Subtotal		3	0		65	0
08:35	08:33					
08:45	08:45	10	12	1,400	233	280
08:55	08:55	10	10	1,400	233	233
09:05	09:05	10	10	1,400	233	233
09:15	09:15	10	10	1,400	233	233
09:25	09:25	10	10	1,400	233	233
09:35	09:35	10	10	1,300	217	217
09:40	09:40	<u>5</u>	<u>5</u>	1,300	<u>108</u>	<u>108</u>
Subtotal		65	67		1,490	1,537
10:15	10:18					
10:25	10:25	10	7	1,250	208	146
10:35	10:35	10	10	1,200	200	200
10:41	10:41	<u>6</u>	<u>6</u>	1,200	<u>120</u>	<u>120</u>
Subtotal		26	23		528	466
10:45	10:45					
10:55	10:55	10	10	1,400	233	233
11:05	11:05	10	10	1,350	225	225
11:15	11:15	10	10	1,300	217	217
11:25	11:25	10	10	1,300	217	217
11:35	11:35	10	10	1,300	217	217
11:45	11:45	10	10	1,300	217	217
	11:48	<u>0</u>	<u>3</u>	1,300	<u>0</u>	<u>65</u>
Subtotal		60	63		1,326	1,391
TOTAL		154	153		3,409	3,394

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-1; OUTLET: SOC-1
 TANK NO. 4

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:27	08:33					
08:35	08:35	8	2	900	120	30
08:45	08:45	10	10	900	150	150
08:55	08:55	10	10	850	142	142
09:05	09:05	10	10	900	150	150
09:15	09:15	10	10	900	150	150
09:25	09:25	10	10	900	150	150
09:35	09:35	10	10	900	150	150
09:45	09:45	10	10	900	150	150
09:55	09:55	10	10	900	150	150
09:57	10:03	<u>2</u>	<u>8</u>	900	<u>30</u>	<u>120</u>
Subtotal		90	90		1,342	1,342
10:15	10:18					
10:25	10:25	10	7	900	150	105
10:35	10:35	10	10	900	150	150
10:45	10:45	10	10	900	150	150
10:55	10:55	10	10	900	150	150
11:05	11:05	10	10	900	150	150
11:15	11:15	10	10	200	33	33
11:25	11:25	10	10	900	150	150
11:35	11:35	10	10	900	150	150
11:45	11:45	10	10	900	150	150
	11:48	<u>0</u>	<u>3</u>	900	<u>0</u>	<u>45</u>
Subtotal		90	90		1,233	1,233
TOTAL		180	180		2,575	2,575

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-2; OUTLET: SOC-2
 TANK NO. 1

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:08	08:11					
08:18	08:18	10	7	500	83	58
08:28	08:28	10	10	500	83	83
08:33	08:33	<u>5</u>	<u>5</u>	500	<u>42</u>	<u>42</u>
Subtotal		25	22		208	183
08:40	08:40					
08:48	08:48	8	8	400	53	53
08:58	08:58	10	10	400	67	67
09:08	09:08	10	10	400	67	67
09:18	09:18	10	10	400	67	67
09:28	09:28	10	10	300	50	50
09:34	09:34	<u>6</u>	<u>6</u>	300	<u>30</u>	<u>30</u>
Subtotal		54	54		334	334
10:02	10:04					
10:08	10:08	6	4	500	50	33
10:18	10:18	10	10	500	83	83
10:28	10:28	10	10	400	67	67
10:38	10:38	10	10	500	83	83
10:40	10:40	<u>2</u>	<u>2</u>	500	<u>17</u>	<u>17</u>
Subtotal		38	36		300	283
10:48	10:48					
10:58	10:58	10	10	250	42	42
11:08	11:08	10	10	250	42	42
11:18	11:18	10	10	250	42	42
11:28	11:28	10	10	200	33	33
11:32	11:34	<u>4</u>	<u>6</u>	200	<u>13</u>	<u>20</u>
Subtotal		44	46		172	179
TOTAL		161	158		1,014	979

