

EPA Report No.
September 1987

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FINAL REPORT

DETERMINATION OF TOTAL CHROMIUM
AND HEXAVALENT CHROMIUM EMISSIONS
FROM CHROME PLATING TANKS

Candidate Plant
Delco Products Division
General Motors Corporation
Livonia, Michigan

by

Helen J. Owens
Joseph T. Swartzbaugh
PEER Consultants, P.C.
Dayton, Ohio 45432

and

Franklin Meadows
Pacific Environmental Services, Inc.
Cincinnati, Ohio 45246

and

Randy P. Strait
Midwest Research Institute
Raleigh, North Carolina 27612

EPA Contract No. 68-02-4346
Work Assignment 01
Technical Directive 1

Task Manager
Frank R. Clay
Emission Standards and Engineering Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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SECTION 1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is currently evaluating whether air emissions of chromium and other potentially toxic metals should be regulated. Chromium emissions are not included in the New Source Performance Standards (NSPS) for stationary sources or the National Emissions Standards for Hazardous Air Pollutants (NESHAP).

As part of this study, the EPA is evaluating uncontrolled emissions from decorative chromium plating operations. The purpose of these tests is to characterize the emission rate and size distribution of uncontrolled emissions of hexavalent chromium (Cr^{+6}) and total chromium (Cr) from a representative industrial operation. A production facility of the Delco Products Division of General Motors Corporation located in Livonia, Michigan, was the selected site at which these tests were performed. The Delco facility was chosen because it is a large-size, captive shop that performs decorative chromium electroplating. At this plant, decorative chromium plate is applied to automobile bumpers. Based on operating parameters such as current, voltage, plating time and chromic acid concentration, the plating tank could be considered typical of other large decorative chromium plating operations. The results from the Delco Products Test Program will be used to characterize the uncontrolled emissions from decorative chrome operations and to revise or confirm uncontrolled emission factors for this type of process developed during another phase of the test program.

In an effort to obtain this data, tests were conducted at the Delco/Livonia plant on March 18 and 19, 1987, under contract to the Emission Measurement Branch (EMB) of the EPA's Emission Standards and Engineering Division. Test team members were PEER Consultants, P.C., located in Dayton, Ohio; Pacific Environmental Services, Inc., (PES), located in Cincinnati, Ohio; and Midwest Research Institute (MRI) located in Raleigh, North

Carolina. Triplicate tests using the Modified Method 13B (MM 13B) sampling train were performed on the exhaust gases from chromium plating Line No. 4. Line No. 4 chrome plating tank is equipped with single-sided hoods on each end and two double-sided hoods between each plating cell. The ventilation hoods on the tank are connected to a common duct that leads to an evaporator/scrubber. Figure 1-1 presents a process diagram. The results of these tests were used to determine Cr^{+6} and total Cr emissions. Particle size distribution measurements were to be taken at the site, but these samples were unobtainable due to the length of the nipples on the sample ports and the inside diameter of each port. Each nipple was approximately 8 inches in length and the inside diameter of the sample port was equal to the outside diameter of the impactor. Both of these factors made it impossible to insert the cascade impactor into the stack. The particle size data were to be collected using the Andersen Mark III, eight-stage impactor with a straight nozzle. In addition to the emissions sampling, samples were taken of the chromium plating solution from each cell of the plating tank at intervals during each emission sample run and analyzed for Cr^{+6} and total Cr.

Some minor modifications to the traverse point locations were required because the duct walls were concave at the sample port location and because the sample port nipples extended into the stack cross section. A detailed discussion of the stack area and traverse point location is presented in Section 4.0.

The remainder of this report describes the process and its operation in Section 2.0. Section 3.0 presents a summary and discussion of results. Section 4.0 describes the sampling locations and test methods while quality assurance is discussed in Section 5.0. Appendix A presents field data sheets, Appendix B calculation sheets for each test, Appendix C laboratory analytical results; Appendix D sampling and analytical procedures, Appendix E equipment calibration sheets, Appendix F project participants and activities log, Appendix G methods followed during the analysis of the samples and Appendix H contains the process monitoring data.

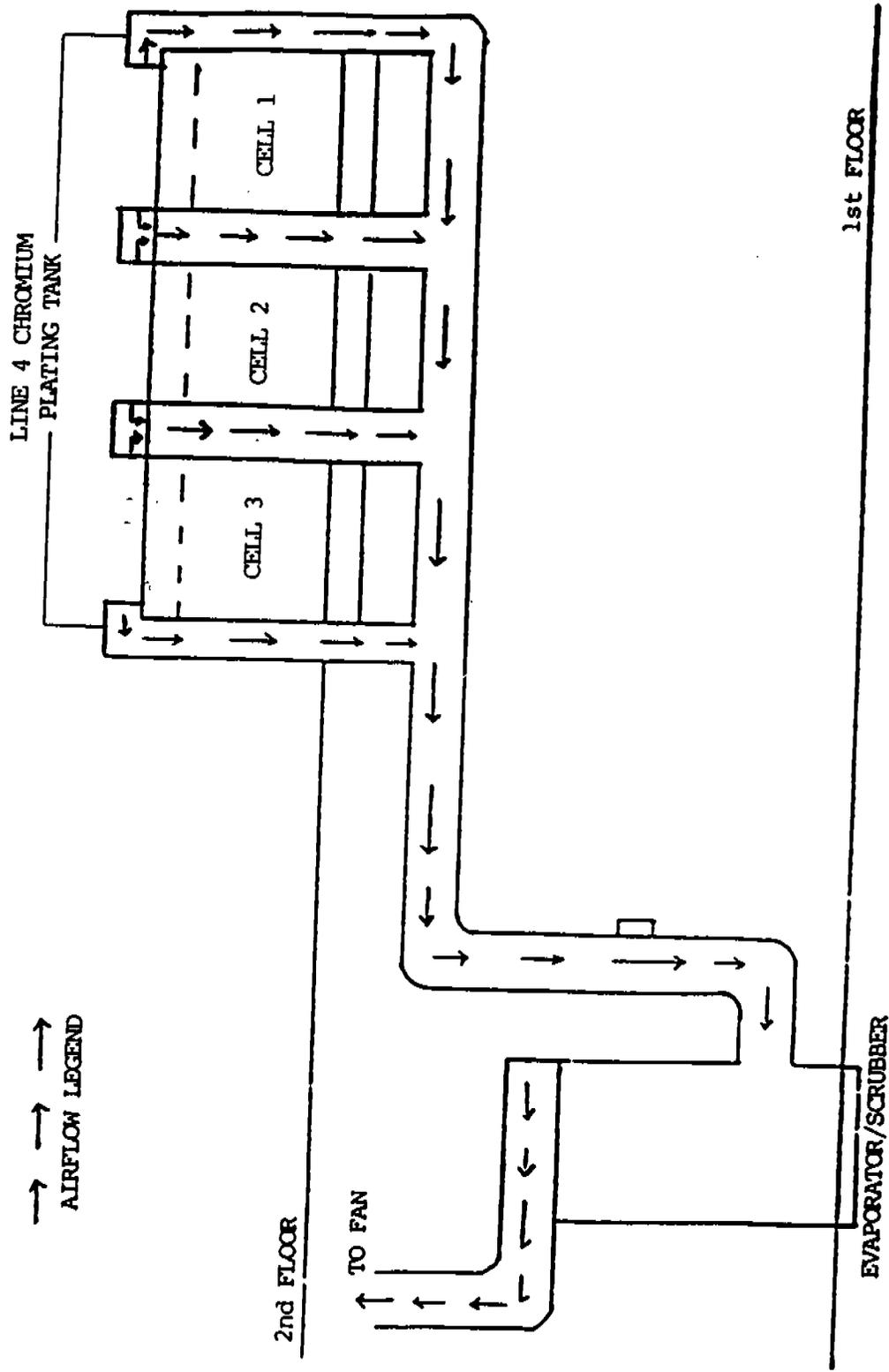


Figure 1-1. Process diagram of chrome plating tank on Line No. 4.

SECTION 2.0 PROCESS OPERATION

2.1 PROCESS DESCRIPTION

The Livonia facility of Delco Products Division, General Motors Corporation (Delco) is a large captive shop that performs decorative chromium electroplating of automobile bumpers. The plating facility consists of five decorative chromium plating lines, but only three lines (Nos. 2, 4, and 5) are currently operated.

Each plating line consists of about 20 tanks containing various cleaning and plating solutions. The lines are serviced by automatically controlled overhead conveyors that transfer racks of up to 14 bumpers to each tank in a programmed sequence. The chromium plating segment of each line consists of a plating tank and several rinse tanks.

The chromium plating tank on Line No. 4 was tested to characterize uncontrolled emissions. Based on size; operating parameters such as current, voltage, and plating time; and chromic acid concentration, the tank is typical of other large decorative chromium plating tanks used in the electroplating industry. The chromium plating tank is 6.1 meters (m) (20 ft) long, 3.65 m (12.0 ft) wide, and 2.75 m (9.0 ft) deep and is divided into three cells that are each 2.0 m (6.7 ft) long. The tank holds approximately 61,170 liters (16,160 gal) of plating solution, which contains chromic acid in a concentration ranging from 250 to 375 grams/liter (g) (33 to 50 ounces/gal) of water. Sulfuric acid is used as a catalyst in a chromic acid to sulfuric acid ratio of 180:1.

Line No. 4 is operated 16 hr/day, 5 days/wk. Typically, two or three cells are operated at a time. One rack of bumpers is plated per cell for about 2.25 minutes (min). Each bumper receives a chromium plate that is

0.305 micrometer (0.012 mil) thick. Two separate transformer/rectifiers charge the electrodes in each cell. For the first 15 seconds of plating, the surface area of the bumpers is activated. During activation, each rectifier is set at 5 to 6 volts (V) and 2,500 to 3,000 amperes (A). After activation, the actual plating phase of the cycle begins. During plating, each rectifier is set at 16 to 17 V and 8,500 to 10,000 A. The electrical settings are determined by the required current density for a particular rack of bumpers. Typical current densities range from 1,600 to 2,150 amperes per square meter (150 to 200 amperes per square foot) of surface area.

2.2 AIR POLLUTION CONTROL

The chromium plating tank on Line No. 4 is equipped with single-sided draft hoods on each end and double-sided draft hoods between each cell (Figure 2-1). The hoods on the tank are connected to a common duct that leads to an extensive evaporator/scrubber system. The total ventilation rate is about 990 cubic meters per minute (35,000 cubic feet per minute).

2.3 PROCESS CONDITIONS DURING TESTING

Three test runs were conducted at the inlet of the evaporator/scrubber to characterize the uncontrolled emissions from the decorative chromium plating tank. The process was operated within normal limits during each test run.

Process operating parameters such as voltage, current, and plating solution temperature were monitored and recorded during each test run. The number of plating cycles and the number of bumpers plated also were recorded for each test run. Data sheets documenting process operating conditions and the workload during each test run are presented in Appendix H. Average values for the operating conditions recorded during each emission test run are presented in Table 2-1.

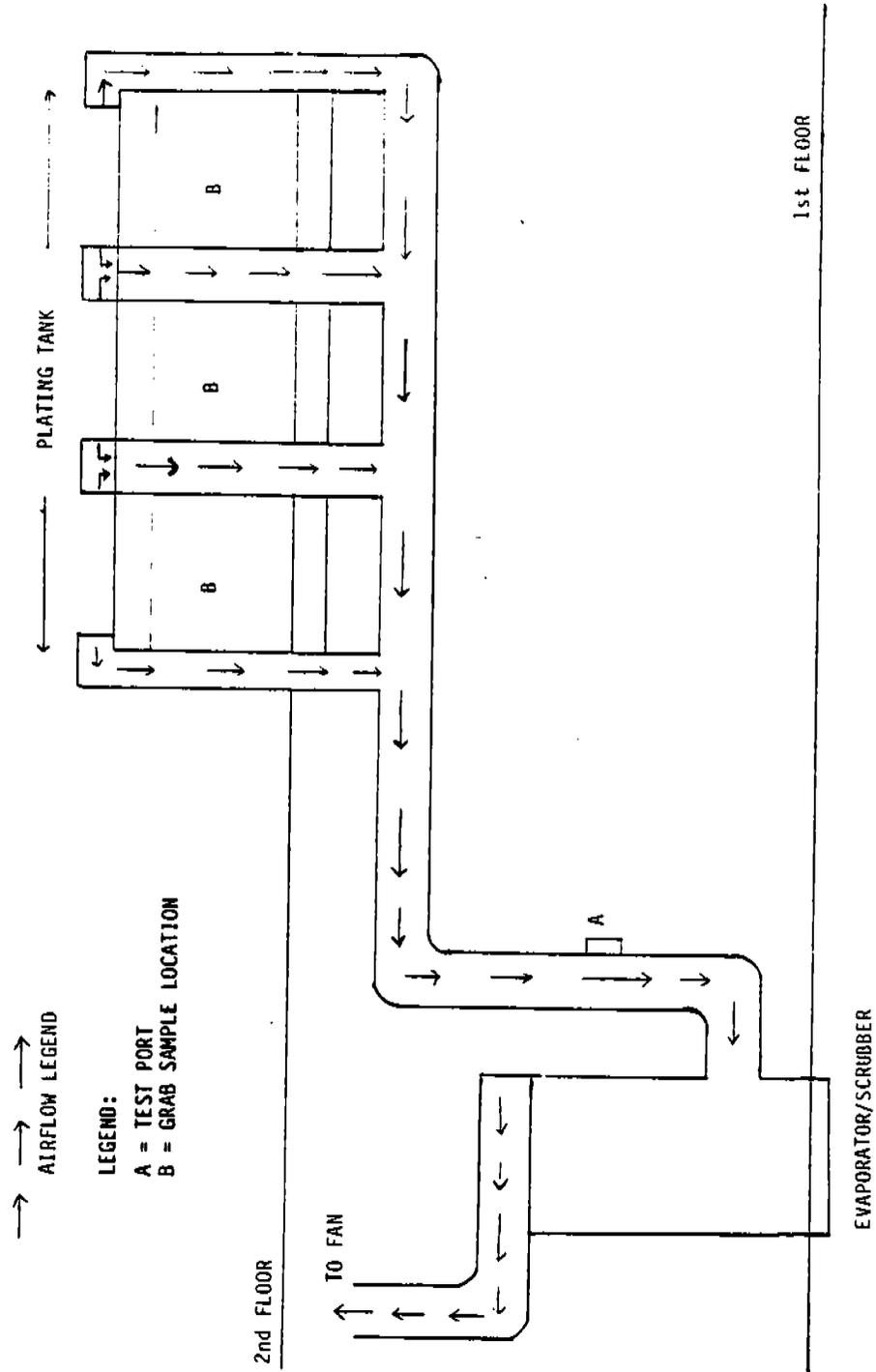


Figure 2-1. Schematic of decorative chromium plating tank tested on Line 4 at Delco Products Division, General Motors Corporation, Livonia, Michigan.

In addition, grab samples of the plating solution were taken from each cell in the tank during the course of each test run to determine the chromic acid concentration of the plating solution. The analytical results for each sample are presented in Section 3.0 of this report.

Test Run No. 1 was interrupted for 13 minutes for electrical repairs on the plating line. Test Run No. 2 was interrupted three times for 51, 3, and 11 min. The 3-minute interruption was caused by delays at the racking station where bumpers were being mounted on the racks. The other two interruptions occurred when the process was stopped for repairs. Test Run No. 3 was interrupted three times for 3, 5, and 165 minutes. The interruptions were a result of malfunctions with the overhead conveyor.

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

TABLE 2-1. AVERAGE OPERATING CONDITIONS RECORDED DURING EACH EMISSION TEST RUN

Test run No.	Bath temperature, °C (°F)	No. of cycles	Voltage, volts	Current, amperes	No. of bumpers
1	54 (130)	138	22.3	20,507	1,043
2	54 (130)	139	22.0	21,697	1,143
3	55 (131)	120	22.8	21,747	984

TABLE 2-2. TOTAL CURRENT CONSUMED DURING EACH EMISSION TEST RUN

Test Run No.	Total current, ampere-hr
1	97,392
2	103,519
3	89,609

SECTION 3.0
SUMMARY OF RESULTS

3.1 INTRODUCTION

Table 3-1 presents the testing schedule along with the sample and analytical parameters. The samples collected from the triplicate emissions tests performed at the inlet and the plating solution sampling from Line No. 4 were analyzed for total Cr and Cr⁺⁶. Cr⁺⁶ analysis was performed using the procedures outlined in "Determination of Hexavalent Chromium Emissions From Stationary Sources." This method is presented in Appendix G. Total Cr concentration was determined by the Inductively Coupled Argon Plasmography (ICAP) Analytical Procedure. This procedure is outlined in EPA Method 3050 of EPA document SW-846, and is also presented in Appendix G. The results of these analytical procedures are presented in the remainder of this section.

TABLE 3-1. TEST SCHEDULE FOR Cr⁺⁶ and Cr EMISSIONS TESTING
AT DELCO PRODUCTS, LIVONIA, MICHIGAN

Run No.	Date (1987)	Time	Sample Parameters		Analytical Parameters	
			MM 13B	Cr ⁺⁶ Diphenylcarbazide Colorimetric Method	Total Cr ICAP	
I-1	3/18	0934 to 1259	X	X	X	
I-2	3/19	1437 to 1851	X	X	X	
I-3	3/19	0945 to 1549	X	X	X	

3.2 HEXAVALENT AND TOTAL CHROMIUM EMISSIONS RESULTS

Table 3-2 summarizes pertinent sample and flue gas data for the chromium tests, and Table 3-3 presents the Cr⁺⁶ and total Cr emissions results. Sample volumes are expressed in dry standard cubic feet (dscf) and dry normal cubic meters (dNm³). Volumetric flow rates are corrected to standard conditions (68°F and 29.92 inches Hg [20°C and 760 mm Hg] and zero percent moisture) and are expressed as dry standard cubic feet per minute (dscfm) and dry normal cubic meters per minute (dNm³/min).

Concentrations of Cr⁺⁶ and total Cr are expressed in grains per dry standard cubic feet (gr/dscf) and milligrams per dry normal cubic meter (mg/dNm³). Mass emissions rates are expressed in pounds per hour (lb/h) and kilograms per hour (kg/h). Each recovered sample consisted of the rinseate from the nozzle and probe combined with the impinger solutions and the rinseate from all connecting glassware. The sample was collected in a polyethylene sample bottle.

As reported in Table 3-2 sample volumes were consistent and ranged from 151.110 to 155.638 dscf for the sample trains. The isokinetic variation ranged from 98.0 to 98.5 percent which is within the acceptable range of 90 to 110 percent.

At the scrubber inlet, the average volumetric flow at standard conditions was 23,000 dscfm (650 dNm³/min). Flue gas temperatures ranged from 74 to 76°F and averaged 75°F (23 to 24°C and averaged 24°C). The moisture content of the gas stream averaged 0.92 percent (based on the average of Runs I-2 and I-3). During the sample recovery of Run I-1, the final impinger weight was incorrectly recorded which resulted in erroneous moisture data. Thus, the average moisture content (0.92 percent) was used in the calculations for Run I-1. The static pressure was checked during the collection of preliminary data and recorded using a 0- to 10-inch H₂O manometer during each test. The static pressure was measured from the negative side of the pitot tube and measured 3.0 inches H₂O.

