Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

ADDENDUM FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY TEST REPORT FOR THE MAY 1991 SOURCE TEST AT THE REMCO HYDRAULICS INCORPORATED ELECTROPLATING FACILITY IN WILLITS, CALIFORNIA

At the request of Midwest Research Institute, this addendum has been prepared for the Remco Hydraulics Test Report. The changes are minor and adjust the control device efficiency values found in the report.

At Inlet B on run three, it is suspected that the probe touched the stack wall and produced a high bias for that run. The emission results from that run are nearly an order of magnitude greater than the emission results from the other two runs at Inlet B. The sample from Inlet B for run three was analyzed twice to insure that the bias was not due to an analytical error. The second analysis confirmed that the first analytical value was correct. For this addendum, run three was not used in the pounds per hour emission rate or the control device efficiency calculations. The attached page shows the differences that occur when run three is not used in data results.

The addendum changes pertain to Chapter 3 only, and a replacement for the entire chapter is provided.

REMCO HYDRAULICS - COMPARISON OF AVERAGE EFFICIENCIES

The table below presents a comparison of the efficiencies of the control device when the averages of runs one, two and three are compared with the averages of runs one and two only.

Three analytical techniques were used: (1) the diphenylcarbazide (colorimetric) method for hexavalent chromium, (2) ion chromatography with a post column reactor (IC) for hexavalent chromium, and (3) inductively coupled argon plasmology (ICP) for total chromium.

During run three at inlet B, it is suspected that the probe touched the stack wall and introduced a high bias into the data. This is the reason for comparing the averages of runs one, two and three with the averages of runs one and two only.

ANALYSIS TYPE	AVERAGE % EFFICIENCY RUNS 1,2, & 3	AVERAGE % EFFICIENCY RUNS 1 & 2	AVERAGE DIFFERENCE (PERCENT)
HEX CHROMIUM COLORIMETRIC	99.9908%	99.9887%	-0.0021%
TOTAL CHROMIUM ICP ANALYSIS	99.9917%	99.9930%	+0.0013%
HEX CHROMIUM IC ANALYSIS	99.9922%	99.9937%	+0.0015%
AVERAGE	99.9916%	99.9918%	+0.0002%

Note: The extreme right hand column gives the percent difference when the average of all three runs is compared with the average of runs one and two only. A plus sign (+) indicates that the efficiency of the control device went up when run three was eliminated and a minus sign (-) indicates that the efficiency went down when run three was eliminated.

SECTION 3

SUMMARY AND DISCUSSION OF RESULTS

Simultaneous sampling was conducted at Inlets IA and IB and at the outlet of the packed bed scrubber (see Figure 1 on page 4-2) under normal operating conditions of the plating processes and control system. Three isokinetic tests were conducted at each site. A sampling time of 360 minutes was employed on each run to insure collection of adequate quantities of chromium at the outlet.

In addition to the emission samples, grab samples of the operating plating baths and of the scrubber water were composited during each sampling run. All of these samples were colorimetrically analyzed on-site for Cr^{+6}. All of the emission samples and a set of scrubber water samples were later analyzed off-site for Cr^{+6} and total chrome using ion chromatography with a post column reactor for Cr^{+6}. Inductively Coupled Argon Plasmology was used to determine total chrome.

In order to meet the California standard for chromium emissions, the outlet location must emit no more than 0.006 milligrams per amp hour or the control device must achieve an efficiency of 99.8%. Emissions at the outlet averaged 0.004 milligrams per amp hour and the efficiency of the control device averaged 99.994 % based on the average of Cr^{+6} emissions from runs one and two only[1].

Summary of Stack Gas Conditions

Stack gas conditions at each sampling location are presented in Table 1. Volumetric flow rates at each location showed little variation between runs. At Inlet A, the velocity averaged 41.02 feet per second (fps), with average temperature of 72°F and moisture content of 1.05%. Volumetric flow rates averaged 13,428.4 actual cubic feet per minute (acfm) and 12,643.0 dry standard cubic feet per minute (dscfm).

At Inlet B, the velocity averaged 44.43 fps, with average temperatures of 73°F and moisture content of 1.29%. Average volumetric flow rates were 10,599.0 acfm and 9,901.5 dscfm. Conditions at the outlet averaged 38.18 fps, 70°F, and 1.88% moisture. Volumetric flow rates at the outlet averaged 25,613.2 acfm and 24,022.8 dscfm.

The stack gases at all sampling locations were essentially ambient air and were assigned a dry molecular weight of 29.0 lb/lb mole. Variations of isokinetic sampling rates were within allowable limits on all sampling runs.

[1] During run three, it is suspected that the probe touched the stack wall during the test. The emission calculations and efficiencies are based on the average of runs one and two only.

1 April 1993

REMCO HYDRAULICS, INC.
(AMP HOUR RESULTS)

Run No.	mg/ah	(gr/ah)
IA-1	144.00	(2.22)
IA-2	107.00	(1.65)
IA-3	138.00	(2.13)
AVERAGE	130.00	(2.01)
IB-1	0.52	(0.008)
IB-2	0.83	(0.013)
IB-3	8.20*	(0.127)*
AVERAGE	0.68	(0.011)
O-1	0.004	(6.25×10^{-5})
O-2	0.002	(3.1×10^{-5})
O-3	0.006	(9.3×10^{-5})
AVERAGE	0.004	(6.2×10^{-5})

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

Discussion of Chromium Samples

Following completion of each sampling run, chromium samples were recovered and analyzed on-site for Cr^{+6} using the diphenylcarbazide method (see Appendix D). Results of these analyses are summarized in Table 2.

Table 2 shows that Inlet A accounts for more than 96% of the chromium going to the scrubber. This finding is consistent with the layout of the process (see Section 2). Inlet A receives emissions from the large rectangular plating tanks while Inlet B receives emissions from the deep cylindrical tanks. The rectangular tanks account for the majority of surface area and would be expected to account for a proportionately larger share of total emissions to the scrubber.

The total mass of Cr^{+6} sampled and the volumetric flow rates at each sampling location were used to calculate emission concentrations and mass emission rates. The average over three sampling runs results in a mass emission rate 5.99 pounds per hour (lb/hr) at Inlet A and 0.0556 lb/hr at Inlet B. For the outlet, an average mass emission rate of 6.30×10^{-4} lb/hr was calculated with this analysis procedure.

After the completion of on-site sampling and analysis, chromium samples were stored on ice and shipped to the Research Triangle Institute Laboratory. Ion chromatography analyses were employed at this location using a post column reactor to determine Cr^{+6} and total chromium was determined by Ion Chromatography. Results of these analyses are reported in Table 3 (ICP analysis for Cr^{+6}) and Table 4 (IC analysis for total Cr).

These analytical procedures produced results which were highly consistent with the colorimetric results reported on Table 2. All three methods exhibited a high degree of consistency from sample to sample. It is normal for ICP analysis for total chromium to result in lower mass quantitation than are found by IC analysis for Cr^{+6}.

At Inlet A, IC analysis for Cr^{+6} produced an average mass emission rate of 6.37 lb/hr while ICP analysis for total Cr resulted in a calculation 6.02 lb/hr. At Inlet B, emission rates were .0558 lb/hr for Cr^{+6} (IC) and .0534 lb/hr for total Cr (ICP). At the outlet, emission rates were 4.12×10^{-4} lb/hr for Cr^{+6} (IC) and 4.34×10^{-4} lb/hr for total Cr (ICP).

Summary of Scrubber Removal Efficiencies

Chromium removal efficiencies for the scrubber system were determined by simultaneously sampling the two inlets and the outlet of the scrubber to determine the mass emission rate at each location. Capture efficiency is represented by the equation:

$$CE = \frac{Ci - Co}{Ci} \times 100$$

where: CE = % Capture Efficiency
Ci = Sum of mass emission rates at inlets to scrubber
Co = Mass emission rate at the scrubber outlet

Mass emission rates for the three analytical procedures presented in Tables 2, 3, and 4 are discussed above. The resultant removal efficiencies are reported in Table 5. Once again the various analytical procedures produced highly comparable results. It is also apparent that the scrubber performed at a high level of efficiency during the test. All of the analysis procedures resulted in chromium removal efficiencies of greater than 99.9%.

Plating Tank Solution and Scrubber Rinse

During each sampling run, grab samples of the plating solution were obtained from plating tanks 1-6 and a sample of rinsewater was obtained from the scrubber. During the final run, scrubber samples were taken during the beginning, middle, and end of the sampling period. These samples were analyzed on-site for Cr^{+6} and the resultant concentrations are summarized in Table 6. The scrubber water samples were also shipped out for Ion Chromatography analysis. These results are summarized in Table 7.

TABLE 1
SUMMARY OF STACK GAS CONDITIONS

INLET A

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	40.79	75	13,246.3	12,424.8	0.78	95.98
2	40.89	71	13,278.9	12,504.4	1.17	95.11
3	42.38	69	13,760.0	12,999.7	1.19	95.86
Average	41.02	72	13,428.4	12,643.0	1.05	95.65

INLET B

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	43.88	75	10,468.8	9,779.5	1.21	98.10
2	44.07	74	10,513.1	9,781.0	1.35	96.92
3	45.33	69	10,815.2	10,144.1	1.31	91.44
Average	44.43	73	10,599.0	9,901.5	1.29	95.49

OUTLET

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	38.23	72	25,647.0	24,012.8	1.74	99.04
2	37.69	72	25,282.3	23,674.2	1.93	98.93
3	38.62	69	25,910.2	24,381.3	1.97	99.82
Average	38.18	71	25,613.2	24,022.8	1.88	99.26

[a]Feet per second at stack conditions
[b]Actual cubic feet per minute at stack conditions
[c]Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2
COLORIMETRIC ANALYSIS OF HEXAVALENT CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	1,372,008.00	9.58×10^{-6}	7.14	6.71×10^{-2}	1.53×10^{-1}
2	919,228.20	6.43×10^{-6}	4.83	4.50×10^{-2}	1.03×10^{-1}
3[d]	1,266,384.00	8.46×10^{-6}	6.60	5.92×10^{-2}	1.35×10^{-1}
Average	--	--	5.99		

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	9,375.00	7.08×10^{-8}	0.0416	4.96×10^{-4}	1.13×10^{-3}
2	15,489.60	1.18×10^{-7}	0.0695	8.26×10^{-4}	1.89×10^{-3}
3[d]	127,694.00	9.99×10^{-7}	0.067	6.99×10^{-3}	1.60×10^{-2}
Average	--	--	0.0556		

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	41.20	3.42×10^{-10}	4.92×10^{-4}	2.39×10^{-6}	5.47×10^{-6}
2	64.10	5.40×10^{-10}	7.67×10^{-4}	3.80×10^{-6}	8.69×10^{6}
3[d]	29.50	2.39×10^{-10}	3.50×10^{-4}	1.67×10^{-6}	3.83×10^{-6}
Average	--	--	6.30×10^{-4}		

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour
[d] This run omitted from average. It is suspected that the probe touched the stack wall during testing.

TABLE 3
ICP ANALYSIS OF TOTAL CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	1,338,000	9.34×10^{-6}	6.96	6.54×10^{-2}	1.50×10^{-1}
2	968,000	6.78×10^{-6}	5.08	4.74×10^{-2}	1.09×10^{-1}
3[d]	1,248,033	8.34×10^{-6}	6.50	5.84×10^{-2}	1.34×10^{-1}
Average	--	--	6.02		

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	9,000	6.80×10^{-8}	0.0399	4.77×10^{-4}	1.09×10^{-3}
2	14,900	1.14×10^{-7}	0.0669	7.98×10^{-4}	1.83×10^{-3}
3[d]	124,254	9.71×10^{-7}	0.5910	6.80×10^{-3}	1.56×10^{-2}
Average	--	--	0.0534		

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	47.00	3.90×10^{-10}	5.62×10^{-4}	2.73×10^{-6}	6.24×10^{-6}
2	25.50	2.15×10^{-10}	3.05×10^{-4}	1.51×10^{-6}	3.44×10^{-6}
3[d]	65.50	5.31×10^{-10}	7.77×10^{-4}	3.71×10^{-6}	8.50×10^{-6}
Average	--	--	4.34×10^{-4}		

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour
[d] This run omitted from average. It is suspected that the probe touched the stack wall during testing.

TABLE 4
ION CHROMATOGRAPHY ANALYSIS OF HEXAVALENT CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	1,390,000	9.70×10^{-6}	7.23
2	1,050,000	7.35×10^{-6}	5.51
3[d]	1,350,030	9.02×10^{-6}	7.04
Average	--	--	6.37

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	9,850	7.44×10^{-8}	0.0437
2	15,100	1.15×10^{-7}	0.0678
3[d]	135,258	1.06 X 106	0.6430
Average	--	--	0.0558

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	43.30	3.59×10^{-10}	5.18×10^{-4}
2	25.50	2.15×10^{-10}	3.05×10^{-4}
3[d]	66.80	5.42×10^{-10}	7.92×10^{-4}
Average	--	--	4.12×10^{-4}

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour
[d] This run omitted from average. It is suspected that the probe touched the stack wall during testing.

TABLE 5
SUMMARY OF CHROMIUM REMOVAL EFFICIENCIES

Cr^{+6} - Colorimetric Analysis

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1		
Inlet	7.1816	
Outlet	0.000492	99.9931
Run No. 2		
Inlet	4.8995	
Outlet	0.000767	99.9843
Run No. 3[a]		
Inlet	7.207	
Outlet	0.000350	99.9951
Average Removal Efficiency (Colorimetric Analysis): 99.9887%		

Cr^{+6} - Ion Chromatography

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1		
Inlet	7.274	
Outlet	0.000518	99.9929
Run No. 2		
Inlet	5.578	
Outlet	0.000305	99.9945
Run No. 3[a]		
Inlet	7.683	
Outlet	0.000792	99.9897
Average Removal Efficiency (IC Analysis): 99.9937%		

[a] This run omitted from average. It is suspected that the probe touched the stack wall during testing.

TABLE 5 (continued)
SUMMARY OF CHROMIUM REMOVAL EFFICIENCIES

Total Cr - ICP Analysis

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1 Inlet Outlet	 7.000 0.000562	 99.9919
Run No. 2 Inlet Outlet	 5.150 0.000305	 99.9941
Run No 3* Inlet Outlet	 7.091 0.000777	 99.9891
Average Removal Efficiency (ICP Analysis): 99.9930%		

* This run omitted from average. It is suspected that the probe touched the stack wall during testing.

TABLE 6
COLORIMETRIC ANALYSIS OF PLATING SOLUTIONS AND SCRUBBER WATER

	Concentration of Cr^{+6} (ug/ml)		
	Run #1	Run #2	Run #3
Plating Task #1	125,592	125,319	118,724
Plating Task #2	125,592	121,098	119,779
Plating Task #3	125,592	126,638	116,085
Plating Task #4	126,928	122,681	120,834
Plating Task #5	128,264	122,681	121,362
Plating Task #6	125,592	125,319	126,111
Scrubber Composite (Rinse Water)	12,078	4,876	16,674
Scrubber Start			17,102
Scrubber Middle			14,774
Scrubber End			19,840

TABLE 7
COMPARATIVE ANALYSIS OF SCRUBBER RINSEATE

Scrubber Rinseate	Concentration (ug/ml)		
	Cr^{+6} (colorimetric)	Cr^{+6} (IC)	Total Cr (ICP)
Run #1 Composite	12,078	14,700	12,450
Run #2 Composite	4,876	4,490	5,200
Run #3 Composite	16,674	16,220	17,500
Run #4 Start	17,102	17,450	18,500
Run #5 Middle	14,774	14,400	13,400
Run #6 End	19,840	19,600	18,900

HEXAVALENT CHROMIUM EMISSIONS EVALUATION

REMCO HYDRAULICS WILLITS, CALIFORNIA

Prepared for:

United States Environmental Protection Agency
Emissions Measurement Branch
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SECTION 1

INTRODUCTION

Emission source tests were conducted at the Remco Hydraulics, Inc. located in Willits, California. The objective was to conduct simultaneous inlet and outlet measurements of hexavalent chromium (Cr^{+6}) emissions that are controlled by an extended packed-bed scrubber. The scrubber is used to control emissions from the seven hard chromium plating tanks at the facility.

The scrubber system at Remco incorporates the use of a coalescing mesh pad in the design. The use of this type of mesh pad is believed to represent state-of-the-art control technology for the collection of chromic acid mist. This was the primary reason the air emissions evaluation was done at Remco. In addition, the Remco plant is considered to be representative of other plants in the industry that perform hard chromium plating and is equipped with draft hoods that appear to be effective in directing the mist from the plating tanks to the control system.

Testing was conducted during the week of June 17, 1991. Emission samples were collected using a modification of USEPA Method 13B. Samples were analyzed on-site for Cr^{+6} using the diphenylcarbazide colorimetric method. Upon completion of field activities, samples were shipped to a contract lab and analyzed for Cr^{+6} and total chrome using ion chromatography procedures. The primary organizations involved in the test program were Pacific Environmental Services, Inc., Remco Hydraulics, Inc., Midwest Research Institute and the USEPA, Emissions Measurement Branch (EMB).

2.0 PROCESS OPERATION

2.1 PROCESS DESCRIPTION

Remco Hydraulics, Inc., in Willits, California, is a job shop that performs hard chromium electroplating of hydraulic cylinders, shock absorbers, offshore equipment, and accumulators. The plating shop consists of seven hard chromium plating tanks. The plating shop typically operates 5 days per week, 16 hours per day, and 52 weeks per year.

During this source test, six of the seven plating tanks were in operation. Table 2-1 presents the dimensions and operating parameter maximum values for each plating tank. The plating solution in each tank consists of chromic acid at a concentration of 240 grams per liter (g/L) (32 ounces per gallon [oz/gal]), and sulfuric acid, a catalyst, at a concentration of 2.4 g/L (0.32 oz/gal). All the plating tanks are equipped with heating and cooling systems and are air agitated to maintain uniform plating bath temperature and composition. During testing, dummy rods were plated in each of the plating tanks. Table 2-2 identifies the plating tank and the number, dimensions, and surface area of each rod plated.

2.2 AIR POLLUTION CONTROL

A schematic of the exhaust system on the plating tanks is shown in Figure 2-1. The capture and control system was manufactured and installed by Duall Industries, Inc., in February 1989. Tank Nos. 1 and 2 are equipped with double-sided hoods and Tank Nos. 3 through 7, the round tanks, are equipped with circular hoods. The ventilation hoods appeared to be

TABLE 2-1. DIMENSIONS AND OPERATING PARAMETERS FOR THE SEVEN HARD CHROMIUM PLATING TANKS AT REMCO HYDRAULICS, INC.

Tank No.	Dimensions, (l,w,d) or (dia.,h), m (ft)	Capacity, liters (gallons)	Maximum rated voltage, per cell, volts	Maximum rated current per cell, amperes
1	4.0,1.5,2.1 (13.3,4.9,7.0)	11,360 (3,000)	2 @ 15	10,000; 3,000
2	3.7,1.7,2.1 (12.0,5.5,6.9)	11,360 (3,000)	2 @ 15	12,000; 3,000
3	0.91,9.4 (3.0,31.0)	6,060 (1,600)	15	8,000
4	1.2,11.6 (4.0,38.0)	13,250 (3,500)	15	16,000
5	0.91,6.1 (3.0,20.0)	4,000 (1,060)	15	8,000
6	1.2,15.2 (4.0,50.0)	17,790 (4,700)	2 @ 15	2 @ 12,000
7[a]	1.2,18.3 (4.0,60.0)	21,580 (5,700)	2 @ 15	2 @ 12,000

[a]Plating tank was not operated during the emission test.

TABLE 2-2. DESCRIPTION OF PARTS PLATED DURING SOURCE TEST AT REMCO HYDRAULICS, INC.

Tank No.	No. of parts	Dimensions of parts, in		Surface area plated, in.^{2}	m^2
		Diameter	Length		
1A	1	12.5	54.5	2,140	1.38
1B	1	6.5	72	1,470	0.95
2A	1	13	72	2,940	1.9
2B	1	11	51	1,762	1.14
3	1	11	149	5,149	3.32
4	1	11	149	5,149	3.32
5	1	11	149	5,149	3.32
6	1	10.25	230	7,406	4.78
7	----------Not running----------				

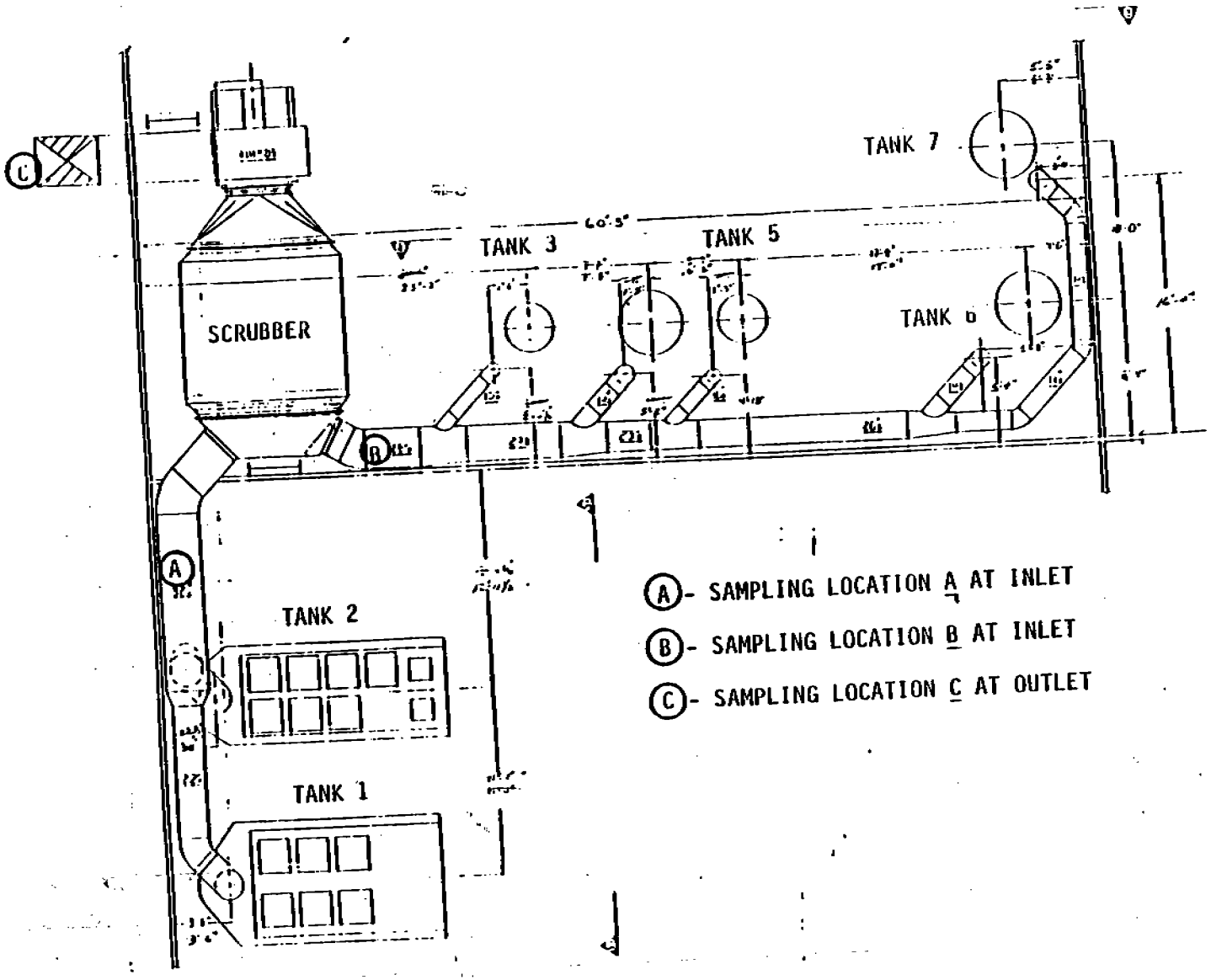


Figure 2-1. Schematic of the ventilation and control system for the hard chromium plating tanks at Remco Hydraulics, Inc.

effective in directing the mist from the plating tanks to the control device.

The chromium emissions from the plating tank(s) are exhausted to a single packed-bed scrubber located on a mezzanine beside the plating tanks. The design airflow rate of the scrubber is 850 cubic meters per minute (m^3/min) (30,000 cubic feet per minute [ft^3/min]). The fan downstream of the scrubber requires a 50-horsepower motor to ventilate the plating tanks. The scrubbing water flow rate is approximately 1,140 liters per minute (300 gallons per minute).

Within the scrubber system, the velocity of the gas stream is reduced to less than 150 meters per minute (500 feet per minute), and the gas stream is humidified by a spray of water. Water is sprayed countercurrent to the gas flow through 22 nozzles. The saturated gas stream then passes through a packed bed of polypropylene, spherical-type mass packing. The packed bed is approximately 2.4 meters (m) (8.0 feet [ft]) high, 3.0 m (10 ft) wide, and 1.8 m (6 ft) deep. The pressure drop across the packing media is approximately 0.30 kPa (1.2 in. w.c.). Entrained mist and water droplets impinge on the packing and drain to the recirculation tank.

A series of 5 water spray lines with 10 spray nozzles per line is located over the packed bed. The overhead water sprays are used to ensure the entire packing section is wetted to prevent chromium buildup on the packing and aid in chromium removal. After operating the scrubber over a period of time, the vendor recommended that only the first two overhead spray lines be operated because the operation of all five spray lines resulted in reentrainment and two lines were sufficient to keep the bed wetted. Behind the packed bed is a mist elimination section that removes entrained water droplets. The first stage allows large droplets to settle by gravity to the bottom of the scrubber. The second stage consists of two mesh pads in series: (1) a composite pad to intercept and coalesce small droplets; and (2) a backup pad to eliminate reentrainment from the composite pad.

These pads are composed of multiple layers of a patented mesh material. Each layer is woven with fibers with the same diameter. The smaller the fiber diameter used, the greater the ability of the pad to capture small particles. In the composite mesh pad, the material layers in the center of the pad are composed of extremely small-diameter fibers (0.01 to 0.02 centimeters [cm] [4 to 8 thousandths of an inch (mil)]). The material layers on either side of the center are composed of progressively larger diameter fibers (0.04 to 0.09 cm [16 to 37 mils]). As the gas stream flows through the composite mesh pad, the small particles that escape the packed bed impinge on the pad and coalesce into larger droplets. These enlarged particles are then removed in the back side of the composite mesh pad or in the backup mesh pad located downstream of the composite pad. The backup mesh pad is composed of multiple layers of material with a fiber diameter of 0.09 cm (37 mils). Each of the mesh pads is split into two sections, each approximately 2.4 m (8 ft) high and 0.09 m (3.7 ft) wide. The thickness of the composite mesh pad is 16.5 cm (6.5 in.), and the thickness of the backup mesh pad is 6.1 cm (2.4 in.). The design pressure drop across the pads is 1.2 kPa (4.75 in. w.c.). The composite mesh pad was originally designed for continuous irrigation with recirculated water to aid in droplet enlargement and to prevent excess chromium from building up and plugging the pad. The back-up mesh pad is not continuously irrigated; however, a fresh water spray line is located prior to this pad to enable the pad to be washed down if a buildup of chromium is detected on the pad.