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-2; OUTLET: SOC-2
 TANK NO. 2

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:08	08:11					
08:18	08:18	10	7	1,100	183	128
08:28	08:28	10	10	1,100	183	183
08:38	08:38	10	10	1,100	183	183
08:45	08:45	<u>7</u>	<u>7</u>	1,100	<u>128</u>	<u>128</u>
Subtotal		37	34		677	622
08:50	08:50					
08:58	08:58	8	8	1,400	187	187
09:08	09:08	10	10	1,400	233	233
09:18	09:18	10	10	1,400	233	233
09:28	09:28	10	10	1,400	233	233
09:38	09:40	<u>10</u>	<u>12</u>	1,400	<u>233</u>	<u>280</u>
Subtotal		48	50		1,119	1,166
10:02	10:04					
10:08	10:08	6	4	1,100	110	73
10:18	10:18	10	10	1,200	200	200
10:28	10:28	10	10	1,200	200	200
10:38	10:38	10	10	1,200	200	200
10:46	10:46	<u>8</u>	<u>8</u>	1,200	<u>160</u>	<u>160</u>
Subtotal		44	42		870	833
10:50	10:50					
10:58	10:58	8	8	1,100	147	147
11:08	11:08	10	10	1,100	183	183
11:18	11:18	10	10	1,100	183	183
11:28	11:28	10	10	1,100	183	183
11:32	11:34	<u>4</u>	<u>6</u>	1,100	<u>73</u>	<u>110</u>
Subtotal		42	44		769	806
TOTAL		171	170		3,435	3,427

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-2; OUTLET: SOC-2
 TANK NO. 4

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
08:08	08:11					
08:18	08:18	10	7	675	112	79
08:28	08:28	10	10	600	100	100
08:38	08:38	10	10	600	100	100
08:48	08:48	10	10	600	100	100
08:58	08:58	10	10	600	100	100
09:08	09:08	10	10	625	104	104
09:18	09:18	10	10	600	100	100
09:28	09:28	10	10	625	104	104
09:38	09:41	<u>10</u>	<u>13</u>	<u>600</u>	<u>100</u>	<u>130</u>
Subtotal		90	90		920	917
10:02	10:04					
10:08	10:08	6	4	600	60	40
10:18	10:18	10	10	600	100	100
10:28	10:28	10	10	625	104	104
10:38	10:38	10	10	600	100	100
10:48	10:48	10	10	600	100	100
10:58	10:58	10	10	600	100	100
11:08	11:08	10	10	600	100	100
11:18	11:18	10	10	600	100	100
11:28	11:28	10	10	600	100	100
11:32	11:34	<u>4</u>	<u>6</u>	<u>600</u>	<u>40</u>	<u>60</u>
Subtotal		90	90		904	904
TOTAL		180	180		1,824	1,821

AMPERE-HOUR CALCULATIONS
 TEST RUN NO.:
 INLET: SIC-3; OUTLET: SOC-3
 TANK NO. 1

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
12:45	12:47					
12:50	12:50	5	3	200	17	10
13:00	13:00	<u>10</u>	<u>10</u>	<u>200</u>	<u>33</u>	<u>33</u>
Subtotal		15	13		50	43
13:05	13:05					
13:10	13:10	5	5	1,000	83	83
13:20	13:20	10	10	1,000	167	167
13:30	13:30	10	10	1,000	167	167
13:40	13:40	10	10	1,000	167	167
13:50	13:50	10	10	1,000	167	167
14:00	14:00	10	10	1,000	167	167
14:10	14:10	10	10	1,000	167	167
14:14	14:14	<u>4</u>	<u>4</u>	<u>1,000</u>	<u>67</u>	<u>67</u>
Subtotal		69	69		1,152	1,152
14:29	14:31					
14:40	14:40	11	9	1,000	183	150
14:50	14:50	10	10	1,000	167	167
15:00	15:00	10	10	1,000	167	167
15:10	15:10	10	10	1,000	167	167
15:20	15:20	10	10	1,000	167	167
15:27	15:27	<u>7</u>	<u>7</u>	<u>1,000</u>	<u>117</u>	<u>117</u>
Subtotal		58	56		968	935
16:02	16:02					
16:10	16:10	8	8	2,000	267	267
16:20	16:20	10	10	2,000	333	333
16:30	16:30	10	10	2,000	333	333
16:33	16:33	<u>3</u>	<u>3</u>	<u>2,000</u>	<u>100</u>	<u>100</u>
Subtotal		31	31		1,033	1,033
TOTAL		173	169		3,203	3,163