TABLE 3-2. SUMMARY OF SAMPLE AND FLUE GAS CONDITIONS (DELCO PRODUCTS - LIVONIA, MICHIGAN)

Run No. in. H ₂ O	Date (1987)	Sample Location	Sample Parameter			Flue Gas Condition				
			Sample Volume dNm ³	Percent Isokinetic	Volumetric Flow Rate dNm ³ /min	Temperature OF	Moisture OC	Static Pressure		
I-1	3/18	Inlet	4.28	98.0	641	22,633	76	24	0.92	-3.0
I-2	3/18	Inlet	4.41	98.5	656	23,183	74	23	1.03	-3.0
I-3	3/19	Inlet	4.39	98.3	656	23,161	75	24	0.82	-3.0

TABLE 3-3. SUMMARY OF Cr+6 AND TOTAL CR EMISSION DATA (DELCO PRODUCTS - LIVONIA, MICHIGAN)

Run No.	Date (1987)	Sample Location	Concentration		Mass Emission Rate					
			Cr+6 mg/dNm ³	Total Cr mg/dNm ³	Cr+6 kg/h	Total Cr kg/h				
I-1	3/18	Inlet	1.95	1.66	0.00085	0.00072	0.08	0.17	0.06	0.14
I-2	3/18	Inlet	1.30	1.21	0.00056	0.00053	0.05	0.11	0.05	0.10
I-3	3/19	Inlet	1.54	1.45	0.00067	0.00063	0.06	0.13	0.06	0.13

Analysis of the gas stream composition was not performed because the process was emitting essentially air. The molecular weight was assigned a value of 29.0 lb/lb-mole.

The Cr^{+6} content of the gas stream at the inlet to the evaporator/scrubber ranged from 5.6×10^{-4} to 8.5×10^{-4} gr/dscf (1.30 to 1.95 mg/dNm³) and averaged 6.8×10^{-4} gr/dscf (1.60 mg/dNm³) for the three tests. The total Cr concentration ranged from 5.3×10^{-4} to 7.2×10^{-4} gr/dscf (1.21 to 1.66 mg/dNm³). The average mass emission rate for total Cr was 0.12 lb/h (0.06 kg/h).

The total amount of Cr^{+6} that was captured in the sample trains during each test was 8.37 mg for Run I-1, 5.71 mg for Run I-2 and 6.78 mg for Run I-3. Total Cr contained in the sample train for these runs was 7.11 mg, 5.37 mg and 6.38 mg, respectively. Note that the Cr^{+6} concentration in the samples is reported to be higher than the total Cr concentration. In Section 5.0 of this report it is demonstrated that the percent recovery of Cr^{+6} in the colorimetric method exceeds that of the ICAP method for total Cr. This difference in recovery rates can account for such apparent discrepancies and the Cr^{+6} would appear to be the more accurate result. In any case, the results indicate that the majority of chromium in these samples is in the form of Cr^{+6} . The calculation sheets for the Cr^{+6} and total Cr concentrations and emission rates are presented in Appendix B.

3.3 PROCESS SAMPLE ANALYSIS

Table 3-4 summarizes results for Cr^{+6} and total Cr from the plating tank solutions collected during each test period. Plating tank solutions from Line No. 4 chrome plating tank, cells 1, 2, and 3 were collected and composited in different bottles for each cell. The samples were taken at three equal intervals during each of the MM 13B tests. Results for both Cr^{+6} and total Cr are expressed in milligrams per liter (mg/l). Analytical procedures were similar to those used for the actual emission

samples with the Cr⁺⁶ determined by the diphenylcarbazide colorimetric method and total Cr by ICAP.

TABLE 3-4. SUMMARY OF RESULTS FROM THE LABORATORY ANALYSIS
PLATING TANK SOLUTIONS

<u>Sample</u>	<u>Total Cr (mg/l)</u>	<u>Cr+6 (mg/l)</u>
<u>Run I-1</u>		
Cell 1	153,000	150,000
Cell 2	147,000	160,000
Cell 3	157,000	153,000
<u>Run I-2</u>		
Cell 1	152,000	152,000
Cell 2	151,000	154,000
Cell 3	146,000	160,000
<u>Run I-3</u>		
Cell 1	151,000	158,000
Cell 2	151,000	158,000
Cell 3	138,000	160,000

SECTION 4.0
SAMPLE LOCATIONS AND TEST METHODS USED

4.1 LOCATION OF MEASUREMENT SITE

Samples were extracted from the inlet to the evaporator/scrubber. Figure 4-1 depicts a simplified process flow diagram and Figure 4-2 is an orthogonal sketch of the inlet sample location. At the inlet to the evaporator/scrubber, six sampling ports were identified (from left to right) as ports A,B,C,D,E, and F.

The scrubber inlet measurement site (identified in Figure 4-1) was located in a vertical rectangular duct having nominal dimensions of 24 x 96 inches. The six 3-inch I.D. sample ports were located at equal distances along the 96-inch side. Upon measurement of the stack's inside dimension, it was discovered that all six sample ports extended into the stack cross-sectional area for 3.5 inches past the inside wall. A visual inspection of the ductwork also revealed that the duct was partially collapsed along the front and back sides. Measurement of the duct inside dimensions through each of the six ports resulted in six different values. These are summarized in Table 4-1. The inside width was 95.8 inches. Using stack dimensions of 20.7 x 95.8 inches the gross area of the duct cross-section at the measurement site was 1983 square inches. In order to compute the net cross-sectional area it was necessary to correct for the area of the nipples which extended into the duct. All nipples were 3.5 inches outside diameter and extended 3.5 inches into the duct cross-sectional area. The total blockage was 73.5 square inches ($3.5 \times 3.5 \times 6$). Thus, the net area of the duct was 1910 square inches. The equivalent stack dimensions were 19.9 x 95.8 inches for an equivalent inside diameter of 33.0 inches.

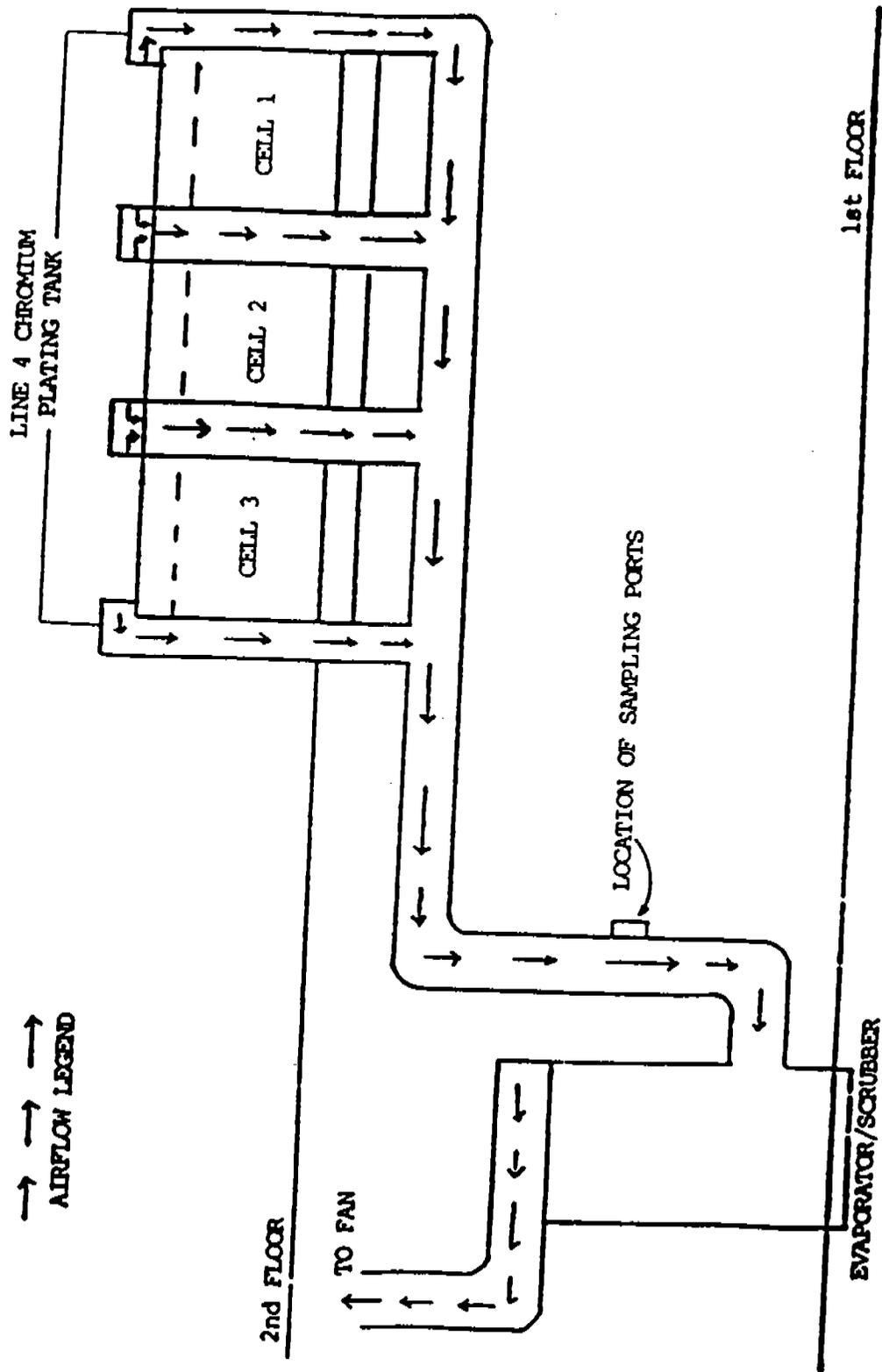


Figure 4-1. Simplified process flow diagram.

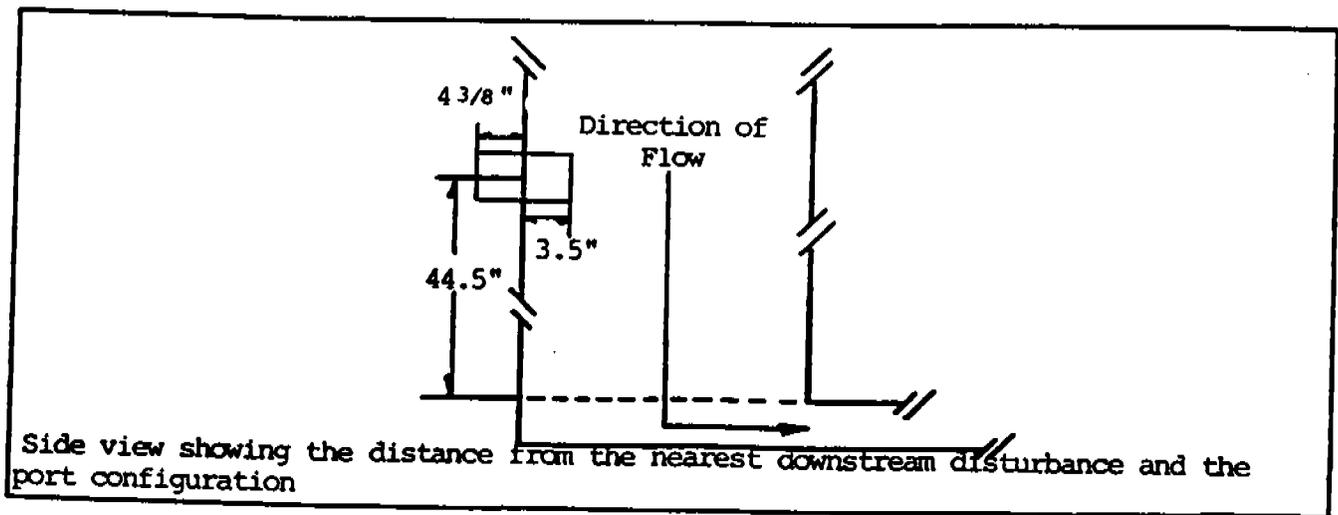
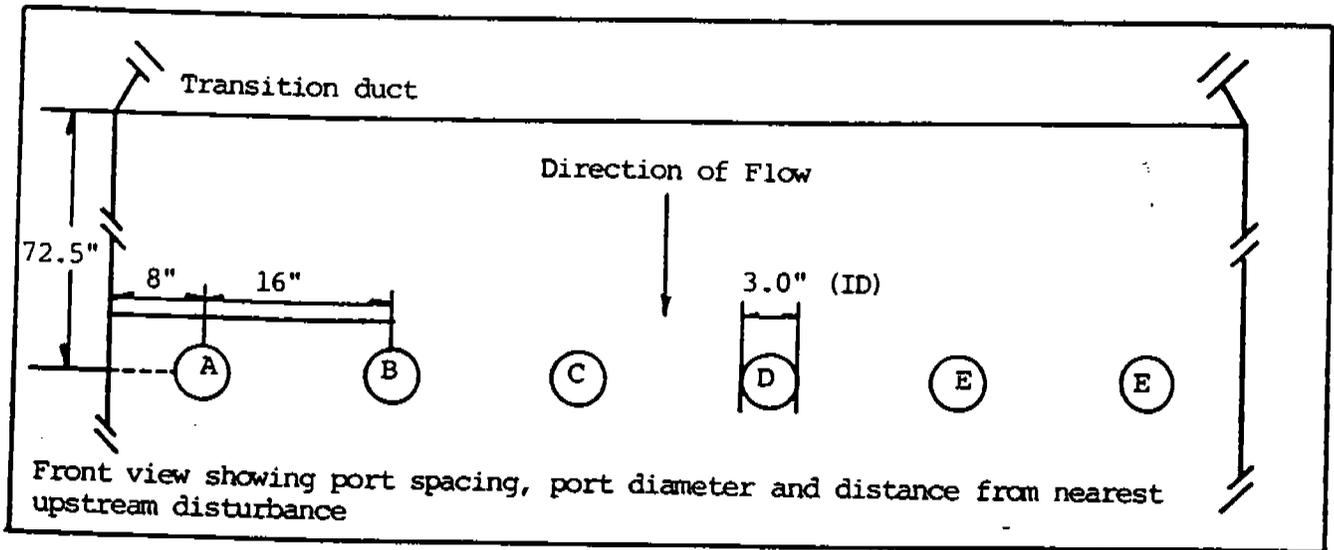
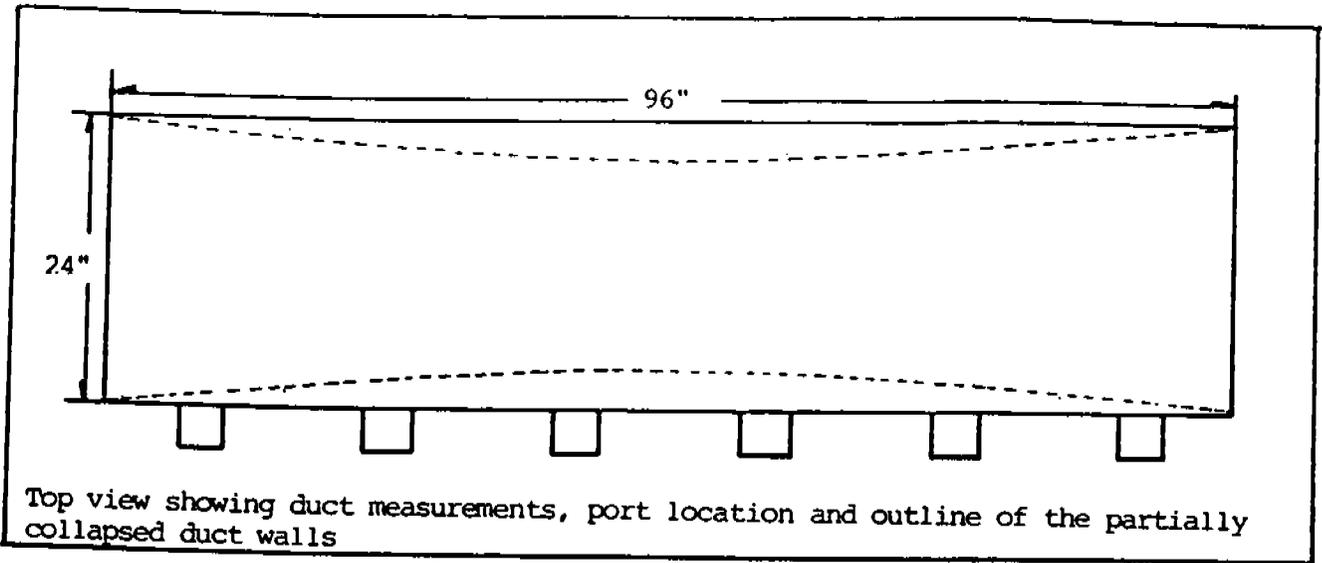


Figure 4-2. Orthogonal sketches of inlet sampling location.

TABLE 4-1. INSIDE DIMENSIONS OF THE DUCT
AT EACH SAMPLE PORT

Port	Inside Depth (Inches)*
A	22.4
B	19.9
C	19.4
D	19.5
E	20.0
F	<u>22.8</u>
Average	20.7

* Does not include 3.5-inch nipple protrusion into the duct.

The measurement side was located 72.5 inches (2.2 duct diameters) downstream of a duct transition and 44.5 inches (1.3 duct diameters) upstream of an elbow. According to EPA Method 1 criteria, this location required 30 sample traverse points using a 6 x 5 matrix. Three sets of sample traverse dimensions were used. Measurements of the distance across the duct from each sample port indicated that the measurements through ports A and F were nearly identical, B and E were nearly identical, and C and D were nearly identical. Thus, three sets of sample traverse points were used. Due to the protrusion of the sample port nipples into the duct, the first traverse point was relocated to 1.0 inch past the end of each nipple. The resultant sample traverse point locations are summarized in Table 4-2, and a cross section of the inlet showing the traverse points is presented in Figure 4-3. The figure is exaggerated but demonstrates the methodology applied in locating the traverse points. This alternative method of locating the traverse points was discussed and approved by the EPA Task Manager. Each point was isokinetically sampled for 6.0 minutes to acquire a total test time of 180 minutes.

4.2 HEXAVALENT AND TOTAL CHROMIUM SAMPLE EXTRACTION AND ANALYSIS

Prior to sampling, velocity, static pressure, moisture content, and temperature were measured to define sampling rates and nozzle sizes as described in the EPA Reference Methods 1, 2 and 4.¹ The stack gas

TABLE 4-2. SUMMARY OF SAMPLE TRAVERSE POINT LOCATIONS

Traverse Point No.	Inside of Near Wall Traverse Point	Nipple Depth to Inside of Near Wall	Traverse Point Location From Outside of Nipple
--------------------	------------------------------------	-------------------------------------	--

Ports A & F (average diameter = 22.6 inches)

1	2.26 (4.5)	4.375	6.6 (9.0)
2	6.78	4.375	11.2
3	11.30	4.375	15.7
4	15.82	4.375	20.2
5	20.34	4.375	24.7

Ports B & E (average diameter = 20.0 inches)

1	2.00 (4.5)	4.375	6.4 (9.0)
2	6.00	4.375	10.4
3	10.00	4.375	14.4
4	14.00	4.375	18.4
5	18.00	4.375	22.4

Ports C & D (average diameter = 19.5 inches)

1	1.95 (4.5)	4.375	6.3 (9.0)
2	5.85	4.375	10.2
3	9.75	4.375	14.1
4	13.65	4.375	18.0
5	17.55	4.375	21.9

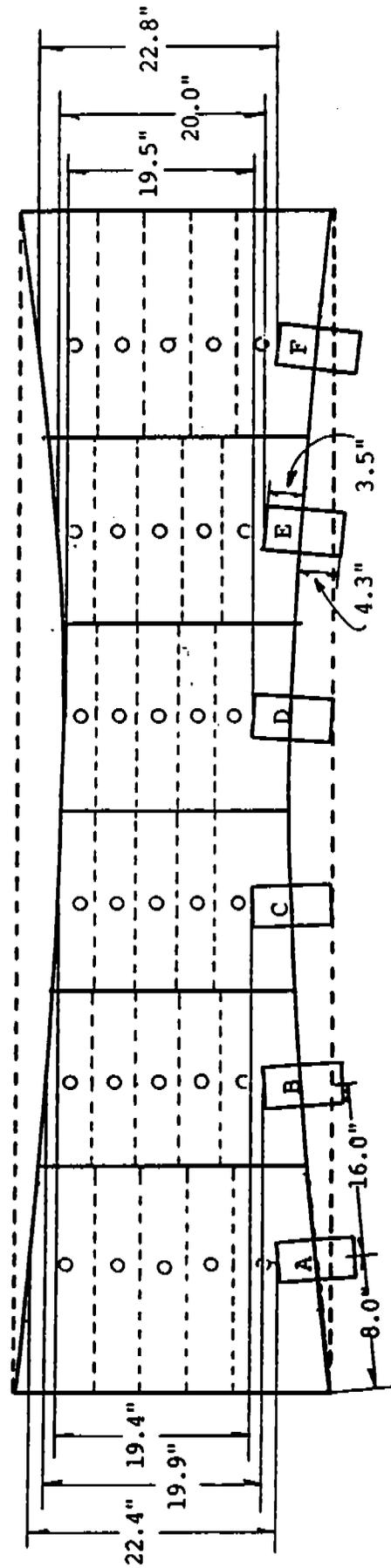


Figure 4-3. Cross-section of sample location indicating traverse points.

molecular weight was not determined by procedures outlined in EPA Method 3. Alternatively, the molecular weight was assigned the value of 29.0 lb/lb mole, as stated in the EPA Method 2, paragraph 3.6. In addition, verification of the absence of cyclonic flow at each sample traverse point was assessed based on procedures described in the EPA Reference Method 1. In this method, the face openings of the Type-S pitot tube are aligned perpendicular to the duct cross-sectional plane, designated "0-degree reference." Null (zero) pitot readings obtained at 0-degree reference indicate an acceptable flow condition at a given point.