The scrubber water drains into a sump in the bottom of the scrubber and is recirculated by a pump. A level indicator (sight gauge) is used to monitor the water level in the tank, which holds approximately 3,790 L (1,000 gal) of water. Approximately 760 L (200 gal) of water are drained from the recirculation tank to the plating tanks each day to make up for plating solution evaporation losses and to reduce the chromic acid concentration in the scrubber water.

Prior to testing, the exhaust rate through the scrubber was measured at the stack. The measured exhaust rate was approximately 350 m^3/min (12,500 ft^3/min), which was less than half of the design air flow rate. Therefore, testing of the unit was delayed one day until modifications could be made to increase the exhaust rate. These modifications consisted of increasing the fan speed, shutting down the recirculation sprays to the composite mesh pad, and increasing the water flow rate to the packed-bed section. These modification increased the exhaust rate to approximately 710 m^3/min (25,000 ft^3/min). At this ventilation rate, the scrubber was operating within its designed gas velocity range, and the capture efficiency of the ventilation system was adequate to operate all of the plating tanks. Discontinuing the wash to the composite mesh pad reduced the pressure drop across the pad to 0.52 kPa (2.0 in. w.c.). Personnel at Kimre, Inc., the manufacturer of the mesh pads, felt that the continuous irrigation of the composite mesh pad was not required, and a periodic washdown would be sufficient to clean the pad. Therefore, the scrubber was believed to be operating at or near optimal conditions at the exhaust rate of 710 m^3/min (25,000 ft^3/min). This exhaust rate was maintained over the course of the three test runs.

2.3 PROCESS CONDITIONS DURING TESTING

Three mass emission test runs were conducted at the inlet locations and the outlet of the scrubber system to characterize the performance of a scrubber system that incorporated the use of a composite mesh pad. Each test run was 6 hours in duration. Test run No. 1 was interrupted for approximately 15 minutes when the control panel on the fan overheated and caused the fan to lose power. All of the test runs were interrupted briefly to change test ports. No other interruptions occurred during sampling.

Process operating parameters monitored and recorded during each test run included the voltage, current, and plating solution temperature of each plating tank in operation. A description (dimensions and surface areas) of each part plated also was

recorded for each test run. Process data sheets documenting the process and control device operating parameters during mass emission testing are presented in Appendix E. Data on the average operating parameters recorded during the mass emission test runs are presented in Table 2-3. The total amount of current supplied to the tanks during each test run is calculated in terms of ampere-hours and included in Appendix E. A tabular summary of the total current values is presented in Table 2-4.

Composite samples were taken from each plating tank to determine the chromic acid concentration of the plating solution during each mass emission test run. Composite samples of the scrubber water were also collected during each test run to determine the average scrubber water concentration. The chromic acid concentration of the composite samples is reported in Section 3 of this report. In addition to the composite samples, grab samples of the scrubber water were taken over the course of each test run to monitor the increase in the chromic acid concentration. The chromic acid concentration of these grab samples were determined by using a hydrometer. The concentrations of these grab samples are reported in Appendix E. The chromic acid concentration measured by the hydrometer were compared to the concentration measured using the colorimetric analysis for one sample to determine the accuracy of the hydrometer. The results of this comparison indicated that the concentration as determined by the hydrometer was approximately 7.5 g/L (1 oz/gal) higher than the actual concentration determined by the colorimetric analysis.

Therefore, the chromic acid concentrations reported in Appendix E should be adjusted down by 7.5 g/L (1 oz/gal) to obtain the actual concentrations in the scrubber water during sampling.

Control device operating parameters monitored during each test run consisted of the pressure drops across the packing media and mesh pads. The average pressure drops across the packing media and mesh pads were 0.30 kPa (1.2 in. w.c.) and 0.60 kPa (2.3 in. w.c.), respectively. A visual inspection was also

TABLE 2-3. AVERAGE OPERATING PARAMETERS MONITORED DURING EACH MASS EMISSIONS TEST RUN

Run No.	Tank No.	Operating voltage, volts	Operating current, amperes	Temp., °F
1	1A	8.0	8,630	126
	1B	8.3	2,670	126
	2A	9.0	8,770	127
	2B	8.0	2,670	127
	3	7.7	6,290	124
	4	12.1	10,910	139
	5	7.1	7,340	133
	6	11.9	7,380	134
		11.8	5,680 6,390	134
2	1A	8.0	8,500	126
	1B	8.4	2,710	127
	2A	9.6	9,360	126
	2B	8.0	2,700	126
	3	7.4	5,840	125
	4	11.4	10,630	138
	5	7.0	7,400	131
	6	11.5	7,130	137
		11.5	5,790	137
3	1A	8.0	8,250	121
	1B	8.4	2,680	121
	2A	9.6	9,550	123
	2B	8.0	2,690	123
	3	7.7	6,010	121
	4	11.2	10,360	135
	5	7.2	7,260	127
	6	11.4	6,740	125
		11.2	5,410	125

Corrected Tank 1A/1B
6253
2810

TABLE 2-4. TOTAL AMPERE-HOURS SUPPLIED TO PLATING TANKS DURING MASS EMISSION TEST RUNS

Test run No.	Total current, ampere-hours[a]		
	Inlet-A	Inlet-B	Outlet
1	136,840	229,690	381,430
2	140,530	221,320	376,200
3	139,090	213,710	366,740

[a]The cumulative inlet ampere-hours will not equal the outlet ampere-hours due to slight differences in the sampling time.

performed periodically during the test runs to ensure proper operation of the control system.

Following the first test run, the composite mesh pad was washed for approximately 5 to 10 minutes. During this time, it was observed that the drainage system on the scrubber could not handle the increased water flow rate, and scrubber water had backed up into the outlet transition zone of the scrubber. The scrubber was turned off, and the backup mesh pad and outlet transition zone were rinsed with fresh water and drained through drain holes located in the bottom of the outlet transition zone behind the backup mesh pad. This section was irrigated with fresh water until the water leaving the drains ran clear. The scrubber was then brought back on line and operated without any parts being plated in the plating tanks until the next morning.

The second test run was conducted over the course of the next day. Following the second test run, the water flow rate to the packed-bed section was decreased, and the composite mesh pad was washed down. During the washdown, however, the sump began to overfill with water. The scrubber was turned off, and the drainage system was examined to determine if any modifications could be made to increase the rate at which water is drained from the scrubber. The examination revealed that the drainage line extended below the fluid level in the recirculation tank, which hampered the liquid flow from the scrubber. The drain line was shortened to a point above the fluid level in the recirculation tank, which allowed the drainage system to handle the full flow of water to the composite mesh pad.

Following this change to the drainage line, the composite mesh pad was washed down for approximately 15 minutes, and the scrubber was brought back on line at a ventilation rate lower than that at which it had operated during the previous two test runs. After the scrubber had operated at this lower ventilation rate for about 15 minutes, reentrained water was observed escaping the second pad which, once again, contaminated the outlet transition zone with chromium. The scrubber was turned off and rinsed with fresh water, as had been done the day before,

and allowed to run overnight. In this instance, however, parts were plated in the plating tanks overnight due to production demands.

The next day, the third test run was conducted. Following this test run, the scrubber was turned off before the composite mesh pad was washed. The pad was irrigated with recirculated water for a period of 15 minutes. The pad was allowed to drain an additional 15 minutes after the spray nozzles were turned off and before the fan was restarted. The scrubber was then brought back on line successfully with no reentrainment problems. As a result, this washdown sequence has been incorporated into the plant's routine maintenance schedule.

Although problems were encountered with the washdown sequence over the course of the source tests, the scrubber was operating at or near optimum conditions during testing. Therefore, the emissions test data can be used to characterize the performance of a scrubber system that incorporates the use of a composite mesh pad.

SECTION 3

SUMMARY AND DISCUSSION OF RESULTS

Simultaneous sampling was conducted at Inlets IA and IB and at the outlet of the packed bed scrubber (see Figure 1 on page 4-2) under normal operating conditions of the plating processes and control system. Three isokinetic tests were conducted at each site. A sampling time of 360 minutes was employed on each run to insure collection of adequate quantities of chromium at the outlet.

In addition to the emission samples, grab samples of the operating plating baths and of the scrubber water were composited during each sampling run. All of these samples were colorimetrically analyzed on-site for Cr^{+6}. All of the emission samples and a set of scrubber water samples were later analyzed off-site for Cr^{+6} and total chrome using ion chromatography with a post column reactor for Cr^{+6}. Inductively Coupled Argon Plasmology was used to determine total chrome.

In order to meet the California standard for chromium emissions, the outlet location must emit no more than 0.006 milligrams per amp hour or the control device must achieve an efficiency of 99.8%. Emissions at the outlet averaged 0.004 milligrams per amp hour and the efficiency of the control device averaged 99.991%.

Summary of Stack Gas Conditions

Stack gas conditions at each sampling location are presented in Table 1. Volumetric flow rates at each location showed little variation between runs. At Inlet A, the velocity averaged 41.02 feet per second (fps), with average temperature of 72°F and moisture content of 1.05%. Volumetric flow rates averaged 13,428.4 actual cubic feet per minute (acfm) and 12,643.0 dry standard cubic feet per minute (dscfm).

At Inlet B, the velocity averaged 44.43 fps, with average temperatures of 73°F and moisture content of 1.29%. Average volumetric flow rates were 10,599.0 acfm and 9,901.5 dscfm. Conditions at the outlet averaged 38.18 fps, 70°F, and 1.88% moisture. Volumetric flow rates at the outlet averaged 25,613.2 acfm and 24,022.8 dscfm.

The stack gases at all sampling locations were essentially ambient air and were assigned a dry molecular weight of 29.0 lb/lb mole. Variations of isokinetic sampling rates were within allowable limits on all sampling runs.

REMCO HYDRAULICS, INC.
(AMP-HOUR RESULTS)

Run No.	mg/ah	(gr/ah)
IA-1	144.00	(2.22)
IA-2	107.00	(1.65)
IA-3	138.00	(2.13)
AVERAGE	130.00	(2.01)
IB-1	0.52	(0.008)
IB-2	0.98	(0.015)
IB-3	8.20*	(0.127)
AVERAGE	0.75	(0.012)
O-1	0.004	(6.25×10^{-5})
O-2	0.002	(3.1×10^{-5})
O-3	0.006	(9.3×10^{-5})
AVERAGE	0.004	(6.2×10^{-5})

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

Discussion of Chromium Samples

Following completion of each sampling run, chromium samples were recovered and analyzed on-site for Cr^{+6} using the diphenylcarbazide method (see Appendix D). Results of these analyses are summarized in Table 2.

Table 2 shows that Inlet A accounts for more than 96% of the chromium going to the scrubber. This finding is consistent with the layout of the process (see Section 2). Inlet A receives emissions from the large rectangular plating tanks while Inlet B receives emissions from the deep cylindrical tanks. The rectangular tanks account for the majority of surface area and would be expected to account for a proportionately larger share of total emissions to the scrubber.

The total mass of Cr^{+6} sampled and the volumetric flow rates at each sampling location were used to calculate emission concentrations and mass emission rates. The average over three sampling runs results in a mass emission rate of 6.19 pounds per hour (lb/hr) at Inlet A and 0.24 lb/hr at Inlet B. For the outlet, an average mass emission rate of 5.36×10^{-4} lb/hr was calculated with this analysis procedure.

After the completion of on-site sampling and analysis, chromium samples were stored on ice and shipped to the Research Triangle Institute Laboratory. Ion chromatography analyses were employed at this location using a post column reactor to determine Cr^{+6} and total chromium was determined by Ion Chromatography. Results of these analyses are reported in Table 3 (ICP analysis for Cr^{+6}) and Table 4 (IC analysis for total Cr).

These analytical procedures produced results which were highly consistent with the colorimetric results reported on Table 2. All three methods exhibited a high degree of consistency from sample to sample. It is normal for ICP analysis for total chromium to result in lower mass quantitation than are found by IC analysis for Cr^{+6}.

At Inlet A, IC analysis for Cr^{+6} produced an average mass emission rate of 6.59 lb/hr while ICP analysis for total Cr resulted in a calculation of 6.18 lb/hr. At Inlet B, emission rates were 0.252 lb/hr for Cr^{+6} (IC) and 0.2326 lb/hr for total Cr (ICP). At the outlet, emission rates were 5.38×10^{-4} lb/hr for Cr^{+6} (IC) and 5.48×10^{-4} lb/hr for total Cr (ICP).

Summary of Scrubber Removal Efficiencies

Chromium removal efficiencies for the scrubber system were determined by simultaneously sampling the two inlets and the outlet of the scrubber to determine the mass emission rate at each location. Capture efficiency is represented by the equation:

$$CE = \frac{Ci - Co}{Ci} \times 100$$

where: CE = % Capture Efficiency
Ci = Sum of mass emission rates at inlets to scrubber
Co = Mass emission rate at the scrubber outlet

Mass emission rates for the three analytical procedures presented in Tables 2, 3, and 4 are discussed above. The resultant removal efficiencies are reported in Table 5. Once again the various analytical procedures produced highly comparable results. It is also apparent that the scrubber performed at a high level of efficiency during the test. All of the analysis procedures resulted in chromium removal efficiencies of greater than 99.99%.

Plating Tank Solution and Scrubber Rinse

During each sampling run, grab samples of the plating solution were obtained from plating tanks 1-6 and a sample of rinsewater was obtained from the scrubber. During the final run, scrubber samples were taken during the beginning, middle, and end of the sampling period. These samples were analyzed on-site for Cr^{+6} and the resultant concentrations are summarized in Table 6. The scrubber water samples were also shipped out for Ion Chromatography analysis. These results are summarized in Table 7.

TABLE 1
SUMMARY OF STACK GAS CONDITIONS

INLET A

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	40.79	75	13,246.3	12,424.8	0.78	95.98
2	40.89	71	13,278.9	12,504.4	1.17	95.11
3	42.38	69	13,760.0	12,999.7	1.19	95.86
Average	41.02	72	13,428.4	12,643.0	1.05	95.65

INLET B

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	43.88	75	10,468.8	9,779.5	1.21	98.10
2	44.07	74	10,513.1	9,781.0	1.35	96.92
3	45.33	69	10,815.2	10,144.1	1.31	91.44
Average	44.43	73	10,599.0	9,901.5	1.29	95.49

OUTLET

Run No.	Velocity fps[a]	Temp. °F	Flow Rate		Moisture %	% Isokinetic Variation
			acfm[b]	dscfm[c]		
1	38.23	72	25,647.0	24,012.8	1.74	99.04
2	37.69	72	25,282.3	23,674.2	1.93	98.93
3	38.62	69	25,910.2	24,381.3	1.97	99.82
Average	38.18	71	25,613.2	24,022.8	1.88	99.26

[a]Feet per second at stack conditions
[b]Actual cubic feet per minute at stack conditions
[c]Dry standard cubic feet per minute at 68°F and 29.92" Hg

TABLE 2
COLORIMETRIC ANALYSIS OF HEXAVALENT CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	1,372,008.00	9.58×10^{-6}	7.14	6.71×10^{-2}	1.53×10^{-1}
2	919,228.20	6.43×10^{-6}	4.83	4.50×10^{-2}	1.03×10^{-1}
3	1,266,384.00	8.46×10^{-6}	6.60	5.92×10^{-2}	1.35×10^{-1}
Average	--	--	6.19		

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	9,375.00	7.08×10^{-8}	0.0416	4.96×10^{-4}	1.13×10^{-3}
2	15,489.60	1.18×10^{-7}	0.0695	8.26×10^{-4}	1.89×10^{-3}
3	127,694.00	9.99×10^{-7}	0.067	6.99×10^{-3}	1.60×10^{-2}
Average	--	--	0.2394		

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	41.20	3.42×10^{-10}	4.92×10^{-4}	2.39×10^{-6}	5.47×10^{-6}
2	64.10	5.40×10^{-10}	7.67×10^{-4}	3.80×10^{-6}	8.69×10^{6}
3	29.50	2.39×10^{-10}	3.50×10^{-4}	1.67×10^{-6}	3.83×10^{-6}
Average	--	--	5.36×10^{-4}		

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour

TABLE 3
ICP ANALYSIS OF TOTAL CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	1,338,000	9.34×10^{-6}	6.96	6.54×10^{-2}	1.50×10^{-1}
2	968,000	6.78×10^{-6}	5.08	4.74×10^{-2}	1.09×10^{-1}
3	1,248,033	8.34×10^{-6}	6.50	5.84×10^{-2}	1.34×10^{-1}
Average	--	--	6.18		

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	9,000	6.80×10^{-8}	0.0399	4.77×10^{-4}	1.09×10^{-3}
2	14,900	1.14×10^{-7}	0.0669	7.98×10^{-4}	1.83×10^{-3}
3	124,254	9.71×10^{-7}	0.5910	6.80×10^{-3}	1.56×10^{-2}
Average	--	--	0.2326		

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]	Grain/Dscf	Gram/Dscm
1	47.00	3.90×10^{-10}	5.62×10^{-4}	2.73×10^{-6}	6.24×10^{-6}
2	25.50	2.15×10^{-10}	3.05×10^{-4}	1.51×10^{-6}	3.44×10^{-6}
3	65.50	5.31×10^{-10}	7.77×10^{-4}	3.71×10^{-6}	8.50×10^{-6}
Average	--	--	5.48×10^{-4}		

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour

TABLE 4
ION CHROMATOGRAPHY ANALYSIS OF HEXAVALENT CHROMIUM EMISSIONS

INLET A

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	1,390,000	9.70×10^{-6}	7.23
2	1,050,000	7.35×10^{-6}	5.51
3	1,350,030	9.02×10^{-6}	7.04
Average	--	--	6.59

INLET B

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	9,850	7.44×10^{-8}	0.0437
2	15,100	$1.15 \text{ X } 10^{-7}$	0.0678
3	135,258	1.06 X 106	0.6430
Average	--	--	0.252

OUTLET

Run No.	Total Mass Sampled ug[a]	Emission Concentration lb/dscf[b]	Mass Emission Rate lb/hr[c]
1	43.30	3.59×10^{-10}	5.18×10^{-4}
2	25.50	2.15×10^{-10}	3.05×10^{-4}
3	66.80	5.42×10^{-10}	7.92×10^{-4}
Average	--	--	5.38×10^{-4}

[a]Micrograms of hexavalent chromium
[b]Pounds per dry standard cubic foot at 68°F and 29.92" Hg
[c]Pounds per hour

TABLE 5
SUMMARY OF CHROMIUM REMOVAL EFFICIENCIES

Cr^{+6} - Colorimetric Analysis

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1		
Inlet	7.1816	
Outlet	0.000492	99.9931
Run No. 2		
Inlet	4.8995	
Outlet	0.000767	99.9843
Run No. 3		
Inlet	7.207	
Outlet	0.000350	99.9951
Average Removal Efficiency (Colorimetric Analysis): 99.9908%		

Cr^{+6} - Ion Chromatography

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1		
Inlet	7.274	
Outlet	0.000518	99.9929
Run No. 2		
Inlet	5.578	
Outlet	0.000305	99.9945
Run No. 3		
Inlet	7.683	
Outlet	0.000792	99.9897
Average Removal Efficiency (IC Analysis): 99.9922%		

TABLE 5 (continued)
SUMMARY OF CHROMIUM REMOVAL EFFICIENCIES

Total Cr - ICP Analysis

	Mass Emission Rate lb/hr	Removal Efficiency %
Run No. 1		
Inlet	7.000	
Outlet	0.000562	99.9919
Run No. 2		
Inlet	5.150	
Outlet	0.000305	99.9941
Run No. 3		
Inlet	7.091	
Outlet	0.000777	99.9891
Average Removal Efficiency (ICP Analysis): 99.9917%		

SECTION 4

SAMPLING LOCATIONS AND TEST METHODS

Sampling Locations

A schematic of the plating tank, scrubber configuration and sampling locations is presented in Figure 1.

Inlet A

Inlet A is located in the duct that captures emissions from the large rectangular plating tanks (tanks 1 and 2). The straight run at this site was approximately 4 feet and the duct diameter was 31.5 inches. The horizontal duct required a vertical traverse for sampling. Due to the short straight run, a 24 point sampling traverse was employed and a cyclonic flow check was conducted. The cyclonic flow check indicated the presence of an acceptable laminar flow at the sampling point.

Inlet B

Inlet B is located in the duct that captures emissions from tanks 3 through 7. This duct also presented a short, horizontal straight run of approximately 4 feet with an inside diameter of 27.0 inches. A vertical traverse with a 24 point sampling traverse was employed. A cyclonic flow check was conducted and indicated the presence of an acceptable laminar flow at this sampling point.

Outlet

The outlet measurement site is located in a vertical, 35 x 46 inch duct. A stack extension was installed at this location to provide an adequate straight run for the sampling points. A 25 point (5x5) sampling array was employed and a cyclonic flow check was conducted to insure the presence of an acceptable laminar flow.

Plating Tanks and Scrubber Effluent

Plating tank solutions were sampled directly from the tanks and scrubber effluent samples were obtained from the scrubber effluent discharge. These sampling points are presented in Figure 1.

Test Methods

The sampling methods used in this test program included EPA Methods 1, 2, and 4 and a modification in Method 13B's sampling train. A brief description of each method is given in the following text.

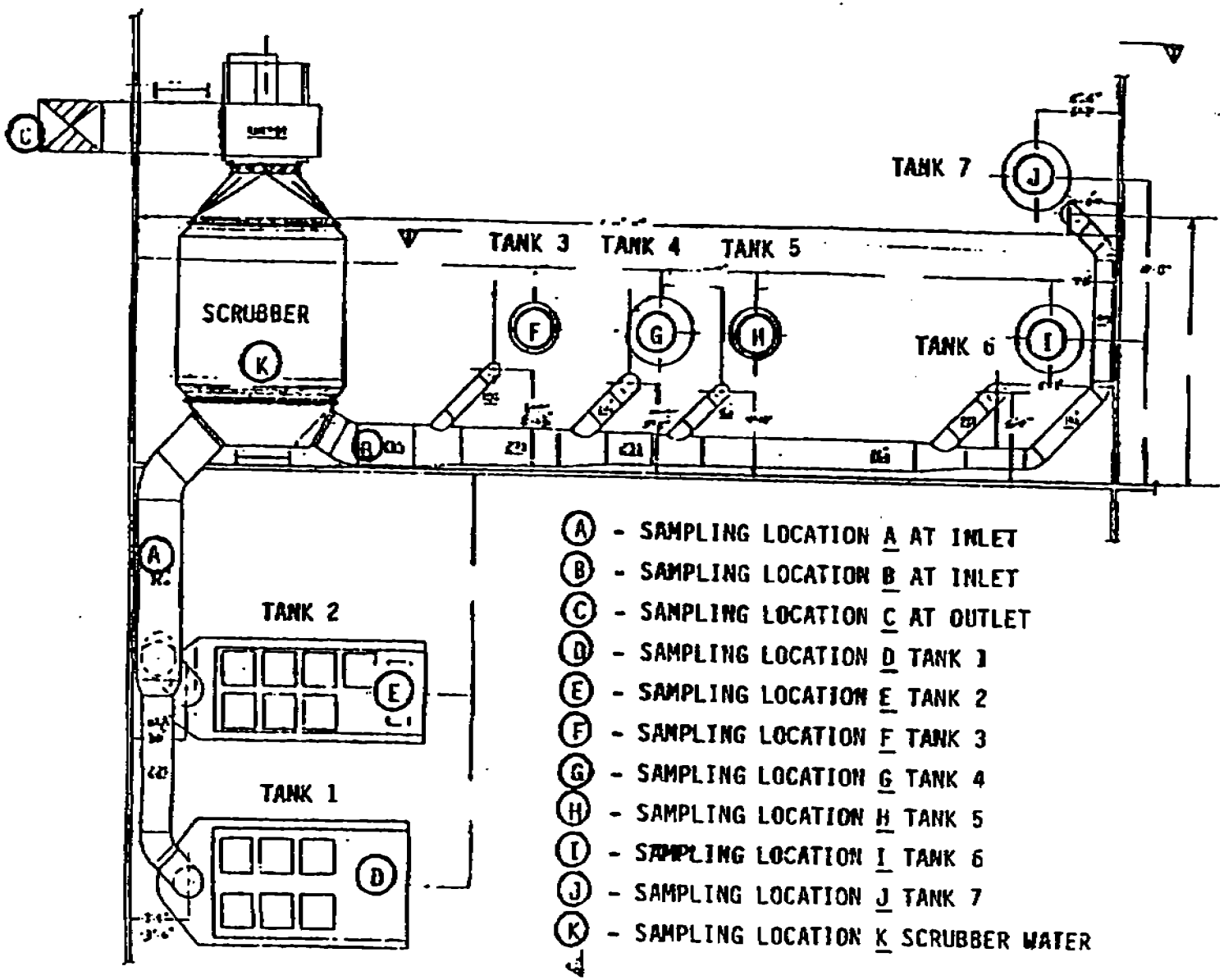


Figure 1. Plating tank and Scrubber configuration

Location of Traverse Points

USEPA Method 1, "Sample and Velocity Traverses for Stationary Sources" was used to determine the location of traverse points for each measurement site. Cyclonic flow checks were conducted at both inlet measurement sites and at the outlet.

Stack Gas Velocity

USEPA Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)" was used to determine the stack velocity and temperature at each measurement site. Type K thermocouples were affixed to S-type pitot tubes having an assigned coefficient of 0.84. The velocity pressure was measured on an inclined manometer. The volumetric flow rate was calculated from the stack gas velocity and the stack cross-sectional area.

Since this source is an ambient source, a dry molecular weight of 29.0 was assigned.

Stack Gas Moisture Content

USEPA Method 4, "Determination of Moisture Content in Stack Gas" was used to determine the stack gas moisture content. This measurement procedure was conducted simultaneously with the hexavalent chromium sampling procedure.

Hexavalent Chromium Emissions

A modification of USEPA Method 13B, "Determination of Total Fluoride Emissions from Stationary Sources," was used to determine the hexavalent chromium emissions. The sample train was modified by utilizing 0.1 Normal Sodium Bicarbonate as the impinger solution and by placing a teflon-coated glass fiber filter between the third and fourth impinger.

The sample train consisted of a Pyrex nozzle and probe connected to the impingers and filter assembly followed by vacuum pump, dry gas meter and calibrated orifice. A schematic of the sample train is presented in Figure 2. Triplicate six hour measurement runs were conducted at each site.

Tank and Scrubber Solutions

Grab samples from each location were obtained during the six-hour emissions test. The grab samples were mixed to form composite samples.

Analytical Procedures

Emission Samples

Following the recovery of the emissions samples, the recovered samples were analyzed on-site to determine the hexavalent chromium concentration. The samples were analyzed using the diphenylcarbazide calorimetric method. This method is presented in Appendix D. Upon the completion of the field activities, the emission samples were packed in coolers and submitted to a contract laboratory to be analyzed for hexavalent chromium and total chromium using ion chromatography procedures.