AMPERE-HOUR CALCULATIONS
 TEST RUN NO:
 INLET: SIC-3; OUTLET: SOC-3
 TANK NO. 2

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
12:45	12:47					
12:50	12:50	5	3	1,000	83	50
12:55	12:55	<u>5</u>	<u>5</u>	1,000	<u>83</u>	<u>83</u>
Subtotal		10	8		166	133
12:58	12:58					
13:10	13:10	12	12	1,200	240	240
13:20	13:20	10	10	1,200	200	200
13:30	13:30	10	10	1,200	200	200
13:40	13:40	10	10	1,200	200	200
13:50	13:50	10	10	1,200	200	200
14:00	14:00	10	10	1,200	200	200
14:10	14:10	10	10	1,200	200	200
14:15	14:17	<u>5</u>	<u>7</u>	1,200	<u>100</u>	<u>140</u>
Subtotal		77	79		1,540	1,580
14:29	14:31					
14:40	14:40	11	9	2,000	367	300
14:50	14:50	10	10	2,000	333	333
15:00	15:00	10	10	1,800	300	300
15:10	15:10	10	10	1,800	300	300
15:20	15:20	10	10	1,800	300	300
15:28	15:28	<u>8</u>	<u>8</u>	1,800	<u>240</u>	<u>240</u>
Subtotal		59	57		1,840	1,773
TOTAL		146	144		3,546	3,486

AMPERE-HOUR CALCULATIONS
 TEST RUN NO:
 INLET: SIC-3; OUTLET: SOC-3
 TANK NO: 4

Time (24-h clock)		Time interval, min		Current, amperes	Ampere-hours	
Inlet	Outlet	Inlet	Outlet		Inlet	Outlet
12:45	12:47					
12:50	12:50	5	3	600	50	30
13:00	13:00	10	10	650	108	108
13:10	13:10	10	10	650	108	108
13:20	13:20	10	10	650	108	108
13:30	13:30	10	10	650	108	108
13:40	13:40	10	10	650	108	108
13:50	13:50	10	10	650	108	108
14:00	14:00	10	10	650	108	108
14:10	14:10	10	10	650	108	108
14:15	14:17	<u>5</u>	<u>7</u>	650	<u>54</u>	<u>76</u>
Subtotal		90	90		968	970
14:29	14:31					
14:40	14:40	11	9	650	119	98
14:50	14:50	10	10	650	108	108
15:00	15:00	10	10	650	108	108
15:10	15:10	10	10	650	108	108
15:20	15:20	10	10	650	108	108
15:28	15:28	<u>8</u>	<u>8</u>	650	<u>87</u>	<u>87</u>
Subtotal		59	57		638	617
16:02	16:02					
16:10	16:10	8	8	675	90	90
16:20	16:20	10	10	675	112	112
16:30	16:30	10	10	675	112	112
16:33	16:35	<u>3</u>	<u>5</u>	700	<u>35</u>	<u>58</u>
Subtotal		31	33		349	372
TOTAL		180	180		1,955	1,959

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 24, 1986
 Tank No.: 1
 Sample type: Total and hexavalent chromium