If the pitot reading was not zero at 0-degree reference, the pitot was rotated until a null reading was obtained. The value of the rotation angle (yaw) was recorded for each point and averaged across the duct. Method 1 criteria stipulate that average angular rotations greater than 20 degrees indicate cyclonic (nonaxial) flow conditions in the duct. The average of the angular rotations was 7.8 degrees, which indicated acceptable flow patterns and enabled the extraction of representative samples from this source. The cyclonic flow data is contained in Appendix A. Following this, sampling was performed by conducting triplicate tests at the inlet to the evaporator/scrubber. Samples were collected to determine the uncontrolled Cr⁺⁶ and total Cr emissions from this source.

An EPA MM 13B² sample train was used to collect the Cr⁺⁶ and total Cr samples. The sample train consisted of a 316 stainless steel button-hook design nozzle, an unheated Pyrex glass-lined probe, and a series of impingers. The first, third and fourth impingers were Greenburg-Smith design, modified by replacing the tip with a 1/2-inch inside diameter glass tube extending to 1/2-inch from the bottom of the flask. The second impinger was a Greenburg-Smith impinger with the standard tip. In the first, second and third impinger 100 mL of 0.1N NaOH was placed, and approximately 200 grams of silica gel was placed in the fourth impinger. The balance of the sampling system consisted of a vacuum pump, dry gas meter, calibrated orifice, and related temperature and pressure indicating apparatus with which to determine dry gas sample volume, stack gas

temperature, volumetric flow rate and isokinetic sampling rates. During sampling, stack gas temperature and the gas temperature exiting the fourth impinger were monitored with thermocouples.

The impingers were weighed before and after each test to determine the moisture content of the flue gas stream. The contents of the impingers were placed in a polyethylene container. All connecting glassware, the nozzle and probe were rinsed with 0.1 N NaOH and combined with the impinger solution in the polyethylene sample bottle. The liquid level was marked on each sample bottle and the pH was checked with pH paper to verify that the pH was above 7.0. Appropriate blank solutions were collected in the field for submission to the laboratory for analysis with the samples. The samples were transported to the laboratory where total volumes of each sample were measured. The volume recovered from Run I-1 was 698 mL, Run I-2 was 770 mL and 672 mL was recovered from Run I-3. Each sample, including blanks, was analyzed for Cr⁺⁶ concentrations using analytical methodology recently developed by the EPA. A copy of the draft method entitled "Determination of Hexavalent Chromium Emissions From Stationary Sources" is contained in Appendix G of this report. This method entails the extraction of the sample with alkaline solution, followed by the diphenylcarbazide colorimetric method.³

At the completion of the Cr⁺⁶ analysis, a separate portion of each sample was digested and analyzed for total Cr by use of ICAP analytical techniques.⁴ Appendix G of this report contains the detailed analytical methodology used for this analysis.

4.3 PROCESS SAMPLES

Process samples (plating tank solutions) were collected by PEER personnel during each test period. A sample from each cell of the chromium plating tank was collected and composited at three equal intervals during the 3-hour test period and placed in corresponding polyethylene containers. These samples were analyzed for Cr⁺⁶ and total Cr following procedures similar to those used for the emission samples.

SECTION 5.0
PROJECT QUALITY ASSURANCE

The application of quality assurance procedures to source emission measurement ensures accurate emission-testing results. Quality assurance guidelines provide the detailed procedures and actions necessary for defining and producing acceptable data. In this project, three documents were used in the preparation of a source-specific test plan that would ensure the collection of acceptable data:

1. Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III; Stationary Source-Specific Methods, EPA-600/4-77-027B;
2. PEI, Laboratory Quality Assurance Plan;
3. "Determination of Hexavalent Chromium Emissions From Stationary Sources," December 13, 1984. This method has recently been developed by the EPA.

In this specific test program, which was reviewed by the EPA's Emission Measurement Branch, the following steps were taken to ensure that the testing and analytical procedures produced quality data:

- On-site quality assurance checks, such as leak checks of the sampling train and pitot tube, detailed information on these checks is presented in Appendix A. On-site quality assurance checks were performed on all test equipment prior to its use.
- Triplicate micrometer measurements of the sampling nozzle. These measurements were recorded on the field data sheets (Appendix A).
- Use of sampling equipment as designated in EPA Method 13B.

- Standard forms were used for recording data and in calculating air flow results.
- The sample recovery was performed in the plant in an area isolated from contamination, and in the van.
- Samples were collected in polyethylene sample bottles. Polyethylene bottles are recommended for storing and shipping of corrosive materials.
- Samples were secured upon completion of the sample recovery activities. The samples and blanks were placed in a designated area in the clean-up van. The van was locked when unattended. For transportation, the samples and blanks were secured in a cooler. No special storage was required for these samples.
- Samples were in the custody of PEER Consultants, P.C., at all times. When the samples were transported to the laboratory, the Sample Custodian acknowledged the laboratory's receipt of the samples (Appendix A).
- All glassware and sample bottles were rinsed with 10 percent nitric acid before use in the field.
- Prior to sampling, the ports were cleaned to minimize the possibility of contamination of the sample train when inserting or removing the probe.
- External contaminated surfaces (probe, nozzle and pitot tube) were rinsed prior to sample recovery. This would eliminate the risk of sample contamination.
- A polyethylene dipper was used to take samples of the chrome plating solution.
- While sampling, the ports were capped and the accessed port was sealed with a rag to prevent the introduction of room air into the duct.

- All field-sampling equipment was calibrated. The pretest and post-test calibration data for the equipment used in the field is contained in Appendix E.
- Duplicate and spiked samples were analyzed in the laboratory, the results of which are presented below.

Table 5-1 list the specific sampling equipment used to perform the MM 13B sampling program. The calibration data for this equipment is presented in detail in Appendix E.

TABLE 5-1. EQUIPMENT USED IN THE MM 13B SAMPLING PROGRAM

<u>Equipment</u>	<u>Identification</u>
Meter Box	RAC 1065
Thermometers	
- meter box	RAC-1
- sample head	SH-1
Pitot Tubes	S-1, S-2
Thermocouple	3-T-1A

On-site calculations were made by the EPA Task Manager on the emissions sampling data to determine the isokinetic variation and moisture content of the stack gas. All final calculations were done after the post-test calibrations had been performed on the equipment following the return from the field test. The final calculations are presented in Appendix B. The following summarizes the quality assurance activities performed during the analytical phase of this project.

Emission and process samples were analyzed in the same batches. The linear regression data of the spectrophotometer calibration for these samples is presented in Appendix C. Standards containing 0, 5, 10, 15, 20 and 25 µg of Cr⁺⁶ per 50 ml were analyzed with the samples. The ICAP was calibrated prior to the total Cr analysis. This calibration data is presented in Appendix C. Reagent blanks that were set-up in the field were analyzed with the actual sample. The blank results are presented in Table 5-2.

In addition to the analysis of the submitted samples and blanks, duplicate and spiked samples were analyzed. Table 5-3 summarizes the results of these QA/QC checks.

TABLE 5-2. SUMMARY OF BLANK ANALYSIS

<u>Blank I.D. No.</u>	<u>Cr⁺⁶ (mg/l)</u>	<u>Total Cr (mg/l)</u>
B1.Run I-1	less than 0.02	0.011
B1.Run I-2	less than 0.02	0.011
B1.Run I-3	less than 0.02	0.013

TABLE 5-3. SUMMARY OF ANALYTICAL RESULTS FROM DUPLICATE AND SPIKED SAMPLES

<u>Sample I.D. No.</u>	<u>Type of Sample</u>	<u>Results</u>
		Cr ⁺⁶
Run I-2, tank 2	duplicate	154,000 mg/l 155,000 mg/l
Run I-1, emission	spiked	98.5% recovery
		Total Cr
Run I-3, tank 1	duplicate	153,000 mg/l 149,000 mg/l
Run I-2, emission	spiked	89.3% recovery

REFERENCES

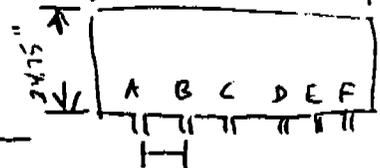
REFERENCES

1. 40 CFR Part 60, Appendix A, EPA Reference Methods 1,2,4, July 1986.
2. 40 CFR part 60, Appendix A, EPA Reference Method 13, July 1987.
3. "Test Methods for Evaluating Solid Waste," U.S. EPA SW-846, 2nd Edition, July 1982, Method 3060.
4. "Test Methods for Evaluating Solid Waste," U.S. EPA SW-846, 2nd Edition, July 1982, Method 3050.

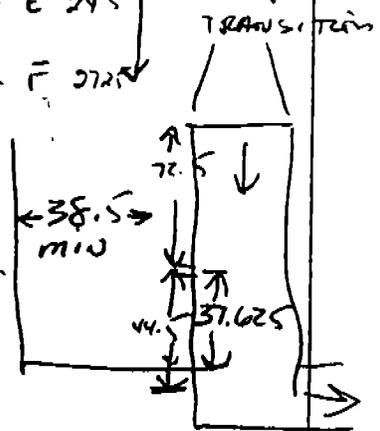
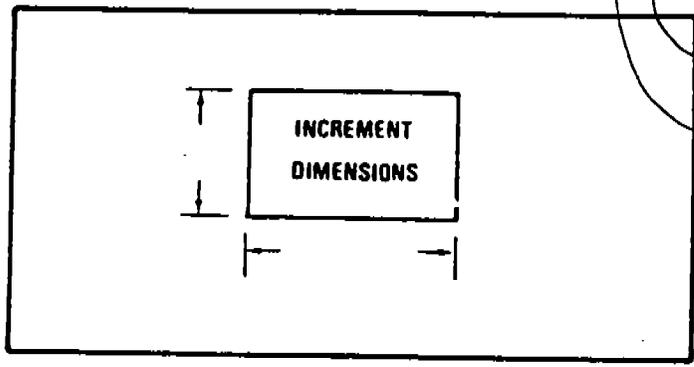
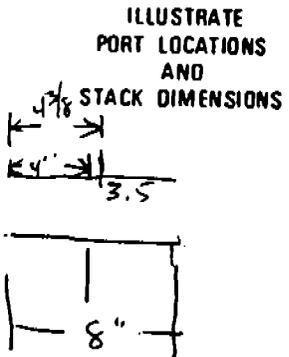
APPENDIX A
Field Data Sheets

TRAVERSE POINT LOCATIONS FOR RECTANGULAR DUCTS 8' - 1/2" →

PLANT DELCO PRODUCTS
 DATE 3-16-87
 SAMPLING LOCATION SCRUBBER INLET
 INSIDE STACK DIMENSIONS 20.8 x 95.8
 * INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE. (Distance B) _____
 EQUIVALENT STACK I.D. _____
 NEAREST UPSTREAM DISTURBANCE 72.5
 NEAREST DOWNSTREAM DISTURBANCE 44.5
 NUMBER OF TRAVERSE POINTS _____ ARRAY _____ X _____
 CALCULATOR _____



- A 26.875
- B 24.75
- C 23 7/8
- D 24.0
- E 24.5
- F 27.25

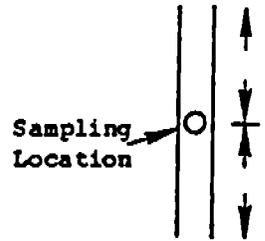
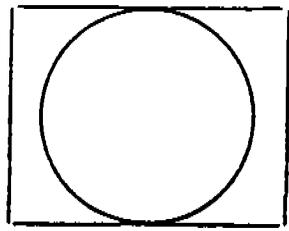


TRAVERSE POINT NUMBER	INSIDE OF NEAR WALL TO TRAVERSE POINT (Distance A)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF DISTANCES A+B)	PORT LOCATION	DISTANCE FROM EDGE OF STACK
1				A	8.75
2				B	24.25
3				C	40.5
4				D	56.5
5				E	72.75
				F	88.5
Note: See Body of report for sample traverse point locations					



PRELIMINARY VELOCITY TRAVERSE

Plant: DELCO PRODUCTS
 Date: 3-16-87
 Location: SCRUBBER INLET
 Stack I.D.: 20.8 x 95.8
 Barometric Pressure, in. Hg: 29.66
 Stack Gauge Pressure, in. H₂O: -3.0
 Operators: F. MEX DOWNS - H. OWENS
 Pitot Tube I.D. Number: S-2
 Temperature Readout I.D.: OMEGA 650
 Pitot Tube Leak Check: OK
 19.9 x 95.8 as calculated



Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (ΔP_s) in. H ₂ O	Stack Temp. (T _s), °F	Cyclonic Flow Check ° from Null
A-1	0.33	73	13°
2	0.34	73	12°
3	0.26	73	0
4	0.22	73	6° clockwise
5	0.24	73	5° clockwise
B-1	0.11	71	18°
2	0.26	71	5°
3	0.22	71	6° clockwise
4	0.19	72	11° clockwise
5	0.20	72	14° clockwise
C-1	0.08	69	17°
2	0.12	69	4°
3	0.14	69	5° clockwise
4	0.17	71	6° clockwise
5	0.23	71	11° clockwise
Average			

Traverse Point Number	Velocity Head (ΔP_s) in. H ₂ O	Stack Temp. (T _s), °F	Cyclonic Flow Check ° from Null
D-1	0.09	70	7°
2	0.15	70	6° clockwise
3	0.17	71	3°
4	0.20	71	2°
5	0.24	72	9°
E-1	0.19	70	10° clockwise
2	0.50	71	10° clockwise
3	0.36	73	3°
4	0.35	72	9°
5	0.31	73	13°
F-1	0.50	72	14° clockwise
2	0.94	73	8° clockwise
3	0.77	73	0°
4	0.62	73	5°
5	0.58	73	1°
A-3			
Average			7.8°



NOMOGRAPH DATA

Plant: DELCO PRODUCTS - LIVONIA Date: 3-18-87

Sampling Location: SCRUBBER INLET

$P_b = 29.41$

Calibrated Pressure Differential Across Orifice, in. H ₂ O	ΔH_o	1.84
Average Meter Temperature (ambient + 20°F), °F	$T_{m \text{ avg}}$	100
Percent Moisture in Gas Stream by Volume	B_{wo}	1.5
Barometric Pressure at Meter, in. Hg.	P_b	29.55
Static Pressure in Stack, in. Hg. ($P_m + 0.073 \times$ stack gauge pressure in in. H ₂ O)	P_s	29.19
Ratio of Static Pressure to Meter Pressure	P_s / P_m	0.988
Average Stack Temperature, °F	$T_{s \text{ avg}}$	76
Average Velocity Head, in. H ₂ O	ΔP_{avg}	0.3
Maximum Velocity Head, in. H ₂ O	ΔP_{max}	0.93
C Factor	1.1	
Calculated Nozzle Diameter, in.		
Actual Nozzle Diameter, in.		0.303
Reference Δp , in. H ₂ O		0.195

FIELD DATA

Plant DELCO PRODUCTS - LIVONIA
 Date 3-18-77
 Sampling Location SCHEMATIC INLET
 Sample Type MOD. 12B
 Run Number I-1
 Operator F. MENDRWS - H. EDWARDS
 Ambient Temperature 71°F
 Barometric Pressure 29.50" Hg
 Static Pressure (P_g) -2.0" H₂O
 Filter Number(s) N/A
 Pretest Leak Rate = 100 cfm @ 16 in. Hg
 Pretest Pitot Leak Check OK
 Pretest Orsat Leak Check N/A
 Read and Record all Data Every 6 Minutes

NOZZLE CALIBRATION
 ① .303
 ② .303
 ③ .303
 MW .303

Probe Length and Type 2' RUBER UNLIMITED
 Pitot Tube I.D. No. S-1
 Nozzle I.D. 0.303
 Assumed Molature, λ 1.5
 Temp. Readout S/N OMEGA 650
 Meter Box Number RAC 1065
 Meter ΔH_g 1.84
 C Factor 1.08
 Meter Gamma 1.81 / 0.988
 Heater Box Setting N/A
 Reference Δp 0.196
 Post Test Leak Rate = 100 cfm @ 12.2 in. Hg
 Post Test Pitot Leak Check OK
 Post Test Orsat Leak Check N/A

Schematic of Traverse Point Layout

3-T-1A

PAGE 1 OF 2

Traverse Point Number	Sampling / Time (min) / (clock)	/Clock	Gas Meter Reading (V) ft ³	Velocity Head (ΔP_g) in. H ₂ O	Orifice Pres. Differential (ΔH) in. H ₂ O		Stack Temp. (T _g) °F	Dry Gas Meter Temp. (T _m) °F		Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Im-pinger Temp. °F
					Desired	Actual		Inlet (T _m) _{in}	Outlet (T _m) _{out}			
A-1	0 / 0934	824.135	0.24	2.20	2.20	71	78	74	4.2	N/A	59	
2	6 / 0940	826.060	0.30	2.80	2.80	77	91	76	4.7		59	
3	12 / 0946	831.462	0.23	2.15	2.15	77	98	78	4.0		62	
4	18 / 0952	836.351	0.18	1.70	1.70	77	103	80	3.7		61	
5	24 / 0958	840.833	0.22	2.02	2.02	78	106	83	3.9		61	
	30 / 1004	845.564	0.22	2.14	2.14	76	102	80	4.1		60.4	
B-1	36 / 1010	849.357	0.12	1.15	1.15	68	101	86	3.0		58	
2	42 / 1020	854.738	0.29	2.65	2.65	75	106	86	4.4		56	
3	48 / 1030	859.288	0.18	1.70	1.70	76	108	89	3.6		58	
4	54 / 1032	863.742	0.17	1.60	1.60	77	106	89	3.6		57	
5	60 / 1038	868.445	0.20	1.90	1.90	78	109	90	3.8		57	
	66 / 1040	871.908	0.4337	1.80	1.80	74	106	88	3.68		57.4	
C-1	72 / 1046	875.720	0.10	0.95	0.95	71	105	91	3.0		56	
2	78 / 1052	880.006	0.12	1.15	1.15	75	107	91	3.1		55	
3	84 / 1104	884.530	0.17	1.43	1.43	78	109	92	3.5		57	
4	90 / 1110	889.401	0.22	1.65	1.65	78	111	93	3.5		58	
5	96 / 1110	894.401	0.3863	2.02	2.02	78	111	94	3.8		57	
				1.44	1.44	76	108.6	92.2	3.38		56.6	