In addition to the emissions samples, grab samples of the plating tank solutions and the scrubber effluent water were analyzed on-site for hexavalent chromium. Scrubber effluent samples were also analyzed using ion chromatography for hexavalent and total chromium.

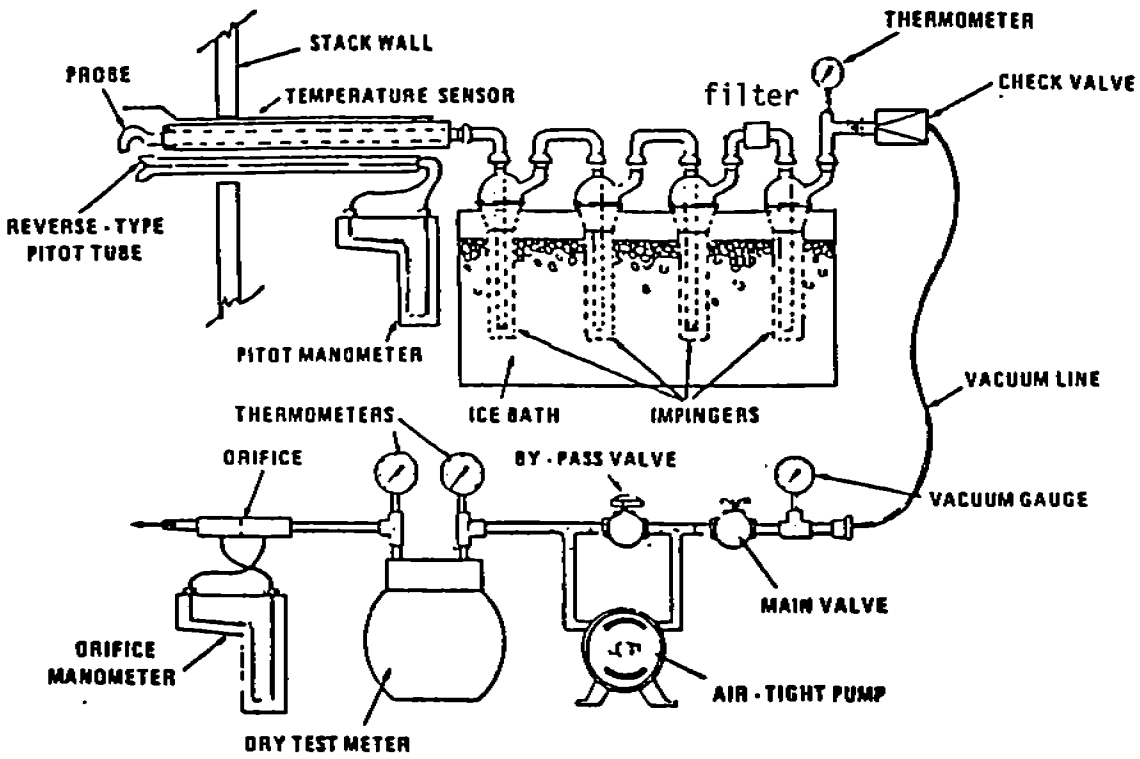


Figure 2. Schematic of the hexavalent chromium sampling train

SECTION 5

QUALITY ASSURANCE PROCEDURES AND PROJECT LOG

Quality Assurance

The equipment used in this test program was calibrated as specified in each respective method. Pre- and post-test equipment calibration data are presented in Appendix F.

All field data was recorded on standard data sheets and field analytical data was documented in a notebook. These are presented in Appendix B.

Quality assurance (QA) of the sample analyses included the preparation of a standard curve and reagents on a daily basis. Sample QA also included analyzing reagent blanks and one standard or duplicate sample with each set of samples being analyzed.

Test Program Personnel

The following is a list of the field team personnel involved in the completion of this test program:

Frank Clay	- USEPA Project Officer
Helen J. Owens	- Project Manager; laboratory analyses
John Chehaske	- Meter reader, outlet
Eric Hollins	- Site Erection Coordinator; meter reader, inlet
Jay Morgan	- Meter reader, inlet
Joey Fuller	- Technician
Darren Machuga	-Technician

Project Log

The following is a summary of the field activities:

6/16/91 - Travel to Willits, California.

6/17/91 - Inventory equipment, initial set-up.

6/18/91 - Completion of site set-up, preliminary velocity traverses, modify process operation to meet test condition requirements.

6/19/91 - Completion of one, six-hour measurement run at each site, recovery and analysis of emission samples.

6/20/91 - Completion of one, six-hour measurement run at each site, recovery and analysis of emission samples.

6/21/91 - Completion of one, six-hour measurement run at each site, recovery and analysis of emission samples; site restoration, pack and ship equipment.

6/22/91 - Travel

APPENDIX A

PROCESS DATA - MRI

APPENDIX B

FIELD DATA SHEETS

SAMPLE RECOVERY DATA

Plant: Remco Hydraulics Run No.: IA-1

Date: 6/18/91 Sample Box No.: 1 Job No.: ~~IA-1~~

Sample Location: Inlet "A"

Sample Type: Cr^{+6} Filter No.: -

Sample Recovery Person: Machuga, Hollins

Comments:

FRONT HALF

Acetone Container No.: IA-1 Liquid Level Marked: Brought to 1000 ml ✓ Sealed: ✓

Filter Container No.: Sealed:

Description of Filter:

Samples stored and locked: ✓

BACK HALF/MOISTURE

Container No:

Liquid Level Marked: Sealed:

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams) INITIAL	FINAL	NET
1	$NaHCO_3$	100	563.0	566.4	3.4
2	$NaHCO_3$	100	569.6	579.4	9.8
3	[illegible]		[illegible]	431.3	4.6
4	Silica Gel		707.0	741.9	34.9
5					
6					
TOTAL					52.7

Description of Impinger Catch:

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant Remco Hydraulics
Date 6/18/91
Sampling Location Inlet A
Sample Type Cr^{+6}
Run Number IA-1
Operator FH - DM
Barometric Pressure (P_b) 28.80
Static Pressure (P_s) -1.9 (28.66)
Filter Number(s) —
Pretest Leak Rate = 0.018 cfm @ 15 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check
Read and Record all Data Every 15 Minutes
Page 1 of 2

CO_2			
O_2			
CO			
N_2			

Condensers
V_f: Silica gel
Total H_2O

Probe Length and Type 4' Glass
Pitot Tube I.D. No. S-58
Nozzle I.D. 0.267, 0.272, 0.270 = 0.270
Assumed Moisture, % 2
Meter Box Number MB-11
Meter Δ H@ 1.84
Meter Gamma 1.028
Reference Δ p ΔP = ΔH 5.5
Post Test Leak Rate = 0.010 cfm @ 7 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

Schematic of Traverse Point Layout

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. °F (T_s)	Probe Temp / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
	0	10:15	070.182					/				
A-1	15	10:45	76.15	0.08	~~0.39~~	0.39	68	/	62	71	70	1
2	30	11:00	82.08	0.09	0.43	0.43	72	/	60	77	73	1
3	45	11:15	88.06	0.09	0.43	0.43	71	/	64	82	77	1
4	60	11:30	95.02	0.11	0.62	0.62	73	/	66	86	80	1.5
5	75	11:45	103.99	0.21	1.15	1.15	73	/	67	91	84	2
6	90	12:00	117.72	0.54	3.0	3.0	74	/	69	96	87	5
7	105	12:15	133.50	0.64	3.6	3.6	74	/	72	103	92	6
8	120	12:30	148.48	0.58	3.2	3.2	73	/	70	104	94	5.5
9	135	12:45	163.20	0.56	3.1	3.1	72	/	63	104	95	5
10	150	13:00	177.89	0.54	3.0	3.0	73	/	59	104	96	5
11	165	13:15	192.44	0.56	3.1	3.1	73	/	59	105	97	5
12	180	13:30	206.476	0.54	3.0	3.0	74	/	59	105	98	5

Plant Name: Rmco Hydraulics

Test Date: 6/19/91

Run Number: IA-1

Operator: E.H / D.M

Pre Test Leak Rate 0.015 @ 10"

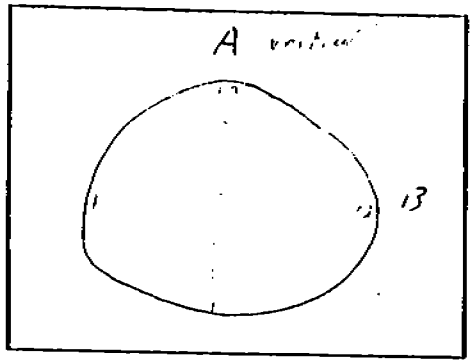
Post Test Leak Rate 0.012 @ 7"

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Orifice Pres. Differential (ΔH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp.° F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
	0	1 19.02	207.246					/				
B-1	15	1 14.17	223.83	0.75	4.1	4.1	76	/	61	94	95	6
2	30	1 14:32	240.67	0.79	4.2	4.2	77	/	57	104	96	6
3	45	1 14:47	257.31	0.75	4.1	4.1	78	/	59	104	96	6
4	60	1 15:02	273.91	0.74	4.1	4.1	77	/	60	104	96	6
5	75	1 15:17	290.49	0.74	4.1	4.1	77	/	60	105	96	6
6	90	1 15:32	307.10	0.74	4.1	4.1	78	/	61	105	97	6
7	105	1 15:47	323.71	0.74	4.1	4.1	77	/	62	104	97	6
8	120	1 1602	338.83	0.70	3.8	3.8	77	/	64	105	96	6
9	135	1 1617	356.67	0.70	3.8	3.8	77	/	64	105	96	6
10	150	1 1632	372.64	0.57	3.2	3.2	77	/	70	103	95	5
11	165	1 1647	387.55	0.60	3.3	3.3	77	/	58	104	96	5
12	180	1 1702	402.526	0.60	3.3	3.3	77	/	56	104	96	5
		/						/				
		/						/				
		/	Vm=	$\sqrt{\Delta P}$=		ΔH =	Ts=	/		Tm=		
		/	352.344	0.6013		2.47	75°F	/		95°F		
		/					535°R	/		555°R		
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant: Remco Hydraulics
Date: 6-20-91
Sampling Location: Inlet 'A'
Sample Type: C.T.O
Run Number: IA-2
Operator: E.H. / D.M.
Barometric Pressure (B): 28.81
Static Pressure (Ps): -1.9
Filter Number(s):
Pretest Leak Rate = 0.003 cfm @ 15 in. Hg
Pretest Pitot Leak Check: ✓
Pretest Orsat Leak Check:
Read and Record all Data Every 15 Minutes
Page 1 of 2



Schematic of Traverse Point Layout

CO_2	
O_2	
CO	
N_2	

Condensers	
V_f: Silica gel	
Total H_2O	

Probe Length and Type: 4' Glass
Pitot Tube I.D. No.: S-5B
Nozzle I.D.: 0.270
Assumed Moisture, %: 2
Meter Box Number: MB-11
Meter Δ H@: 1.84
Meter Gamma: 1.028
Reference Δ p: 1 = 5.6
Post Test Leak Rate = 0.002 cfm @ 8 in. Hg
Post Test Pitot Leak Check:
Post Test Orsat Leak Check:

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24 hour clock)	Gas Meter Reading (Vm) ft³	Velocity Head (ΔPs) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp °F (Ts)	Probe Temp / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
	0	0925	402.723									
A-1	15	0940	409.58	0.12	0.62	0.62	67		63	70	69	1
2	30	0955	415.89	0.10	0.56	0.56	67		56	75	71	1
3	45	1010	422.25	0.10	0.56	0.56	68		63	80	74	1
4	60	1025	428.90	0.11	0.62	0.62	69		67	85	79	1
5	75	1040	437.47	0.20	1.1	1.1	71		70	88	82	2
6	90	1055	450.60	0.51	2.8	2.8	70		71	92	85	5
7	105	1110	466.15	0.68	3.8	3.8	70		64	97	87	7
8	120	1125	482.40	0.61	3.4	3.4	71		65	99	89	6
9	135	1140	496.52	0.58	3.2	3.2	72		65	101	92	5
10	150	1155	510.54	0.54	3.0	3.0	73		65	102	94	5
11	165	1210	525.10	0.52	2.9	2.9	74		64	103	95	4.5
12	180	1225	538.872	0.54	3.0	3.0	74		65	104	96	
			Vm 350.710	Vap	ΔH							
				.7110	3.00		TS 71			TM 94		
							R 531			R 554		

Plant Name: Remco Hydraulics

Test Date: 6-20-91

Run Number: IA-2

Operator: FM, DM

Pre Test Leak Rate 0.003 @ 10"

Post Test Leak Rate = 0.004 @

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Orifice Pres. Differential (ΔH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp.° F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
	0	1 12:45	539.090					/				
B-1	15	/	555.58	0.77	4.1	4.1	76	/	66	94	94	7
2	30	/	572.23	0.75	4.1	4.1	77	/	65	103	95	7
3	45	/	588.89	0.74	4.1	4.1	78	/	67	105	97	7
4	60	/	605.41	0.73	4.0	4.0	78	/	69	106	98	7
5	75	/	621.99	0.73	4.0	4.0	78	/	71	106	99	7
6	90	/	638.64	0.74	4.1	4.1	78	/	55	106	99	7
7	105	/	655.66	0.77	4.3	4.3	78	/	54	106	99	7
8	120	/	672.45	0.75	4.1	4.1	79	/	54	106	99	7
9	135	/	688.77	0.69	3.8	3.8	79	/	54	105	98	7
10	150	/	704.47	0.65	3.6	3.6	77	/	54	105	98	6
11	165	/	719.17	0.55	3.1	3.1	77	/	55	105	98	5
12	180	1545	733.711	0.55	3.1	3.1	77	/	55	104	98	5
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				
		/						/				

Plant Name: Rock Hill Lime Co.

Run Number: IA-3

Test Date: 6-21-91

Operator: EH, DM

PreTest Leak Rate 0.006 @ 10"

PostTest Leak Rate = 0.002 @ 5"

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Orifice Pres. Differential (ΔH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp.° F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
B	0	11:25	877.788	—				/				
B-1	15	11:40	894.81	0.78	4.4	4.4	77	/	56	88	89	4
2	30	11:55	912.29	0.82	4.5	4.5	75	/	62	99	91	4
3	45	1210	929.68	0.80	4.5	4.5	76	/	67	103	93	4
4	60	1225	947.11	0.80	4.5	4.5	77	/	64	105	96	4
5	75	1240	964.32	0.77	4.3	4.3	77	/	64	107	98	4
6	90	1255	981.69	0.78	4.4	4.4	78	/	65	108	99	4
7	105	1310	999.07	0.78	4.4	4.4	78	/	67	109	100	4
8	120	1325	016.12	0.74	4.2	4.2	79	/	70	109	102	4
9	135	1340	032.58	0.64	3.9	3.9	80	/	58	109	102	4
10	150	1355	048.21	0.63	3.5	3.5	80	/	57	109	102	3
11	165	1410	063.56	0.61	3.4	3.4	81	/	56	108	102	3
12	180	1425	078.641	0.60	3.3	3.3	79	/	58	108	102	3
		/						/				
		/	200.503					/				
		/						/				
		/						/				
		/						/				
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		/						/				
		/						/				
		/						/				
		/						/				
		/						/				

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant	Remco Hydraulics
Date	6-21-91
Sampling Location	Inlet 'A'
Sample Type	Cr VI
Run Number	IA-3
Operator	EH, DM
Barometric Pressure (B)	28.80
Static Pressure (P_s)	-1.9
Filter Number(s)	—
Pretest Leak Rate =	0.005 cfm @ 10 in. Hg
Pretest Pitot Leak Check	✓
Pretest Orsat Leak Check	
Read and Record all Data Every	15 Minutes
Page	1 of 2

CO_2			
O_2			
CO			
N_2			

Condensers	
V_{lc}: Silica gel	
Total H_2O	

Probe Length and Type	5' Glass
Pitot Tube I.D. No.	S-5B
Nozzle I.D.	0.270
Assumed Moisture, %	2
Meter Box Number	M3-11
Meter $\Delta H@$	1.84
Meter Gamma	1.028
Reference Δp	1.5.6
Post Test Leak Rate =	0.014 cfm @ 10 in. Hg
Post Test Pitot Leak Check	
Post Test Orsat Leak Check	

Schematic of Traverse Point Layout

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
	0	7:47	733.967									
A-1	15	8:02	741.01	0.33	.72	.72	60		53	61	60	1
2	30	8:17	747.97	0.13	0.72	.72	62		44	67	63	1
3	45	8:32	754.92	0.12	0.68	0.68	62		47	73	66	1
4	60	8:47	762.04	0.13	0.72	0.72	64		49	76	70	1
5	75	9:02	771.02	0.22	1.2	1.2	65		50	80	73	1
6	90	10917	789.39	0.51	2.8	2.8	67		52	85	76	3
7	105	0932	800.53	0.71	4.0	4.0	68		55	90	80	4
8	120	0947	816.28	0.65	3.7	3.7	67		58	94	83	4
9	135	1002	831.02	0.57	3.1	3.1	68		59	95	86	3
10	150	1017	845.45	0.57	3.1	3.1	70		58	96	87	3
11	165	1032	861.17	0.68	3.8	3.8	71		59	97	84	4
12	180	1047	877.637	0.72	4.0	4.0	72		60	99	90	4
			Vm 377.473	√P 0.777								
					AH		TS			Tm 91		
			377.634		3.297		69					
							R			R		
			445.610				529			550		
		VM	344.523									

SAMPLE RECOVERY DATA

Plant: Remco Hydraulics Run No.: I4-3

Date: 6-20-99 Sample Box No.: 1 Job No.: _____

Sample Location: Inlet "A"

Sample Type: Cr^{+6} Filter No.: _____

Sample Recovery Person: D. Mackoen / C. Holtrop

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____

Liquid Level Marked: _____ Sealed: _____

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	$NaHCO_3$	100	562.3	577.2	14.9
2	$NaHCO_3$	100	571.4	581.5	10.1
3	MT		426.8	431.8	5.0
4	Silica Gel		674.9	728.9	54.0
5					
6					
TOTAL					84.0

Description of Impinger Catch: _____

SAMPLE RECOVERY DATA

Plant: Remco Hydraulics Run No.: I4-3

Date: 6-20-99 Sample Box No.: 1 Job No.: _____

Sample Location: Inlet "A"

Sample Type: Cr^{+6} Filter No.: _____

Sample Recovery Person: D. MacHolm / C. Holtan

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	$NaHCO_3$	100	562.3	577.2	14.9
2	$NaHCO_3$	100	571.4	581.5	10.1
3	MT		426.8	431.8	5.0
4	Silica Gel		674.9	728.9	54.0
5					
6					
TOTAL					84.0

Description of Impinger Catch: _____

SAMPLE RECOVERY DATA

Plant: Remco Hydraulics Run No.: IA-2

Date: 6-19-91 Sample Box No.: 1 Job No.:

Sample Location: Inlet "A"

Sample Type: Cr^{+6} Filter No.:

Sample Recovery Person: D Machuca / E Hollins

Comments:

FRONT HALF

Acetone Container No.: Liquid Level Marked: Sealed:

Filter Container No.: Sealed:

Description of Filter:

Samples stored and locked:

BACK HALF/MOISTURE

Container No:

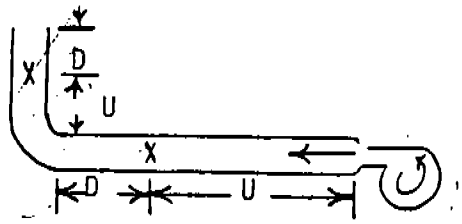
Liquid Level Marked: Sealed:

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	$NaHCO_3$	100	562.0	581.3	19.3
2	$NaHCO_3$	100	571.9	569.2	-2.7
3	MT		426.6	431.6	5.0
4	Silica Gel		697.9	755.3	57.4
5					
6					
TOTAL					79.0

Description of Impinger Catch:

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Lemco Hydrolucs
DATE 6/17/91
SAMPLING LOCATION Inlet A
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A) 31.75
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B) 0.25
STACK I.D., (DISTANCE A - DISTANCE B) 31.50
NEAREST UPSTREAM DISTURBANCE (U)
NEAREST DOWNSTREAM DISTURBANCE (D)
CALCULATOR

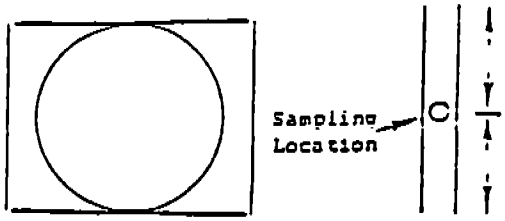


SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	0.021	31.5	0.662	0.25	0.912
2	0.067		2.11		2.36
3	0.118		3.72		3.97
4	0.177		5.58		5.83
5	0.250		7.88		8.13
6	0.356		11.21		11.46
7	0.644		20.29		20.54
8	0.750		23.63		23.88
9	0.823		25.92		26.17
10	0.882		27.78		28.03
11	0.933		29.39		29.64
12	0.979		30.84		31.09

PRELIMINARY VELOCITY TRAVERSE

Plant: Pennce Hydraulics
Job No. 4371
Run No. Pre 1.2
Time: 12:00
Date: 6/18/91
Location: Inlet A
Stack I.D.: 31.5"
Barometric Pressure, in. Hg: 28.65
Stack Gauge Pressure, in. H_2O: -19
Operators: EH, DM
Pitot Tube Number: S-5B
Thermocouple No. 5A
Temperature Readout I.D.: MB-11
Pitot Tube Leak Check: ✓



Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A-1	0.39	74	+2
2	0.38	74	0
3	0.37	74	0
4	0.36	74	0
5	0.36	74	0
6	0.37	74	-2
7	0.35	74	-2
8	0.32	74	-2
9	0.29	74	-2
10	0.31	73	-3
11	0.30	73	+10
12	0.33	72	+3

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
B 1	0.09	74	+8
2	0.08	74	+5
3	0.07	74	0
4	0.08	73	0
5	0.11	74	0
6	0.20	74	-5
7	0.34	74	-3
8	0.32	74	-2
9	0.30	74	-2
10	0.30	74	-5
11	0.29	73	-3
12	0.28	73	0

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant: Remco Hydraulics
Date: 6/19/91
Sampling Location: Inlet B
Sample Type: Cr
Run Number: IB-1
Operator: JM AF
Barometric Pressure (P_b): 28.80
Static Pressure (P_s): -.8
Filter Number(s): N/A
Pretest Leak Rate = 0.002 cfm @ 15 in. Hg
Pretest Pilot Leak Check: ok
Pretest Orsat Leak Check:
Read and Record all Data Every 15 Minutes
Page 1 of 1

CO_2			
O_2			
CO			
N_2			

Condensers
V_{lc}: Silica gel
Total H_2O

Probe Length and Type: 4ft glass
Pitot Tube I.D. No.: S-3A
Nozzle I.D.: 0.248
Assumed Moisture, %: 2
Meter Box Number: MB-13
Meter $\Delta H@$: 1.90
Meter Gamma: 1.019
Reference Δp: 1-9.2
Post Test Leak Rate = 0.002 cfm @ 8 in. Hg
Post Test Pilot Leak Check: ok
Post Test Orsat Leak Check:

Schematic of Traverse Point Layout

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Press. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
B 1	0	1030	693.029	0.74	3.1	3.1	71		66	70	67	6
2	15		707.14	0.67	2.5	2.5	71		56	82	69	5
3	30		720.86	0.72	3.0	3.0	73		57	91	74	6
4	45		735.23	0.71	3.0	3.0	74		58	95	79	6
5	60		749.50	0.72	3.0	3.0	75		60	99	84	6
6	75		763.75	0.69	2.8	2.8	76		60	102	87	5
7	90		777.76	0.46	1.8	1.8	76		59	101	89	4
8	105		789.43	0.53	2.2	2.2	75		57	101	87	5
9	120		802.13	0.49	2.1	2.1	76		58	100	89	5
10	135		814.20	0.63	2.7	2.7	78		56	99	89	5
11	150		828.11	0.72	3.0	3.0	77		58	100	89	5
12	165		841.76	0.54	2.3	2.3	77		58	101	89	5
A 1	180	1350/1358	334.340/341.454	0.69	2.8	2.8	78		74	86	85	5
2	195		348.28	0.65	2.7	2.7	75		50	95	85	5
3	210		881.63	0.70	2.9	2.9	75		50	98	86	5
4	225		895.65	0.67	2.8	2.8	75		50	99	88	5
5	240		909.40	0.64	2.7	2.7	76		50	100	88	5
6	255		922.5	0.64	2.7	2.7	76		50	100	88	5
7	270		936.55	0.42	1.8	1.8	75		50	99	89	4
8	285		947.60	0.37	1.6	1.6	75		50	96	88	4
9	300	1600/1614	958.27	0.38	1.6	1.6	76		50	94	87	4
10	315		968.46	0.57	2.4	2.4	74		50	92	85	4
11	330		981.14	0.33	1.3	1.3	72		50	96	86	5
12	345		990.82	0.34	1.3	1.3	75		50	92	85	5
	360		000.293	$\sqrt{\Delta P}$ = 0.7595			T_s = 75.0					

Shutdown 1600 *

SAMPLE RECOVERY DATA

Plant: Rancc Run No.: IB-1

Date: 6/17/91 Sample Box No.: 2 Job No.: 4371

Sample Location: Inlet "B"

Sample Type: Ch 6 Filter No.: ---

Sample Recovery Person: D. Machuga

Comments:

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	Na_2HCO_3	100	559.5	590.3	30.8
2	Na_2HCO_3	100	580.8	593.4	12.6
3	mt	–	456.3	458.6	2.3
4	Silica Gel		670.0	700.1	30.1
5					
6					
TOTAL					75.8

Description of Impinger Catch: _____

SAMPLE RECOVERY DATA

Plant: Remco Hydraulics Run No.: IB-2

Date: 6-19-91 Sample Box No.: 2 Job No.: _____

Sample Location: Inlet "B"

Sample Type: Cr^{+6} Filter No.: _____

Sample Recovery Person: D Machugh / E Hollins

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	$NaHCO_3$	100	563.5	586.5	23.0
2	$NaHCO_3$	100	579.9	596.1	16.2
3	MT		457.4	460.0	2.6
4	Silica Gel		628.1	669.9	41.8
5					
6					
TOTAL					83.6

Description of Impinger Catch: _____

SAMPLE RECOVERY DATA

Plant: REMCO HYDRAULICS Run No.: IB-3

Date: 6-20-91 Sample Box No.: 2 Job No.: _____

Sample Location: INLET "B"

Sample Type: Cr^{+6} Filter No.: _____

Sample Recovery Person: D. MACHUGA / E. HOLLINS

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

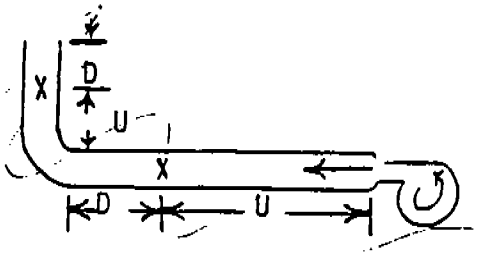
Liquid Level Marked: _____ Sealed: _____

IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams)		
			INITIAL	FINAL	NET
1	$NaHCO_3$	100	560.7	581.0	20.3
2	$NaHCO_3$	100	580.6	591.7	11.1
3	MT		457.5	459.3	1.8
4	SILICA GEL		646.8	693.3	46.5
5					
6					
TOTAL					79.7

Description of Impinger Catch: _____

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Remco Hydraulics
DATE 6/17/91
SAMPLING LOCATION Inlet B
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A) 27.25
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B) 0.25
STACK I.D., (DISTANCE A - DISTANCE B) 27
NEAREST UPSTREAM DISTURBANCE (U)
NEAREST DOWNSTREAM DISTURBANCE (D)
CALCULATOR

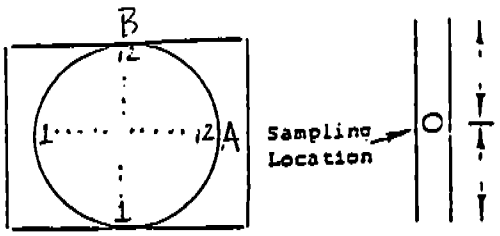


SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	0.021	27.0	0.567	0.25	0.82
2	0.067		1.809		2.06
3	0.118		3.186		3.44
4	0.177		4.779		5.03
5	0.250		6.750		7.00
6	0.356		9.612		9.86
7	0.644		17.388		17.64
8	0.750		20.250		20.50
9	0.823		22.221		22.47
10	0.882		23.814		24.06
11	0.933		25.191		25.44
12	0.979		26.433		26.68

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco Hydraulics Job No. _____
Run No. 1 Time: 1600
Date: 6-17-91
Location: Inlet B
Stack I.D.: 27
Barometric Pressure, in. Hg: _____
Stack Gauge Pressure, in. H_2O: ~~4M~~ -1.1
Operators: JM DM
Pitot Tube Number: S-3A
Thermocouple No. 3B
Temperature Readout I.D.: MB-13
Pitot Tube Leak Check: OK



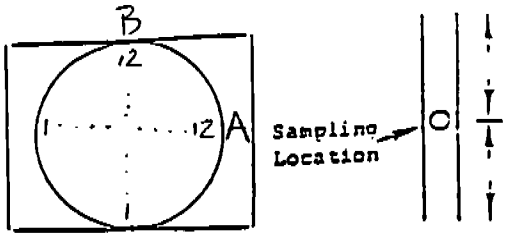
Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A 1	0.15	85	4M ~~10~~ 7
2	0.16	85	4
3	0.17	85	6
4	0.17	85	5
5	0.17	84	3
6	0.14	85	0
7	0.12	86	0
8	0.11	85	0
9	0.10	85	0
10	0.10	86	-4
11	0.10	86	13
12	0.11	85	11

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
B 1	0.16	84	7
2	0.17	84	11
3	0.18	84	4
4	0.18	84	8
5	0.18	84	6
6	0.16	84	2
7	0.13	84	0
8	0.15	85	2
9	0.17	85	0
10	0.20	85	-1
11	0.20	85	-1
12	0.19	85	-2

PRELIMINARY VELOCITY TRAVERSE

Plant: Tenneco Hydraulics Job No. _____
Run No. 2 Time: 1100
Date: 6/18/91
Location: Inlet B.
Stack I.D.: 27
Barometric Pressure, in. Hg: 28.70
Stack Gauge Pressure, in. H_2O: -1.8
Operators: TM. JF
Pitot Tube Number: S-3A
Thermocouple No. 3B
Temperature Readout I.D.: MB-13
Pitot Tube Leak Check: OK



Schematic of Traverse Point Layout

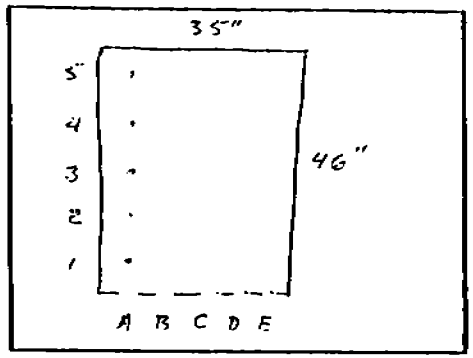
Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A 1	0.29	72	5
2	0.29	72	—
3	0.32	72	—
4	0.33	72	0
5	0.30	72	—
6	0.29	73	—
7	0.20	74	—
8	0.17	74	0
9	0.22	74	—
10	0.30	74	—
11	0.31	73	7
12	0.28	73	5

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
B 1	0.26	73	10
2	0.27	72	8
3	0.31	72	—
4	0.32	72	12
5	0.30	72	5
6	0.30	73	—
7	0.25	73	—
8	0.30	73	5
9	0.29	74	—
10	0.43	75	0
11	0.59	76	~~10~~ 15
12	0.60	76	10

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant Remco Hydraulics
Date 6-~~28~~ 19-91
Sampling Location Outlet
Sample Type Cr
Run Number 0-1
Operator Chehoske
Barometric Pressure (P_B) 28.75
Static Pressure (P_s) -0.33
Filter Number(s)
Pretest Leak Rate = 0.005 cfm @ 15 in. Hg
Pretest Pitot Leak Check OK
Pretest Orsat Leak Check NA
Read and Record all Data Every 15 Minutes
Page 1 of



Schematic of Traverse Point Layout

CO_2	
O_2	
CO	
N_2	

Condensers	
V_f: Silica gel	
Total H_2O	

Probe Length and Type 48" Glass Lined
Pitot Tube I.D. No. S-2
Nozzle I.D. 0.247, .246, .247
Assumed Moisture, % 2
Meter Box Number MB-10
Meter Δ H@ 1.727
Meter Gamma 1.042
Reference Δ p 0.46
Post Test Leak Rate = 0.02 cfm @ 17½ in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
	0	10:10	23.513					/				
A-5	2	10:12	24.437	0.34	1.40	1.40	67	Stop; Fan Down		57	56	
A-5	2	10:28	24.437	0.34	1.40	1.40		Restart Test	62	58	57	7
A-4	15	10:41	32.63	0.37	1.50	1.50	69	/	62	64	59	8
A-3	30	10:56	42.60	0.41	1.60	1.60	69	/	62	65	61	9
A-2	45	11:11	52.88	0.65	2.45	2.45	69	/	58	70	63	13¾
A-1	60	11:26	65.80	0.97	3.70	2.75	70	/	57	73	66	16
A-1	75	11:41	79.355	Stop	For Port Change			/				
B-5	75	11:43	77.355	0.28	1.05	1.05	72	/	61	72	68	6
B-4	90	11:58	88.10	0.31	1.20	1.20	72	/	59	74	69	6½
B-3	105	12:13	97.21	0.34	1.30	1.30	72	/	57	72	68	7
B-2	120	12:28	106.80	0.46	1.75	1.75	70	/	55	74	69	10
B-1	135	12:43		~~0.84~~ 0.82	~~3.20~~ 3.10	2.90	70	/	56	77	70	17
B-1	150	12:58	131.585	Stop	For Port Change			/		~~74~~	~~71~~	
C-5	150	13:01	131.535	0.25	0.95	0.95	74	/	60	74	71	5½
C-4	165	13:16	139.58	0.27	1.05	1.05	73	/	58	78	74	6
C-3	180	13:31	148.60	0.33	1.25	1.25	73	/	58	79	74	6½
C-2	195	13:46	157.79	0.53	2.00	2.00	71	/	56	79	73	10¾
C-1	210	14:01	169.42	0.76	2.90	2.90	71	/	58	80	74	17
C-1	225	14:16	183.412	Stop	To Change Parts			/				
B-5	225	14:18	183.412	0.26	1.00	1.00	73	/	58	77	74	5¾
B-4	240	14:33	191.90	0.27	1.03	1.05	74	/	57	80	75	6
B-3	255	14:48	200.54	0.32	1.20	1.20	73	/	54	79	74	6½
B-2	270	15:03	209.60	0.59	2.20	2.20	73	/	54	80	74	12

Plant Name: Remco Hydraulics **Test Date:** 6-19-91

Run Number: 0-1 **Operator:** Chehaske

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Orifice Pres. Differential (ΔH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
B-1	285	15:18	222.00	0.89	3.30	2.90	73	/	54	81	75	17
B-1	300	/	235.862	Stop to		Change	Ports	/		~~76~~	~~73~~	
D-5	300	15:35	235.862	0.27	1.03	1.03	73	/	54	76	73	6
D-4	315	15:50	244.39	0.26	1.00	1.00	73	/	54	76	73	5 3/4
D-4	324:30	15:59:30	249.843	Stop Test 1D			Fan Down	/				
D-4	324.5	16:12:30	249.843	Restart		Test		/				
D-3	330	16:18:00	253.01	0.30	1.15	1.15	73	/	52	75	73	6 1/4
D-2	345	16:33	261.91	0.67	2.50	2.50	73	/	54	78	72	14 1/4
D-1	360	16:48	274.92	0.82	3.05	2.90	73	/	54	78	73	17 1/2
D-1	375	17:03	288.991					/				
		/				ΔH =		/				
		/	V_m=	$\sqrt{\Delta P}$=		ΔP - 1.71	T_s=	/		T_m=		
		/	265.778	0.6639		1.71	72°F	/		72°F		
		/					532°R	/		532°R		
		/						/				
		/						/				
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		/						/				
		/						/				

SAMPLE RECOVERY DATA

Plant: Kowco Run No.: O-1

Date: 6-17&18-91 Sample Box No.: W-1 Job No.: 4371

Sample Location: Scrubber Outlet

Sample Type: Cr^{+6} Filter No.: —

Sample Recovery Person:

Comments:

FRONT HALF

Acetone Container No.: Liquid Level Marked: ✓ brought to 1000 ml volume Sealed: ✓ yes

Filter Container No.: Sealed:

Description of Filter:

Samples stored and locked:

BACK HALF/MOISTURE

Container No:

Liquid Level Marked: Sealed:

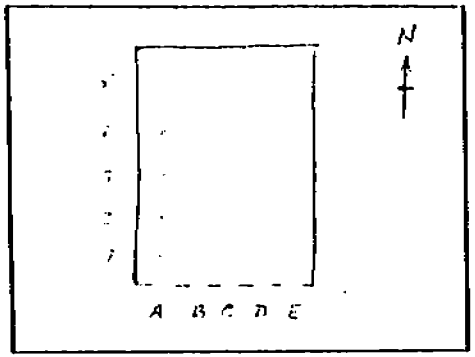
IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams) INITIAL	FINAL	NET
1		100	551.8	607.9	56.1
2		100	562.4	569.2	6.8
3		-0-	476.4	479.1	2.7
4			743.7	777.9	34.2
5					
6					
TOTAL					99.8

Description of Impinger Catch:

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant: Ronco Hydraulics
Date: 6-20-91
Sampling Location: Outlet
Sample Type: C
Run Number: C-2
Operator: Chelinski
Barometric Pressure (P_b): 28.81
Static Pressure (P_s): -0.33
Filter Number(s):
Pretest Leak Rate = 0.004 cfm @ 15 in. Hg
Pretest Pitot Leak Check: OK
Pretest Orsat Leak Check: NA
Read and Record all Data Every 15 Minutes
Page 1 of



Schematic of Traverse Point Layout

CO_2	
O_2	
CO	
N_2	

V_f: Condensers	
Silica gel	
Total H_2O	

Probe Length and Type: 4' Glass Lined
Pitot Tube I.D. No.: S-8
Nozzle I.D.: 0.247, 0.246, 0.247
Assumed Moisture, %: 2.0
Meter Box Number: MB-1C
Meter ΔH@: 1.727
Meter Gamma: 1.0142
Reference Δp: 0.47
Post Test Leak Rate = 0.004 cfm @ 15 in. Hg
Post Test Pitot Leak Check: OK
Post Test Orsat Leak Check: NA

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24 hour clock)	Gas Meter Reading (Vm) ft³	Velocity Head (P_v) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp °F (T_s)	Probe Temp / Filter Temp. °F	Impingers Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
A-5	0	10:00	307.204	0.33	1.30	1.30	68		54	58	57	4
A-4	15	10:13	311.31	0.34	1.30	1.30	66		54	65	58	4
A-3	30	10:30	315.31	0.38	1.45	1.45	67		56	67	60	5
A-2	45	10:45	320.25	0.31	2.00	2.00	68		54	71	63	3 1/2
A-1	60	10:55	324.06	0.23	3.45	3.45	67		55	73	65	11 1/2
B-5	75	10:45	326.534	Stop To Change Probe Liner						71	67	
B-5	75	10:45	326.534	0.27	1.00	1.00	70		57	71	67	3 3/4
B-4	90	11:00	335.30	0.30	1.15	1.15	70		55	72	67	4
B-3	105	11:15	344.15	0.34	1.30	1.30	71		57	74	67	4 1/4
B-2	120	11:30	353.50	0.34	1.65	1.65	71		57	76	70	5 1/2
B-1	135	11:45	363.78	0.34	2.75	2.75	69		58	78	72	7
B-1	150	12:00	367.608	Stop To Change Probe						78	74	
C-5	150	12:01	367.608	0.21	0.70	0.70	73		57	78	74	3 1/2
C-4	165	12:16	405.50	0.25	0.73	0.73	73		57	81	76	3 1/2
C-3	180	12:31	414.06	0.32	1.25	1.25	73		58	83	78	4 1/4
C-2	195	12:46	423.35	0.30	1.75	1.75	73		57	86	80	6 1/4
C-1	210	13:01	434.62	0.39	2.85	2.85	71		58	87	82	9 1/2
D-1	225	13:16	448.770	Stop To Change Probes								
D-5	225	13:18	448.770	0.25	0.96	0.96	75		60	87	83	3 1/2
D-4	240	13:33	457.08	0.25	0.96	0.96	75		59	88	84	3 1/2
D-3	255	13:45	465.46	0.30	1.05	1.05	74		60	89	87	4
D-2	270	14:03	474.10	0.61	2.30	2.30	74		60	89	85	7 1/4
D-1	285	14:16	480.55	0.87	3.30	3.30	72		62	92	84	[illegible]

Vm 264.135 Vm 1.513 ΔH 72 Ts 72 Tm 70

Plant Name: Remco Hydraulics **Test Date:** 6-20-91

Run Number: 0-2 **Operator:** Chehaske

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
D-1	~~315~~ 300	14:33	501.597	Stop	To	Change	Ports					
E-5	~~315~~ 300	14:35	501.597	0.26	1.00	1.00	75		63	87	84	4
E-4	~~330~~ 315	14:50	510.10	0.27	1.05	1.05	75		60	87	83	4
E-3	~~345~~ 330	15:05	518.89	0.31	1.20	1.20	75		62	88	83	4
E-2	345	15:20	527.85	0.66	2.60	2.60	74		61	90	84	9½
E-1	360	15:35	541.10	0.85	3.30	3.30	74		63	92	85	11
E-1	375	15:50	556.142	END	TEST	0-2						
						ΔH						
			V_m	$\sqrt{\Delta P}$		1.72		15/105b		T_m: 78		
				.6552								
							T_s					

SAMPLE RECOVERY DATA

Plant: REMCO HYDRAULICS Run No.: C-2

Date: 6-19-91 Sample Box No.: W-1 Job No.: _____

Sample Location: SCRUBBER OUTLET

Sample Type: Cr^{+6} Filter No.: _____

Sample Recovery Person: _____

Comments: _____

FRONT HALF

Acetone Container No.: _____ Liquid Level Marked: _____ Sealed: _____

Filter Container No.: _____ _____ _____ Sealed: _____

Description of Filter: _____

Samples stored and locked: _____

BACK HALF/MOISTURE

Container No: _____ _____ _____

Liquid Level Marked: _____ Sealed: _____

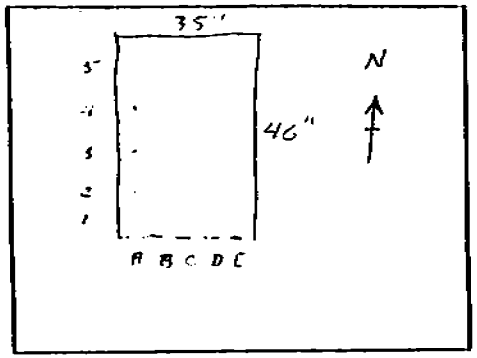
IMP. NO.	CONTENTS	INITIAL VOL (ml)	WEIGHT (grams) INITIAL	FINAL	NET
1	$NaHCO_3$	100	551.4	549.9	
2	$NaHCO_3$	100	561.3	576.9	
3	MT		477.4	480.4	
4	SILICA GEL		815.7	858.0	
5					
6					
TOTAL					

Description of Impinger Catch: _____

PACIFIC ENVIRONMENTAL SERVICES, INC.

FIELD DATA

Plant: Renco Hydraulics
Date: 6-21-91
Sampling Location: Outlet
Sample Type: Cr
Run Number: 0-3
Operator: Chelaske
Barometric Pressure (P_b): 28.80
Static Pressure (P_s): -0.33
Filter Number(s):
Pretest Leak Rate = 0.004 cfm @ 15 in. Hg
Pretest Pitot Leak Check: OK
Pretest Orsat Leak Check: NA
Read and Record all Data Every 15 Minutes
Page 1 of 2



Schematic of Traverse Point Layout

CO_2			
O_2			
CO			
N_2			

Condensers
V_f: Silica gel
Total H_2O

Probe Length and Type: 4' Glass Lined
Pitot Tube I.D. No.: 5-2
Nozzle I.D.: 0.247, 0.246, 0.247
Assumed Moisture, %: 2
Meter Box Number: MB-10
Meter Δ H@: 1.727
Meter Gamma: 1.042
Reference Δ p: 0.50
Post Test Leak Rate = 0.003 cfm @ 12 1/2 in. Hg
Post Test Pitot Leak Check: OK
Post Test Orsat Leak Check: NA

Temp. Sensor ID No.

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (P_s) in. H_2O	Orifice Pres. Differential (dH) in. H_2O Desired	Orifice Pres. Differential (dH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp / Filter Temp. °F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg
A-5	0	107:49	556.723	0.36	1.35	1.35	62		44	47	45	4 1/2
A-4	15	108:04	566.10	0.39	1.45	1.45	62		44	54	47	5
A-3	30	108:19	575.92	0.45	1.70	1.70	62		47	59	51	5 3/4
A-2	45	108:34	586.47	0.60	2.25	2.25	64		51	63	54	7 3/4
A-1	60	108:49	598.74	0.96	3.60	3.60	65		54	65	57	12
A-1	75	109:04	614.133	Stop	To	Change	Port					
B-5	75	109:05	614.133	0.31	1.15	1.15	65		57	66	59	4
B-4	90	109:20	622.90	0.33	1.25	1.25	66		56	68	61	4 1/4
B-3	105	109:35	632.16	0.34	1.30	1.30	66		57	71	64	4 1/4
B-2	120	109:50	641.57	0.46	1.70	1.70	67		61	74	67	6
B-1	135	110:05	652.35	0.82	3.0	3.0	66		60	78	70	10
B-1	150	110:20	666.-	~~0.21~~	~~0.74~~	~~0.74~~	Stop to	Change Port			-	
C-5	150	110:22	666.-	0.25	0.74	0.74	68		64	76	72	2.5
C-4	165	110:37	675.01	0.26	0.98	0.98	69		61	77	72	2 3/4
C-3	180	110:52	683.42	0.36	1.40	1.40	70		62	78	73	4 3/4
C-2	195	111:07	693.14	0.55	2.10	2.10	70		58	80	74	6 3/4
C-1	210	111:22	705.04	0.87	3.30	3.30	69		59	81	74	11
C-1	225	111:37	719.998	Stop	for	Port Change						
D-5	225	111:39	719.998	0.26	0.79	0.99	72		65	82	77	3 3/4
D-4	240	111:54	728.60	0.25	0.77	0.97	72		58	85	78	3 3/4
D-3	255	112:09	736.98	0.30	1.15	1.15	72		59	84	79	4
D-2	270	112:24	745.76	0.62	2.35	2.35	72		58	88	81	7 1/2
D-1	285	112:39	755.42	0.93	3.50	3.50	70		60	90	83	11 1/2

V_m 211.461 VAP .0734 H 1.825 TS 69.5 TA 73°F

Plant Name: Remco Hydraulics **Test Date:** 6-21-91

Run Number: 0-3 **Operator:** Chehaske

Traverse Point Number	Sampling Time, (min.)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft³	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Orifice Pres. Differential (ΔH) in. H_2O Actual	Stack Temp. °F (T_s)	Probe Temp. / Filter Temp.° F	Impinger Temp. °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Dry Gas Meter Temp. Outlet ($T_{m_{out}}$) °F	Pump Vacuum In. Hg
D-1	300	12:54	773.828	Stop To Change Port				/				
E-5	300	12:56	773.828	0.26	1.00	1.00	74	/	62	88	84	3 1/2
E-4	315	13:11	782.37	0.27	1.05	1.05	74	/	59	88	84	3 3/4
E-3	330	13:26	791.10	0.31	1.20	1.20	73	/	59	86	83	4 1/4
E-2	345	13:41	800.15	0.65	2.50	2.50	73	/	58	86	82	8 1/4
E-1	360	13:56	815.30	0.87	3.45	3.45	71	/	61	81	83	11 1/2
E-1	375	14:11	828.684	END RUN No. 0-3				/				
		/						/				
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TRAVERSE POINT LOCATIONS FOR RECTANGULAR DUCTS

PLANT Reco[illegible] Inc

DATE 17 June 199[illegible]

SAMPLING LOCATION Outlet

INSIDE STACK DIMENSIONS [illegible] x 46 [illegible]

INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE. (Distance B) [illegible]

EQUIVALENT STACK I.D. 3[illegible]

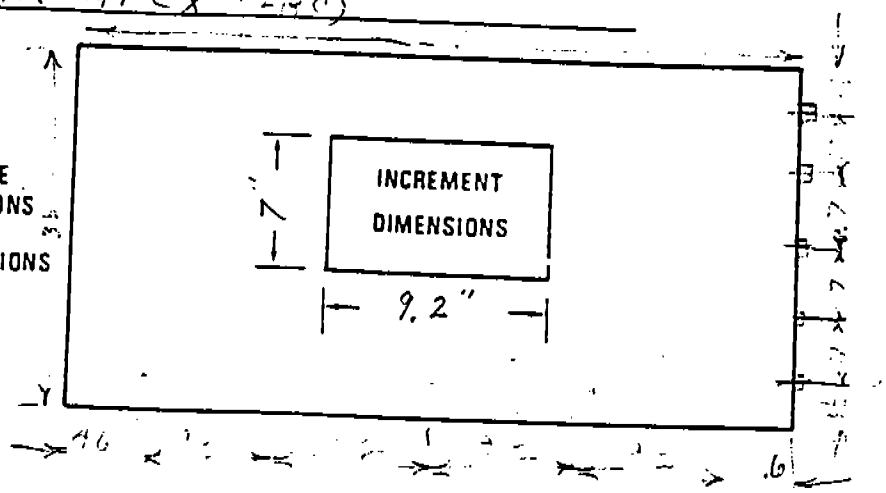
NEAREST UPSTREAM DISTURBANCE 79.25

NEAREST DOWNSTREAM DISTURBANCE 19[illegible]

NUMBER OF TRAVERSE POINTS 25 ARRAY 5 x 5

CALCULATOR HP 41 CX (FRC)

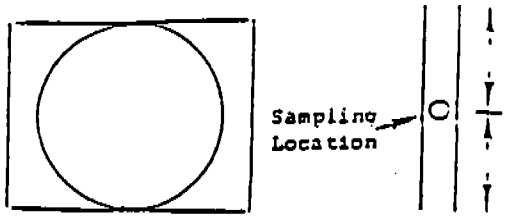
ILLUSTRATE PORT LOCATIONS AND STACK DIMENSIONS



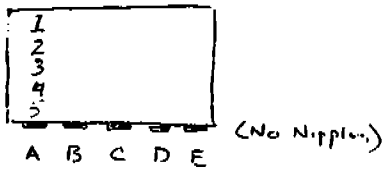
TRAVERSE POINT NUMBER	INSIDE OF NEAR WALL TO TRAVERSE POINT (Distance A)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF DISTANCES A+B)	PORT LOCATION	DISTANCE FROM EDGE OF STACK
1	4.6	0.25	4.85		
2	13.8	0.25	14.05		
3	23.0	0.25	23.25		
4	32.2	0.25	32.45		
5	41.4	0.25	41.65		

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco Hydraulic
Job No. ____
Run No.: 1
Time: 0950
Date: 6/13/91
Location: Outlet
Stack I.D.: 35" x 46"
Barometric Pressure, in. Hg: 28.65
Stack Gauge Pressure, in. H_2O: -0.06
Operators: John Chebeske
Pitot Tube Number: 32
Thermocouple No. 3B
Temperature Readout I.D.: MB 10
Pitot Tube Leak Check: OK



Schematic of Traverse Point Layout

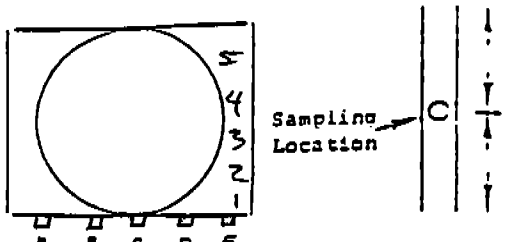


Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A 1	0.10	67	0
2	0.09	67	0
3	0.09	67	0
4	0.14	66	0
5	0.23	66	0
B 1	0.09	67	0
2	0.09	67	0
3	0.09	67	0
4	0.10	67	0
5	0.17	66	0
C 1	0.08	67	0
2	0.08	67	0
3	0.08	67	0
4	0.10	66	0
5	0.18	66	0

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
D 1	0.08	67	0
2	0.07	67	0
3	0.08	67	0
4	0.14	67	0
5	0.19	67	0
E 1	0.08	67	0
2	0.08	67	0
3	0.08	67	0
4	0.18	67	0
5	0.19	67	0

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco Hydraulics Job No. 4371
Run No. Prelim Outlet #2 Time: 10:40
Date: 6-18-91
Location: Scrubber Outlet
Stack I.D.: 35" x 46"
Barometric Pressure, in. Hg: 28.65
Stack Gauge Pressure, in. H_2O: -0.08
Operators: Chebaske & Hollins
Pitot Tube Number: S-2
Thermocouple No.
Temperature Readout I.D.: MB-10
Pitot Tube Leak Check: OK