Test stop time
 Inlet: 11:45
 Outlet: 11:48

Test start time
 Inlet: 08:27
 Outlet: 08:33

Test Run No.
 Inlet: SIC-1
 Outlet: SOC-1

Time (24-h clock) Inlet Outlet	Temp., °F	Voltage, volts	Current, amperes	Notes
08:27 08:33	125	6.0	1,200	Started inlet testing: 08:27
08:35 08:35	125	6.0	1,000	Started outlet testing: 08:33
08:40 08:40	125	6.0	1,000	Work plated: textile comb for looms Surface area: 3.44 ft Stopped plating: 08:40
08:54 08:54	125	9.5	3,000	Started plating: 08:54
09:05 09:05	125	5.5	1,500	Work plated: textile comb for looms
09:15 09:15	125	5.5	1,500	Surface area: 4.54 ft
09:25 09:25	125	5.5	1,500	Grab samples taken: 08:40 and 09:50
09:35 09:35	125	5.5	1,400	Stopped inlet testing: 09:57
09:45 09:45	125	5.5	1,500	Stopped plating: 09:54
09:54 09:54	125	5.5	1,500	Stopped outlet testing: 10:03
10:17 10:18	125	5.5	3,000	Started plating: 10:17
10:25 10:25	125	5.5	3,000	Started inlet testing: 10:15
10:35 10:35	125	5.2	2,750	Started outlet testing: 10:18
10:45 10:45	125	5.2	3,000	Work plated: 10 lease bars for looms
10:55 10:55	125	5.3	2,900	Surface area: 15.38 ft
11:05 11:05	125	5.3	2,900	Stopped plating: 11:14
11:14 11:14	125	5.3	2,900	

(continued)

SOURCE SAMPLING PROGRAM PROCESS DATA SHEETS (continued)

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
11:25	125	5.5	2,900	Started plating: 11:25
11:35	125	5.5	2,900	Work plated: 10 lease bars for looms
11:45	125	5.3	2,800	Surface area: 15.38 ft
11:48	125	5.2	2,800	Grab sample: 11:35
				Stopped inlet testing: 11:45
				Stopped outlet testing: 11:48

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 24, 1986
 Tank No.: 2
 Sample type: Total and hexavalent chromium

Test Run No. _____
 Inlet: SIC-1
 Outlet: SOC-1

Test start time
 Inlet: 08:27
 Outlet: 08:33

Test stop time
 Inlet: 11:45
 Outlet: 11:48

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
08:27	125	5.8	1,300	Started inlet testing: 08:27
08:35	125	8.0	2,000	Started outlet testing: 08:33
08:45	125	6.2	1,400	Stopped plating: 08:30
08:55	125	6.2	1,400	Work plated: comb for ₂ textile looms
09:05	125	6.0	1,400	Surface area: 4.17 ft ²
09:15	125	6.0	1,400	Started plating: 08:33
09:25	125	6.0	1,400	Work plated: textile combs
09:35	125	5.8	1,300	Surface area: 4.54 ft ²
09:40	125	5.8	1,300	Grab sample: 08:40 and 09:50
				Stopped inlet testing: 09:57
				Stopped outlet testing: 10:03
				Stopped plating: 09:40
10:15	125	5.8	1,300	Started plating: 09:50
10:25	125	5.6	1,250	Started inlet testing: 10:15
10:35	125	5.6	1,200	Started outlet testing: 10:18
10:41	125	5.6	1,200	Work plated: comb for ₂ textile looms
				Surface area: 4.56 ft ²
				Stopped plating: 10:41
10:45	125	6.0	1,400	Started plating: 10:45
10:55	125	6.0	1,400	Work plated: comb for ₂ textile looms
11:05	125	6.0	1,350	Surface area: 4.56 ft ²
11:15	125	6.0	1,300	

(continued)

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET (cont inued)

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
11:25	125	5.8	1,300	Grab sample: 11:35
11:35	130	5.5	1,300	
11:45	130	5.6	1,300	Stopped inlet testing: 11:45
11:48	133	5.6	1,300	Stopped outlet testing: 11:48

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 24, 1986
 Tank No.: 4
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC-1
 Outlet: SOC-1