Plant Name: PERCO PRODUCTS - LIVINGIA

Test Date: 3-18-87

Run Number: T-1

Operator: F. MENTOWS - H. OWENS

Traverse Point Number	Sampling Time, (min) / (24-hour clock)	Gas Meter Reading, (V) ft ³	Velocity Head (ΔPs) in. H ₂ O	Orifice Pres. (ΔH) in. H ₂ O		Stack Temp. (T _S) °F	Dry Gas Meter Temp. (T _m) °F		Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Im-pinger Temp. °F
				Desired	Actual		Inlet (T _m _{In})	Outlet (T _m _{out})			
D-1	96 / 1112	869.401	-	-	-	71	-	-	N/A	(A)	
2	102 / 1118	893.050	0.11	1.05	1.05	71	107	3.0	N/A	56	
3	108 / 1124	897.287	0.14	1.35	1.35	76	108	3.3	N/A	55	
4	108 / 1130	901.753	0.16	1.50	1.50	78	111	3.5	N/A	54	
5	114 / 1136	906.451	0.20	1.85	1.85	77	111	3.7	N/A	56	
	120 / 1142	911.335	0.22	2.02	2.02	77	112	3.8	N/A	57	
	1144		0.4044	1.554	1.554	75.8	109.8	3.46	N/A	55.6	
E-1	126 / 1150	917.550	0.37	2.40	2.40	72	112	5.2	N/A	56	
2	132 / 1156	925.900	0.48	4.40	4.40	76	120	6.9	N/A	58	
*3	138 / 1157	927.925	0.31	2.85	2.85	78	116	4.4	N/A	60	
*4	144 / 1158	930.746	0.31	2.85	2.85	78	100	4.4	N/A	53	
5	150 / 1227	936.170	0.27	2.50	2.50	78	106	4.0	N/A	49	
F-1	156 / 1235	941.626	0.28	2.40	2.40	79	109	4.0	N/A	55	
2	162 / 1241	950.400	0.13	5.60	5.60	76	116	11.9	N/A	53	
3	168 / 1247	969.095	0.15	7.70	7.70	79	126	10.4	N/A	56	
4	174 / 1253	977.380	0.58	6.20	6.20	79	129	9.0	N/A	55	
5	180 / 1259	985.755	0.58	5.3	5.3	79	128	8.2	N/A	54	
			0.8456	6.62	6.62	78.4	125.4	8.2	N/A	54	
			0.5222	2.790	2.790	76.3	109.3	9.54	N/A	54.4	
TOTAL AVG	180 / 1205	1164.620	0.5237	2.790	2.790	76.3	109.3	80.6	AVG: 41.84V	AVG: 56.62V	
			0.5222			56.1R	56.1R	550.6		516.6R	
			0.273			58.4R					
						76.2R					
						57.9R					

* TEST STOPPE FOR PROCESS INTERRUPTION @ 12:12

Checked *J Meadows*



Box 2

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant WACO PRODUCTS (LTD.) Sample date 3/18/87
 Sample location CHROMELINE 4 S/C PLUBBER INLET Run number I-1
 Sample recovery person A. WEISMAN Recovery date 3/18/87
 Filter(s) number N/A

MOISTURE

<u>Impingers</u>		<u>Silica gel</u>
Final volume (wt) _____ ml (g)		Final wt <u>733.5g</u> _____ g
Initial volume (wt) <u>3.50g</u> ml (g)		Initial wt <u>721.6g</u> _____ g
Net volume (wt) _____ ml (g)		Net wt <u>11.9g</u> _____ g
Total moisture _____ g		
Color of silica gel _____		
Description of impinger water _____		

RECOVERED SAMPLE

Blank filter container number _____ Sealed _____
 Filter container number _____ Sealed _____
 Description of particulate on filter _____

Acetone rinse container number _____	Liquid level marked? _____
Acetone blank container number _____	Liquid level marked? _____

Samples stored and locked _____
 Remarks _____

 Date of laboratory custody _____
 Laboratory personnel taking custody _____
 Remarks _____

NO.	INITIAL WT.	FINAL WT.		
1	566.3g	568.3	2.0	I 2475.5
2	601.6g	590.8	-10.8	F 2480.7
3	586.0g	588.1	2.1	A-7
			-6.7	

FIELD DATA

Plant DELCO PRODUCTS - NUMON
 Date 3-16-87
 Sampling Location SC40608R DUCT
 Sample Type MOD. 13B
 Run Number I-2
 Operator F. MICHROPOPO - H. OWENS
 Ambient Temperature _____
 Barometric Pressure 29.41 in. Hg
 Static Pressure (P_g) -3.0 in. H₂O
 Filter Number(s) N/A
 Pretest Leak Rate = _____ cfm @ _____ in. Hg
 Pretest Pitot Leak Check OK
 Pretest Orsat Leak Check N/A
 Read and Record all Data Every 6 Minutes

Probe Length and Type 2' FIBREX HEATED
 Pitot Tube I.D. No. S-1
 Nozzle I.D. 0.303
 Assumed Moleture, % 1.50
 Temp. Readout S/N 650
 Meter Box Number 11AC-1065
 Meter ΔH_g 1.84
 C Factor 1.10
 Meter Gamma 0.481/0.95F
 Heater Box Setting N/A
 Reference ΔP 0.115
 Post Test Leak Rate = 0.00 cfm @ 15 in. Hg
 Post Test Pitot Leak Check OK
 Post Test Orsat Leak Check N/A

Nozzle 0.303
 0.303
 0.303
 MC 0.303

Schematic of Traverse Point Layout
 1C

3-T-1A

Traverse Point Number	Sampling Time (min) / Clock	Gas Meter Reading (V) ft	Velocity Head (ΔP _g) in. H ₂ O	Orifice Pres. Differential (ΔH) in. H ₂ O		Stack Temp. (T _g) °F	Dry Gas Meter Temp. (T _m) °F		Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Im-pinger Temp. °F
				Desired	Actual		Inlet (T _m _{in})	Outlet (T _m _{out})			
A-1	0 / 1437	988.914	-	-	-	72	92	78	6.8	N/A	54
A-2	6 / 1443	992.340	0.33	3.60	3.10	74	96	78	5.7	N/A	57
A-3	12 / 1540	998.278	0.33	3.10	3.10	74	79	78	5.7	N/A	54
A-4	18 / 1546	1003.692	0.28	2.60	2.60	74	88	78	4.8	N/A	51
A-5	24 / 1552	1009.022	0.27	2.50	2.50	73	97	79	4.3	N/A	56
A-6	30 / 1558	1014.377	0.27	2.50	2.50	74	103	81	4.3	N/A	58
A-7	36 / 1601	1017.860	0.5535	2.86	2.86	74	92.9	78	5.13	N/A	54.5
A-8	42 / 1607	1022.742	0.10	0.95	0.95	72	99	84	3.7	N/A	57
A-9	48 / 1613	1027.221	0.23	2.12	2.12	73	105	86	3.9	N/A	54
A-10	54 / 1619	1031.973	0.19	1.70	1.70	74	107	87	3.4	N/A	55
A-11	60 / 1625	1037.973	0.19	1.80	1.80	74	108	89	3.5	N/A	56
A-12	66 / 1631	1043.6152	0.19	1.80	1.80	74	111	91	3.5	N/A	56
A-13	72 / 1637	1049.154	0.08	1.67	1.67	73	106	87.4	3.4	N/A	55.6
A-14	78 / 1643	1054.765	0.13	0.77	0.77	73	104	93	2.2	N/A	57
A-15	84 / 1649	1060.050	0.19	1.25	1.25	74	108	93	3.0	N/A	53
A-16	90 / 1655	1065.695	0.19	1.42	1.42	74	108	93	3.2	N/A	54
A-17	96 / 1661	1071.441	0.20	1.80	1.80	74	111	94	3.4	N/A	55
A-18	102 / 1704	1077.441	0.20	1.50	1.50	74	113	95	3.5	N/A	55
A-19	108 / 1710	1083.288	0.20	1.42	1.42	73.6	108.4	95.6	3.06	N/A	54.5

* PROCESS DOWN @ 1445 TEST RESUMED @ 1530
 **

0000

Box 1

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant ELCO PRODUCTS (LIVONIA) Sample date 3/18/87
Sample location CHROME LINE 4 SCRUBBER INLET Run number I-2
Sample recovery person A. WEISMAN Recovery date 3/18/87
Filter(s) number N/A

MOISTURE

Impingers Silica gel
Final volume (wt) 294 ml (g) Final wt 737.2 g
Initial volume (wt) 300 ml (g) Initial wt 706.8 g
Net volume (wt) _____ ml (g) Net wt _____ g
Total moisture _____ g
Color of silica gel _____

Description of impinger water 0.1N NaOH - clear

RECOVERED SAMPLE

Blank filter container number _____ Sealed _____
Filter container number _____ Sealed _____
Description of particulate on filter _____

Acetone rinse container number _____ Liquid level marked? _____
Acetone blank container number _____ Liquid level marked? _____
Samples stored and locked _____

Remarks _____

Date of laboratory custody _____

Laboratory personnel taking custody _____

Remarks _____

Imp. No.	INITIAL (wt)	FINAL (wt)				
1	553.03	551.7	-1.30	95		
2 (4)	570.09	573.3	3.30	100		
3	553.59	555.6	2.10	81		
4 silica	706.8g	737.2	30.40	294		
			A-10		2383.3	2417.8

Plant Name: BELCO PRODUCTS - LUDLOW Test Date: 3-19-87
 Run Number: I-3 Operator: F. MEADERS - H. OWENS

Traverse Point Number	Sampling Time (min)	/Clock Time / (24-hour clock)	Gas Meter Reading (V) ft	Velocity Head (APg) in. H ₂ O	Orifice Pres. Differential (ΔH) in. H ₂ O		Stack Temp. (T _g) °F	Dry Gas Meter Temp. (T _m) °F		Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Im-pinger Temp. °F
					Desired	Actual		Inlet (T _m _{in})	Outlet (T _m _{out})			
1	90	11414	225.740	0.12	1.15	1.15	73	104	86	3.2	53	50
2	96	11420	229.618	0.12	1.25	1.25	75	105	88	3.3	50	50
3	102	11427	233.618	0.13	1.25	1.25	75	107	90	3.8	50	50
4	108	11433	238.219	0.17	1.62	1.62	75	111	91	4.3	50	50
5	114	11439	243.041	0.22	2.05	2.05	75	103	93	4.5	50	50
5	120	11445	248.180	0.23	2.12	2.12	76	106	81.6	38.2	50.6	50.6
E-1	126	11447	256.073	0.4136	4.38	4.38	74.8	106	95	11.0	50	50
2	132	11453	263.580	0.52	4.80	4.80	73	124	96	9.6	51	51
3	138	11459	269.818	0.47	4.30	4.30	75	123	97	6.5	51	51
4	144	11516	275.448	0.34	3.15	3.15	76	119	98	5.3	50	50
5	150	11517	281.166	0.28	2.55	2.55	76	118	98	5.7	50	50
F-1	156	11519	290.115	0.31	2.90	2.90	76	118	98	7.2	50.4	50.4
2	162	11525	299.125	0.4780	5.54	5.54	75.2	118	96.8	16.6	50	50
3	168	11531	308.050	0.64	7.60	7.60	72	128	98	16.6	51	51
4	174	11537	316.735	0.74	8.00	8.00	75	134	101	16.0	51	51
5	180	11543	325.412	0.64	6.70	6.70	76	137	102	14.8	51	51
				0.64	5.85	5.85	76	138	103	14.8	51	51
				0.8640	6.80	6.80	75	131	100.4	15.6	50.8	50.8
TOTAL AVG				0.5127	AVE = 3.7240	AVE = 3.7240	AVE = 74.90	AVE = 106.30	AVE = 97.220	AVE = 6.65	AVE = 51.90	51.90
				0.5348	3.9240	3.9240	53.92	106.30	547.220	6.65	51.90	51.90

Test Pressure down @ 1470 or at 1471
 Checked *J. M. ...*

SAMPLE RECOVERY AND INTEGRITY DATA FORM

Plant Delco Products Sample date 3-19-87
Sample location Chrome Line 4/Scrubber Tank Run number I-3
Sample recovery person H. Owens Recovery date 3-19-87
Filter(s) number n/a

MOISTURE

Impingers Silica gel
Final volume (wt) 300 ml (g) Final wt _____ g _____ g
Initial volume (wt) 300 ml (g) Initial wt 737.3 g _____ g
Net volume (wt) _____ ml (g) Net wt _____ g _____ g
Total moisture _____ g
Color of silica gel _____
Description of impinger water _____

RECOVERED SAMPLE

Blank filter container number _____ Sealed _____
Filter container number _____ Sealed _____
Description of particulate on filter _____
Acetone rinse container number _____ Liquid level marked? _____
Acetone blank container number _____ Liquid level marked? _____
Samples stored and locked _____
Remarks _____

Date of laboratory custody _____
Laboratory personnel taking custody _____
Remarks _____

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Final	554.1	571.6	558.3	760.7
Initial	552.6 gr	570.0	557.5	737.3
	1.5	1.6	0.8	23.4

SAMPLE CHAIN OF CUSTODY

Plant: Delco Products-Mivonia Test Number: _____

Date Sampled: 3/19/87 Run Number: I-3 Blank

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>Blank 3/19/87</u>	<u>0.1 NaOH 400 ml</u>
_____	_____
_____	_____

Person Engaged in Sample Recovery

Signature: [Signature]

Title: Recovery Coordinator

Location at which Recovery was Done: Plant

Date and Time of Recovery: 3/19/87 4:00 PM

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: [Signature]

Title: Sample Control

Date and Time of Receipt: 3/22/87 3:30

Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____



SAMPLE CHAIN OF CUSTODY

Plant: Delco Products-Livonia Test Number: _____
Date Sampled: 3/19/87 Run Number: I-3

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>I-3</u>	<u>0.1N NaOH Rinse of Probe, nozzle, impinger 1,2,3 and connecting glassware. PH checked @ 8.5</u>

Person Engaged in Sample Recovery

Signature: [Signature]
Title: Recovery Coordinator
Location at which Recovery was Done: @ plant
Date and Time of Recovery: 3/19/87 4:00pm

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____
Title: _____
Date and Time of Receipt: _____
Sample Storage: _____

Laboratory Person Receiving Sample

Signature: [Signature]
Title: Sample Custodian
Date and Time of Receipt: 3-22-87 3:30
Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>

PN 958

SAMPLE CHAIN OF CUSTODY

Plant: DELCO PRODUCTS - KNOXIA Test Number: _____
Date Sampled: 3-18-87 Run Number: I-2

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>I-2</u>	<u>D. IONANON Rinse of Probe, nozzle, & IMPINGERS</u>
	<u>pH adjusted to >8.5 (no adjustment was</u>
	<u>required)</u>

Person Engaged in Sample Recovery

Signature: [Signature]
Title: Recovery Coordinator
Location at which Recovery was Done: AT PLANT
Date and Time of Recovery: 3/18/87 1900

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____
Title: _____
Date and Time of Receipt: _____
Sample Storage: _____

Laboratory Person Receiving Sample

Signature: [Signature]
Title: Sample Custodian
Date and Time of Receipt: 3/23/87 3:30
Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____



SAMPLE CHAIN OF CUSTODY

Plant: DELCO PRODUCTS - LIVONIA Test Number: _____

Date Sampled: 3/18/87 Run Number: BLANK

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>B-1</u>	<u>0.1 N NaOH BLANK FOR RUN NOS. I-1 & I-2</u>
_____	_____
_____	_____

Person Engaged in Sample Recovery

Signature: Aileen Owens

Title: Recovery Coordinator

Location at which Recovery was Done: AT PLANT

Date and Time of Recovery: 3/18/87 8:20 PM

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Laura Rotella

Title: Sample Coordinator

Date and Time of Receipt: 3/23/87 3:30

Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SAMPLE CHAIN OF CUSTODY

Plant: DELCO, LIVONIA, MICH. Test Number: _____
Date Sampled: 3/19/87 Run Number: I-3

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>TANK 1</u>	<u>PLATING SOLUTION 3/19/87 10:00 Am, 2:20Pm, 3:30Pm</u>
<u>TANK 2</u>	<u>PLATING SOLUTION 3/19/87 10:05 Am, 2:25Pm, 3:35 Pm</u>
<u>TANK 3</u>	<u>PLATING SOLUTION 3/19/87 10:10 Am, 2:30Pm, 3:40Pm</u>

Person Engaged in Sample Recovery:

Signature: Andrew Williamson
Title: TECHNICIAN
Location at which Recovery was Done: AT PLANT
Date and Time of Recovery: 3/19/87 3:40 Pm

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____
Title: _____
Date and Time of Receipt: _____
Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Lauren Roberts
Title: Sample Custodian
Date and Time of Receipt: 3/23/87 3:30
Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SAMPLE CHAIN OF CUSTODY

Plant: DELCO, LYONIA, MICH. Test Number: _____

Date Sampled: 3/18/87 & 3/19/87 Run Number: _____

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>C, SCREENING TEST</u>	<u>3 BLANK FILTERS, 12 SAMPLE FILTERS, 24 NaOH (2N)</u>
_____	<u>RINSINGS, 1 NaOH BLANK</u>
_____	_____
_____	_____

Person Engaged in Sample Recovery

Signature: Andrew W. Weisman

Title: TECHNICIAN

Location at which Recovery was Done: AT PLANT

Date and Time of Recovery: 3/18 - 3/19/87

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Laura P. Della

Title: Sample Coordinator

Date and Time of Receipt: 3/22/87 3:30

Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____



SAMPLE CHAIN OF CUSTODY

Plant: DELCO, LIVONIA MICH. Test Number: _____
Date Sampled: 3/18/87 Run Number: I-1

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>TANK 1</u>	<u>PLATING SOLUTION 3/18/87 9:50 AM, 11:10 AM, 12:40 PM</u>
<u>TANK 2</u>	<u>PLATING SOLUTION 3/18/87 9:55 AM, 11:15 AM, 12:45 PM</u>
<u>TANK 3</u>	<u>PLATING SOLUTION 3/18/87 10:00 AM, 11:20 AM, 12:50 PM</u>

Person Engaged in Sample Recovery

Signature: Andrew W. Weisman
Title: TECHNICIAN
Location at which Recovery was Done: AT PLANT
Date and Time of Recovery: 3/18/87 12:50 PM

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____
Title: _____
Date and Time of Receipt: _____
Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Lauri Kotzko
Title: Sample Custodian
Date and Time of Receipt: 3/23/87 3:30
Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

SAMPLE CHAIN OF CUSTODY

Plant: DILCO, LYONIA MICH. Test Number: _____

Date Sampled: 3/18/87 Run Number: I-2

SAMPLE RECOVERY

<u>Container Code</u>	<u>Description</u>
<u>TANK 1</u>	<u>PLATING SOLUTION: 3/18/87 3:45PM, 5:35PM, 6:30PM</u>
<u>TANK 2</u>	<u>PLATING SOLUTION 3/18/87 3:50PM, 5:40PM, 6:35PM</u>
<u>TANK 3</u>	<u>PLATING SOLUTION: 3/18/87 3:55PM, 5:45PM, 6:40PM</u>

Person Engaged in Sample Recovery

Signature: Andrew W. Weisman

Title: TECHNICIAN

Location at which Recovery was Done: AT PLANT

Date and Time of Recovery: 3/18/87 6:40 PM

Sample(s) Recipient Upon Recovery if Not Recovery Person

Signature: _____

Title: _____

Date and Time of Receipt: _____

Sample Storage: _____

Laboratory Person Receiving Sample

Signature: Lawrence Potalle

Title: Sample Control

Date and Time of Receipt: 3/23/87 3:30

Sample Storage: _____

ANALYSIS

<u>Container Code</u>	<u>Method of Analysis</u>	<u>Date and Time of Analysis</u>	<u>Signature of Analyst</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

APPENDIX B
Calculations



EMISSION TEST CALCULATIONS

PLANT DELCO PRODUCTS - LIVONIA SOURCE/RUN I-1 DATE 3-18-87

1. Leakage Correction for Volume Metered

V_{mc} = V_m - (Lp - La)θ = V_m - (Lp - 0.02)θ = () - (-0.02) ()