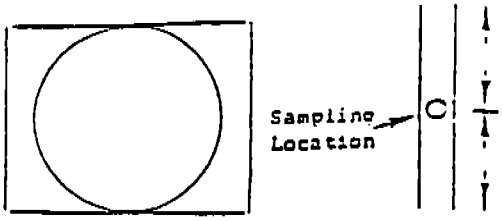
Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
E-~~5~~ 4 ~~96~~	0.14	70	
-~~4~~ 3 ~~96~~	0.14	69	
-~~3~~ 2 ~~96~~	0.34	68	
-~~2~~ 1 ~~96~~	0.36	68	
-~~1~~	0.15	68	
D-5	0.14	69	
-4	0.13	68	
-3	0.15	69	
-2	0.27	68	
-1	0.39	67	
C-5	0.15	69	
-4	0.16	69	
-3	0.17	69	
-2	0.28	69	
-1	0.46	68	

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
B-5	0.15	69	
-4	0.16	69	
-3	0.15	68	
-2	0.22	68	
-1	0.36	67	
A-5	0.18	69	
-4	0.15	70	
-3	0.16	70	
-2	0.25	69	
-1	0.46	67	

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco
Job No.
Run No. Prelim - 3
Time: 14:47
Date: 6-18-91
Location: Outlet
Stack I.D.: 35 x 46
Barometric Pressure, in. Hg:
Stack Gauge Pressure, in. H_2O: ~~-0.0~~ 0.1
Operators: Chehaske & Clay
Pitot Tube Number: S-2
Thermocouple No.
Temperature Readout I.D.: MB-10
Pitot Tube Leak Check:



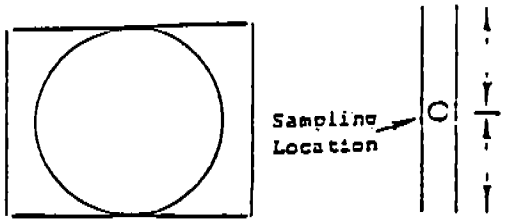
Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A-1	0.54	74	
-2	0.35	74	
-3	0.24	74	
-4	0.17	74	
-5	0.19	74	
B-1	0.48	76	
-2	0.30	76	
-3	0.28	74	
-4	0.21	75	
-5	0.20	75	
C-1	0.50	76	
-2	0.31	76	
-3	0.18	76	
-4	0.17 ~~0.19~~	74	
-5	0.18	74	

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
D-1	0.57	76	
-2	0.41	76	
-3	0.20	77	
-4	0.16	77	
-5	0.17	77	
E-1	0.57	77	
-2	0.45	77	
-3	0.21	77	
-4	0.16	78	
-5	0.18	78	

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco Job No. _____
Run No. Prelim 5 Time: _____
Date: 6-18-91
Location: Outlet
Stack I.D.: 46" x 35"
Barometric Pressure, in. Hg: _____
Stack Gauge Pressure, in. H_2O: -0.17
Operators: Chehaske & Owens
Pitot Tube Number: 5-2
Thermocouple No. _____
Temperature Readout I.D.: MB-10
Pitot Tube Leak Check: _____



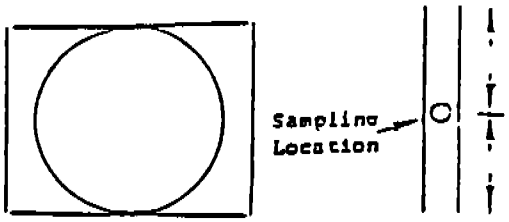
Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A-5	0.26	71	
-4	0.27	71	
-3	0.32	71	
-2	0.49	71	
-1	0.79	71	
B-5	0.25	71	
-4	0.27	71	
-3	0.28	71	
-2	0.38	71	
-1	0.62	71	
C-5	0.21	70	
-4	0.21	71	
-3	0.24	71	
-2	0.45	71	
-1	0.68	71	

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
D-5	0.21	71	
-4	0.21	71	
-3	0.24	71	
-2	0.45	71	
-1	0.73	71	
E-5	0.22	71	
-4	0.21	71	
-3	0.23	71	
-2	0.53	73	
-1	0.66	73	

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco
Job No. 4371
Run No. Prelim. 6
Time: 08:25
Date: 6-19-91
Location: Outlet
Stack I.D.: 35" x 46"
Barometric Pressure, in. Hg: 28.75
Stack Gauge Pressure, in. H_2O: -0.33
Operators: Chehaske & Owens
Pitot Tube Number: 5-2
Thermocouple No.
Temperature Readout I.D.: MB-10
Pitot Tube Leak Check: OK



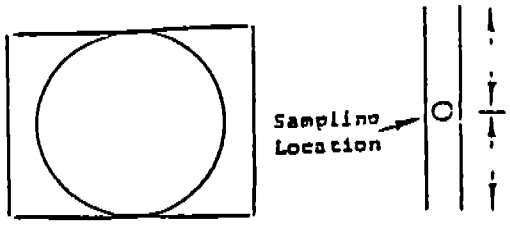
Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
E-1	0.85	64	
-2	0.63	64	
-3	0.27	64	
-4	0.25	64	
-5	0.27	65	
D-5	0.28	64	
-4	0.29	64	
-3	0.31	65	
-2	0.61	65	
-1	0.85	64	
C-5	0.28	64	
-4	0.27	64	
-3	0.32	64	
-2	~~0.52~~ 0.5696	64	
-1	0.80	64	

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
B-5	0.30	64	
-4	0.32	64	
-3	0.35	64	
-2	0.46	64	
-1	0.77	64	
A-5	0.35	64	
-4	0.37	65	
-3	0.42	65	
-2	0.57	65	
-1	0.88	65	

PRELIMINARY VELOCITY TRAVERSE

Plant: Remco Job No. _____
Run No. Prelim 7 Time: _____
Date: 6-20-91
Location: Outlet
Stack I.D.: 35" x 46"
Barometric Pressure, in. Hg: 28.81
Stack Gauge Pressure, in. H_2O: -0.33
Operators: Chelioske
Pitot Tube Number: S-2
Thermocouple No. _____
Temperature Readout I.D.: MB-10
Pitot Tube Leak Check: OK



Schematic of Traverse Point Layout

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null
A-4	0.37	~~71~~ 65	
A-3	0.39	65	
A-2	0.56	65	
A-1	0.98	65	
A-5	0.37	65	

Traverse Point Number	Velocity Head (Δp_s) in. H_2O	Stack Temp. (T_s), °F	Cyclonic Flow Check ° from Null

PACIFIC ENVIRONMENTAL SERVICES, INC.

Project No.	Page of
Client	
Location	

Prepared By	Date	Checked By	Date	Sheet Title

212-242-6367

99
x 2
19.8
13.25
33 1/2

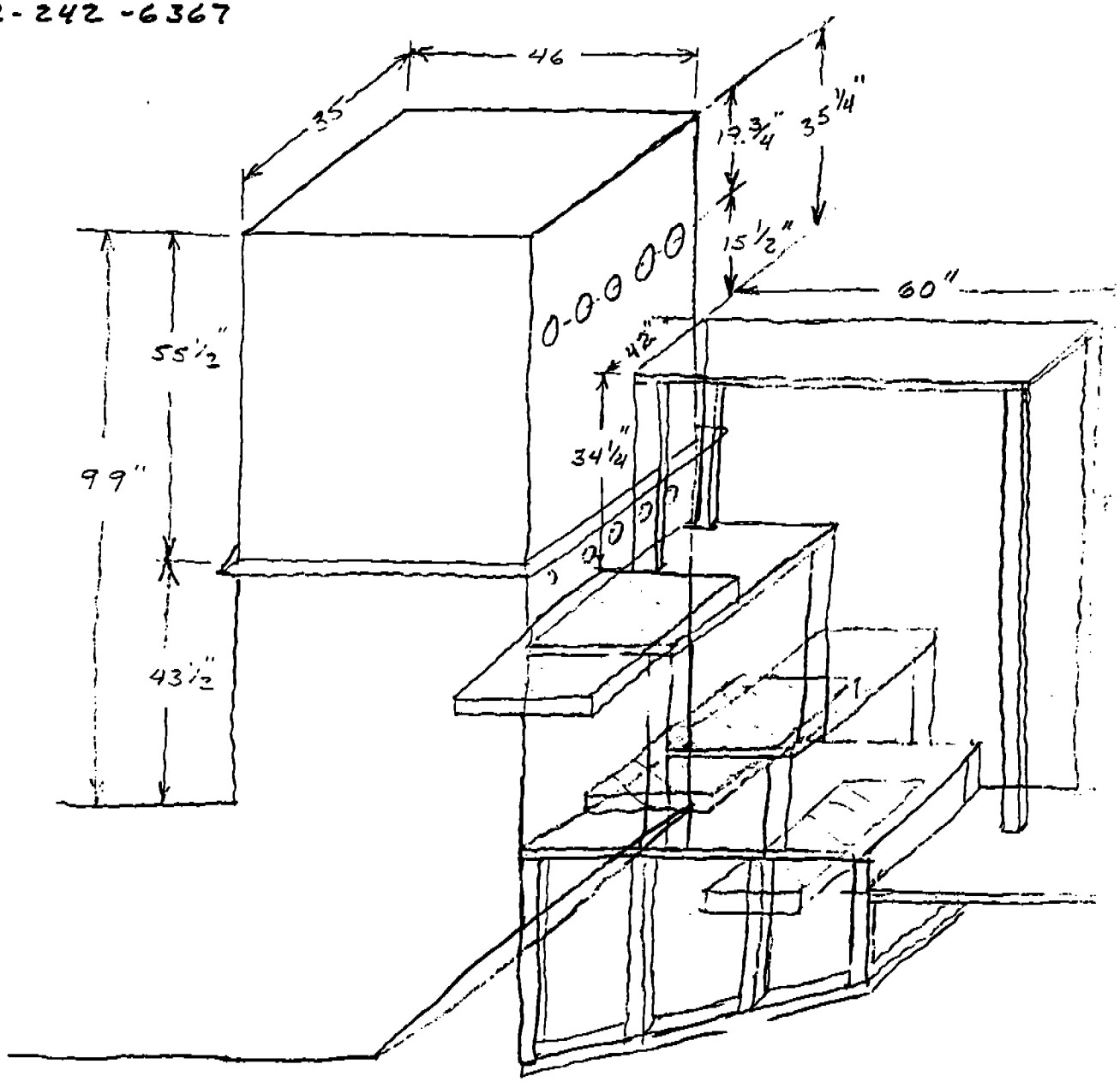
9.50
17.75
18.375
45.625
+ 38
83

55.5
14
69.5

15 s 16 1/2

19.75
15.5
35.25

32.5
25.75
34.25
45.92
80.175



Remco Hydraulics 4/19/91 Hjo

35.3145 ft³ / m³

Std Curve

Std	%T
100 ug/100ml	11.9
75 ug/100ml	19.2
50 ug/100ml	33.0
35 ug/100ml	46.0
25 ug/100ml	57.8
10 ug/100ml	80.5
Bl	100.0

Kc = ~~1.1135~~ 114.334

Sample	Volume, ml	%T	A	dilution	aliquot, ml	ug/ml	total ug
100 ug/ml	100	11.9	(0.940)	1	100		107.5
IA-1	1000	87.5	(0.06)	1:1000	5		1,372,008
IB-1	1000	83.0	(0.082)	1	1		9,375
IA-1	1000	65.9	(0.180)	1:1000	15		1,372,008
O-1	1000	95.5	(0.018)	1	50		41.2
OH.I-1	500	98.0	(0.01)	1	50		11.43
IB-1	1000	6.5	(1.2)	1	15		9,47

Run No.	Volume metered	ug Cr+6 sample	ug Cr+6 dscf	flow rate dscfm	ug Cr+6 hr
IA-1	315.108	1,372,008	4354	12419	3,244,339,560 (3,244,340 mg/hr)
IB-1	291.055	9375	32.2	9811	18,954,852 ~~315,914~~ (18955 mg/hr)
O-1	265.159	41.2	0.155	23995	223,153 (223 mg/hr)

Remco Hydraulics 6/20/91 HJO

Std. Curve @ 540 nm

Std	%T	A
100 ug/100ml	12.0	0.930
75 ug/100ml	20.0	0.700
50 ug/100ml	33.5	0.475
35 ug/100ml	46.1	0.335
25 ug/100ml	58.0	0.235
10 ug/100ml	80.4	0.095
AC	99.0	0.005

$K_c = 106.887$

Sample	volume, ml	%T	A	dilution	aliquot, ml	ug/ml	total ug
6/19 Scrubber		27.0	0.565	1:1000	5	12,078	
6/19 Tank #1		34.0	0.470	1:25,000	10	25,592	
6/19 Tank #2		34.0	0.470	1:25,000	10	125,592	
6/19 Tank #3		33.9	0.470	1:25,000	10	25,592	
6/19 Tank #4		33.5	0.475	1:25,000	10	126,928	
6/19 Tank #5		33.0	0.480	1:25,000	10	128,264	
6/19 Tank #6		34.0	0.470	1:25,000	10	25,592	
50 ug/100ml	100	33.0	0.480	1	100		51.3
OMT-2	500	99.0	0.005	1	50		5.3
O-2	1000	43.5	0.03	1	50		64.1
IA-2	1000	36.8	0.430	1:100	*95		919,228.2
IB-2	1000	3.8	1.45	1	10		15,498.6
IB-2	1000	19.0	0.730	1	5		15,605.5
6/21 Scrubber Start		15.5	0.800	1:1000	5	17,102	~~17,102~~

$K_c = \cancel{5(}$

$$5 \frac{2(0.095) + 5(0.235) + 7(0.335) + 10(0.475) + 15(0.700) + 20(0.930)}{(0.095)^2 + (0.235)^2 + (0.335)^2 + (0.475)^2 + (0.700)^2 + (0.930)^2}$$

$$5\left(\frac{37.560}{1.757}\right) = 106.887$$

$K_c = 106.887$

Rimco Hydraulics 6/21/91 4/0

Std Curve

Std	%T	Abs	Abs Blank Corr.
100 ug/100ml	11.4	0.950	0.945
75 ~~50~~ ug/100ml	19.0	0.720	0.715
50 ug/100ml	33.0	0.480	0.475
35 ug/100ml	46.2	0.335	0.330
25 ug/100ml	57.9	0.238	0.233
10 ug/100ml	80.1	0.097	0.092
Bl.	98.8	0.005	

$K_c = 105.532$

~~Sampl~~ $K_c = 5 \dfrac{2(0.092)+5(0.233)+7(0.330)+10(0.475)+15(0.715)+20(0.945)}{(0.092)^2+(0.233)^2+(0.330)^2+(0.475)^2+(0.715)^2+(0.945)^2}$

$5\left(\dfrac{38.034}{1.802}\right) = 105.532$

	Sample	Total Volume, ml	%T	Abs	dilution	aliquot, ml	ug/ml	total
(dupl)	TB-1	1000	14.5	0.840	1	10		886
	Scrubber UC (HP)		20.0	0.700	1:1000	5	14,774	~~14,774~~
	75 ug/100ml	100	19.4	0.720	1	100		76
	SW-2		58.5	0.231	1:1000	5	4876	
	6/20 T-1		33.6	0.475	1:25000	10	125,319	
	6/20 T-2		35.0	0.459	1:25000	10	121,098	
	6/20 T-3		33.4	0.480	1:25000	10	126,638	
	6/20 T-4		34.1	0.465	1:25000	10	122,681	
	6/20 T-5		34.5	0.465	1:25000	10	122,681	
	6/20 T-6		33.5	0.475	1:25000	10	125,319	
	6/21 SW-E		11.8	0.940	1:1000	5	19,840	
	6/21 SW-Comp		16.0	0.790	1:1000	5	16,674	
	6/21 T-1		35.5	0.450	1:25000	10	118,724	
	6/21 T-2		35.0	0.454	1:25000	10	119,779	
	6/21 T-3		36.0	0.440	1:25000	10	116,085	
	6/21 T-4		35.0	0.458	1:25000	10	120,834	
	6/21 T-5		34.8	0.460	1:25000	10	121,362	
	6/21 T-6		33.2	0.478	1:25000	10	126,111	
	DI	1000	96.8	0.014	1	50		29
	OM T-3	500	99.0	0.004	1	50		4

Sample	volume	%T	A	dilution	aliquot, ml	total ug
25 ug/100ml	100	58.5	0.232	1	100	24.5
IA-3	~~25~~ 1000	25.3	0.600	1:100	5	1,266,384
IB-3	1000	75.2	0.121	1:100	10	127,694
IB-3	1000	55.5	0.255	1:100	20	134,553

APPENDIX C

LABORATORY ANALYSIS REPORTS

RESEARCH TRIANGLE INSTITUTE

Center for Environmental Measurements and Quality Assurance

August 27, 1991

Ms. Helen Owens
Pacific Environmental Services
4700 Duke Drive, Suite 150
Mason, OH 45040

Dear Ms. Owens,

Enclosed are the Cr(VI) and total chromium results as determined by ion chromatography and ICP, respectively, for the impinger samples received on July 2, 1991 for RTI Project No. 4848-02E, Pacific Environmental Services P.O. No. 91-167.

If you have any questions, please call me at 919-541-6569 or Peter Grohse at 919-541-6897.

Sincerely,

Kate Luk

Kate K. Luk, Ph.D.

Ref: 4848-02E
cc: W. Gutknecht
P. Grohse
J. Merricks
C. Decker

AUG - 8

Post Office Box 12194 Research Triangle Park, North Carolina 27709-2194
Telephone 919 541-6914 Fax: 919 541-5929

RTI Project No. : 4848-02E

Samples : Impinger Samples
Company : Pacific Environmental Services (P.O.# 91-167)
Analyte : Cr(VI)
Method of Analysis : Ion Chromatography (Cr(VI)); ICP (Total Cr)
Samples Received : 7-2-91
Report Date : 8-27-91

Sample	Orig. Total Volume mL	Cr(VI) ug/mL	Cr(VI) Total,ug	Volume Taken for Digestion mL	Total Cr ug/mL	Orig. Total Cr ug/mL	Orig. Total Cr Total,ug
91-779 Inlet A-1	1000	1390	1390000	2.00	53.5	1338	1338000
91-780 Inlet A-2	1000	1050	1050000	2.00	38.7	968	968000
91-781 Inlet A-3 (Rinse)	1000	1350	1350000	2.00	49.9	1248	1248000
91-782 Inlet A-3 (Filter)	200	0.150	30.0	20.0	0.0670	0.168	33.5
91-783 Inlet B-1	1000	9.85	9850	10.0	1.80	9.00	9000
91-784 Inlet B-2	1000	15.1	15100	10.0	2.98	14.9	14900
91-785 Inlet B-3 (Rinse)	1000	135	135000	10.0	24.7	124	124000
91-786 Inlet B-3 (Filter)	200	1.29	258	20.0	0.507	1.27	254
91-787 Outlet-1	1000	0.0433	43.3	200	0.188	0.0470	47.0
91-788 Outlet-2	1000	0.0255	25.5	200	0.102	0.0255	25.5
91-789 Outlet-3 (Rinse)	1000	0.0240	24.0 } 46.8	200	0.0820	0.0205	20.5
91-790 Outlet-3 (Filter	200	0.214	42.8 }	50.0	0.225	0.225	45.0
91-791 $NaHCO_3$ Rinse Blank	500	ND	ND	250	ND	ND	ND
91-792 $NaHCO_3$ Filter Blank	200	ND	ND	100	ND	ND	ND
91-793 Outlet 1 (MJ)	500	0.0170	8.50	250	0.0840	0.0168	8.40
91-794 Outlet 2 (MJ)	500	0.00700	3.50	250	0.0360	0.00720	3.60
91-795 Outlet 3 (MJ)	500	0.0115	5.75	250	0.0540	0.0108	5.40
91-796 Scrubber Water 1	1000	14700	14700000	1.00	249	12450	12450000
91-797 " " 2	1000	4490	4490000	1.00	104	5200	5200000
91-798 " " 3	1000	16220	16220000	1.00	350	17500	17500000
91-799 " " 4	395	17450	6892750	1.00	370	18500	7307500
91-800 " " 5	345	14400	4968000	1.00	268	13400	4623000
91-801 " " 6	375	19600	7350000	1.00	378	18900	7087500
Detection Limit		0.0015			0.007		

ND : Non-detectable; less than detection limit
Total Cr digestion : Concentrated HNO3 was used.
Final volume for digested sample = 50.00 mL
Orig Total Cr, ug/mL = (Total Cr, ug/mL * Final volume, mL / Vol. Taken for Digestion)*
Orig. Total Vol., mL

RTI Project No. : 4848-02E

Samples : QC for Impinger Samples
Company : Pacific Environmental Services (P.O.# 91-167)
Analyte : Cr(VI)
Method of Analysis : Ion Chromatography (Cr(VI)); ICP (Total Cr)
Samples Received : 7-2-91
Report Date : 8-27-91

Calibration Check Sample, ug/mL

Sample	Cr(VI) ug/mL Measured	Cr(VI) ug/mL Expected	Total Cr ug/mL Measured	Total Cr ug/mL Expected
QC	0.0102	0.0100	1.87	2.00
QC	0.0106	0.0100	2.10	2.00
QC	0.0107	0.0100	2.03	2.00

Results of Blank, Duplicate, and Spike for Cr(VI) Analysis, ug/mL

Sample	Cr(VI) ug/mL Measured	Spike Cr(VI) ug/mL Measured	Spike Cr(VI) ug/mL Expected	Spike Cr(VI) % Recovery
RTI DIW	ND	--	--	--
91-787 Dup	0.0411	--	--	--
91-795 Dup	0.0115	--	--	--
91-788 Spk	--	0.0102	0.0100	102

Results of SRM, Blank, Duplicate, and Spike for Total Cr Analysis, ug/mL

Sample	Total Cr ug/mL Measured	Total Cr ug/mL Expected	Spike Total Cr ug/mL Measured	Spike Total Cr ug/mL Expected	Spike Total Cr % Recovery
Reagent Blk	ND	ND	--	--	
SRM WP481	0.0524	0.0520	--	--	--
91-781 Dup	47.3	--	--	--	--
91-784 Dup	2.97	--	--	--	--
91-784 Spk	--	--	4.28	4.00	107
91-780 Spk	--	--	1.90	2.00	95

ND : Non-detectable; less than detection limit

ANALYTICAL REQUEST AND CHAIN OF CUSTODY

PLANT: Remco Hyd.

PROJECT NO.: 4371

RECOVERY PERSON: D. Machuga / E. Hollins

SAMPLE TECHNICIAN: Machuga, Hollins, Morgan, Fuller, Chehaske, Clay

SAMPLE IDENTIFICATION	COLLECTION DATE	COLLECTION TIME	SAMPLE NAME	NUMBER OF CONTAINERS	hexavalent Cr *	total Cr *									COMMENTS (Type of container, special preparation, special handling, etc.)
91-779	6-19		IA-1 Inlet A Rinse + Filter	1	X	X									* ion chromatog
91-780	6-20		IA-2 Inlet A Rinse + Filter	1	X	X									
91-781	6-21		IA-3 Inlet A Rinse	1	X	X									
91-782	6-21		IA-3 Inlet A Filter	1	X	X									
91-783	6-19		IB-1 Inlet B Rinse + Filter	1	X	X									
91-784	6-20		IB-2 Inlet B Rinse + Filter	1	X	X									
91-785	6-21		IB-3 Inlet B Rinse	1	X	X									
91-786	6-21		IB-3 Inlet B Filter	1	X	X									
91-787	6-19		O-1 Outlet Rinse + Filter	1	X	X									
91-788	6-20		O-2 Outlet Rinse + Filter	1	X	X									
91-789	6-21		O-3 Outlet Rinse	1	X	X									
91-790	6-21		O-3 Outlet Filter	1	X	X									

Helen J. Owens
RELINQUISHER'S NAME:

7/1/91 / 3:59 pm
DATE / TIME

Helen Owens
RELINQUISHER'S SIGNATURE

9026966480
SHIPPER'S NAME AND IDENTIFICATION NUMBER

RECEIVER'S NAME:

DATE / TIME

RECEIVER'S SIGNATURE

ANALYTICAL REQUEST AND CHAIN OF CUSTODY

PLANT: REMCO HYD.