Test start time
 Inlet: 08:27
 Outlet: 08:33

Test stop time
 Inlet: 11:45
 Outlet: 11:48

Time (24-h clock) Inlet Outlet	Temp., °F	Voltage, volts	Current, amperes	Notes
08:27	110	7.0	900	Started inlet testing: 08:27
08:35	110	7.0	900	Started outlet testing: 08:33
08:45	110	7.0	900	Work plated: dummy part (expanded metal)
08:55	110	6.5	850	Surface area: 6.13 ft
09:05	110	6.5	900	
09:15	110	6.5	900	Grab samples: 08:40 and 09:50
09:25	110	6.5	900	
09:35	110	6.5	900	Stopped inlet testing: 09:57
09:45	110	6.5	900	Stopped testing: 10:03
09:55	110	6.5	900	
09:57	110	6.5	900	
10:15	110	6.5	900	Started inlet testing: 10:15
10:25	110	6.5	900	Started outlet testing 10:18
10:35	110	6.5	900	
10:45	110	6.5	900	
10:55	110	6.5	900	
11:05	110	6.5	900	
11:15	110	3.5	200*	*Operator inadvertently turned amperage down at 11:06 but was corrected at 11:15
11:25	110	6.5	900	Grab sample: 11:35
11:35	110	6.5	900	Stoped inlet testing: 11:45
11:45	110	6.5	900	Stopped outlet testing: 11:48
11:48	110	6.5	900	

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 1
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC-2
 Outlet: SOC-2

Test start time
 Inlet: 08:08
 Outlet: 08:11

Test stop time
 Inlet: 11:32
 Outlet: 11:34

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
08:08	125	5.5	500	Started inlet testing: 08:08 Started outlet testing: 08:11 Work plated: comb for ₂ textile looms Surface area: 4.30 ft ² Grab samples: 08:12 Stopped plating: 08:33
08:18	125	5.5	500	
08:28	125	5.5	500	
08:33	125	5.5	500	
08:40	125	5.0	400	Started plating: 08:40 Work plated: Comb for ₂ textile looms Surface area: 2.97 ft ²
08:48	125	5.0	400	
08:58	125	5.0	400	
09:08	125	5.0	400	
09:18	125	5.0	400	Stopped inlet testing: 09:38 Stopped outlet testing: 09:41 Stopped plating: 09:34
09:28	125	5.0	300	
09:34	125	5.0	300	
10:02	125	5.5	500	Started plating: 09:40 Started inlet testing: 10:02 Started outlet testing: 10:04 Work plated: comb for ₂ textile looms Surface area: 3.03 ft ² Stopped plating: 10:40
10:08	125	5.5	500	
10:18	125	5.5	500	
10:28	125	5.5	400	
10:38	125	5.5	500	
10:40	125	5.6	500	

(continued)

SOURCE SAMPLING PROGRAM PROCESS DATA SHEETS (continued)

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
10:48	125	5.6	250	Started plating: 10:48
10:58	125	5.5	250	Work plated: comb for ₂ textile looms
11:08	125	5.6	250	Surface area: 1.67 ft ²
11:18	125	5.5	250	Grab samples: 11:02
11:28	125	4.8	200	Stopped plating: 12:00
11:32	125	4.8	200	Stopped outlet testing: 11:34
				Stopped inlet testing: 11:32

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 2
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC-2
 Outlet: SOC-2