V_{mc} = 164,620 ft³

2. Volume Metered, Standard Conditions (68°F, 29.92 in.Hg)

V_{mstd} = 17.64 V_{mc} Y ((P_{bar} + ΔH / 13.6) / T_m) = 17.64 (164,620) (.981) ((29.50) + (2.79) / 13.6) (560)

V_{mstd} = 151.110 dscf

3. Volume Water Vapor Collected, Standard Conditions

Impingers = V_{wc} = 0.04707 (V_f - V_i) = 0.04707 () = _____ scf

Silica Gel = V_{wsg} = 0.04715 (W_f - W_i) = 0.04715 () = _____ scf

V_{wstd} = V_{wc} + V_{wsg} = _____ scf

4. Percent Moisture, By Volume

B_{ws} = V_{wstd} / (V_{wstd} + V_{mstd}) = () / () = 0.0092

ASSUMED BASED ON AVERAGE OF RUN I-2 and I-3

M. J. Jordan

5. Molecular Weight, Stack Gas

Dry Molecular Weight, M_d = 0.440 (%CO₂) + 0.320 (%O₂) + 0.280 (%N₂ + %CO)

= 0.440 () + 0.320 () + 0.280 ()

M_d = 29.0 lb/lb - mole

Percent Excess Air, %EA =

[(%O₂ - 0.5 %CO) / (0.264 (%N₂) - (%O₂ - 0.5 %CO))] X 100 [() - 0.5 () / (0.264 () - () - 0.5 ())] X 100

%EA = _____

M_s = M_d (1 - B_{ws}) + 18.0 (B_{ws}) = (29.0) (1 - .0092) + 18.0 (.0092) = 28.90 lb/lb-mole

6. Stack Gas Velocity, Average

$$V_{s,avg} = 85.49 C_p (\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49 (.84) (.5222) \sqrt{\frac{(536)}{(29.28)(28.90)}}$$

$$V_{s,avg} = \underline{29.85} \text{ ft/s}$$

7. Stack Volumetric Flow Rate, Actual Conditions (Stack Temperature and Pressure)

$$Q_a(\text{circular}) = \left(\frac{60 \times V_s (\pi d^2/4)}{144} \right) = 60 \times V_s (5.454 \times 10^{-3}) (d^2)$$

$$= 60 \times \underline{\hspace{2cm}} (5.454 \times 10^{-3}) (\underline{\hspace{2cm}})^2$$

"or" $Q_a(\text{rectangular}) = 60 \times V_s \left(\frac{L \times W}{144} \right) = 60 \times V_s (L \times W) 6.944 \times 10^{-3}$

$$= 60 \times \underline{29.85} (\underline{19.9} \times \underline{95.6}) 6.944 \times 10^{-3}$$

$$Q_a = \underline{23,706} \text{ acfm}$$

8. Stack Volumetric Flow Rate, Standard Conditions (68°F, 29.92 in. Hg)

$$Q_{std} = 17.64 Q_a (1 - B_{ws}) \left(\frac{P_s}{T_s} \right) = 17.64 (23,706) (1 - 0.0092) \left(\frac{29.28}{536} \right)$$

$$Q_{std} = \underline{22,633} \text{ dscfm}$$

9. Isokinetic Variation

$$\%I = K \frac{T_s V_{m(std)}}{P_s V_s A_n \theta (1 - B_{ws})}$$

$$= 0.0944 \frac{(536) (151,110)}{(29.28) (29.85) (5.0074 \times 10^{-4}) (180) (1 - 0.0092)}$$

$$= \underline{98.0} \%$$



EMISSION TEST CALCULATIONS

PLANT DELCO PRODUCTS - LIVONIA SOURCE/RUN I-2 DATE 3-18-87

1. Leakage Correction for Volume Metered

$$V_{m_c} = V_m - (L_p - L_a)\theta = V_m - (L_p - 0.02)\theta = (\quad) - (\quad - 0.02) (\quad)$$

$$V_{m_c} = \underline{170.317} \text{ ft}^3$$

2. Volume Metered, Standard Conditions (68°F, 29.92 in.Hg)

$$V_{m_{std}} = 17.64 V_{m_c} Y \left(\frac{P_{bar} + \Delta H / 13.6}{T_m} \right) = 17.64 (170.317) (0.981) \frac{(29.41) + (2.92) / 13.6}{(561)}$$

$$V_{m_{std}} = \underline{155.638} \text{ dscf}$$

3. Volume Water Vapor Collected, Standard Conditions

$$\text{Impingers} = V_{wc} = 0.04707 (V_f - V_i) = 0.04707 (4.1 \quad) = \underline{0.193} \text{ scf}$$

$$\text{Silica Gel} = V_{wsg} = 0.04715 (W_f - W_i) = 0.04715 (30.4 \quad) = \underline{1.433} \text{ scf}$$

$$V_{w_{std}} = V_{wc} + V_{wsg} = \underline{1.626} \text{ scf}$$

4. Percent Moisture, By Volume

$$B_{ws} = \frac{V_{w_{std}}}{V_{w_{std}} + V_{m_{std}}} = \frac{(1.626)}{(1.626) + (155.638)} = \underline{0.0103} \times 100 = \underline{1.03\%}$$

35.5% saturated

5. Molecular Weight, Stack Gas

$$\text{Dry Molecular Weight, } M_d = 0.440 (\%CO_2) + 0.320 (\%O_2) + 0.280 (\%N_2 + \%CO)$$

$$= 0.440 (\quad) + 0.320 (\quad) + 0.280 (\quad)$$

$$M_d = \underline{29.0} \text{ lb/lb - mole}$$

Percent Excess Air, %EA =

$$\left[\frac{\%O_2 - 0.5 \%CO}{0.264 (\%N_2) - (\%O_2 - 0.5 \%CO)} \right] \times 100 \left[\frac{(\quad) - 0.5 (\quad)}{0.264 (\quad) - 0.5 (\quad)} \right] \times 100$$

$$\%EA = \underline{\hspace{2cm}}$$

$$M_s = M_d (1 - B_{ws}) + 18.0 (B_{ws}) = (29.0) (1 - 0.0103) + 18.0 (0.0103) = \underline{28.89} \text{ lb/lb-mole}$$

6. Stack Gas Velocity, Average

$$V_{savg} = 85.49 C_p (\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49 (0.84) (0.5352) \sqrt{\frac{(534)}{(29.19)(28.89)}}$$

$$V_{savg} = \underline{30.584} \text{ ft/s}$$

7. Stack Volumetric Flow Rate, Actual Conditions (Stack Temperature and Pressure)

$$Q_a(\text{circular}) = \left(\frac{60 \times V_s (\pi d^2/4)}{144} \right) = 60 \times V_s (5.454 \times 10^{-3}) (d^2)$$

$$= 60 \times \underline{\hspace{2cm}} (5.454 \times 10^{-3}) (\underline{\hspace{2cm}})^2$$

"or" $Q_a(\text{rectangular}) = 60 \times V_s \left(\frac{L \times W}{144} \right) = 60 \times V_s (L \times W) 6.944 \times 10^{-3}$

$$= 60 \times \underline{30.584} (\underline{19.9} \times \underline{95.8}) 6.944 \times 10^{-3}$$

$$Q_a = \underline{24,292} \text{ acfm}$$

8. Stack Volumetric Flow Rate, Standard Conditions (68°F, 29.92 in. Hg)

$$Q_{std} = 17.64 Q_a (1 - B_{ws}) \left(\frac{P_s}{T_s} \right) = 17.64 (24,292) (1 - 0.0103) \left(\frac{29.19}{534} \right)$$

$$Q_{std} = \underline{23,183} \text{ dscfm}$$

9. Isokinetic Variation

$$\%I = K \frac{T_s V_m(\text{std})}{P_s V_s A_n \theta (1 - B_{ws})}$$

$$= 0.0944 \frac{(534) (155.635)}{(29.19) (30.584) (5.0014 \times 10^{-4}) (180) (1 - 0.0103)}$$

$$= \underline{98.5} \%$$



EMISSION TEST CALCULATIONS

PLANT DELCO PRODUCTS - LIVONIA SOURCE/RUN I-3 DATE 3-19-87

1. Leakage Correction for Volume Metered

$$V_{m_c} = V_m - (L_p - L_a)\theta = V_m - (L_p - 0.02)\theta = (\quad) - (\quad - 0.02) (\quad)$$

$$V_{m_c} = \underline{168,937} \text{ ft}^3$$

2. Volume Metered, Standard Conditions (68°F, 29.92 in.Hg)

$$V_{m_{std}} = 17.64 V_{m_c} Y \left(\frac{P_{bar} + \Delta H / 13.6}{T_m} \right) = 17.64 (168,937) (0.981) \frac{(29.35) + (2.88) / 13.6}{(557)}$$

$$V_{m_{std}} = \underline{155.156} \text{ dscf}$$

3. Volume Water Vapor Collected, Standard Conditions

$$\text{Impingers} = V_{wc} = 0.04707 (V_f - V_i) = 0.04707 (3.9) = \underline{0.184} \text{ scf}$$

$$\text{Silica Gel} = V_{wsg} = 0.04715 (W_f - W_i) = 0.04715 (23.4) = \underline{1.103} \text{ scf}$$

$$V_{w_{std}} = V_{wc} + V_{wsg} = \underline{1.287} \text{ scf}$$

4. Percent Moisture, By Volume

$$B_{ws} = \frac{V_{w_{std}}}{V_{w_{std}} + V_{m_{std}}} = \frac{(1.287)}{(1.287) + (155.156)} = \underline{0.0082} \times 100 = \underline{0.82\%}$$

27% saturated

5. Molecular Weight, Stack Gas

$$\text{Dry Molecular Weight, } M_d = 0.440 (\%CO_2) + 0.320 (\%O_2) + 0.280 (\%N_2 + \%CO)$$

$$= 0.440 (\quad) + 0.320 (\quad) + 0.280 (\quad)$$

$$M_d = \underline{29.0} \text{ lb/lb - mole}$$

Percent Excess Air, %EA =

$$\left[\frac{\%O_2 - 0.5 \%CO}{0.264 (\%N_2) - (\%O_2 - 0.5 \%CO)} \right] \times 100 \left[\frac{(\quad) - 0.5 (\quad)}{0.264 (\quad) - 0.5 (\quad)} \right] \times 100$$

$$\%EA = \underline{\hspace{2cm}}$$

$$M_s = M_d (1 - B_{ws}) + 18.0 (B_{ws}) = (29.0) (1 - 0.0082) + 18.0 (0.0082) = \underline{28.91} \text{ lb/lb-mole}$$

6. Stack Gas Velocity, Average

$$V_{savg} = 85.49 C_p (\sqrt{\Delta P})_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49 (.84) (.5348) \sqrt{\frac{(535)}{(29.13)(28.91)}}$$

$$V_{savg} = \underline{30.610} \text{ ft/s}$$

7. Stack Volumetric Flow Rate, Actual Conditions (Stack Temperature and Pressure)

$$Q_a(\text{circular}) = \left(\frac{60 \times V_s (\pi d^2/4)}{144} \right) = 60 \times V_s (5.454 \times 10^{-3}) (d^2)$$

$$= 60 \times \underline{30} (5.454 \times 10^{-3}) (\underline{\quad\quad\quad})^2$$

"or" $Q_a(\text{rectangular}) = 60 \times V_s \left(\frac{L \times W}{144} \right) = 60 \times V_s (L \times W) 6.944 \times 10^{-3}$

$$= 60 \times \underline{30.610} (\underline{19.9} \times \underline{95.8}) 6.944 \times 10^{-3}$$

$$Q_a = \underline{24,314} \text{ acfm}$$

8. Stack Volumetric Flow Rate, Standard Conditions (68°F, 29.92 in. Hg)

$$Q_{std} = 17.64 Q_a (1 - B_{ws}) \left(\frac{P_s}{T_s} \right) = 17.64 (24,314) (1 - .0082) \left(\frac{29.13}{535} \right)$$

$$Q_{std} = \underline{23,161} \text{ dscfm}$$

9. Isokinetic Variation

$$\%I = K \frac{T_s V_{m(std)}}{P_s V_s A_n \theta (1 - B_{ws})}$$

$$= 0.0944 \frac{(535) (155.156)}{(29.13) (30.610) (5.0074) (180) (1 - .0082) \times 10^{-4}}$$

$$= \underline{98.3} \%$$

CALCULATION OF Cr^{+6} CONCENTRATIONS & EMISSION RATES

RUN I-1

SAMPLE VOLUME = $151.110 \text{ ft}^3 = 4.279 \text{ dNm}^3$

SAMPLE CONC. = 12.0 mg/L

BLANK CONC. = 0.011 mg/L

Solution volume = 0.698 L

TOTAL MASS IN SAMPLE

$$\left[\frac{12.0 \text{ mg}}{\text{L}} - \frac{0.011 \text{ mg}}{\text{L}} \right] \times 0.698 \text{ L} = 8.368 \text{ mg} = Cr^{+6}$$

Concentration

$$\frac{(8.368 \text{ mg})(0.0154 \text{ gr/mg})}{151.110 \text{ ft}^3} = \boxed{0.000853 \text{ gr/dscft}}$$

$$\frac{(8.363 \text{ mg})}{4.279 \text{ dNm}^3} = \boxed{1.95 \text{ mg/dNm}^3}$$

EMISSION RATE

$$(0.000853 \text{ gr/dscft}) \left(\frac{1 \text{ lb}}{7000 \text{ gr}} \right) \left(\frac{22,633 \text{ ft}^3}{\text{min}} \right) \left(\frac{60 \text{ min}}{\text{hr}} \right) = \boxed{0.165 \text{ lb/hr}}$$

$$\left(\frac{0.165 \text{ lb}}{\text{hr}} \right) \left(\frac{0.45359 \text{ kg}}{\text{lb}} \right) = \boxed{0.075 \text{ kg/hr}}$$

RUN I-2

SAMPLE VOLUME = $155.638 \text{ ft}^3 = 4.407 \text{ dNm}^3$

SAMPLE CONC. = 7.42 mg/L

BLANK CONC. = 0.011 mg/L

Solution volume = 0.770 L

B-8

TOTAL MASS IN SAMPLE

$$\left(\frac{7.42 \text{ mg}}{\text{L}} - \frac{0.011 \text{ mg}}{\text{L}} \right) (0.770 \text{ L}) = 5.705 \text{ mg} - \text{Cr}^{+6}$$

CONCENTRATION

$$\frac{(5.705 \text{ mg}) (0.0154 \text{ gr/mg})}{155.638 \text{ ft}^3} = \boxed{0.000564 \text{ gr/dscf}}$$

$$\frac{(5.705 \text{ mg})}{4.407 \text{ dNm}^3} = \boxed{1.295 \text{ mg/dNm}^3}$$

EMISSION RATE

$$\left(\frac{0.000564 \text{ gr}}{\text{ft}^3} \right) \left(\frac{1 \text{ lb}}{7000 \text{ gr}} \right) \left(\frac{23,153 \text{ ft}^3}{\text{min}} \right) \left(\frac{60 \text{ min}}{\text{hr}} \right) = \boxed{0.112 \text{ lb/hr}}$$

$$\left(\frac{0.136 \text{ lb}}{\text{hr}} \right) \left(\frac{0.45359 \text{ kg}}{\text{lb}} \right) = \boxed{0.0619 \text{ kg/hr}}$$

RUN T-3

$$\text{SAMPLE VOLUME} = 155.156 \text{ ft}^3 = 4.394 \text{ dNm}^3$$

$$\text{SAMPLE CONC} = 10.1 \text{ mg/L}$$

$$\text{BLANK CONC} = 0.013 \text{ mg/L}$$

$$\text{SOLUTION VOLUME} = 0.672 \text{ L}$$

TOTAL MASS IN SAMPLE

$$\left(\frac{10.1 \text{ mg}}{\text{L}} - \frac{0.013 \text{ mg}}{\text{L}} \right) (0.672 \text{ L}) = 6.778 \text{ mg} - \text{Cr}^{+6}$$

CONCENTRATION

$$\frac{(6.778 \text{ mg}) (0.0154 \text{ gr/mg})}{155.156 \text{ ft}^3} = \boxed{0.000673 \text{ gr/dscf}}$$

$$\frac{(6.778 \text{ mg})}{4.394 \text{ dNm}^3} = \boxed{1.543 \text{ mg/dNm}^3}$$

EMISSION RATE

$$\left(\frac{0.000673 \text{ gr}}{\text{ft}^3}\right) \left(\frac{1 \text{ lb}}{7000 \text{ gr}}\right) \left(\frac{23,141 \text{ ft}^3}{\text{min}}\right) \left(\frac{60 \text{ min}}{\text{hr}}\right) = \boxed{0.134 \text{ lb/hr}}$$

$$\left(\frac{0.134 \text{ lb}}{\text{hr}}\right) \left(\frac{0.45359 \text{ kg}}{\text{lb}}\right) = 0.0606 \text{ kg/hr}$$

CALCULATION OF TOT. CHROME CONCENTRATIONS & EMISSION RATES

RUN I-1

SAMPLE VOLUME = 151.110 ft³ = 4.279 dNm³

SAMPLE CONC. = 10.2 mg/L

BLANK CONC. = < 0.02 mg/L

SOLUTION VOLUME = 0.698 L

TOTAL MASS IN SAMPLE

(10.2 mg/L - 0.02 mg/L) (0.698 L) = 7.106 mg-TOT. Cr

CONCENTRATION

(7.106 mg) (.0154 g/mg) / 151.110 ft³ = 0.000724 g/dscft

7.106 mg / 4.279 dNm³ = 1.661 mg/dNm³

EMISSION RATE

(0.000724 g/ft³) (1 lb / 7000 g) (22,633 ft³ / min) (60 min / hr) = 0.14045 lb/hr

(0.14045 lb/hr) (0.45359 kg / lb) = 0.0637 kg/hr

RUN I-2

SAMPLE VOLUME = 155.638 ft³ = 4.407 dNm³

SAMPLE CONCENT. = 6.93 mg/L

BLANK CONC. = < 0.02 mg/L

SOLUTION VOLUME = 0.770 L

TOTAL MASS IN SAMPLE

$$\left(\frac{6.93 \text{ mg}}{\text{L}} - \frac{0.02 \text{ mg}}{\text{L}}\right)(0.770 \text{ L}) = 5.321 \text{ mg tot. Cr}$$

CONCENTRATION

$$\frac{(5.321 \text{ mg})(0.0154 \text{ g/mg})}{155.638 \text{ ft}^3} = \boxed{0.000526 \text{ g/dscf}}$$

$$\frac{5.328 \text{ mg}}{4.407 \text{ dNm}^3} = \boxed{1.209 \text{ mg/dNm}^3}$$

EMISSION RATE

$$\left(\frac{0.000526 \text{ g}}{\text{ft}^3}\right)\left(\frac{1 \text{ lb}}{7000 \text{ g}}\right)\left(\frac{23,183 \text{ ft}^3}{\text{min}}\right)\left(\frac{60 \text{ min}}{\text{hr}}\right) = \boxed{0.1046 \text{ lb/hr}}$$

$$\left(\frac{0.1046 \text{ lb}}{\text{hr}}\right)\left(\frac{0.45359 \text{ kg}}{\text{lb}}\right) = \boxed{0.0475 \text{ kg/hr}}$$

RUN I-3

$$\text{SAMPLE VOLUME} = 155.156 \text{ ft}^3 = 4.394 \text{ dNm}^3$$

$$\text{SAMPLE CONC.} = 9.52 \text{ mg/L}$$

$$\text{BLANK CONC.} = 0.02 \text{ mg/L}$$

$$\text{SOLUTION VOLUME} = 0.672 \text{ L}$$

TOTAL MASS IN SAMPLE

$$\left(\frac{9.52 \text{ mg}}{\text{L}} - \frac{0.02 \text{ mg}}{\text{L}}\right)(0.672 \text{ L}) = 6.384 \text{ mg tot chrome}$$