PROJECT NO.: 4371

RECOVERY PERSON: D. MACHUGA / E. HOLLINS

SAMPLE TECHNICIAN: MACHUGA, HOLLINS, MORGAN, FULLER, CHEHASKE, CLAY

SAMPLE IDENTIFICATION	COLLECTION DATE	COLLECTION TIME	SAMPLE NAME	NUMBER OF CONTAINERS	HEXAVALENT Cr*	TOTAL Cr*									COMMENTS (Type of container, special preparation, special handling, etc.)
91-791	6-21		RINSE BLANK $NaHCO_3$	1	X	X									* ION CHROMATOGRAPH
91-792	6-21		FILTER BLANK $NaHCO_3$	1	X	X									
91-793	6-19		OUTLET MASON JAR OMJ-1	1	X	X									
91-794	6-20		OUTLET MASON JAR OMJ-2	1	X	X									
91-795	6-21		OUTLET MASON JAR OMJ-3	1	X	X									
91-796	6-19		SCRUBBER WATER #1 SW-1	1	X	X									
91-797	6-20		SCRUBBER WATER #2 SW-2	1	X	X									
91-798	6-21		SCRUBBER WATER #3 SW-3	1	X	X									
91-799	6-21		SCRUBBER WATER SW-START	1	X	X									
91-800	6-21		SCRUBBER WATER SW-MID	1	X	X									
91-801	6-21		SCRUBBER WATER SW-END	1	X	X									

Helen J. Owens
RELINQUISHER'S NAME:

7/1/91 / 3:59 pm
DATE / TIME

Helen J. Owens
RELINQUISHER'S SIGNATURE

9026966480
SHIPPER'S NAME AND

APPENDIX D

CALCULATIONS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	INLET A		
DATE/TIME:	6-19-91/		
RUN #:	IA-1		
STATIC PRESSURE("H20):	-1.90	"HG	28.66
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	332.344
ACTUAL METER VOLUME:	332.344	DSCF	315.233
SQ. ROOT /\P:	0.707		
AVG ORIFICE /\H:	2.97		
AVG STACK TEMP °F:	75.0	°R	535.0
AVG METER TEMP °F:	95.0	°R	555.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF<0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.91
VOL CONDENSATE(ml):	52.70	% H20	0.78
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	1372008.00		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	40.79	FT/SEC
STACK GAS FLOW (Qs):	13246.3	ACFM
:	12424.8	DSCFM
MOISTURE (%H20):	0.78	%
STACK GAS TEMP :	75	Deg F
ISOKINETIC :	95.98	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	6.70E-02	Gr/DSCF
:	9.58E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.14E+00	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET A
DATE/TIME:	6-19-91/
RUN #:	IA-1

STATIC PRESSURE("H20):	-1.90	"HG	28.66
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	332.344
ACTUAL METER VOLUME:	332.344	DSCF	315.233
SQ. ROOT /\P:	0.707		
AVG ORIFICE /\H:	2.97		
AVG STACK TEMP 'F:	75.0	'R	535.0
AVG METER TEMP 'F:	95.0	'R	555.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.91
VOL CONDENSATE(ml):	52.70	% H20	0.78

ANALYTE #1 : TOTAL CHROMIUM
MOLE WEIGHT:
ug/sample : 1338000.00
ANALYTE #2 : HEXAVALENT CHROMIUM
MOLE WEIGHT:
ug/sample : 1390000.00

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	40.79	FT/SEC
STACK GAS FLOW (Qs):	13246.3	ACFM
:	12424.8	DSCFM
MOISTURE (%H20):	0.78	%
STACK GAS TEMP :	75	Deg F
ISOKINETIC :	95.98	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	6.54E-02	Gr/DSCF
:	9.34E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.96E+00	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	6.79E-02	Gr/DSCF
:	9.70E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.23E+00	lb/hr

Reinco Hydraulics
IA-1 6/20/91

6. Stack Gas Velocity, Average

$$V_{s_{avg}} = 85.49 C_p \left(\sqrt{\Delta P}\right)_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49 \ (0.84) \ (0.706) \sqrt{\frac{(535)}{(28.66)(28.91)}}$$

$V_{s_{avg}}$ = 40.8 ft/s

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

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

$$= 60 \times \underline{40.8} \ (5.454 \times 10^{-3}) \ (\underline{31.5''})^2$$

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

$$= 60 \times \underline{\quad} \ (\underline{\quad} \times \underline{\quad}) \ 6.944 \times 10^{-3}$$

Qa = 13,248 acfm

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

$$Q_{std} = 17.64 \ Q_a (1 - B_{ws}) \left(\frac{P_s}{T_s}\right) = 17.64 \ (13248) \ (1 - 0.005) \left(\frac{28.66}{535}\right)$$

Q_{std} = 12,419 dscfm

9. Isokinetic Variation

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

$$= 0.0944 \frac{(535)(315.108)}{(28.66)(40.8)(3.95 \times 10^{-4})(360)(1 - 0.005)}$$

= 95.5 %

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET A
DATE/TIME:	6-20-91/
RUN #:	IA-2

STATIC PRESSURE("H20):	-1.90	"HG	28.67
BAROMETRIC("HG):	28.81		
SAMPLE TIME(min):	360.00	Vm(corr)	330.710
ACTUAL METER VOLUME:	330.710	DSCF	314.382
SQ. ROOT /\P:	0.711		
AVG ORIFICE /\H:	3.00		
AVG STACK TEMP 'F:	71.0	'R	531.0
AVG METER TEMP 'F:	94.0	'R	554.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	79.00	% H20	1.17
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	919228.20		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	40.89	FT/SEC
STACK GAS FLOW (Qs):	13278.9	ACFM
:	12504.4	DSCFM
MOISTURE (%H20):	1.17	%
STACK GAS TEMP :	71	Deg F
ISOKINETIC :	95.11	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	4.50E-02	Gr/DSCF
:	6.43E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	4.83E+00	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET A
DATE/TIME:	6-20-91,
RUN #:	IA-2

STATIC PRESSURE("H2O):	-1.90	"HG	28.67
BAROMETRIC("HG):	28.81		
SAMPLE TIME(min):	360.00	Vm(corr)	330.710
ACTUAL METER VOLUME:	330.710	DSCF	314.382
SQ. ROOT /\P:	0.711		
AVG ORIFICE /\H:	3.00		
AVG STACK TEMP °F:	71.0	°R	531.0
AVG METER TEMP °F:	94.0	°R	554.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	79.00	% H2O	1.17
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	968000.00		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	1050000.00		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	40.89	FT/SEC
STACK GAS FLOW (Qs):	13278.9	ACFM
:	12504.4	DSCFM
MOISTURE (%H2O):	1.17	%
STACK GAS TEMP :	71	Deg F
ISOKINETIC :	95.11	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	4.74E-02	Gr/DSCF
:	6.78E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.08E+00	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	5.14E-02	Gr/DSCF
:	7.35E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.51E+00	lb/hr

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET A
DATE/TIME:	6-21-91/
RUN #:	IA-3

STATIC PRESSURE("H20):	-1.90	"HG	28.66
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	344.523
ACTUAL METER VOLUME:	344.523	DSCF	329.391
SQ. ROOT /\P:	0.738		
AVG ORIFICE /\H:	3.25		
AVG STACK TEMP °F:	69.0	°R	529.0
AVG METER TEMP °F:	91.0	°R	551.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	84.00	% H20	1.19
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	1266384.00		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	42.38	FT/SEC
STACK GAS FLOW (Qs):	13760.0	ACFM
:	12999.7	DSCFM
MOISTURE (%H20):	1.19	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	95.86	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	5.92E-02	Gr/DSCF
:	8.46E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.60E+00	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	INLET A		
DATE/TIME:	6-21-91/		
RUN #:	IA-3		
STATIC PRESSURE("H2O):	-1.90	"HG	28.66
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	344.523
ACTUAL METER VOLUME:	344.523	DSCF	329.391
SQ. ROOT /\P:	0.738		
AVG ORIFICE /\H:	3.25		
AVG STACK TEMP 'F:	69.0	'R	529.0
AVG METER TEMP 'F:	91.0	'R	551.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.270	An(ft^2)	3.98E-04
METER GAMMA:	1.028		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	5.41
DIA OR DIM (inches):	31.50		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	84.00	% H2O	1.19
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	1248033.50		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	1350030.00		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	42.38	FT/SEC
STACK GAS FLOW (Qs):	13760.0	ACFM
:	12999.7	DSCFM
MOISTURE (%H2O):	1.19	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	95.86	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	5.33E-02	Gr/DSCF
:	8.34E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.50E+00	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	6.31E-02	Gr/DSCF
:	9.[illegible]E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.[illegible]E+00	lb/hr

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET b
DATE/TIME:	6-19-91/
RUN #:	IB-1

STATIC PRESSURE("H20):	-1.80	"HG	28.67
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	307.264
ACTUAL METER VOLUME:	307.264	DSCF	291.224
SQ. ROOT /\P:	0.760		
AVG ORIFICE /\H:	2.57		
AVG STACK TEMP °F:	75.0	°R	535.0
AVG METER TEMP °F:	90.0	°R	550.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	75.80	% H20	1.21
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	9375.00		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	43.88	FT/SEC
STACK GAS FLOW (Qs):	10468.8	ACFM
:	9779.5	DSCFM
MOISTURE (%H2O):	1.21	%
STACK GAS TEMP :	75	Deg F
ISOKINETIC :	98.10	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	4.96E-04	Gr/DSCF
:	7.08E-08	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	4.16E-02	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET 5
DATE/TIME:	6-19-91/
RUN #:	IB-1

STATIC PRESSURE("H20):	-1.80	"HG	28.67
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	307.264
ACTUAL METER VOLUME:	307.264	DSCF	291.224
SQ. ROOT /\P:	0.760		
AVG ORIFICE /\H:	2.57		
AVG STACK TEMP °F:	75.0	°R	535.0
AVG METER TEMP °F:	90.0	°R	550.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.87
VOL CONDENSATE(ml):	75.80	% H20	1.21
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	9000.00		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	9850.00		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	43.88	FT/SEC
STACK GAS FLOW (Qs):	10463.8	ACFM
:	9779.5	DSCFM
MOISTURE (%H20):	1.21	%
STACK GAS TEMP :	75	Deg F
ISOKINETIC :	98.10	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	4.76E-04	Gr/DSCF
:	6.80E-08	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	3.99E-02	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	5.21E-04	Gr/DSCF
:	7.44E-08	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	4.37E-02	lb/hr

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EMISSION TEST CALCULATIONS

PLANT Remco Hydraulics SOURCE/RUN IB-1 DATE 6-19-91

1. Leakage Correction for Volume Metered

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

$V_{m_c} =$ _____ ft^3

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

$$V_{m_{std}} = 17.64\ V_{m_c} Y \left(\frac{P_{bar} + \Delta H / 13.6}{T_m}\right) = 17.64\ (307.269)(Y\ 1.019)\frac{(28.80)+(2.57)/13.}{(90+460)}$$

550.1

$V_{m_{std}} =$ ~~141.395~~ 291.055 dsm dscf

3. Volume Water Vapor Collected, Standard Conditions

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

Silica Gel $= V_{wsg} = 0.04707\ (W_f - W_i) = 0.04707\ (75.8) =$ 3.568 scf

$V_{w_{std}} = V_{wc} + V_{wsg} =$ 3.568 scf

4. Percent Moisture, By Volume

$$B_{ws} = \frac{V_{w_{std}}}{V_{w_{std}} + V_{m_{std}}} = \frac{(3.568)}{(3.568)+(\cancel{141.395}\ 291.055)} = \frac{0.012}{\cancel{0.025}\ \text{dsm}}$$

5. Molecular Weight, Stack Gas

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

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

$M_d =$ 29 lb/lb - mole

Percent Excess Air, %EA =

$$\left[\frac{\%O_2 - 0.5\ \%CO}{0.264(\%N_2)-(\%O_2-0.5\ \%CO)}\right] X100 \left[\frac{(\quad)-0.5(\quad)}{0.264(\quad)-(\quad -0.5(\quad))}\right] X\ 100$$

%EA = _____

$M_s = M_d\ (1-B_{ws}) + 18.0\ (B_{ws}) = (29)(1-0.025) + 18.0\ (0.025) =$ 28.725 lb/lb-mole

6. Stack Gas Velocity, Average

$$V_{s_{avg}} = 85.49 C_p \left(\sqrt{\Delta P}\right)_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49\ (0.84)\ (0.1579) \sqrt{\frac{(535)}{(28.67)(28.125)}}$$

$V_{s_{avg}}$ = 43.96 ft/s

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

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

$$= 60 \times \underline{43.96}\ (5.454 \times 10^{-3})\ (\underline{27})^2$$

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

$$= 60 \times \underline{\quad}\ (\underline{\quad} \times \underline{\quad})\ 6.944 \times 10^{-3}$$

Qa = 10,487 acfm

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

$$Q_{std} = 17.64\, Q_a (1-B_{ws}) \left(\frac{P_s}{T_s}\right) = 17.64\ (10,487)\ (1-\cancel{0.025}\ 0.012)\ \left(\frac{28.67}{535}\right)$$

Q_{std} = ~~9,666~~ 9,811 dscfm

9. Isokinetic Variation

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

$$= 0.0944 \frac{(535)\ (\cancel{241.055}\ 241.055)}{(28.67)\ (43.96)\ (\cancel{0.01637}\ 3.35 \times 10^{-4})\ (300)\ (1-0.025)}$$

= 97.9 %

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	INLET B		
DATE/TIME:	6-20-91/		
RUN #:	IB-2		
STATIC PRESSURE("H20):	-3.70	"HG	28.54
BAROMETRIC("HG):	28.81		
SAMPLE TIME(min):	360.00	Vm(corr)	304.700
ACTUAL METER VOLUME:	304.700	DSCF	287.744
SQ. ROOT /\P:	0.762		
AVG ORIFICE /\H:	2.43		
AVG STACK TEMP °F:	74.0	°R	534.0
AVG METER TEMP °F:	92.0	°R	552.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.85
VOL CONDENSATE(ml):	83.60	% H20	1.35
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	15489.00		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	44.07	FT/SEC
STACK GAS FLOW (Qs):	10513.1	ACFM
:	9781.0	DSCFM
MOISTURE (%H20):	1.35	%
STACK GAS TEMP :	74	Deg F
ISOKINETIC :	96.92	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	8.29E-04	Gr/DSCF
:	1.18E-07	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.95E-02	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	INLET B		
DATE/TIME:	6-20-91/		
RUN #:	IB-2		
STATIC PRESSURE("H2O):	-3.70	"HG	28.54
BAROMETRIC("HG):	28.81		
SAMPLE TIME(min):	360.00	Vm(corr)	304.700
ACTUAL METER VOLUME:	304.700	DSCF	287.744
SQ. ROOT /\P:	0.762		
AVG ORIFICE /\H:	2.43		
AVG STACK TEMP 'F:	74.0	'R	534.0
AVG METER TEMP 'F:	92.0	'R	552.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.85
VOL CONDENSATE(ml):	33.60	% H2O	1.35
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	14900.00		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	15100.00		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	44.07	FT/SEC
STACK GAS FLOW (Qs):	10513.1	ACFM
:	9781.0	DSCFM
MOISTURE (%H2O):	1.35	%
STACK GAS TEMP :	74	Deg F
ISOKINETIC :	96.92	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	7.97E-04	Gr/DSCF
:	1.14E-07	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.69E-02	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	8.08E-04	Gr/DSCF
:	1.15E-07	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.78E-02	lb/hr

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET B
DATE/TIME:	6-21-91/
RUN #:	IB-3

STATIC PRESSURE("H20):	-4.20	"HG	28.49
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	295.127
ACTUAL METER VOLUME:	295.127	DSCF	281.548
SQ. ROOT /\P:	0.787		
AVG ORIFICE /\H:	2.26		
AVG STACK TEMP °F:	69.0	°R	529.0
AVG METER TEMP °F:	86.0	°R	546.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.86
VOL CONDENSATE(ml):	79.70	% H20	1.31
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	127694.00		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	45.33	FT/SEC
STACK GAS FLOW (Qs):	10815.2	ACFM
:	10144.1	DSCFM
MOISTURE (%H2O):	1.31	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	91.44	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	6.98E-03	Gr/DSCF
:	9.98E-07	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	6.07E-01	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	INLET B
DATE/TIME:	6-21-91/
RUN #:	IB-3

STATIC PRESSURE("H2O):	-4.20	"HG	28.49
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	360.00	Vm(corr)	295.127
ACTUAL METER VOLUME:	295.127	DSCF	281.548
SQ. ROOT /\P:	0.787		
AVG ORIFICE /\H:	2.26		
AVG STACK TEMP °F:	69.0	°R	529.0
AVG METER TEMP °F:	86.0	°R	546.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.248	An(ft^2)	3.35E-04
METER GAMMA:	1.019		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	1	As(ft^2)	3.98
DIA OR DIM (inches):	27.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.86
VOL CONDENSATE(ml):	79.70	% H2O	1.31
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	124254.00		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	135258.00		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	45.33	FT/SEC
STACK GAS FLOW (Qs):	10815.2	ACFM
:	10144.1	DSCFM
MOISTURE (%H2O):	1.31	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	91.44	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	6.80E-03	Gr/DSCF
:	9.71E-07	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.91E-01	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	7.40E-03	Gr/DSCF
:	1.06E-06	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.43E-01	lb/hr

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

EXAMPLE CALCULATION

CLIENT/PROJECT NUMBER: REMCO HYDRAULICS
SAMPLE LOCATION: INLET A
DATE/TIME: 6-19-91/
RUN #: IA-1

1.SAMPLE VOLUME(DSCF):

Vmc = Vm-(Lp-La)*Time = Vm-(Lp-0.02)*Time = 332.344
Vm(std) = 17.647*Vmc*Y*(Pbar+/\H/13.6)/Tm(°R) = 315.233

2.MOISTURE FRACTION:

%H2O = 100*Vlc*0.04707/(Vlc*0.04707+Vm(std)) = 0.78

2.MOLECULAR WEIGHT:

Md = 0.44*(%CO2)+0.32*(%O2)+0.28(%N2+%CO) = 29.00
Ms = Md*(1-Bws)+(18.0*Bws) = 28.91

3.VOLUMETRIC FLOW RATE(Q):

Vs = 85.49*Cp*Avg(/\P^0.5)*[Ts(°R)/(Ps"Hg*Ms)]^0.5 = 40.8
Qa = Vs*60*As(ft2) = 13246.3
Qstd = Qa*17.647*(1-%H2O)*Ps/Ts(°R) = 12424.8

4.ISOKINETIC:

%I = 0.0945*Ts(°R)*Vm(std)/[Ps*Vs*An*Time*(1-Bws)] = 95.98

EMISSION DATA FOR

5.CONCENTRATION(Cs):

Cs(gr/dscf) = 0.0154*Wt(mg)/Vm(std) = 6.70E-02
Cs(lb/dscf) = 2.20E-06*Mn(mg)/Vstd = 9.58E-06
Cs(ppm) = 3.855E08*Cs(lb/dscf)/mole wt = NA

6.EMISSION RATE(Er):

Er(lb/hr) = Cs(lb/dscf)*Qstd*60 = 7.14E+00

EMISSION DATA FOR

7.CONCENTRATION(Cs):

Cs(gr/dscf) = 0.0154*Wt(mg)/Vm(std) = NA
Cs(lb/dscf) = 2.20E-06*Mn(mg)/Vstd = NA
Cs(ppm) = 3.855E08*Cs(lb/dscf)/mole wt = NA

8.EMISSION RATE(Er):

Er(lb/hr) = Cs(lb/dscf)*Qstd*60 = NA

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	OUTLET
DATE/TIME:	6-19-91/
RUN #:	O-1

STATIC PRESSURE("H2O):	-0.33	"HG	28.73
BAROMETRIC("HG):	28.75		
SAMPLE TIME(min):	375.00	Vm(corr)	265.778
ACTUAL METER VOLUME:	265.778	DSCF	265.264
SQ. ROOT /\P:	0.664		
AVG ORIFICE /\H:	1.71		
AVG STACK TEMP °F:	72.0	°R	532.0
AVG METER TEMP °F:	72.0	°R	532.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.247	An(ft^2)	3.33E-04
METER GAMMA:	1.042		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	0	As(ft^2)	11.18
DIA OR DIM (inches):	1610.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.81
VOL CONDENSATE(ml):	99.80	% H20	1.74
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	41.20		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	38.23	FT/SEC
STACK GAS FLOW (Qs):	25647.0	ACFM
:	24012.8	DSCFM
MOISTURE (%H2O):	1.74	%
STACK GAS TEMP :	72	Deg F
ISOKINETIC :	99.04	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	2.39E-06	Gr/DSCF
:	3.42E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	4.92E-04	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS
SAMPLE LOCATION:	OUTLET
DATE/TIME:	6-19-91/
RUN #:	0-1

STATIC PRESSURE("H2O):	-0.33	"HG	28.73
BAROMETRIC("HG):	28.75		
SAMPLE TIME(min):	375.00	Vm(corr)	265.778
ACTUAL METER VOLUME:	265.778	DSCF	265.264
SQ. ROOT /\P:	0.664		
AVG ORIFICE /\H:	1.71		
AVG STACK TEMP °F:	72.0	°R	532.0
AVG METER TEMP °F:	72.0	°R	532.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.247	An(ft^2)	3.33E-04
METER GAMMA:	1.042		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	0	As(ft^2)	11.18
DIA OR DIM (inches):	1610.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.81
VOL CONDENSATE(ml):	99.30	% H2O	1.74
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	47.00		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	43.30		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	38.23	FT/SEC
STACK GAS FLOW (Qs):	25647.0	ACFM
:	24012.8	DSCFM
MOISTURE (%H2O):	1.74	%
STACK GAS TEMP :	72	Deg F
ISOKINETIC :	99.04	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	2.73E-06	Gr/DSCF
:	3.90E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.62E-04	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	2.31E-06	Gr/DSCF
:	3.59E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	5.18E-04	lb/hr

EMISSION TEST CALCULATIONS

PLANT Remco Hydraulics SOURCE/RUN Scrubber exhaust/0-1 DATE 6/19/91

1. Leakage Correction for Volume Metered

$V_{m_c} = V_m - (Lp-La)\theta = V_m - (Lp-0.02)\theta = (\quad)-(\quad -0.02)(\quad)$

$V_{m_c} =$ _____ ft^3

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

$$V_{m_{std}} = 17.64\ V_{m_c} Y \left(\frac{P_{bar} + \Delta H / 13.6}{T_m}\right) = 17.64\ (265.778)(1.042)\frac{(28.75)+(1.71)/13}{(532)}$$

$V_{m_{std}} =$ 265.159 dscf

Volume Water Vapor Collected, Standard Conditions

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

Silica Gel = $V_{wsg} = 0.04707\ (W_f - W_i) = 0.04707\ (99.8) =$ 4.698 scf

$V_{w_{std}} = V_{wc} + V_{wsg} =$ 4.698 scf

Percent Moisture, By Volume

$$B_{w_s} = \frac{V_{w_{std}}}{V_{w_{std}} + V_{m_{std}}} = \frac{(4.698)}{(4.698)+(265.159)} = 0.017$$

Molecular Weight, Stack Gas

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

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

$M_d =$ 29.0 lb/lb - mole

Percent Excess Air, %EA =

$$\left[\frac{\%O_2 - 0.5\ \%CO}{0.264(\%N_2)-(\%O_2-0.5\ \%CO)}\right] X100 \left[\frac{(\quad)-0.5(\quad)}{0.264(\quad)-(\quad -0.5(\quad)}\right] X\ 100$$

%EA = _____

$M_s = M_d\ (1-B_{ws}) + 18.0\ (B_{ws}) = (29.0)(1-0.017) + 18.0\ (0.017) =$ 28.81 lb/lb-mole

Renco Hydraulics
C-1 6/19/91

6. Stack Gas Velocity, Average

$$V_{s_{avg}} = 85.49 C_p \left(\sqrt{\Delta P}\right)_{avg} \sqrt{\frac{T_s}{P_s M_s}} = 85.49\ (0.84)\ (0.0037) \sqrt{\frac{(532)}{(28.73)(28.81)}}$$

$V_{s_{avg}}$ = 38.2 ft/s

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

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

$$= 60 \times \_\_\_\_\_\ (5.454 \times 10^{-3})\ (\_\_\_\_\_)^2$$

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

$$= 60 \times 38.2\ (35 \times 46)\ 6.944 \times 10^{-3}$$

Qa = 25,624 acfm

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

$$Q_{std} = 17.64\, Q_a (1-B_{ws}) \left(\frac{P_s}{T_s}\right) = 17.64\ (25,624)\ (1-0.017)\ \left(\frac{28.73}{532}\right)$$

Q_{std} = 23995 dscfm

9. Isokinetic Variation

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

$$= 0.0944 \frac{(532)\ (26.5154)}{(28.73)\ (38.2)\ (3.55 \times 10^{-4})\ (375)\ (1-0.017)}$$

= 98.8 %

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	OUTLET		
DATE/TIME:	6-20-91/		
RUN #:	C-2		
STATIC PRESSURE("H2O):	-0.33	"HG	28.79
BAROMETRIC("HG):	28.81		
SAMPLE TIME(min):	375.00	Vm(corr)	264.138
ACTUAL METER VOLUME:	264.138	DSCF	261.236
SQ. ROOT /\P:	0.655		
AVG ORIFICE /\H:	1.72		
AVG STACK TEMP °F:	72.0	°R	532.0
AVG METER TEMP °F:	78.0	°R	538.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.247	An(ft^2)	3.33E-04
METER GAMMA:	1.042		
LEAK RATE(IF<0.02):			
CIRC STACK? 1=Y,0=N:	0	As(ft^2)	11.18
DIA OR DIM (inches):	1610.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.79
VOL CONDENSATE(ml):	109.40	% H2O	1.93
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	64.10		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	37.69	FT/SEC
STACK GAS FLOW (Qs):	25282.3	ACFM
:	23674.2	DSCFM
MOISTURE (%H2O):	1.93	%
STACK GAS TEMP :	72	Deg F
ISOKINETIC :	98.93	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	3.78E-06	Gr/DSCF
:	5.40E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.67E-04	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	OUTLET		
DATE/TIME:	6-21-91/		
RUN #:	0-3		
STATIC PRESSURE("H20):	-0.33	"HG	28.78
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	375.00	Vm(corr)	271.961
ACTUAL METER VOLUME:	271.961	DSCF	271.471
SQ. ROOT /\P:	0.673		
AVG ORIFICE /\H:	1.82		
AVG STACK TEMP °F:	69.0	°R	529.0
AVG METER TEMP °F:	73.0	°R	533.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.247	An(ft^2)	3.33E-04
METER GAMMA:	1.042		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	0	As(ft^2)	11.18
DIA OR DIM (inches):	1610.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.78
VOL CONDENSATE(ml):	116.10	% H20	1.97
ANALYTE #1 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	29.50		
ANALYTE #2 :			
MOLE WEIGHT:			
ug/sample :			

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	38.62	FT/SEC
STACK GAS FLOW (Qs):	25910.2	ACFM
:	24381.3	DSCFM
MOISTURE (%H20):	1.97	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	99.82	%

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	1.67E-06	Gr/DSCF
:	2.39E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	3.50E-04	lb/hr

EMISSION DATA FOR

CONCENTRATION (Cs):	NA	Gr/DSCF
:	NA	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	NA	lb/hr

COMMENTS: COLORIMETRIC ANALYSIS

PACIFIC ENVIRONMENTAL SERVICES EMISSIONS CALCULATIONS

CLIENT/PROJECT #:	REMCO HYDRAULICS		
SAMPLE LOCATION:	OUTLET		
DATE/TIME:	6-21-91/		
RUN #:	0-3		
STATIC PRESSURE("H2O):	-0.33	"HG	28.78
BAROMETRIC("HG):	28.80		
SAMPLE TIME(min):	375.00	Vm(corr)	271.961
ACTUAL METER VOLUME:	271.961	DSCF	271.471
SQ. ROOT /\P:	0.673		
AVG ORIFICE /\H:	1.82		
AVG STACK TEMP °F:	69.0	°R	529.0
AVG METER TEMP °F:	73.0	°R	533.0
Cp PITOT :	0.84		
NOZZLE DIA.(inches):	0.247	An(ft^2)	3.33E-04
METER GAMMA:	1.042		
LEAK RATE(IF <0.02):			
CIRC STACK? 1=Y,0=N:	0	As(ft^2)	11.18
DIA OR DIM (inches):	1610.00		
% O2 :		DRY MOLE WT	29.00
% CO2 :		ST MOLE WT	28.78
VOL CONDENSATE(ml):	116.10	% H2O	1.97
ANALYTE #1 :	TOTAL CHROMIUM		
MOLE WEIGHT:			
ug/sample :	65.50		
ANALYTE #2 :	HEXAVALENT CHROMIUM		
MOLE WEIGHT:			
ug/sample :	66.80		

********** CALCULATED RESULTS **********

GAS VELOCITY (Vs):	38.62	FT/SEC
STACK GAS FLOW (Qs):	25910.2	ACFM
:	24381.3	DSCFM
MOISTURE (%H2O):	1.97	%
STACK GAS TEMP :	69	Deg F
ISOKINETIC :	99.82	%

EMISSION DATA FOR TOTAL CHROMIUM

CONCENTRATION (Cs):	3.72E-06	Gr/DSCF
:	5.31E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.77E-04	lb/hr

EMISSION DATA FOR HEXAVALENT CHROMIUM

CONCENTRATION (Cs):	3.79E-06	Gr/DSCF
:	5.42E-10	lb/DSCF
:	NA	PPM
EMISSION RATE (Er):	7.92E-04	lb/hr

COMMENTS: [illegible]

Remco Hydraulics - Process Emission Rates

Run #	I-A mg/Ah (gr/Ah)	I-B mg/Ah (gr/Ah)	0-1 mg/Ah (gr/Ah)
1	139 (2.15)	0.473 (0.007)	0.004 (6.2×10^{-5})
2	98.7 (1.52)	0.824 (0.013)	0.002 (3.1×10^{-5})
3	127 (1.96)	7.53* (0.116)	0.006 (9.3×10^{-5})
Avg	122 (1.88)	0.649 (0.010)	0.004 (6.2×10^{-5})

***Not included in average**

APPENDIX E

DRAFT METHOD - DETERMINATION OF HEXAVALENT CHROMIUM EMISSIONS FROM DECORATIVE AND HARD CHROME ELECTROPLATING

3. Apparatus

3.1 Sampling Train. Same as Method 5, Section 2.1, but omit filter, and use quartz probe tip in place of stainless steel.