Test start time
 Inlet: 08:08
 Outlet: 08:11

Test stop time
 Inlet: 11:32
 Outlet: 11:34

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
08:08	125	5.8	1,100	Started inlet testing: 08:08
08:18	125	5.8	1,100	Started outlet testing: 08:11
08:28	125	5.8	1,100	Work plated: comb for ₂ textile looms
08:38	125	5.8	1,100	Surface area: 4.30 ft
08:45	125	5.8	1,100	Grab samples: 08:12
				Stopped plating: 08:45
08:50	125	6.0	1,400	Started plating: 08:50
08:58	125	6.0	1,400	Work plated: comb for ₂ textile looms
09:08	125	6.0	1,400	Surface area: 4.30 ft
09:18	125	6.0	1,400	Stopped inlet testing: 09:38
09:28	125	6.0	1,400	Stopped outlet testing: 09:41
09:38	125	6.0	1,400	Stopped plating: 09:40
10:02	125	5.5	1,100	Started plating: 09:50
10:08	125	5.5	1,100	Started inlet testing: 10:02
10:18	125	5.8	1,200	Started outlet testing: 10:04
10:28	125	5.7	1,200	Work plated: comb for ₂ textile looms
10:38	125	5.7	1,200	Surface area: 3.03 ft
10:46	125	5.7	1,200	Stopped plating: 10:46
10:50	125	5.8	1,100	Started plating: 10:50
10:58	125	5.8	1,100	Work plated: comb for ₂ textile looms
11:08	125	6.0	1,100	Surface area: 2.94 ft
11:18	125	5.8	1,100	Grab samples: 11:02
11:28	125	5.8	1,100	Stopped plating: 12:55
11:32	125	5.8	1,100	Stopped inlet testing: 11:32
				Stopped outlet testing: 11:34

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 4
 Sample type: Total and hexavalent chromium

Test start time
 Inlet: 08:08
 Outlet: 08:11

Test stop time
 Inlet: 11:32
 Outlet: 11:34

Test Run No.
 Inlet: SIC-2
 Outlet: SOC-2

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
08:08	110	6.5	650	Started inlet testing: 08:08 Started outlet testing: 08:11 Work plated: dummy part (expanded metal) Surface area: 3.89 ft ² Grab samples: 08:12
08:18	110	6.5	675	
08:28	110	7.0	600	
08:38	110	6.75	600	
08:48	110	7.0	600	
08:58	110	7.0	600	
09:08	110	6.75	625	
09:18	110	6.75	600	
09:28	110	7.0	625	
09:38	110	6.75	600	
10:02	110	6.75	600	Stopped inlet testing: 09:38 Stopped outlet testing: 09:41
10:08	110	6.75	600	
10:18	110	6.75	600	
10:28	110	6.75	625	
10:38	110	6.75	600	
10:48	110	6.75	600	
10:58	110	6.75	600	
11:08	110	7.0	600	
11:18	110	6.75	600	
11:28	110	6.75	600	
11:32	110	6.75	600	Stopped inlet testing: 11:32 Stopped outlet testing: 11:34

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 1
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC3
 Outlet: SOC3

Test start time
 Inlet: 12:45
 Outlet: 12:47

Test stop time
 Inlet: 16:33
 Outlet: 16:35

Time (24-h clock) Inlet Outlet	Temp., °F	Voltage, volts	Current, amperes	Notes
12:45	125	5.0	200	Started inlet testing: 12:45 Started outlet testing: 12:47 Work plated: 3 comb for textile looms Surface area: 0.23 ft ² Stopped plating 13:00
12:50	125	5.0	200	
13:00	125	5.0	200	
13:05	125	9.4	2,250	Started plating: 13:05 Work plated: comb for ² textile looms Surface area: 3.94 ft ²
13:10	125	5.5	1,000	
13:20	125	5.5	1,000	
13:30	125	5.5	1,000	
13:40	125	5.5	1,000	
13:50	125	5.5	1,000	
14:00	125	5.5	1,000	Stopped inlet testing: 14:15 Stopped outlet testing: 14:17 Stopped plating: 14:14
14:10	125	5.5	1,000	
14:14	125	5.5	1,000	
14:29	125	5.5	900	
14:40	125	5.5	1,000	Started inlet testing: 14:29 Started outlet testing: 14:31 Started plating: 14:19 Grab sample: 14:40 Work plated: comb for ² textile looms Surface area: 3.06 ft ² Added water to tank
14:50	125	5.5	1,000	
15:00	125	5.5	1,000	
15:10	125	5.5	1,000	
15:20	125	5.5	1,000	
15:27	125	5.5	1,000	