CONCENTRATION

$$\frac{(6.384 \text{ mg})(0.0154 \text{ g/mg})}{155.156} = \boxed{0.000634 \text{ g/dscf}}$$

$$\frac{6.384 \text{ mg}}{4.394 \text{ dNm}^3} = \boxed{1.453 \text{ mg/dNm}^3}$$

EMISSION RATE

$$\left(\frac{0.000634 \text{ gr}}{\text{ft}^3}\right) \left(\frac{1 \text{ lb}}{7000 \text{ gr}}\right) \left(\frac{23,161 \text{ ft}^3}{\text{min}}\right) \left(\frac{60 \text{ min}}{\text{hr}}\right) = \boxed{0.126 \text{ lb/hr}}$$

$$\left(\frac{0.126 \text{ lb}}{\text{hr}}\right) \left(\frac{.45359 \text{ kg}}{\text{lb}}\right) = \boxed{0.0571 \text{ kg/hr}}$$

APPENDIX C
Laboratory Analytical Results



PEI Associates, Inc.
 11499 Chester Rd.
 Cincinnati, OH 45246
 (513) 782-4700

APR 14 1987

Client: Peer Consultants
 4134 Linden Avenue
 Suite 202
 Dayton, Ohio 45432

Project No.: 4761
 Requisition No.: T7-03-136
 Date Received: 3/23/87
 Sampled by: Client
 Date Reported: 4/14/87

Attn: Ms. Helen Owens

Sample ID	PEI No.	Total Chromium, mg/l	Hexavalent Chromium, mg/l
Run 1-1 Tank 1	01A	153,000	150,000
Run 1-1 Tank 2	02A	147,000	160,000
Run 1-1 Tank 3	03A	157,000	153,000
Run 1-2 Tank 1	04A	152,000	152,000
Run 1-2 Tank 2	05A	151,000	154,000
Run 1-2 Tank 3	06A	146,000	160,000
Run 1-3 Tank 1	07A	151,000	158,000
Run 1-3 Tank 2	08A	151,000	158,000
Run 1-3 Tank 3	09A	138,000	160,000
Run 1-1 Emission Sample	10A	10.2	12.0
Run 1-2 Emission Sample	11A	6.93	7.42
Run 1-3 Emission Sample	12A	9.52	10.1
Blank for Run 1&2	13A	<0.02	0.011
Blank for Run 3	14A	<0.02	0.013

Submitted by: *Cyrus Sims-Becker*



PEI Associates, Inc.
 11499 Chester Rd.
 Cincinnati, OH 45246
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APR 14 1987

Client: Peer Consultants
 4134 Linden Avenue
 Suite 202
 Dayton, Ohio 45432

Project No.: 4761
 Requisition No.: T7-03-137
 Date Received: 3/23/87
 Sampled by: Client
 Date Reported: 4/14/87

Attn: Ms. Helen Owens

Sample ID	PEI No.	Hexvalent Chromium, ug
Filter #AC-2	01A	<0.8
Filter #AC-2A	02A	<0.8
Filter #AC-4	03A	<0.8
Filter #AC-4A	04A	<0.8
Filter #BC-6	05A	1.3
Filter #BC-6A	06A	<0.8
Filter #DC-5	07A	<0.8
Filter #DC-5A	08A	0.9
Filter #EC-1	09A	<0.8
Filter #EC-1A	10A	<0.8
Filter #EC-3	11A	6.5
Filter #EC-3A	12A	<0.8
Blank Filter #1	13A	<0.8
Blank Filter #2	14A	<0.8
Blank Filter #3	15A	<0.8

Submitted by: *Caprice Sims-Bearden*



PEI Associates, Inc.
 11499 Chester Rd.
 Cincinnati, OH 45246
 (513) 782-4700

APR 14 1987

Client: Peer Consultants
 4134 Linden Avenue
 Suite 202
 Dayton, Ohio 45432

Project No.: 4761
 Requisition No.: T7-03-137
 Date Received: 3/23/87
 Sampled by: Client
 Date Reported: 4/14/87

Attn: Ms. Helen Owens

Sample ID	PEI No.	Hexvalent Chromium, ug
NaOH Sample #AC-2	16A	1.8
NaOH Sample #AC-2A	17A	8.0
NaOH Sample #AC-4	18A	<0.8
NaOH Sample #AC-4A	19A	<0.8
NaOH Sample #BC-6	20A	<0.8
NaOH Sample #BC-6A	21A	7.0
NaOH Sample #DC-5	22A	18.2
NaOH Sample #DC-5A	23A	1.9
NaOH Sample #EC-1	24A	12
NaOH Sample #EC-1A	25A	<0.8
NaOH Sample #EC-3	26A	14.1
NaOH Sample #EC-3A	27A	0.9
NaOH Sample #AP-6	28A	<0.8
NaOH Sample #AT-6	29A	1.6
NaOH Sample #BP-2	30A	<0.8
NaOH Sample #BP-4	31A	2.2
NaOH Sample #BT-2	32A	1.5
NaOH Sample #BT-4	33A	1.0
NaOH Sample #CP-5	34A	<0.8
NaOH Sample #CT-5	35A	2.0
NaOH Sample #FP-1	36A	<0.8
NaOH Sample #FP-3	37A	<0.8
NaOH Sample #FT-1	38A	<0.8
NaOH Sample #FT-3	39A	<0.8
NaOH Blank	40A	<0.008 mg/l

Submitted by: *Cynthia Sims-Bender*

LABORATORY DATA

Client Monsanto, Penn. Consultants
 PN 4730; 4761 Date 4/4/87
 Analyst L. Stephenson



Analysis CR + 6
 Method Number _____
 Checker Lmn rds

	Height	Final Volume	abs @ 540	% from Curve	% total CR + 6	
T7-04-044 - 01A	10	50	0.028	1.0258	0.1026	
spike	↓		0.275	10.5952	95.69% Rec'y	
01A	50		0.6199	0.134	5.1335	0.0124
spike	↓		6.7712	0.292	11.2535	67.41% Rec'y
Blank	↓		0.118	4.5126		
T7-03-137-21A	25		0.002	0.0187	0.0007	
spike	↓		0.258	9.9365	99.36% Rec'y	
02A			0.006	0.1734	0.0069	
spike	↓		0.264	10.1240	101.69% Rec'y	
03A			0.002	0.0187	0.0007	
spike	↓		0.259	9.9753	99.75% Rec'y	
04A			0.003	0.0572	0.0033	
spike	↓		0.261	10.0528	100.53% Rec'y	
05A			0.010	0.3284	0.0131	
spike	↓		0.258	9.9365	96.05% Rec'y	
Std's Curve:						
Stock 22, Thru	0		0.000	0		
	1		0.130	5		
	2		0.253	10		
	3		0.393	15		
	4	C-5	0.512	20		
	5	✓	0.648	25		
For Detection Limit			0.0035	0.1928		

1	0	0
2	5	.18
3	10	.262
4	15	.373
5	20	.512
6	25	.648

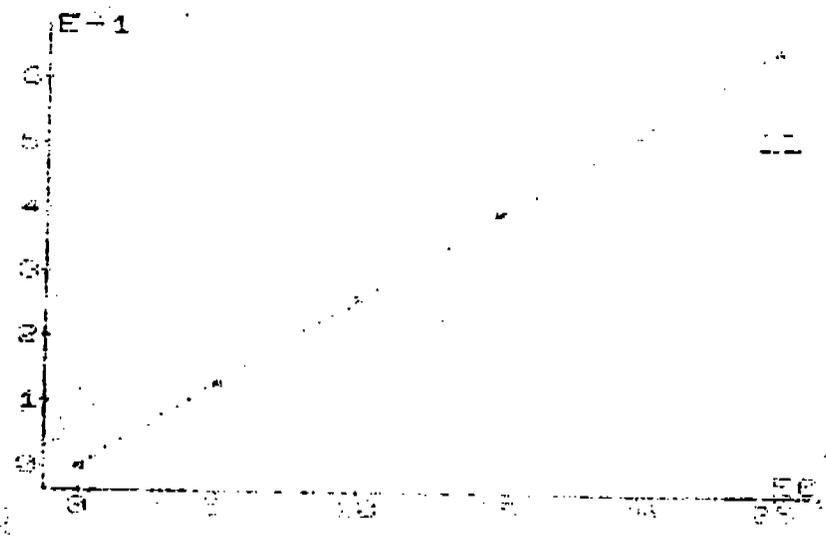
STANDARD ERROR (Y: N) 7 <>

REGRESSIONS ARE A=1.51380943E-03 B=1.02581101E-06
 COEFFICIENT OF DETERMINATION = .997759318
 COEFFICIENT OF CORRELATION = .999094903
 STANDARD ERROR OF ESTIMATE = 3.91394632E-03

STANDARD ERROR (Y: N) 7 <>

X	Y	VALUE	MULTIPLIER
1	6.5E-03	.192790203	1
2	.028	1.02575456	1
3	.275	10.595159	1
4	.134	5.15246255	1
5	.292	11.253782	1
6	.118	4.5125821	1
7	2E-03	.0184488264	1
8	.258	9.93653605	1
9	6E-03	.173418939	1
10	.244	10.1689912	1
11	2E-03	.0184488264	1
12	.257	9.97527858	1
13	4E-03	.0871913846	1
14	.261	10.0527636	1
15	.0	.328369052	1
16	.258	9.93653605	1

STANDARD ERROR (Y: N) 7 <>



LABORATORY DATA

Client Lees Consultants
 PN 4761 Date 4/7/87
 Analyst L. Stephens



Analysis Ce +6
 Method Number _____
 Checker _____

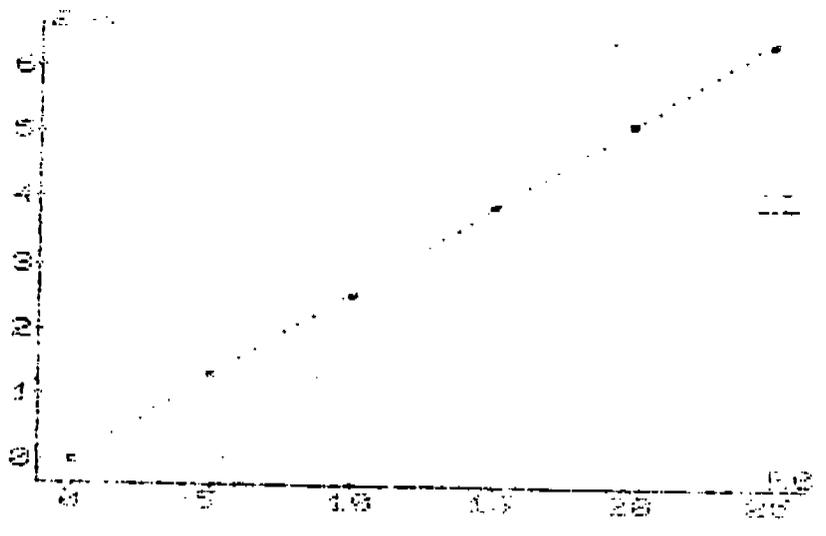
	Aliquot	Total Volume	A.L.S @ 540nm	Ng/ml Sp. from Curve	Ng/ml Ce +6
77-03-137-06A	25	50	0.005	<0.1933	<0.0077
07A			0.003		
08			0.007	0.2247	
09			0.004	<0.1933	<0.0077
10			0.004		
10 Dup			0.003		
10					
11			0.043	1.2232	0.0651
11 Dup			0.300	11.6366	100.1704
12			0.004	<0.1933	<0.0077
13			0.002		
14			0.004		
15			0.001		
<i>Slide Curve</i>					
Dupe/20, then	0		0.000	0	
	1		0.131	5	
	2		0.256	10	
	3		0.389	15	
	4		0.516	20	
	5		0.641	25	
For Direct Limit			0.0062	0.1933	0.0077

1	0	0
2	5	.131
3	10	.256
4	15	.389
5	20	.516
6	25	.641

COEFFICIENTS ARE R = 1.2E-03 L = 0.0256742857
 COEFFICIENT OF DETERMINATION = .999729202
 COEFFICIENT OF CORRELATION = .9999646
 STANDARD ERROR OF ESTIMATE = 2.25935731E-03
 SATISFACTORY (Y: N) ?

Y	VALUE	MULTIPLIER
1	6.2E-03	.193263092
2	5E-03	.14852412
3	3E-03	.0686252657
4	7E-03	.224425174
5	4E-03	.107574743
6	4E-03	.107574743
7	3E-03	.0686252657
8	.043	1.62660434
9	.3	11.6366199
10	4E-03	.107574743
11	2E-03	.0292737007
12	4E-03	.107574743
13	1E-03	OUT OF RANGE

MORE UNKNOWN (Y: N) ?



LABORATORY DATA

Client Peer Consultants

PN 4761 Date 3-30-87

Analyst P. DuckRata



Analysis Hexavalent Chrome.

Method Number 307 B

Checker Wm. J. ...

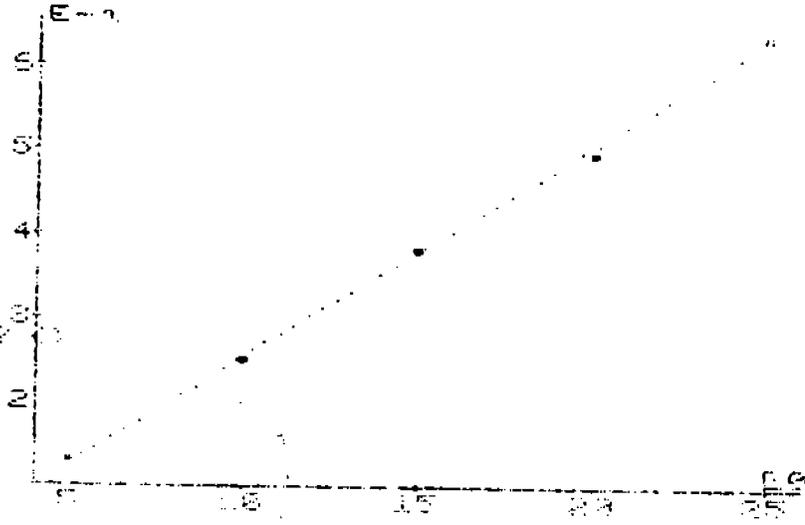
Sample ID	Run #	Total Volume	Aliquot ml's	Abs.	µg/ml	µg
STP 5.0 µg				.129		
10.0				.251		
15.0				.392		
20.0				.496		
25.0				.637		
77-03-137-16A	AC-2	90 ml's	25	.013	0.50	45
17A	AC-2A	91		.056	2.32	211
18A	AC-4	95		.003	0.12	11
19A	AC-4A	94		.000	0.00	0
20A	BC-6	98		.000	0.00	0
20A (R)				.001		
21A	BC-6A	93		.048	1.91	177
21A (+spike)				.266	10.64	968
22A	DC-5	96		.120	4.80	432
23A	DC-5A	93		.013	0.50	45
24A	EC-1	95		.032	1.28	115
25A	EC-1A	89		.004	0.16	15
26A	EC-3	85		.105	4.20	378
27A	EC-3A	100		.006	0.24	22
28A	AP-6	99		.003	0.12	11
29A	AT-6	95		.011	0.44	40
30A	BP-2	87		.000	0.00	0
30A (R)				.000		
31A	BP-4	94		.015	0.60	54
31A (+spike)				.235	9.40	855
32A	BT-2	99		.010	0.40	36
33A	BT-4	99		.007	0.28	25
34A	CP-5	92		.000	0.00	0
35A	CT-5	98		.013	0.50	45
36A	FP-1	92	C-9	.001	0.04	4
37A	FP-3	99		.001	0.04	4
38A	FT-1	93		.002	0.08	7
39A	FT-3	100		.003	0.12	11

X= Y=
 5 .129
 10 .251
 15 .392
 20 .496
 25 .557

PROPERTY: NIP

	VALUE	NUMBER
1E-01	OUT OF RANGE	
1E-02	OUT OF RANGE	
3E-02	OUT OF RANGE	
0	OUT OF RANGE	
0	OUT OF RANGE	
1E-03	OUT OF RANGE	
.048	OUT OF RANGE	
.056	21.0386581	
.10	OUT OF RANGE	
.000	OUT OF RANGE	
.001	OUT OF RANGE	
4E-03	OUT OF RANGE	
.100	OUT OF RANGE	
6E-02	OUT OF RANGE	
6E-03	OUT OF RANGE	
.01	OUT OF RANGE	
0	OUT OF RANGE	
0	OUT OF RANGE	
.001	OUT OF RANGE	
.000	18.5804917	
.10	OUT OF RANGE	
7E-03	OUT OF RANGE	
0	OUT OF RANGE	
.013	OUT OF RANGE	
1E-01	OUT OF RANGE	
1E-05	OUT OF RANGE	
1E-03	OUT OF RANGE	
3E-03	OUT OF RANGE	
2E-03	OUT OF RANGE	

TIME UNKNOWN (Y: 0) ?