3.2 Sample Recovery. Same as Method 5, Section 2.2, but use 0.1N NaOH in place of acetone.

3.3 Analysis. The following equipment is needed.

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

3.3.2 Volumetric Flasks. 100-ml and other appropriate volumes.

3.3.3 Pipettes. Assorted sizes, as needed.

3.3.4 Spectrophotometer. To measure absorbance at 540 nm.

4. Reagents

Unless otherwise indicated, all reagents shall conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society. Where such specifications are not available, use the best available grade.

4.1 Sampling.

4.1.1 0.1N NaOH.

4.2 Sample Recovery.

4.2.2 0.1N NaOH.

4.3 Analysis. The following reagents are required.

4.3.1 Water. Deionized distilled, meeting American Society for Testing and Materials (ASTM) specifications for type 2 reagent - ASTM Test Method D 1193-77 (incorporated by reference - see § 61.18).

4.3.2 Potassium Dichromate Stock Solution. Dissolve 141.4 mg of analytical reagent grade $K_2Cr_2O_7$ in water, and dilute to 1 liter (1 ml = 50 μg Cr^{+6}).

additions procedure used on the single source sample do not agree to within 10 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 are normally 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 shall read correctly with ±5 nm at all calibration points; otherwise, repair and recalibrate the spectrophotometer. 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 the 50 μg Cr^{+6} standard solution (Section 4.3.4) in the sample cell and a blank solution in the reference cell. If a peak does not occur, the spectrophotometer is

malfunctioning. When a peak is obtained within the 530 to 550 nm range, record and use the wavelength at which this peak occurs as the optimum wavelength for the measurement of absorbance of both the standards and the samples. For single-beam spectrophotometer, follow the scanning procedure described above, except scan the blank and standard solutions separately. For this instrument, the optimum wavelength is the wavelength at which the maximum difference in absorbance between the standard and the blank occurs.

6.2.2 Spectrophotometer Calibration. Alternative calibration procedures are allowed, provided acceptable accuracy and precision can be demonstrated. Add 0.0 ml, 1 ml, 2 ml, 5 ml, 10 ml, 15 ml, and 20 ml of the working standard solution (1 ml = 5 μg Cr^{+6}) to a series of seven 100-ml volumetric flasks. Dilute each to mark with water. Analyze these calibration standards as in Section 5.6.1. Repeat this calibration procedure on each day that samples are analyzed. Calculate the spectrophotometer calibration factor K_c as follows:

$$K_c = 5 \frac{A_1 + 2A_2 + 5A_3 + 10A_4 + 15A_5 + 20A_6}{A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + A_6^2} \qquad \text{Eq.-2}$$

where:

K_c = Calibration factor.

A_1 = Absorbance of the 5 μg Cr^{+6}/100 ml standard.

A_2 = Absorbance of the 10 μg Cr^{+6}/100 ml standard.

A_3 = Absorbance of the 25 μg Cr^{+6}/100 ml standard.

A_4 = Absorbance of the 50 μg Cr^{+6}/100 ml standard.

A_5 = Absorbance of the 75 μg Cr^{+6}/100 ml standard.

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

6.2.2.1 Spectrophotometer Calibration Quality Control. Multiply the absorbance value obtained for each standard by the K_c factor (least squares slope) to determine the distance each calibration point lies from the theoretical calibration line. These calculated concentration values shall not differ from the actual concentrations (i.e., 5, 10, 25, 50, 75, and 100 μg Cr^{+6}/100 ml) by more than __ percent for five of the six standards.

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:

$$m = \frac{V_{sl} K_c AF}{V_a} \qquad \text{Eq. -3}$$

where:

V_{sl} = Volume in ml of total sample.

A = Absorbance of sample.

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

V_a = Volume in ml of aliquot analyzed.

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:

$$c_s = (10^{-6}\ g/\mu g)[m/V_{m(std)}] \qquad \text{Eq. -4}$$

7.5 Isokinetic Variation, Acceptable Results. Same as Method 5, Sections 6.11 and 6.12, respectively.

8. Bibliography

8.1 Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency. SW-846, 2nd Edition. July 1982.

8.2 Cox, X.B., R.W. Linton, and 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.

8.3 Same as in Bibliography of Method 5, Citations 2 to 5 and 7.

APPENDIX E.

AMPERE-HOUR CALCULATIONS

Ampere-hour Calculations

Test Run No. 1
Tank No. 1A

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
	10:10	--	--	8,100	--	--
	10:12	--	2	8,500	--	280
Subtotal			2			280
	10:28	--	--		--	--
10:30	10:30	--	2	8,500	--	280
10:45	10:45	15	15	8,500	2,125	2,125
11:00	11:00	15	15	8,500	2,125	2,125
11:15	11:15	15	15	8,500	2,125	2,125
11:30	11:30	15	15	8,500	2,125	2,125
11:41	11:41	11	11	8,500	1,558	1,558
Subtotal		71	75		10,058	10,608
11:43	11:43	2	--	8,500	280	--
11:45	11:45	2	2	8,500	280	280
12:00	12:00	15	15	8,500	2,125	2,125
12:15	12:15	15	15	8,500	2,125	2,125
12:45	12:45	30	30	8,500	4,250	4,250
12:58	12:58	13	13	8,500	1,842	1,842
Subtotal		77	75		10,902	10,622
13:01	13:01	3	--	8,500	425	--
13:15	13:15	14	14	8,500	1,983	1,983
13:30	13:30	15	15	8,500	2,125	2,125
Subtotal		32	29		4,533	4,108
14:02	13:58	--	28	8,500	--	3,967
14:15	14:15	13	17	8,600	1,863	2,437
14:16	14:16	1	1	8,600	143	143
Subtotal		14	46		2,006	6,547

Ampere-hour Calculations
Test Run No. 1
Tank No. 1B

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
--	10:10				--	--
--	10:12	--	2	2,600	--	87
Subtotal			2			87
10:30	10:28	--	--		--	--
10:45	10:45	15	17	2,600	650	740
11:00	11:00	15	15	2,650	663	663
11:15	11:15	15	15	2,650	663	663
11:30	11:30	15	15	2,650	663	663
11:41	11:41	11	11	2,650	486	486
Subtotal		71	75		3,125	3,215
11:43	11:43	2	--	2,650	88	--
11:45	11:45	2	2	2,650	88	88
12:00	12:00	15	15	2,650	663	663
12:15	12:15	15	15	2,700	675	675
12:45	12:45	30	30	2,700	1,350	1,350
12:58	12:58	13	13	2,700	585	585
Subtotal		77	75		3,449	3,361
13:01	13:01	3	--	2,700	135	--
13:15	13:15	14	14	2,700	630	630
13:30	13:30	15	15	2,700	675	675
Subtotal		32	29		1,440	1,305
14:02	14:02	--	28	2,700	--	1,260
14:15	14:15	13	17	2,700	585	765
14:16	14:16	1	1	2,700	45	45
Subtotal		14	46		630	2,070

Ampere-hour Calculations
Test Run No. 1
Tank No. 2A

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
--	10:10					
--	10:12	--	2	8,800	--	293
Subtotal			2			293
10:30	10:28	--	--		--	--
10:45	10:45	15	17	8,600	2,150	2,437
11:00	11:00	15	15	8,800	2,200	2,200
11:15	11:15	15	15	8,800	2,200	2,200
11:30	11:30	15	15	8,800	2,200	2,200
11:41	11:41	11	11	8,800	1,613	1,613
Subtotal		71	75		10,363	10,650
11:43	11:43	2	--	8,800	293	--
11:45	11:45	2	2	8,800	293	293
12:00	12:00	15	15	8,800	2,150	2,150
12:15	12:15	15	15	8,800	2,200	2,200
12:45	12:45	30	30	8,800	4,400	4,400
12:58	12:58	13	13	8,800	1,907	1,907
Subtotal		77	75		11,243	10,950
13:01	13:01	3	--	8,800	440	--
13:15	13:15	14	14	8,800	2,053	2,053
13:30	13:30	15	15	8,800	2,200	2,200
Subtotal		32	29		4,693	4,253
14:02	14:02	--	28	8,800	--	4,107
14:15	14:15	13	17	8,800	1,907	2,493
14:16	14:16	1	1	8,800	147	147
Subtotal		14	46		2,054	6,747

Ampere-hour Calculations
Test Run No. 1
Tank No. 2B

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	2,600	--	87
Subtotal			2			87
10:30	10:28	--	--		--	--
10:45	10:45	15	17	2,600	650	737
11:00	11:00	15	15	2,650	663	663
11:15	11:15	15	15	2,650	663	663
11:30	11:30	15	15	2,650	663	663
11:41	11:41	11	11	2,650	486	486
Subtotal		71	75		3,125	3,212
11:43	11:43	2	--	2,650	88	--
11:45	11:45	2	2	2,650	88	88
12:00	12:00	15	15	2,650	663	663
12:15	12:15	15	15	2,650	663	663
12:45	12:45	30	30	2,650	1,325	1,325
12:58	12:58	13	13	2,650	574	574
Subtotal		77	75		3,401	3,313
13:01	13:01	3	--	2,650	133	--
13:15	13:15	14	14	2,650	618	618
13:30	13:30	15	15	2,650	663	663
Subtotal		32	29		1,414	1,281
14:02	14:02	--	28	2,650	--	1,237
14:15	14:15	13	17	2,650	574	750
14:16	14:16	1	1	2,650	44	44
Subtotal		14	46		618	2,031

Ampere-hour Calculations
Test Run No. 1
Tank No. 3

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	6,500	--	217
Subtotal			2		--	217
10:30	10:28	--	--		--	--
10:45	10:45	15	17	6,400	1,600	1,813
11:00	11:00	15	15	6,300	1,575	1,575
11:15	11:15	15	15	6,200	1,550	1,550
11:30	11:30	15	15	6,200	1,550	1,550
11:41	11:41	11	11	6,200	1,137	1,137
Subtotal		71	75		7,412	7,625
11:43	11:43	2	--	6,200	207	--
11:45	11:45	2	2	6,200	207	207
12:00	12:00	15	15	6,200	1,550	1,550
12:15	12:15	15	15	6,200	1,550	1,550
12:45	12:45	30	30	6,200	3,100	3,100
12:58	12:58	13	13	6,200	1,343	1,343
Subtotal		77	75		7,957	7,750
13:01	13:01	3	--	6,200	310	--
13:15	13:15	14	14	6,200	1,447	1,447
13:30	13:30	15	15	6,200	1,550	1,550
Subtotal		32	29		3,307	2,997
14:02	14:02	--	28	6,200	--	2,893
14:15	14:15	17	17	6,200	1,757	1,757
14:16	14:16	1	1	6,200	103	103
Subtotal		18	46		1,860	4,753

Ampere-hour Calculations
Test Run No. 1
Tank No. 4

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	11,200	--	373
Subtotal			2			373
10:30	10:28	--	--		--	--
10:45	10:45	15	17	11,200	2,800	3,173
11:00	11:00	15	15	11,200	2,800	2,800
11:15	11:15	15	15	11,000	2,750	2,750
11:30	11:30	15	15	11,400	2,850	2,850
11:41	11:41	11	11	11,400	2,090	2,090
Subtotal		71	75		13,290	13,663
11:43	11:43	2	--	11,400	380	--
11:45	11:45	2	2	11,400	380	380
12:00	12:00	15	15	11,500	2,875	2,875
12:15	12:15	15	15	11,600	2,900	2,900
12:45	12:45	30	30	11,600	5,800	5,800
12:58	12:58	13	13	11,600	2,513	2,513
Subtotal		77	75		14,848	14,468
13:01	13:01	3	--	11,600	580	--
13:15	13:15	14	14	11,600	2,707	2,707
13:30	13:30	15	15	11,600	2,900	2,900
Subtotal		32	29		6,187	5,607
14:02	14:02	--	28	11,600	--	5,413
14:15	14:15	17	17	11,600	3,287	3,287
14:16	14:16	1	1	11,600	193	193
Subtotal		18	46		3,480	8,893

Ampere-hour Calculations
Test Run No. 1
Tank No. 5

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	7,400	--	247
Subtotal			2			247
10:30	10:28	--	--		--	--
10:45	10:45	15	17	7,400	1,850	2,097
11:00	11:00	15	15	7,200	1,800	1,800
11:15	11:15	15	15	7,400	1,850	1,850
11:30	11:30	15	15	7,400	1,850	1,850
11:41	11:41	11	11	7,400	1,357	1,357
Subtotal		71	75		8,707	8,954
11:43	11:43	2	--	7,400	247	--
11:45	11:45	2	2	7,400	247	247
12:00	12:00	15	15	7,400	1,850	1,850
12:15	12:15	15	15	7,400	1,850	1,850
12:45	12:45	30	30	7,400	3,700	3,700
12:58	12:58	13	13	7,400	1,603	1,603
Subtotal		77	75		9,497	9,250
13:01	13:01	3	--	7,400	370	--
13:15	13:15	14	14	7,400	1,727	1,727
13:30	13:30	15	15	7,400	1,850	1,850
Subtotal		32	29		3,947	3,577
14:02	14:02	--	28	7,400	--	3,453
14:15	14:15	17	17	7,400	2,097	2,097
14:16	14:16	1	1	7,400	123	123
Subtotal		18	46		2,220	5,673

Ampere-hour Calculations
Test Run No. 1
Tank No. 6; Rectifier No. 1

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	7,200	--	240
Subtotal			2			240
10:30	10:28	--	--	7,200	--	--
10:45	10:45	15	17	7,000	1,750	1,983
11:00	11:00	15	15	7,200	1,800	1,800
11:15	11:15	15	15	7,200	1,800	1,800
11:30	11:30	15	15	7,200	1,800	1,800
11:41	11:41	11	11	7,200	1,320	1,320
Subtotal		77	75		8,470	8,703
11:43	11:43	2	--	7,200	240	--
11:45	11:45	2	2	7,200	240	240
12:00	12:00	15	15	7,300	1,825	1,825
12:15	12:15	15	15	7,400	1,850	1,850
12:45	12:45	30	30	7,400	3,700	3,700
12:58	12:58	13	13	7,400	1,603	1,603
Subtotal		77	75		9,458	9,218
13:01	13:01	3	--	7,400	370	--
13:15	13:15	14	14	7,500	1,750	1,750
13:30	13:30	15	15	7,500	1,875	1,875
Subtotal		32	29		3,995	3,625
14:02	14:02	--	28	7,400	--	3,453
14:15	14:15	17	17	7,400	2,097	2,097
14:16	14:16	1	1	7,400	123	123
Subtotal		18	46		2,220	5,673

Ampere-hour Calculations
Test Run No. 1
Tank No. 6; Rectififer No. 2

Date: June 19, 1991

Inlet-A	Inlet-B	Outlet
Start time: 10:30	Start time: 10:30	Start time: 10:10
Stop time: 17:02	Stop time: 17:14	Stop time: 17:03

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
--	10:10	--	--		--	--
--	10:12	--	2	5,400	--	180
Subtotal			2			180
10:30	10:28	--	--		--	--
10:45	10:45	15	17	5,400	1,350	1,530
11:00	11:00	15	15	5,400	1,350	1,350
11:15	11:15	15	15	5,600	1,400	1,400
11:30	11:30	15	15	5,500	1,375	1,375
11:41	11:41	11	11	5,500	1,008	1,008
Subtotal		71	75		6,483	6,663
11:43	11:43	2	--	5,400	180	--
11:45	11:45	2	2	5,400	180	180
12:00	12:00	15	15	5,600	1,400	1,400
12:15	12:15	15	15	5,600	1,400	1,400
12:45	12:45	30	30	5,600	2,800	2,800
12:58	12:58	13	13	5,600	1,213	1,213
Subtotal		77	75		7,173	6,993
13:01	13:01	3	--	5,600	280	--
13:15	13:15	14	14	5,700	1,330	1,330
13:30	13:30	15	15	5,700	1,425	1,425
Subtotal		32	29		3,035	2,755
14:02	14:02	--	28	5,700	--	2,660
14:15	14:15	17	17	5,800	1,643	1,643
14:16	14:16	1	1	5,800	97	97
Subtotal		18	46		1,740	4,400

Ampere-hour Calculations
Test Run No. 2
Tank No. 1A

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
9:25	9:28	--	--		--	--
9:45	9:45	20	17	8,500	2,833	2,408
10:15	10:15	30	30	8,500	4,250	4,250
10:43	10:43	28	28	8,500	3,967	3,967
Subtotal		78	75		11,050	10,625
10:45	10:45	2	--	8,500	283	--
11:15	11:15	30	30	8,500	4,250	4,250
11:45	11:45	30	30	8,500	4,250	4,250
12:00	12:00	15	15	8,500	2,125	2,125
Subtotal		77	75		10,908	10,625
12:01	12:01	1	--	8,500	142	--
12:25	12:25	24	24	8,500	3,400	3,400
Subtotal		25	24		3,542	3,400
12:48	12:48	--	23	8,500	--	3,258
13:15	13:15	27	27	8,500	3,825	3,825
13:16	13:16	1	1	8,500	142	142
Subtotal		28	51		3,967	7,225
13:18	13:18	2	--	8,500	283	--
13:45	13:45	27	27	8,500	3,825	3,825
14:15	14:15	30	30	8,500	4,250	4,250
14:33	14:33	18	18	8,500	2,550	2,550
Subtotal		77	75		10,908	10,625

Ampere-hour Calculations
Test Run No. 2
Tank No. 1B

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
9:25	9:28	--	--		--	--
9:45	9:45	20	17	2,650	883	751
10:15	10:15	30	30	2,650	1,325	1,325
10:43	10:43	28	28	2,700	1,260	1,260
Subtotal		78	75		3,468	3,336
10:45	10:45	2	--	2,700	900	--
11:15	11:15	30	30	2,700	1,350	1,350
11:45	11:45	30	30	2,700	1,350	1,350
12:00	12:00	15	15	2,700	675	675
Subtotal		77	75		4,275	3,375
12:01	12:01	1	--	2,700	45	--
12:25	12:25	24	24	2,700	1,080	1,080
Subtotal		25	24		1,125	1,080
12:48	12:48	--	23	2,750	--	1,054
13:15	13:15	27	27	2,750	1,238	1,238
13:16	13:16	1	1	2,750	46	46
Subtotal		28	51		1,284	2,338
13:18	13:18	2	--	2,750	92	--
13:45	13:45	27	27	2,750	1,238	1,238
14:15	14:15	30	30	2,750	1,375	1,375
14:33	14:33	18	18	2,750	825	825
Subtotal		77	75		3,530	3,438

Ampere-hour Calculations
Test Run No. 2
Tank No. 2A

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
9:25	9:28	--	--		--	--
9:45	9:45	20	17	9,000	3,000	2,550
10:15	10:15	30	30	9,000	4,500	4,500
10:43	10:43	28	28	9,200	4,293	4,293
Subtotal		78	75		11,793	11,343
10:45	10:45	2	--	9,200	307	--
11:15	11:15	30	30	9,400	4,700	4,700
11:45	11:45	30	30	9,400	4,700	4,700
12:00	12:00	15	15	9,400	2,350	2,350
Subtotal		77	75		12,057	11,750
12:01	12:01	1	--	9,400	157	--
12:25	12:25	24	24	9,400	3,760	3,760
Subtotal		25	24		3,917	3,760
12:48	12:48	--	23	9,500	--	3,642
13:15	13:15	27	27	9,400	4,230	4,230
13:16	13:16	1	1	9,400	157	157
Subtotal		28	51		4,387	8,029
13:18	13:18	2	--	9,400	313	--
13:45	13:45	27	27	9,400	4,230	4,230
14:15	14:15	30	30	9,400	4,700	4,700
14:33	14:33	18	18	9,400	2,820	2,820
Subtotal		77	75		12,063	11,750

Ampere-hour Calculations
Test Run No. 2
Tank No. 2B

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
9:25	9:28	--	--		--	--
9:45	9:45	20	17	2,600	867	737
10:15	10:15	30	30	2,600	1,300	1,300
10:43	10:43	28	28	2,600	1,213	1,213
Subtotal		78	75		3,380	3,250
10:45	10:45	2	--	2,650	88	--
11:15	11:15	30	30	2,700	1,350	1,350
11:45	11:45	30	30	2,700	1,350	1,350
12:00	12:00	15	15	2,700	675	675
Subtotal		77	75		3,463	3,375
12:01	12:01	1	--	2,700	45	--
12:25	12:25	24	24	2,700	1,080	1,080
Subtotal		25	24		1,125	1,080
12:48	12:48	--	23	2,700	--	1,035
13:15	13:15	27	27	2,750	1,238	1,238
13:16	13:16	1	1	2,750	46	46
Subtotal		28	51		1,284	2,319
13:18	13:18	2	--	2,750	92	--
13:45	13:45	27	27	2,750	1,238	1,238
14:15	14:15	30	30	2,750	1,375	1,375
14:33	14:33	18	18	2,750	825	825
Subtotal		77	75		3,530	3,438

Ampere-hour Calculations
Test Run No. 2
Tank No. 3

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
9:23	9:28	--	--		--	--
9:45	9:45	22	17	6,500	2,383	1,842
10:15	10:15	30	30	6,500	3,250	3,250
10:43	10:43	28	28	6,500	3,033	3,033
Subtotal		80	75		8,666	8,125
10:45	10:45	2	--	6,500	217	--
11:15	11:15	30	30	5,600	2,800	2,800
11:45	11:45	30	30	5,600	2,800	2,800
12:00	12:00	15	15	5,600	1,400	1,400
Subtotal		77	75		7,217	7,000
12:01	12:01	1	--	5,600	93	--
12:23	12:23	22	22	5,600	2,053	2,053
Subtotal		23	22		2,146	2,053
12:46	12:46	--	23	5,600	--	2,147
13:15	13:15	29	29	5,600	2,706	2,706
13:16	13:16	1	1	5,600	93	93
Subtotal		30	53		2,799	4,946
13:18	13:18	2	--	5,600	187	--
13:45	13:45	27	27	5,600	2,520	2,520
14:15	14:15	30	30	5,600	2,800	2,800
14:33	14:33	18	18	5,600	1,680	1,680
Subtotal		77	75		7,187	7,000

Ampere-hour Calculations
Test Run No. 2
Tank No. 4

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
9:23	9:28	--	--		--	--
9:45	9:45	22	17	11,000	4,033	3,117
10:15	10:15	30	30	11,200	5,600	5,600
10:43	10:43	28	28	11,200	5,227	5,227
Subtotal		80	75		14,860	13,944
10:45	10:45	2	--	11,000	367	--
11:15	11:15	30	30	11,000	5,500	5,500
11:45	11:45	30	30	11,000	5,500	5,500
12:00	12:00	15	15	11,000	2,750	2,750
Subtotal		77	75		14,177	13,750
12:01	12:01	1	--	11,000	183	--
12:23	12:23	22	22	11,000	4,033	4,033
Subtotal		23	22		4,216	4,033
12:46	12:46	--	23	11,000	--	4,217
13:15	13:15	29	29	11,200	5,413	5,413
13:16	13:16	1	1	11,200	187	187
Subtotal		30	53		5,600	9,817
13:18	13:18	2	--	11,200	373	--
13:45	13:45	27	27	10,000	4,500	4,500
14:15	14:15	30	30	10,000	5,000	5,000
14:33	14:33	18	18	10,000	3,000	3,000
Subtotal		77	75		12,873	12,500

Ampere-hour Calculations
Test Run No. 2
Tank No. 5

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
9:23	9:28	--	--		--	--
9:45	9:45	22	17	7,400	2,713	2,097
10:15	10:15	30	30	7,400	3,700	3,700
10:43	10:43	28	28	7,400	3,453	3,453
Subtotal		80	75		9,866	9,250
10:45	10:45	2	--	7,400	247	--
11:15	11:15	30	30	7,400	3,700	3,700
11:45	11:45	30	30	7,400	3,700	3,700
12:00	12:00	15	15	7,400	1,850	1,850
Subtotal		77	75		9,497	9,250
12:01	12:01	1	--	7,400	123	--
12:23	12:23	22	22	7,400	2,713	2,713
Subtotal		23	22		2,836	2,713
12:46	12:46	--	23	7,400	--	2,837
13:15	13:15	29	29	7,400	3,577	3,577
13:16	13:16	1	1	7,400	123	123
Subtotal		30	53		3,700	6,537
13:18	13:18	2	--	7,400	247	--
13:45	13:45	27	27	7,400	3,330	3,330
14:15	14:15	30	30	7,400	3,700	3,700
14:33	14:33	18	18	7,400	2,220	2,220
Subtotal		77	75		9,497	9,250

Ampere-hour Calculations
Test Run No. 2
Tank No. 6; Rectifier No. 1

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
9:23	9:28	--	--		--	--
9:45	9:45	22	17	5,600	2,053	1,587
10:15	10:15	30	30	5,700	2,850	2,850
10:43	10:43	28	28	5,800	2,707	2,707
Subtotal		80	75		7,610	7,144
10:45	10:45	2	--	5,800	193	--
11:15	11:15	30	30	6,000	3,000	3,000
11:45	11:45	30	30	6,000	3,000	3,000
12:00	12:00	15	15	6,000	1,500	1,500
Subtotal		77	75		7,693	7,500
12:01	12:01	1	--	6,000	100	--
12:23	12:23	22	22	6,000	2,200	2,200
Subtotal		23	22		2,300	2,200
12:46	12:46	--	23	7,000	--	2,683
13:15	13:15	29	29	7,200	3,480	3,480
13:16	13:16	1	1	7,200	120	120
Subtotal		30	53		3,600	6,283
13:18	13:18	2	--	7,200	240	--
13:45	13:45	27	27	7,300	3,285	3,285
14:15	14:15	30	30	7,300	3,650	3,650
14:33	14:33	18	18	7,300	2,190	2,190
Subtotal		77	75		9,365	9,125

Ampere-hour Calculations
Test Run No. 2
Tank No. 6; Rectifier No. 2

Date: June 20, 1991

Inlet-A	Inlet-B	Outlet
Start time: 9:25	Start time: 9:23	Start time: 9:28
Stop time: 15:48	Stop time: 15:46	Stop time: 15:50