(continued)

SOURCE SAMPLING PROGRAM PROCESS DATA SHEETS (continued)

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes	
				Inlet	Outlet
				Stopped plating: 15:27	15:28
				Stopped inlet and outlet testing:	
				Started inlet and outlet testing: 16:02	
16:02	125	9.0	6,500	Started plating: 16:00	
16:10	125	5.0	2,000	Work plated: pinching washers	
16:20	125	4.8	2,000	Surface area: 36.14 ft	
16:30	125	5.0	2,000	Stopped outlet testing: 16:35	
16:33	125	5.0	2,000	Stopped plating: 16:33	
				Stopped inlet testing: 16:33	

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 2
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC3
 Outlet: SOC3

Test start time
 Inlet: 12:45
 Outlet: 12:47

Test stop time
 Inlet: 16:33
 Outlet: 16:35

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
12:45	125	5.7	1,000	Start inlet testing: 12:45 Start outlet testing: 12:47 Work plated: comb for ₂ textile looms Surface area: 2.94 ft ² Stopped plating: 12:55
12:50	125	5.6	1,000	
12:55	125	5.6	1,000	
12:58	125	6.7	2,000	Started plating: 12:58 Work plated: comb for ₂ textile looms Surface area: 3.44 ft ²
13:10	125	5.6	1,200	
13:20	125	5.6	1,200	
13:30	125	5.6	1,200	Stopped inlet testing: 14:15 Stopped outlet testing: 14:17 Stopped plating: 14:20
13:40	125	5.5	1,200	
13:50	125	5.5	1,200	
14:00	125	5.5	1,200	Started inlet testing: 14:29 Started plating: 14:24 Started outlet testing: 14:31 Work plated: comb for ₂ textile looms Surface area: 6.08 ft ²
14:10	125	5.4	1,200	
14:15	125	5.4	1,200	
14:29	125	7.4	2,000	
14:40	125	7.6	2,000	
14:50	125	7.6	2,000	
15:00	125	7.0	1,800	
15:10	125	6.8	1,800	

(continued)

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET (continued)

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
15:20	125	6.8	1,800	Grab samples: 14.40 Added water to tank Stopped plating and inlet and outlet testing: 15:28
15:28	125	6.8	1,800	

SOURCE SAMPLING PROGRAM PROCESS DATA SHEET

Place: Steel Heddle
 Date: June 25, 1986
 Tank No.: 4
 Sample type: Total and hexavalent chromium

Test Run No.
 Inlet: SIC3
 Outlet: SOC3

Test start time
 Inlet: 12:45
 Outlet: 12:47

Test stop time
 Inlet: 16:33
 Outlet: 16:35

Time (24-h clock)	Temp., °F	Voltage, volts	Current, amperes	Notes
Inlet				
Outlet				
12:45	110	6.75	600	Started inlet testing: 12:45
12:50	110	6.75	600	Started outlet testing: 12:47
13:00	110	7.0	650	Work plated: dummy part (expanded metal)
13:10	110	7.0	650	Surface area: 3.89 ft ²
13:20	110	7.0	650	
13:30	110	7.0	650	
13:40	110	7.0	650	Grab samples: 14:40
13:50	110	7.0	650	
14:00	110	7.0	650	Stopped inlet testing: 14:15
14:10	110	7.0	650	Stopped outlet testing: 14:17
14:15	110	7.0	650	Port change
14:29	110	7.0	650	Started testing: 14:29
14:40	110	7.0	650	
14:50	110	7.0	650	
15:00	110	7.0	650	
15:10	110	7.0	650	
15:20	110	7.0	650	
15:28	110	7.0	650	Stopped testing: 15:28
16:02	110	7.0	675	Started inlet and outlet testing: 16:02
16:10	110	7.0	675	
16:20	110	7.0	675	
16:30	110	7.0	675	Stopped inlet testing: 16:33
16:33	110	7.0	700	Stopped outlet testing: 16:35