LABORATORIUM UATM

Client Pera Consultant
 PN 4761 Date 4/7/87
 Analyst Sy. S. D. Phoenix



Analysis C₁ +6
 Method Number _____
 Checker Leopold

	Liquid	Total Volume	AT-5 6 540nm	μg from Curve	μg total C ₁ +6	
77-03--136--C1	141:10:00	50	0.394	15.0093	150.198	15.02
C2			0.419	15.9515	159.815	15.95
C3			0.400	15.2566	152.566	15.25
C4			0.393	15.1737	151.737	15.17
C5			0.403	15.3260	153.660	15.32
C6 Dip			0.407	15.5199	155.199	15.52
C6			0.420	16.0200	160.200	16.02
C7			0.413	15.7507	157.507	15.75
C8			0.414	15.7892	157.892	15.79
C9			0.419	15.9815	159.815	15.98
C10	5 of 1:10		0.160	6.0178	12.0356	
C10 up to	+6.1	+6.1	0.413	15.8661	98.4814	98.48
C11			0.100	3.7096	7.4192	
C12			0.135	5.0561	10.1122	
C13	2.5		0.018	0.2858	0.0114	
C14			0.012	0.3242	0.0130	
<u>Stand Curve:</u>						
Start per then	0		0.000	0		
	1		0.138	5		
	2		0.265	10		
	3		0.392	15		
	4		0.522	20		
	5		0.654	25		
For concentration		C-13	0.0054	0.1234	0.0077	

N	AF	YH
1	0	0
2	3	.138
3	10	.265
4	15	.392 ✓
5	20	.522
6	25	.654

PL(0) STANDARDS (Y:N)? Y

COEFFICIENTS ARE A=1.57467843E-03 B=1.0114942E-07

COEFFICIENT OF DETERMINATION = .999866449

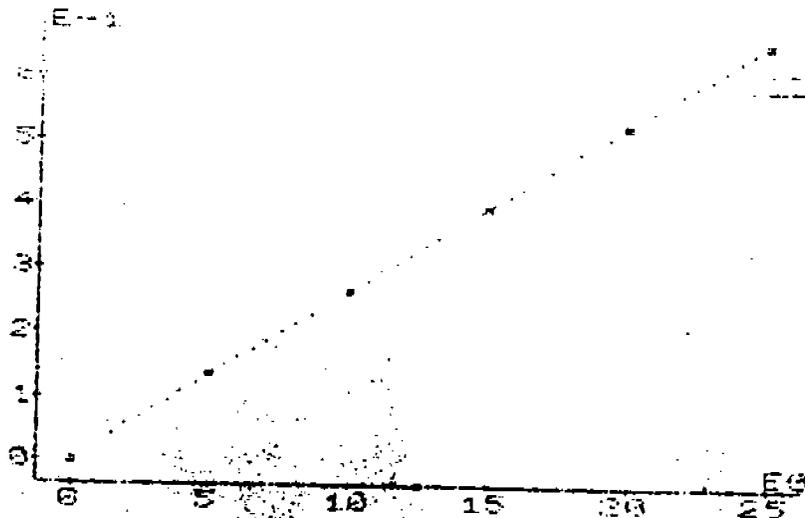
COEFFICIENT OF CORRELATION = .999933222

STANDARD ERROR OF ESTIMATE = 3.14187971E-03

SAISFACTORY (Y:N)? <>

#	YH	VALUE	MULTIPLIER
1	0.00E+00	15.3449115	1
2	.094	15.0197846	1
3	.419	15.9815344	1
4	.4	15.2506048	1
5	.398	15.1736605	1
6	.403	15.3660145	1
7	.407	15.5198945	1
8	.42	16.0200044	1
9	.413	15.7507145	1
10	.414	15.7891845	1
11	.419	15.9815344	1
12	.14	6.01780611	1
13	.15	15.8661244	1
14	.1	3.70960651	1
15	.108	5.05605626	1
16	.011	.285777099	1
17	.012	1.324247092	1

ARE LINKNOWN (Y:N)? <>



INDUCTIVELY COUPLED PLASMA
ANALYTICAL REPORT

Client: Peer Consultants
PN: 4761

Date of Analysis: 4-9-87
W.O.# T7-03-136

Rgt Blk		O_Cr_	
	mean	-0.0055	
	units	mg/l	<.0199
PEI #3 prp		O_Cr_	
	mean	0.9834	
	units	mg/l	
3-136-1a1:100		O_Cr_	
	mean	15.3100	
	units	mg/l = 1531	153100 mg/l
136-2a 1:100		O_Cr_	
	mean	14.7250	
	units	mg/l = 147250	mg/l
136-3a 1:100		O_Cr_	
	mean	15.7250	
	units	mg/l = 157250	mg/l
136-4a 1:100		O_Cr_	
	mean	15.2200	
	units	mg/l = 152200	mg/l
136-5a 1:100		O_Cr_	
	mean	15.0850	
	units	mg/l = 150850	mg/l
136-6a 1:100		O_Cr_	
	mean	14.6350	
	units	mg/l 146350	mg/l
136-7a 1:100		O_Cr_	
	mean	15.3200	
	units	mg/l 153200	mg/l
136-7aR 1:100		O_Cr_	
	mean	14.9100	
	units	mg/l 149100	mg/l
136-8a 1:100		O_Cr_	
	mean	15.1200	
	units	mg/l 151200	mg/l
136-9a 1:100		O_Cr_	
	mean	13.7500	
	units	mg/l 137500	mg/l

136-10a		O_Cr_
	mean	10.2000
	units	mg/l
136-11a		O_Cr_
	mean	6.9260
	units	mg/l
136-11a +1		O_Cr_
var 5' 10/500	mean	7.6655
	units	mg/l : 84.390
136-12a		O_Cr_
	mean	9.5220
	units	mg/l
136-13a		O_Cr_
	mean	-0.0015
	units	mg/l
	status	window edge
		<.0199
136-14a		O_Cr_
	mean	-0.0044
	units	mg/l
		<.0199

VLAB

INDUCTIVELY COUPLED PLASMA
Q.C. DATA

Client: Crown Cntrl. Peer Consultants
PN: 6310,4761

Date of Analysis: 4-9-87

Cal Blk		O_Cr_	O_Pb_
	mean	-0.0018	0.0438
	units	mg/l	mg/l
	status	window edge	<.0528
		<.0199	
Chk Std #1		O_Cr_	O_Pb_
	mean	2.5370	5.0765
	units	mg/l	mg/l
PEI #3		O_Cr_	O_Pb_
	mean	0.9899	1.0057
	units	mg/l	mg/l
Cal Blk		O_Cr_	O_Pb_
	mean	-0.0000	-0.0007
	units	mg/l	mg/l
	status	window edge	<.0828
		<.0199	
Chk Std #1		O_Cr_	O_Pb_
	mean	2.5365	5.0720
	units	mg/l	mg/l
Cal Blk		O_Cr_	O_Pb_
	mean	0.0034	-0.0021
	units	mg/l	mg/l
		<.0199	<.0828
Chk Std #1		O_Cr_	O_Pb_
	mean	2.5805	5.2735
	units	mg/l	mg/l
PEI #3		O_Cr_	O_Pb_
	mean	1.0022	1.0096
	units	mg/l	mg/l

APPENDIX D
Determination of Cr⁺⁶ and Total Cr Emissions

APPENDIX D
DETERMINATION OF Cr⁶ AND TOTAL Cr EMISSIONS

The following sample and analytical procedures were used during this test program. Sampling procedures generally followed those described in the EPA Test Method 13B (MM 13B).¹ The sample train used at the evaporator/scrubber inlet test location was assembled by test crew personnel and consisted of the following items:

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

Probe - Borosilicate glass without a heating system.

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

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

Draft Gauge - An incline manometer made by Dwyer with a range of 0 to 10 inches of H₂O.

Impingers - Four Greenburg-Smith impingers connected in series with glass ball joints. The second impinger was of the standard Greenburg-Smith design. The first, third, and fourth impingers were of the Greenburg-Smith design, but modified by replacing the tip with a

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

1/2-inch i.d. glass tube extending to 1/2-inch from the bottom of the flask.

Metering System - Vacuum gauge, dry gas meter, leak-free pump, thermometers and related equipment to maintain an isokinetic sampling rate and to determine the sample volume.

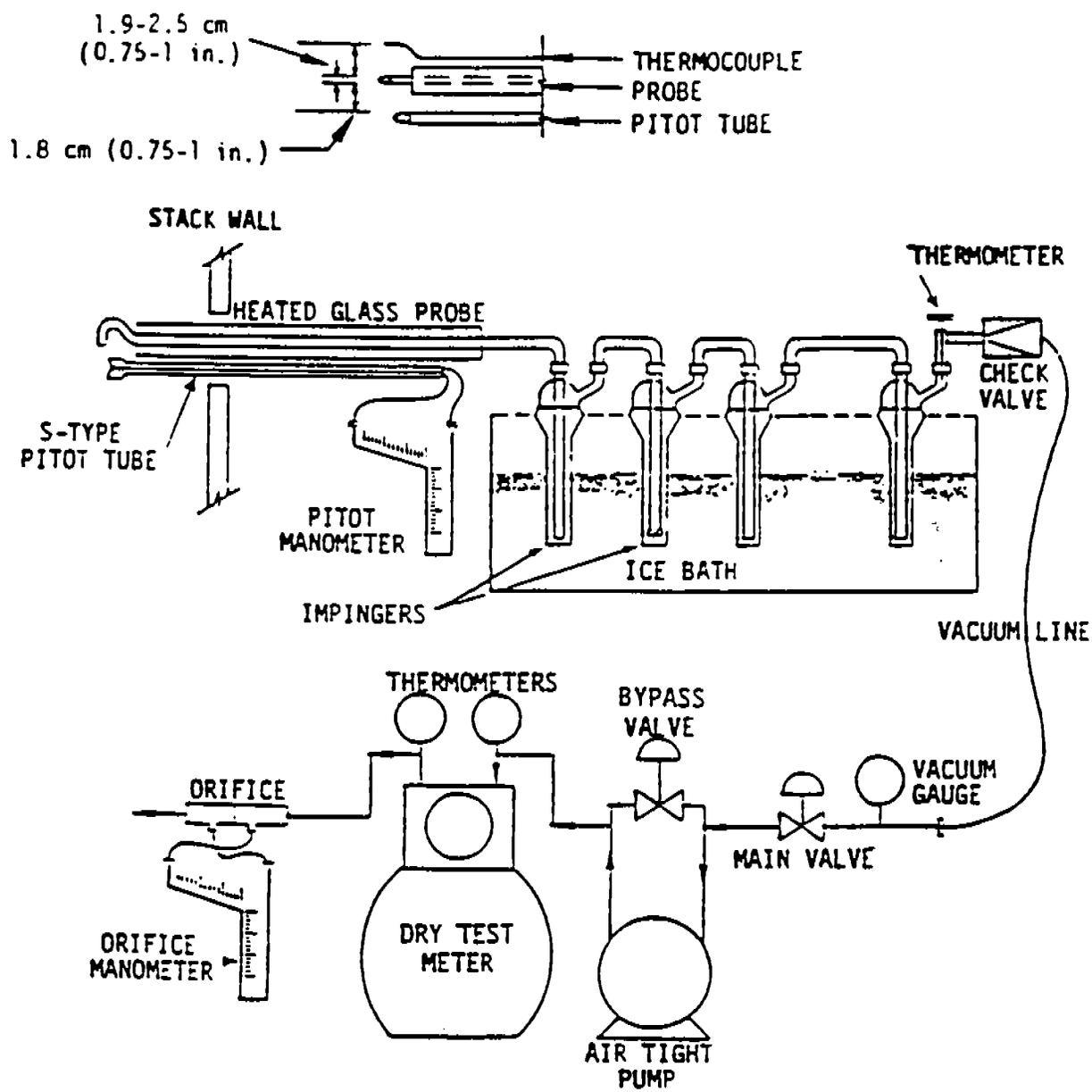
Barometer - Aneroid type to measure atmospheric pressures to within (approximately) 2.5 mm Hg (approximately 0.1 in. Hg).

Sampling Procedures

Prior to departure, all glassware used in this study was washed with 10 percent nitric acid to minimize the potential for contamination. On hundred mL of 0.1 N NaOH was placed in each of the first three impingers; approximately 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- to 16-inch 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 three or more inches of water was recorded on the manometer and then capping the impact opening and holding it for 15 seconds to assure that it was leak free. The static pressure side of the pitot tube was leak checked using the same procedure, except suction was used to obtain the 3-inch H₂O manometer reading. Crushed ice was placed around the impingers to keep the temperature of the gases leaving the impinger at 68°F (20°C) or less.

During sampling, stack gas and sampling train data were recorded at each sampling point to monitor when significant changes in stack flow conditions



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.

occurred so proper adjustments could be made. Isokinetic sampling rates were set throughout the sampling period with the aid of a nomograph.

Sample Recovery Procedures

The MM 13B trains were moved carefully from the test site to the designated cleanup/recovery area. The cleanup area was located in the plant in an area isolated from possible contamination and when possible, sample recovery was done in the cleanup van.

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

Container No. 1 - The nozzle and probe were rinsed with 0.1N NaOH and brushed with a nylon brush. This rinseate was collected in a polyethylene bottle. The inter-connecting glassware was rinsed with 0.1 NaOH and combined with the probe and nozzle rinses. After the impingers were weighed, their contents were combined with the rinseates from the nozzle, probe and glassware in the sample bottle. The impingers were also rinsed with 0.1N NaOH and this rinseate was combined with the rinses from the other sample train constituents in the polyethylene sample bottle.

Container No. 2 - Approximately 400 mL of 0.1 N NaOH was taken during each sample recovery activity 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 recent developed by the 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 3050.²

Prior to analysis, 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/N₂CO₃ 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 care was taken to avoid evaporating the solution to dryness.

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 small aliquot of the prepared sample was transferred to a volumetric flask. A two percent volume-to-volume ratio of diphenylcarbazide solution was added. The solution was allowed to stand for approximately 10 minutes for color development. A portion of the sample was transferred to a 1-cm absorption cell, which was placed in the spectrophotometer. The absorbance was then measured at the optimum wavelength using the blank solution as zero reference.

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

Sample Analysis - Total Chromium

The filtrates from the impinger contents (Container 1) were analyzed for total Cr using preparation described in EPA Method 3050.² Inductively Coupled Argon Plasma (ICAP) spectroscopy techniques were used for sample analysis.

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

APPENDIX E
Equipment Calibration

PRETEST CALIBRATION DATA

DRY GAS METER AND ORIFICE CALIBRATION

Date: 2/24/87 Box No.: RAC 106.5
 Barometric Pressure, $P_b = 30.15$ in. Hg Dry Gas Meter No.:

Orifice Manometer Setting, ΔH , in. H ₂ O	Gas Vol. Wet Test Meter V_w , ft ³	Gas Vol. Dry Gas Meter V_d , ft ³	Temperature				Time θ , min.	Y	ΔH_e
			Wet Test Meter t_w , °F	Dry Gas Meter					
				Inlet t_{di} , °F	Outlet t_{do} , °F	Average t_d , °F			
0.5	3.905	4.041	72.5	87	77.5	80.8	10.0	0.980	1.81
1.0	5.612	5.846	73.5	93.5	77.5		10.0	0.979	1.74
2.0	7.578	7.924	74.0	97.5	80.5		10.0	0.978	1.90
4.0	11.028	11.508	75.0	100.0	82.0		10.0	0.978	1.80
6.0									
8.0	14.801	15.287	75.0	108.0	86.0		10.0	0.989	1.97
Average								0.981	1.84

Calculations:

ΔH	$\frac{\Delta H}{13.6}$	Y	ΔH_e
		$\frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$	$\frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460) e}{V_w} \right]^2$
0.5	0.0368	$\frac{(3.905)(30.15)(541)}{(4.041)(30.19)(533)}$	
1.0	0.0737	$\frac{(5.612)(30.15)(541)}{(5.846)(30.19)(533)}$	
2.0	0.147		
4.0	0.294		
6.0	0.431		
8.0	0.588		

Y = ratio of accuracy of wet test meter to dry test meter. Tolerance = 0.01.

ΔH_e = orifice pressure differential that gives 0.75 cfm of air at 70°F and 29.92 inches of mercury, in. H₂O. Tolerance = 0.15.



TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-13-87 Thermocouple number RAC 1 RAC 1065

Ambient temperature _____ °C Barometric pressure _____ in. Hg

Calibrator M. J. J. J. Reference: mercury-in-glass _____
other _____

Reference point number ^a	Source ^b (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, % ^c
Meter Inlet	AMBIENT	76 °F (24.4)	74 °F (23.3)	0.37
Meter Outlet		76 °F (24.4)	76 °F (24.4)	0

^aEvery 30°C (50°F) for each reference point.

^bType of calibration system used.

^c
$$\left[\frac{(\text{ref temp, } ^\circ\text{C} + 273) - (\text{test thermom temp, } ^\circ\text{C} + 273)}{\text{ref temp, } ^\circ\text{C} + 273} \right] 100 \leq 1.5\%$$



PITOT TUBE CALIBRATION DATA SHEET

Calibrated By: *J. M. Anderson*

Date: 3-15-87

Pitot I.D. No.: S-1

Effective Length: 2'

Pitot Tube Assembly Level? Yes ✓ No _____

Pitot Tube Openings Damaged? Yes (explain below) _____ No ✓

$\alpha_1 =$ 0 ° (<10°) $\alpha_2 =$ 1 ° (<10°)

$\beta_1 =$ 1 ° (<5°) $\beta_2 =$ 2 ° (<5°)

$\gamma =$ _____ ° $\theta =$ _____ ° $A =$ _____ °

$z = A \sin \theta =$.03 cm (in.) 0.32 cm (<1/8 in.)

$w = A \sin \gamma =$ 0 cm (in.) 0.08 cm (<1/32 in.)

$P_A =$ 0.452 cm (in.)

$P_B =$ 0.452 cm (in.)

$D_t =$ 0.375 cm (in.)

Comments: _____

Calibration Required? Yes _____ No ✓



PITOT TUBE CALIBRATION DATA SHEET

Calibrated By: *A. M. Jones*

Date: 3/15/87

Pitot I.D. No.: S-2

Effective Length: PITOT TIP ONLY 7"

Pitot Tube Assembly Level? Yes No

Pitot Tube Openings Damaged? Yes (explain below) No

$\alpha_1 = \underline{0}^\circ (<10^\circ)$ $\alpha_2 = \underline{0}^\circ (<10^\circ)$

$\beta_1 = \underline{1}^\circ (<5^\circ)$ $\beta_2 = \underline{3}^\circ (<5^\circ)$

$Y = \underline{\hspace{2cm}}^\circ$ $\theta = \underline{\hspace{2cm}}^\circ$ $A = \underline{\hspace{2cm}}^\circ$

$z = A \sin \theta = \underline{0.050} \text{ cm (in.)}$ 0.32 cm (<1/8 in.)

$w = A \sin \alpha = \underline{0} \text{ cm (in.)}$ 0.08 cm (<1/32 in.)

$P_A = \underline{0.467} \text{ cm (in.)}$

$P_B = \underline{0.469} \text{ cm (in.)}$

$D_t = \underline{0.375} \text{ cm (in.)}$

Comments: _____

Calibration Required? Yes No
E-6

TEMPERATURE SENSOR CALIBRATION DATA FORM

SAMPLE HEAD

Date 3-15-87 Thermocouple number SH-1

Ambient temperature _____ °C Barometric pressure _____ in. Hg

Calibrator P. Madala Reference: mercury-in-glass _____

other _____

Reference point number ^a	Source ^b (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, % ^c
1	AMBIENT	70.6 °F (21.4)	71 °F (21.7)	→ 0.1 %

^aEvery 30°C (50°F) for each reference point.

^bType of calibration system used.

^c
$$\left[\frac{(\text{ref temp, } ^\circ\text{C} + 273) - (\text{test thermom temp, } ^\circ\text{C} + 273)}{\text{ref temp, } ^\circ\text{C} + 273} \right] 100 < 1.5\%$$

POST-TEST CALIBRATION DATA

POSTTEST DRY GAS METER CALIBRATION DATA FORM

Date 3/25/57 Meter box number RAC-1065 Plant _____
 Barometric pressure, $P_b =$ 30.2 in. Hg Dry gas meter number _____ Pretest $Y =$ 0.981

Orifice manometer setting, (ΔH), in. H ₂ O	Gas volume		Temperature		Time (θ), min	Vacuum setting, in. Hg	Y_i	Y_i
	Ref. meter (V_w), ft ³	Dry gas meter (V_d), ft ³	Ref. meter (t_w), °F	Dry gas meter Inlet (t_{d_i}), °F				
0.70	63.541	347.795	73	93	84	5	0.985	$V_w P_b (t_d + 460)$ $V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)$
0.70	73.775	352.550	73	105	88	5	0.981	
0.70	74.274	352.274	73	122	85	5	0.997	
	74.313	352.266	73	124	91	5		
			73	109	93			$Y = 0.988$

^a If there is only one thermometer on the dry gas meter, record the temperature under t_d .

- V_w = Gas volume passing through the wet test meter, ft³.
- V_d = Gas volume passing through the dry gas meter, ft³.
- t_w = Temperature of the gas in the wet test meter, °F.
- t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F.
- t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F.
- t_d = Average temperature of the gas, in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o} , °F.
- ΔH = Pressure differential across orifice, in H₂O.
- Y_i = Ratio of accuracy of wet test meter to dry gas meter for each run.
- Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest $Y \pm 0.05Y$
- P_b = Barometric pressure, in. Hg.
- θ = Time of calibration run, min.

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 4-14-87 Thermocouple number RAC 1065
 Ambient temperature 74°F °C Barometric pressure 29.40 in. Hg
 Calibrator FM Reference: mercury-in-glass ASTM 15-67C
 other _____

Reference point number ^a	Source ^b (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, % ^c
METER INLET	Amb. AIR	74°F (23.3°C)	72°F (22.2°C)	0.37
METER OUTLET	Amb. AIR	74°F (23.3°C)	72°F (22.2°C)	0.37

^a Every 30°C (50°F) for each reference point.

^b Type of calibration system used.

^c
$$\left[\frac{(\text{ref temp, } ^\circ\text{C} + 273) - (\text{test thermom temp, } ^\circ\text{C} + 273)}{\text{ref temp, } ^\circ\text{C} + 273} \right] 100 \leq 1.5\%$$



TEMPERATURE SENSOR CALIBRATION DATA FORM

STACK

Date 4/11/87 Thermocouple number 37-1H
Ambient temperature 73°F °C Barometric pressure 29.4 in. Hg
Calibrator HWJ Reference: mercury-in-glass 15 167C
other

Reference point number ^a	Source ^b (specify)	Reference thermometer temperature, °C/F	Thermocouple potentiometer temperature, °C/F	Temperature difference, % ^c
1	ICE WATER	34°F	34°F	0
2	AMBIENT (AIR)	73°F	73°F	0
3	BOILING WATER	208°F	208°F	0
4	HEATED OIL	386°F	386°F	0

^a Every 30°C (50°F) for each reference point.

^b Type of calibration system used.

^c
$$\left[\frac{(\text{ref temp, } ^\circ\text{C} + 273) - (\text{test thermom temp, } ^\circ\text{C} + 273)}{\text{ref temp, } ^\circ\text{C} + 273} \right] 100 \leq 1.5\%$$

TEMPERATURE SENSOR CALIBRATION DATA FORM

SAMPLE HEAD

Date 11/14/87 Thermocouple number 511-1

Ambient temperature 70 °C Barometric pressure 27.4 in. Hg

Calibrator AWW Reference: mercury-in-glass 15.167C

other

Reference point number ^a	Source ^b (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference, % ^c
1	KE WATER	35°F	35°F	0
2	AMBIENT (AIR)	70°F	70°F	0

^a Every 30°C (50°F) for each reference point.

^b Type of calibration system used.

^c
$$\left[\frac{(\text{ref temp, } ^\circ\text{C} + 273) - (\text{test thermom temp, } ^\circ\text{C} + 273)}{\text{ref temp, } ^\circ\text{C} + 273} \right] \times 100 \leq 1.5\%$$

APPENDIX F

Project Participants and Activity Log

TABLE F-1. PROJECT PARTICIPANTS

Name	Title	Responsibility
F. Clay	Task Manager U.S. EPA - EMB	Coordinated test activity, on-site data reduction and calculations.
J. Swartzbaugh	PEER Consultants, P.C. Program Manager	Coordinated test activity with subcontractors and EPA, report preparation.
H. Owens	PEER Consultants, P.C. Project Leader	Coordinated test activity with EPA, MRI, PES and Delco personnel, report preparation.
A. Weisman	PEER Consultants, P.C. Technician	Collected process samples, sample recovery.
F. Meadows	PES Project Leader	Site leader for inlet testing, data reduction
R. Barker	MRI NSPS contractor	Monitored process operation and coordinated test activity.

TABLE F-2. ON-SITE ACTIVITY LOG

Date	Activity
03-16-87	Test crew and equipment travel to Livonia, Michigan, set up equipment, prepared site, conducted preliminary measurements.
03-17-87	No testing - process not operating.
03-18-87	Conducted two MM 13B and collected all relative process samples, monitored the process conditions.
03-19-87	Conducted one MM 13B, collected process samples, monitored process conditions, packed van, returned to home offices.

APPENDIX G

Analytical Methods For Determining
Cr⁺⁶ and Cr

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:

$$m = K_C \ 2AF \qquad \text{Eq. G-3}$$

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.

METHOD 3050

ACID DIGESTION OF SLUDGES

1.0 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, Be, Cd, Cr, Cu, Pb, Ni, and Zn. Nitric acid is employed as the final reflux acid for the furnace analysis of As, 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.

2 / WORKUP TECHNIQUES - Inorganic

- 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 250-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.

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, 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 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, 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.

APPENDIX H

Process Data Monitored During Tests

CALCULATION OF TOTAL CURRENT IN AMPERE-HOURS FOR RUN NO. 1

No. of plating cycles during test: 207-69 = 138
No. of bumpers plated during test: 1,162-119 = 1,043

A. Plating Cycle

Average current, 20,507 A per cycle
Average plating time, 2.00 min

1. Average Ampere-Hours for One Plating Cycle

Ah/cycle = (average current)*(plating time)
684 Ah/cycle = (20,507 amperes/cycle)*(2.00 min)*(1 h/60 min)

2. Average Ampere-Hours for all Plating Cycles

Ah = (Ah/cycle)*(No. of cycles)
94,392 Ah = (684 Ah/cycle)*(138 cycles)

B. Activation Cycle

Average current, 5,217 A per cycle
Average activation time, 15 s

1. Average Ampere-hours for One Activation Cycle

Ah/cycle = (average current)*(activation time)
21.74 Ah/cycle = (5,217 amperes/cycle)*(15 s)*(1 h/3,600 s)

2. Average Ampere-Hours for all Activation Cycles

Ah = (Ah/cycle)*(No. of cycles)
3,000 Ah = (21.74 Ah/cycle)*(138 cycles)

C. Total Ampere-Hours for Run No. 1

Ah = (Ah for plating cycles)+(Ah for activation cycles)
97,392 Ah = (94,392 Ah)+(3,000 Ah)

CALCULATION OF TOTAL CURRENT IN AMPERE-HOURS FOR RUN NO. 2

No. of plating cycles during test: $144-5 = 139$
No. of bumpers plated during test: $2,890-1,747 = 1,143$

A. Plating Cycle

Average current, 21,697 A per cycle
Average plating time, 2.00 min

1. Average Ampere-Hours for One Plating Cycle

$Ah/cycle = (\text{average current/cycle}) * (\text{plating time})$
 $723 Ah/cycle = (21,697 \text{ amperes/cycle}) * (2.00 \text{ min}) * (1 \text{ h}/60 \text{ min})$

2. Average Ampere-Hours all for Plating Cycles

$Ah = (Ah/cycle) * (\text{No. of cycles})$
 $100,497 Ah = (723 Ah/cycle) * (139 \text{ cycles})$

B. Activation Cycle

Average current, 5,217 A per cycle
Average activation time, 15 s

1. Average Ampere-Hours for One Activation Cycle

$Ah/cycle = (\text{average current}) * (\text{activation time})$
 $21.74 Ah/cycle = (5,217 \text{ amperes/cycle}) * (15 \text{ s}) * (1 \text{ h}/3,600 \text{ s})$

2. Average Ampere-Hours for all Activation Cycles

$Ah = (Ah/cycle) * (\text{No. of cycles})$
 $3,022 Ah = (21.74 Ah/cycle) * (139 \text{ cycles})$

C. Total Ampere-Hours for Run No. 2

$Ah = (Ah \text{ for plating cycles}) + (Ah \text{ for activation cycles})$
 $103,519 Ah = (100,497 Ah) + (3,022 Ah)$

CALCULATION OF TOTAL CURRENT IN AMPERE-HOURS FOR RUN NO. 3

No. of plating cycles during test: $(97-55)-(110-97)+(210-119) = 120$
No. of bumpers plated during test: $(315-0)-(382-315)-(1191-455) = 984$

A. Plating Cycle

Average current, 21,747 A per cycle
Average plating time, 2.00 min

1. Average Ampere-Hours for One Plating Cycle

Ah/cycle = (average current)*(plating time)
 $725 \text{ Ah/cycle} = (21,747 \text{ amperes/cycle}) * (2.00 \text{ min}) * (1 \text{ h}/60 \text{ min})$

2. Average Ampere-Hours for all Plating Cycles During Run No. 3

Ah = (Ah/cycle)*(No. of cycles)
 $87,000 \text{ Ah} = (725 \text{ Ah/cycle}) * (120 \text{ cycles})$

B. Activation Cycle

Average current, 5,217 A per cycle
Average activation time, 15 s

1. Average Ampere-Hours for One Activation Cycle

Ah/cycle = (average current)*(activation time)
 $21.74 \text{ Ah/cycle} = (5,217 \text{ amperes/cycle}) * (15 \text{ s}) * (1 \text{ h}/3,600 \text{ s})$

2. Average Ampere-Hours for all Activation Cycles

Ah = (Ah/cycle)*(No. of cycles)
 $2,609 \text{ Ah} = (21.74 \text{ Ah/cycle}) * (120 \text{ cycles})$

C. Total Ampere-Hours for Run No. 3

Ah = (Ah for plating cycles)+(Ah for activation cycles)
 $89,609 \text{ Ah} = (87,000 \text{ Ah}) + (2,609 \text{ Ah})$

SOURCE SAMPLING PROCESS DATA SHEET

Place: Delco Products Division
 General Motors Corporation
 Livonia, Michigan

Date: March 18, 1987

Test run No.: 1
 Test start time: 09:34
 Test stop time: 12:59

Counter Readings
 No. of bumpers (start): 119
 No. of bumpers (end): 1,162
 No. of plating cycles (start): 69
 No. of plating cycles (end): 207

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
09:35	1	128	26.0	19,000	
	2	128	24.0	20,000	
	3	128	26.0	20,000	
09:40	1	128	17.5	19,500	
	2	128	20.0	19,400	
09:45	3	128	24.0	21,000	
09:50	2	128	19.0	20,750	Grab samples of plating solution taken at 09:50
	3	128	22.5	20,250	
09:55	1	128	21.0	21,750	
	2	128	19.5	22,000	
10:00	1	130	20.5	21,000	
	2	130	21.0	20,500	
10:05	2	130	22.0	19,600	
	3	130	22.5	19,250	
10:10	3	130	24.0	19,000	
10:15	1	130	21.5	22,000	
	3	130	24.5	19,000	
10:20	1	130	22.0	21,750	Plating cycle: 2.0 min Activation cycle: 15 s
	2	130	19.5	20,500	
10:25	1	130	22.5	20,500	
	2	130	21.5	19,400	
10:30	2	130	21.0	18,800	
	3	130	22.0	20,750	
10:35	1	130	22.0	21,250	
	3	130	22.5	18,750	
10:40	1	130	22.5	21,250	
	2	130	20.0	19,800	
10:45	2	130	20.0	19,800	
	3	130	23.0	19,000	
10:50	1	130	23.5	20,750	Plating cycle: 2.08 min Activation cycle: 15 s
	2	130	20.0	19,050	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
10:55	1	130	24.5	20,300	
	2	130	20.5	19,200	
11:00	1	130	23.5	20,100	
	2	130	20.5	21,250	
11:05	2	130	20.0	20,250	
	3	130	22.0	18,750	
11:10	1	130	24.0	20,800	Grab samples of plating solution taken at 11:10
	2	130	20.5	19,400	
11:15	1	130	23.5	20,500	
	2	130	19.5	20,000	
11:20	2	130	21.0	20,000	
	3	130	25.0	19,750	
11:25	2	132	22.5	20,250	
	3	132	23.5	20,250	
11:30	3	132	24.0	21,500	Plating cycle: 2.08 min Activation cycle: 15 s
11:35	2	130	21.0	21,250	
	3	130	25.0	19,800	
11:40	1	130	22.5	21,000	
11:45	1	130	23.5	20,500	
	3	130	23.5	20,000	
11:50	1	130	23.5	21,250	
	2	130	22.0	21,500	
11:55	1	130	22.5	21,500	Stopped testing: 11:59 (electrical repair)
	2	130	20.0	20,050	
12:15	1	130	22.0	22,750	Started testing: 12:12
	2	130	20.0	21,250	
12:20	2	130	20.5	21,250	Plating cycle: 2.00 min Activation cycle: 15 s
	3	130	23.5	20,250	
12:25	1	130	23.5	22,000	
	3	130	25.5	21,750	
12:30	2	130	21.0	20,250	
	3	130	23.5	24,000	
12:35	1	130	24.0	21,250	
12:40	1	130	22.0	20,750	Grab samples of plating solution taken at 12:40
	3	130	24.5	22,000	
12:45	1	130	22.0	20,500	
	3	130	24.5	21,500	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
12:50	1	130	23.0	19,600	Plating cycle: 2.00 min Activation cycle: 15 s
	2	130	21.0	19,200	
12:55	2	130	21.0	22,000	
	3	130	24.5	19,500	
13:00	1	130	23.5	20,000	Testing stopped at 12:59
	3	130	22.5	23,250	
Average		130	22.3	20,507	

SOURCE SAMPLING PROCESS DATA SHEET

Place: Delco Products Division
 General Motors Corporation
 Livonia, Michigan

Date: March 18, 1987

Test run No.: 2
 Test start time: 14:37
 Test stop time: 18:51

Counter Readings
 No. of bumpers (start): 1,747
 No. of bumpers (end): 2,890
 No. of plating cycles (start): 5
 No. of plating cycles (end): 144

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
14:35	1	134	22.5	21,250	Started testing: 14:37
	2	134	20.8	20,500	
14:40	2	134	20.0	22,500	Stopped testing: 14:45 (Blown fuse) Started testing: 15:36
15:35	1	128	22.0	21,250	
	2	128	20.0	21,750	
15:40	1	130	22.5	24,250	
	2	130	19.5	22,750	
15:45	1	130	22.0	23,000	Grab samples of plating solution taken at 15:45
	3	130	23.0	22,750	
15:50	1	130	20.5	22,000	
	2	130	21.0	21,250	
15:55	2	130	19.0	22,500	Plating cycle: 2.00 min Activation cycle: 15 s at 5,000 amps, 10 volts
	3	130	23.5	20,250	
16:00	1	130	22.5	24,500	
	2	130	20.5	21,000	
16:05	1	130	22.5	21,000	
	2	130	20.5	21,250	
16:10	2	130	20.5	22,000	
	3	130	23.5	21,250	
16:15	1	130	23.5	22,250	Activation cycle: 15 s at 5,000 amps, 10 volts
16:20	1	130	24.0	21,000	
	2	130	21.0	20,250	
16:25	2	130	21.0	21,250	Stopped testing: 16:31 (Racking line down) Started testing: 16:34
	3	130	24.0	19,600	
16:35	1	130	23.0	20,500	Activation cycle: 15 s at 5,000 amps, 10 volts
	2	130	20.0	21,500	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
16:40	2	130	21.5	20,250	
	3	130	23.5	20,300	
16:45	2	130	21.0	19,000	Plating cycle: 2.00 min Activation cycle: 15 s
	3	130	25.5	20,350	
16:50	1	130	23.5	19,600	
	3	130	25.5	20,500	
16:55	1	130	23.5	20,750	
	3	130	25.0	21,500	
17:00	2	130	20.0	21,000	
	3	130	24.0	20,250	
17:05	1	130	23.5	19,600	Stopped testing: 17:10 (Electrical repair) Started testing: 17:21
	3	130	22.0	21,000	
17:20	1	130	21.0	19,000	
	3	130	24.5	19,600	
17:25	2	130	19.5	20,500	
	3	130	23.5	22,500	
17:30	3	130	23.5	24,000	
17:35	1	130	22.5	19,000	Grab samples of plating solution taken at 17:35
	3	130	24.5	21,750	
17:40	1	130	24.5	19,800	
	2	130	20.5	18,800	
17:45	1	130	20.5	18,200	
	2	130	20.0	23,750	
17:50	2	130	20.5	20,750	
	3	130	22.5	23,250	
17:55	1	130	24.0	22,250	
	3	130	21.5	23,500	
18:00	1	130	22.0	23,750	
	2	130	19.0	23,500	
18:05	2	130	20.0	21,250	
	3	130	23.0	23,500	
18:10	1	130	21.5	23,250	Plating cycle: 2.00 min Activation cycle: 15 s
	3	130	24.0	22,750	
18:15	1	130	22.5	24,500	
	2	130	19.0	23,000	
18:20	2	130	21.5	20,500	
	3	130	23.5	23,750	
18:25	3	130	23.5	24,750	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
18:30	1	130	22.5	22,250	Grab samples of plating solution taken at 18:30
	2	130	19.0	23,500	
18:35	2	130	21.0	22,000	
	3	130	22.5	23,500	
18:40	2	130	21.5	23,250	Plating cycle: 2.00 min Activation cycle: 15 s
	3	130	25.0	21,750	
18:45	1	130	22.0	24,250	
	2	130	20.5	20,200	
18:50	2	130	20.0	24,000	Testing stopped at 18:51
	3	130	24.0	22,250	
Average		130	22.0	21,697	

SOURCE SAMPLING PROCESS DATA SHEET

Place: Delco Products Division
 General Motors Corporation
 Livonia, Michigan

Date: March 19, 1987

Test run No.: 3
 Test start time: 09:45
 Test stop time: 15:49

Counter Readings
 No. of bumpers (start): 0
 No. of bumpers (end): 1,191
 No. of plating cycles (start): 59
 No. of plating cycles (end): 210

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
09:45	1	130	23.5	19,600	Started testing: 09:45
	3	130	24.5	22,000	
09:50	1	130	21.0	22,500	Activation cycle: 15 s at 5,500 amps, 9.5 volts
	2	130	17.5	19,800	
09:55	2	130	21.0	22,000	
	3	130	23.5	22,500	
10:00	2	130	20.0	24,500	Grab samples of plating solution taken at 10:00
	3	130	23.0	21,750	
10:05	1	130	22.0	23,500	Plating cycle: 2.00 min Activation cycle: 15 s at 5,800 amps, 10.0 volts
	2	130	20.0	23,000	
	3	130	23.5	23,500	
10:10	1	130	23.5	23,500	
	3	130	21.5	22,000	
10:15	1	130	24.0	23,000	Plating cycle: 2.00 min Activation cycle: 15 s at 5,000 amps
	2	130	20.0	21,500	
10:20	2	130	21.0	22,500	
	3	130	24.0	20,550	
10:25	1	130	23.0	21,750	Stopped testing: 10:31 (Conveyor down) Started testing: 10:35
	3	130	24.0	21,000	
10:35	1	130	24.0	20,250	Stopped testing: 10:41 (Conveyor down) Started testing: 10:46
	3	130	23.5	21,000	
10:45	1	130	23.5	21,750	Stopped testing: 10:51 (Conveyor down) Started testing: 13:34
	3	130	23.5	21,750	
13:35	1	130	23.0	22,500	No. of bumpers (stop): 315 No. of cycles (stop): 97
	2	130	20.0	21,500	
13:40	1	130	25.0	21,750	No. of bumpers (stop): 455 No. of cycles (start): 119
	2	130	22.0	19,850	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
13:45	2	130	22.0	22,000	
	3	130	23.0	21,000	
13:50	2	130	21.5	23,500	
	3	130	25.0	21,750	
13:55	1	130	22.5	21,050	
	3	130	24.0	20,750	
14:00	1	130	23.0	21,750	
	2	130	21.0	20,750	
14:05	1	130	23.5	23,500	
	2	130	21.5	20,300	
14:10	1	131	24.0	20,750	
	2	131	21.0	20,500	
14:15	2	131	20.5	22,500	
	3	131	23.5	20,250	
14:20	3	131	26.5	21,500	Stopped testing: 14:20 (electrical repair) Started testing: 14:21
14:25	2	131	23.0	21,750	Grab samples of plating solution taken at 14:20
14:30	1	131	25.0	23,250	
	2	131	21.0	21,750	
14:35	1	131	23.5	21,500	
	2	131	20.5	22,250	
14:40	2	131	21.0	22,750	
	3	131	24.0	19,800	
14:45	1	131	24.0	19,950	
	3	131	24.0	20,500	
14:50	1	131	24.0	21,500	
	2	131	21.0	20,750	
14:55	1	131	21.5	22,250	
	3	131	24.0	21,000	
15:05	1	131	23.5	20,050	
	3	131	23.5	20,750	
15:10	1	131	23.0	20,550	
	3	131	24.0	19,400	
15:15	2	132	21.5	21,750	
	3	132	23.5	20,750	
15:20	1	132	23.0	21,250	
	3	132	24.5	22,500	

(continued)

SOURCE SAMPLING PROCESS DATA SHEET (continued)

Time, 24-h clock	Tank cell No.	Temp., °F	Operating voltage, volts	Operating current, amperes	Notes
15:25	2	132	21.5	23,500	
	3	132	24.0	21,750	
15:30	2	132	22.5	22,750	Grab samples of plating solution taken at 15:30
	3	132	26.0	21,500	
15:35	1	132	24.0	20,050	
	3	132	25.0	21,750	
15:40	1	133	25.0	23,000	
	3	133	25.0	22,750	
15:45	2	133	20.5	24,250	Stopped testing: 15:49
	3	133	23.5	20,250	
Average		131	22.8	21,747	