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
9:23	9:28	--	--		--	--
9:45	9:45	22	17	7,000	2,567	1,983
10:15	10:15	30	30	7,000	3,500	3,500
10:43	10:43	28	28	7,000	3,267	3,267
Subtotal		80	75		9,334	8,750
10:45	10:45	2	--	7,200	240	--
11:15	11:15	30	30	7,400	3,700	3,700
11:45	11:45	30	30	7,400	3,700	3,700
12:00	12:00	15	15	7,400	1,850	1,850
Subtotal		77	75		9,490	9,250
12:01	12:01	1	--	7,400	123	--
12:23	12:23	22	22	7,400	2,713	2,713
Subtotal		23	22		2,836	2,713
12:46	12:46	--	23	6,000	--	2,300
13:15	13:15	29	29	6,000	2,900	2,900
13:16	13:16	1	1	6,000	100	100
Subtotal		30	53		3,000	5,300
13:18	13:18	2	--	6,000	200	--
13:45	13:45	27	27	6,000	2,700	2,700
14:15	14:15	30	30	6,000	3,000	3,000
14:33	14:33	18	18	6,000	1,800	1,800
Subtotal		77	75		7,700	7,500

Ampere-hour Calculations
Test Run No. 3
Tank No. 1A

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
7:47	7:49	--	--		--	--
8:15	8:15	28	26	8,250	3,850	3,575
8:45	8:45	30	30	8,250	4,125	4,125
9:04	9:04	19	19	8,250	2,613	2,613
Subtotal		77	75		10,588	10,313
9:05	9:05	1	--	8,250	138	--
9:15	9:15	10	10	8,250	1,375	1,375
9:45	9:45	30	30	8,250	4,125	4,125
10:15	10:15	30	30	8,250	4,125	4,125
10:20	10:20	5	5	8,250	688	688
Subtotal		76	75		10,451	10,313
10:22	10:22	2	--	8,250	275	--
10:45	10:45	23	23	8,250	3,163	3,163
10:47	10:47	2	2	8,250	275	275
Subtotal		27	25		3,713	3,438
11:25	11:25	--	38	8,250	--	5,225
11:37	11:37	12	12	8,250	1,650	1,650
Subtotal		12	50		1,650	6,875
11:39	11:39	2	--	8,250	275	--
11:45	11:45	6	6	8,250	825	825
12:15	12:15	30	30	8,250	4,125	4,125
12:45	12:45	30	30	8,250	4,125	4,125
12:54	12:54	9	9	8,250	1,238	1,238
Subtotal		77	75		10,588	10,313

Ampere-hour Calculations
Test Run No. 3
Tank No. 1B

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
7:47	7:49	--	--		--	--
8:15	8:15	28	26	2,650	1,237	1,148
8:45	8:45	30	30	2,650	1,325	1,325
9:04	9:04	19	19	2,650	839	839
Subtotal		77	75		3,401	3,312
9:05	9:05	1	--	2,650	44	--
9:15	9:15	10	10	2,650	442	442
9:45	9:45	30	30	2,650	1,325	1,325
10:15	10:15	30	30	2,650	1,325	1,325
10:20	10:20	5	5	2,650	221	221
Subtotal		76	75		3,357	3,313
10:22	10:22	2	--	2,650	88	--
10:45	10:45	23	23	2,650	1,016	1,016
10:47	10:47	2	2	2,650	88	88
Subtotal		27	25		1,192	1,104
11:25	11:25	--	38	2,725	--	1,726
11:37	11:37	12	12	2,725	545	545
Subtotal		12	50		545	2,271
11:39	11:39	2	--	2,725	91	--
11:45	11:45	6	6	2,725	273	273
12:15	12:15	30	30	2,700	1,350	1,350
12:45	12:45	30	30	2,700	1,350	1,350
12:54	12:54	9	9	2,700	405	405
Subtotal		77	75		3,469	3,378

Ampere-hour Calculations
Test Run No. 3
Tank No. 2A

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
7:47	7:49	--	--		--	--
8:15	8:15	28	26	9,400	4,387	4,073
8:45	8:45	30	30	9,500	4,750	4,750
9:04	9:04	19	19	9,500	3,008	3,008
Subtotal		77	75		12,145	11,831
9:05	9:05	1	--	9,500	158	--
9:15	9:15	10	10	9,500	1,583	1,583
9:45	9:45	30	30	9,600	4,800	4,800
10:15	10:15	30	30	9,400	4,700	4,700
10:20	10:20	5	5	9,400	783	783
Subtotal		76	75		12,024	11,866
10:22	10:22	2	--	9,400	313	--
10:45	10:45	23	23	9,400	3,603	3,603
10:47	10:47	2	2	9,400	313	313
Subtotal		27	25		4,229	3,916
11:25	11:25	--	38	9,600	--	6,080
11:37	11:37	12	12	9,600	1,920	1,920
Subtotal		12	50		1,920	8,000
11:39	11:39	2	--	9,600	320	--
11:45	11:45	6	6	9,600	960	960
12:15	12:15	30	30	9,500	4,750	4,750
12:45	12:45	30	30	9,600	4,800	4,800
12:54	12:54	9	9	9,600	1,440	1,440
Subtotal		77	75		12,270	11,950

Ampere-hour Calculations
Test Run No. 3
Tank No. 2B

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-A	Outlet	Inlet-A	Outlet		Inlet-A	Outlet
7:47	7:49	--	--		--	--
8:15	8:15	28	26	2,600	1,213	1,127
8:45	8:45	30	30	2,650	1,325	1,325
9:04	9:04	19	19	2,650	839	839
Subtotal		77	75		3,377	3,291
9:05	9:05	1	--	2,650	44	--
9:15	9:15	10	10	2,700	450	450
9:45	9:45	30	30	2,700	1,350	1,350
10:15	10:15	30	30	2,700	1,350	1,350
10:20	10:20	5	5	2,700	225	225
Subtotal		76	75		3,419	3,375
10:22	10:22	2	--	2,700	90	--
10:45	10:45	23	23	2,700	1,035	1,035
10:47	10:47	2	2	2,700	90	90
Subtotal		27	25		1,215	1,125
11:25	11:25	--	38	2,700	--	1,710
11:37	11:37	12	12	2,700	540	540
Subtotal		12	50	2,700	540	2,250
11:39	11:39	2	--	2,700	90	--
11:45	11:45	6	6	2,700	270	270
12:15	12:15	30	30	2,700	1,350	1,350
12:45	12:45	30	30	2,700	1,350	1,350
12:54	12:54	9	9	2,700	405	405
Subtotal		77	75		3,465	3,375

Ampere-hour Calculations
Test Run No. 3
Tank No. 3

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
7:45	7:49	--	--		--	--
8:15	8:15	30	26	6,400	3,200	2,773
8:45	8:45	30	30	6,400	3,200	3,200
9:04	9:04	19	19	6,400	2,027	2,027
Subtotal		79	75		8,427	8,000
9:05	9:05	1	--	6,400	107	--
9:15	9:15	10	10	6,400	1,067	1,067
9:45	9:45	30	30	6,400	3,200	3,200
10:15	10:15	30	30	6,400	3,200	3,200
10:20	10:20	5	5	6,400	533	533
Subtotal		76	75		8,107	8,000
10:22	10:22	2	--	6,400	213	--
10:45	10:45	23	23	6,400	2,453	2,453
Subtotal		25	23		2,666	2,453
11:22	11:22	--	37	5,500	--	3,392
11:37	11:37	15	15	5,500	1,375	1,375
Subtotal		15	52		1,375	4,767
11:39	11:39	2	--	5,500	183	--
11:45	11:45	6	6	5,500	550	550
12:15	12:15	30	30	5,500	2,750	2,750
12:45	12:45	30	30	5,500	2,750	2,750
12:54	12:54	9	9	5,500	825	825
Subtotal		77	75		7,058	6,875

Ampere-hour Calculations
Test Run No. 3
Tank No. 4

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
7:45	7:49	--	--		--	--
8:15	8:15	30	26	10,500	5,250	4,550
8:45	8:45	30	30	10,800	5,400	5,400
9:04	9:04	19	19	10,800	3,420	3,420
Subtotal		79	75		14,070	13,370
9:05	9:05	1	--	10,800	180	--
9:15	9:15	10	10	10,800	1,800	1,800
9:45	9:45	30	30	10,800	5,400	5,400
10:15	10:15	30	30	10,800	5,400	5,400
10:20	10:20	5	5	10,800	900	900
Subtotal		76	75		13,680	13,500
10:22	10:22	2	--	10,800	360	--
10:45	10:45	23	23	10,800	4,140	4,140
Subtotal		25	23		4,500	4,140
11:22	11:22	--	37	10,000	--	6,167
11:37	11:37	15	15	10,000	2,500	2,500
Subtotal		15	52		2,500	8,667
11:39	11:39	2	--	10,000	333	--
11:45	11:45	6	6	10,000	1,000	1,000
12:15	12:15	30	30	10,000	5,000	5,000
12:45	12:45	30	30	10,000	5,000	5,000
12:54	12:54	9	9	10,000	1,500	1,500
Subtotal		77	75		12,833	12,500

Ampere-hour Calculations
Test Run No. 3
Tank No. 5

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
7:45	7:49	--	--		--	--
8:15	8:15	30	26	6,400	3,200	2,773
8:45	8:45	30	30	7,400	3,700	3,700
9:04	9:04	19	19	7,400	2,343	2,343
Subtotal		79	75		9,243	8,816
9:05	9:05	1	--	7,400	123	--
9:15	9:15	10	10	7,400	1,233	1,233
9:45	9:45	30	30	7,400	3,700	3,700
10:15	10:15	30	30	6,400	3,200	3,200
10:20	10:20	5	5	6,400	533	533
Subtotal		76	75		8,789	8,666
10:22	10:22	2	--	6,400	213	--
10:45	10:45	23	23	6,400	2,453	2,453
Subtotal		25	23		2,666	2,453
11:22	11:22	--	37	6,400	--	3,947
11:37	11:37	15	15	6,400	1,600	1,600
Subtotal		15	52		1,600	5,547
11:39	11:39	2	--	6,400	213	--
11:45	11:45	6	6	7,400	740	740
12:15	12:15	30	30	7,400	3,700	3,700
12:45	12:45	30	30	7,400	3,700	3,700
12:54	12:54	9	9	7,400	1,110	1,110
Subtotal		77	75		9,463	9,250

Ampere-hour Calculations
Test Run No. 3
Tank No. 6; Rectifier No. 1

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
7:45	7:49	--	--		--	--
8:15	8:15	30	26	6,400	3,200	2,773
8:45	8:45	30	30	6,600	3,300	3,300
9:04	9:04	19	19	6,600	2,090	2,090
Subtotal		79	75		8,590	8,163
9:05	9:05	1	--	6,600	110	--
9:15	9:15	10	10	6,600	1,100	1,100
9:45	9:45	30	30	6,700	3,350	3,350
10:15	10:15	30	30	6,700	3,350	3,350
10:20	10:20	5	5	6,700	558	558
Subtotal		76	75		8,468	8,358
10:22	10:22	2	--	6,700	223	--
10:45	10:45	23	23	6,700	2,568	2,568
Subtotal		25	23		2,791	2,568
11:22	11:22	--	37	6,800	--	4,193
11:37	11:37	15	15	6,800	1,700	1,700
Subtotal		15	52		1,700	5,893
11:39	11:39	2	--	6,800	227	--
11:45	11:45	6	6	6,800	680	680
12:15	12:15	30	30	6,800	3,400	3,400
12:45	12:45	30	30	6,900	3,450	3,450
12:54	12:54	9	9	6,900	1,035	1,035
Subtotal		77	75		8,792	8,565

Ampere-hour Calculations
Test Run No. 3
Tank No. 6; Rectifier No. 2

Date: June 21, 1991

Inlet-A	Inlet-B	Outlet
Start time: 7:47	Start time: 7:45	Start time: 7:49
Stop time: 14:25	Stop time: 14:22	Stop time: 14:11

Time, 24-h clock		Time interval, min		Current, amperes	Ampere-hours	
Inlet-B	Outlet	Inlet-B	Outlet		Inlet-B	Outlet
7:45	7:49	--	--		--	--
8:15	8:15	30	26	5,000	2,500	2,167
8:45	8:45	30	30	5,200	2,600	2,600
9:04	9:04	19	19	5,200	1,647	1,647
Subtotal		79	75		6,747	6,414
9:05	9:05	1	--	5,200	87	--
9:15	9:15	10	10	5,200	867	867
9:45	9:45	30	30	5,400	2,700	2,700
10:15	10:15	30	30	5,400	2,700	2,700
10:20	10:20	5	5	5,400	450	450
Subtotal		76	75		6,804	6,717
10:22	10:22	2	--	5,400	180	--
10:45	10:45	23	23	5,400	2,070	2,070
Subtotal		25	23		2,250	2,070
11:22	11:22	--	37	5,500	--	3,392
11:37	11:37	15	15	5,500	1,375	1,375
Subtotal		15	52		1,375	4,767
11:39	11:39	2	--	5,500	183	--
11:45	11:45	6	6	5,500	550	550
12:15	12:15	30	30	5,600	2,800	2,800
12:45	12:45	30	30	5,600	2,800	2,800
12:54	12:54	9	9	5,600	840	840
Subtotal		77	75		7,173	6,990

Process Data Sheets
Remco Hydraulics, Inc.
Willits, California

Test Run No. 1			Date: 6/19/91		Page 1 of 5
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
10:10	1A	8,100	9		Start test @ 10:10
	1B	2,600	8.6		
	2A	8,800	9		
	2B	2,600	8		
	3	6,500	7.6		
	4		11.6		Stop test @ 10:12
	5				Fan down
	6				Baume reading of scrubber water = 3.0
					Scrubber water conc. = 4.1 oz/gal
10:30	1A	8,500	8.0		Start test @ 10:30
	1B	2,550	8.2		
	2A	8,600	9.0		ΔP pack = 1.3
	2B	2,600	8.0		ΔP pad = 2.0
	3	6,500	7.6		
	4	11,200	12		Composite samples taken of scrubber water and
	5	7,400	7.0		plating tanks
	6	7,200	12		
	6	5,400	11.8		
10:45	2A	8,600	9.0		ΔP pack = 1.3
	2B	2,600	8.0		ΔP pad = 2.0
	1A	8,500	8.2		
	1B	2,600	8.2		
	3	6,400	7.6		
	4	11,200	12		
	5	7,400	7.0		
	6	7,000	12		
	6	5,400	11.8		
11:00	1A	8,500	8.2	120	
	1B	2,650	8.2	120	
	2A	8,800	9.0	120	
	2B	2,650	8.0	120	
	3	6,300	7.8	120	
	4	11,200	12	120	
	5	7,400	7	120	
	6	7,200	12	120	
	6	5,400	11.8	120	

Test Run No. 1		Date: 6/19/91			Page 3 of 5
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
12:45	1A	8,500	8.0		ΔP pack = 1.3
	1B	2,700	8.4		ΔP pad = 2.0
	2A	8,800	9.0		
	2B	2,650	8.0		
	3	6,200	7.6		
	4	11,600	12		
	5	7,400	7		
	6	7,400	12		
	6	5,600	11.8		
1:15	1A	8,500	8.0	125	
	1B	2,700	7.4	125	
	2A	8,800	9	125	
	2B	2,650	8.0	125	
	3	6,200	7.7	125	
	4	11,600	12.2	140	
	5	7,400	7.2	132	
	6	7,500	12.2	138	
	6	5,700	11.8		
1:45	1A	8,500	8.0		ΔP pack = 1.3
	1B	2,700	8.4		ΔP pad = 2.0
	2A	8,800	9.0		
	2B	2,700	8.0		Scrubber water
	3	6,200	7.8		Baume reading = 3
	4	11,600	12.2		Conc. = 4.1 oz/gal
	5	7,400	7.2		
	6	7,400	11.8		Composite samples taken from plating tanks and
	6	5,700	11.8		scrubber water
2:15	1A	8,600	8.0		
	1B	2,700	8.4		
	2A	8,800	9.0		
	2B	2,700	8.0		
	3	6,200	7.8		
	4	11,600	12.2		
	5	7,400	7.2		
	6	7,400	11.8		
	6	5,800	11.8		

Test Run No. 1		Date: 6/19/91			Page 5 of 5
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
5:15	1A	9,000	8.0		
	1B	2,700	8.4		
	2A	8,800	9.0		
	2B	2,700	7.0		
	3	6,400	7.8		
	4	11,600	12.4		
	5	7,100	7.0		
	6	7,600	11.8		
	6	6,000	11.8		
5:30	1A	9,000	8.0		
	1B	2,700	8.4		
	2A	8,800	9.0		
	2B	2,700	8.0		
	3	6,400	7.8		
	4	11,600	12.4		
	5	7,100	7.0		
	6	7,600	11.8		
	6	6,000	11.8		Stopped testing @ 5:03

Test Run No. 2			Date: 6/20/91		Page 2 of 4
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
10:45	1A	8,500	8.0		ΔP pack = 2.4
	1B	2,700	8.4		ΔP pad = 1.2
	2A	9,200	9.6		
	2B	2,650	8.0		
	3	6,500	8.0		
	4	11,200	11.8		Tank 3 was dropped down to 5,500 A @ 11:00
	5	7,400	7.2		because rectifier overheated
	6	7,200	12.0		
	6	5,800	11.6		
11:15	1A	8,500	8.0	124	ΔP pack = 1.2
	1B	2,700	8.4	124	ΔP pad = 2.4
	2A	9,400	9.6	126	
	2B	2,700	8.0	126	
	3	5,600	7.2	124	
	4	11,000	11.6	140	
	5	7,400	7.0	133	
	6	7,400	12	130	
	6	6,000	11.8		
11:45	1A	8,500	8.0		
	1B	2,700	8.4		
	2A	9,400	9.6		
	2B	2,700	8.0		
	3	5,600	7.2		
	4	11,000	11.6		
	5	7,400	7.0		
	6	7,400	11.8		
	6	6,000	11.8		
12:15	1A	8,500	8.0		ΔP pack = 1.2
	1B	2,700	8.4		ΔP pad = 2.4
	2A	9,400	9.6		
	2B	2,700	8.0		Scrubber water
	3	5,600	7.2		Baume reading= 1.5
	4	11,000	11.6		Conc. = 2.5 oz/gal
	5	7,400	7.0		
	6	7,400	11.8		Composit samples taken from plating tanks and
	6	6,000	11.8		scrubber water
12:45	1A	8,500	8.0		
	1B	2,750	8.4		
	2A	9,500	9.6		
	2B	2,700	8.0		
	3	5,600	7.2		
	4	11,000	11.6		
	5	7,400	7.0		
	6	6,000	11.6		
	6	7,000	11.6		

Test Run No. 2			Date: 6/20/91		Page 4 of 4
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
3:45	1A	8,500	8.0		ΔP pack = 1.2
	1B	2,750	8.4		ΔP pad = 2.4
	2A	9,600	9.6		
	2B	2,750	8.0		
	3	5,600	7.2		
	4	10,000	10.8		
	5	7,400	7.0		
	6	5,600	10.6		
	6	7,000	10.8		
4:00	1A	8,500	8.0		ΔP pack = 1.2
	1B	2,750	8.4		ΔP pad = 2.4
	2A	9,600	9.6		
	2B	2,750	8.0		Stopped testing @ 4:50
	3	5,600	7.2		
	4	10,000	11		
	5	7,400	7.0		
	6	5,600	10.8		
	6	7,000	10.8		

Test Run No. 3		Date: 6/21/91			Page 2 of 3
Time	Tank No.	Operating current, amperes	Operating voltage, volts	Operation temp., °F	Notes
9:45	1A	8,250	8.0		Scrubber water
	1B	2,650	8.4		Baume reading = 5.0
	2A	9,600	9.6		Conc. = 6.8 oz/gal
	2B	2,700	8.0		
	3	6,400	8.0		Baume readings are approximately reading about
	4	10,800	11.4		an ounce per gallon too high because of metal
	5	7,400	7.2		contaminants as determined by comparing
	6	6,700	11.4		concentration per hydrometer by that detected
	6	5,400	11.2		using colorimetric method.
10:15	1A	8,250	8.0		ΔP pack = 1.1
	1B	2,650	8.4		ΔP pad = 2.1
	2A	9,400	9.6		
	2B	2,700	8.0		Drained approximately ~200 gallons out of
	3	6,400	8.0		scrubber water recirculation tank.
	4	10,800	11.4		
	5	6,400	7.2		
	6	6,700	11.4		
	6	5,400	11.2		
11:00	1A	8,250	8.0		Scrubber water
	1B	2,700	8.4		Baume reading = 3.5
	2A	9,600	9.6		Conc. = 4.8 oz/gal
	2B	2,700	8.0		
	3	6,400	8.0		Collected composite samples from plating tanks
	4	11,000	11.4		and scrubber water
	5	7,400	7.2		
	6	6,800	11.4		Rectifier on Tank No. 4 getting hot; dropped amps
	6	5,400	11.2		by 1,000 at 11:15
11:15	1A	8,250	8.0	122	ΔP pack = 1.2
	1B	2,725	8.4	122	ΔP pad = 2.1
	2A	9,600	9.6	124	
	2B	2,700	8.0	124	
	3	6,400	8.0	121	
	4	10,000	11.0	139	
	5	7,400	7.1	131	
	6	6,800	11.4	128	
	6	5,500	11.2		
11:45	1A	8,250	8.0		Tank No. 3 rectifier overheated-shutdown at 11:25
	1B	2,725	8.4		
	2A	9,600	9.6		Tank No. 3 backup at 11:30 at 5,500A
	2B	2,700	8.1		
	3	5,500	7.4		
	4	10,000	10.0		
	5	7,400	7.1		
	6	6,800	11.4		
	6	5,500	11.2		

APPENDIX F

DETERMINATION OF TOTAL CHROMIUM AND HEXAVALENT

CHROMIUM EMISSIONS

FROM STATIONARY SOURCES (CARB 425)

State of California
Air Resources Board

Method 425

Determination of Total Chromium and Hexavalent Chromium Emissions from Stationary Sources

Adopted: January 22, 1987

Amended: September 12, 1990

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METHOD 425
DETERMINATION OF TOTAL CHROMIUM AND HEXAVALENT CHROMIUM
EMISSIONS FROM STATIONARY SOURCES

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METHOD 425
DETERMINATION OF TOTAL CHROMIUM AND HEXAVALENT CHROMIUM EMISSIONS FROM STATIONARY SOURCES

1 APPLICABILITY, PRINCIPLE, AND FIGURES

1. 1 APPLICABILITY

This method applies to the determination of hexavalent chromium (Cr(VI)) and total chromium emissions from stationary sources. Applicability has been demonstrated for the metal finishing and glass industries. Its applicability has not been demonstrated for sources with high particulate mass emission rates.

1. 2 PRINCIPLE

Particulate emissions are collected from the source in an alkaline medium by use of CARB Method 5, with modifications noted in this method. The components of the collected sample are each divided into two equal portions with one portion of each component used for total chromium analysis and the other portion used for hexavalent chromium analysis.

1. 2. 1 Hexavalent Chromium Analysis

For the hexavalent chromium analysis the collected sample component portions are extracted in an alkaline solution and analyzed by the diphenylcarbazide colorimetric method.

1. 2. 2 Total Chromium Analysis

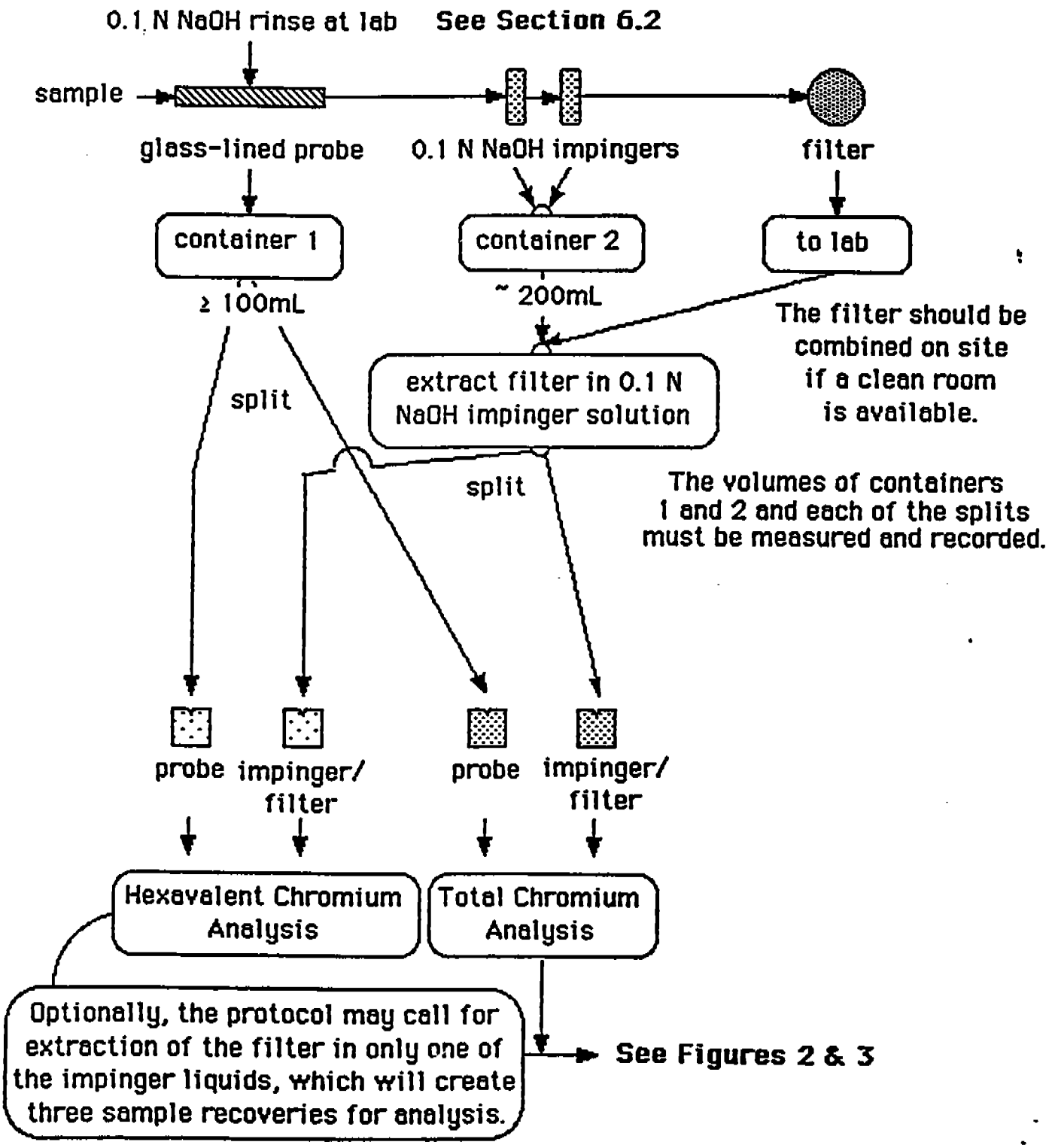
For the total chromium analysis the collected samples must be prepared in order to convert organic forms of chromium to inorganic forms, to minimize organic interferences, and to convert the sample to a suitable solution for analysis. Samples are then subjected to an acid digestion procedure. Following the appropriate dissolution and dilution of the sample, a representative aliquot is placed manually or by means of an automatic sampler into a graphite tube furnace. The sample aliquot is then slowly evaporated to dryness, charred (ashed), and atomized. The absorption of hollow cathode radiation during atomization will be proportional to the chromium concentration.

1. 3 FIGURES

The following figures summarize features of this method.

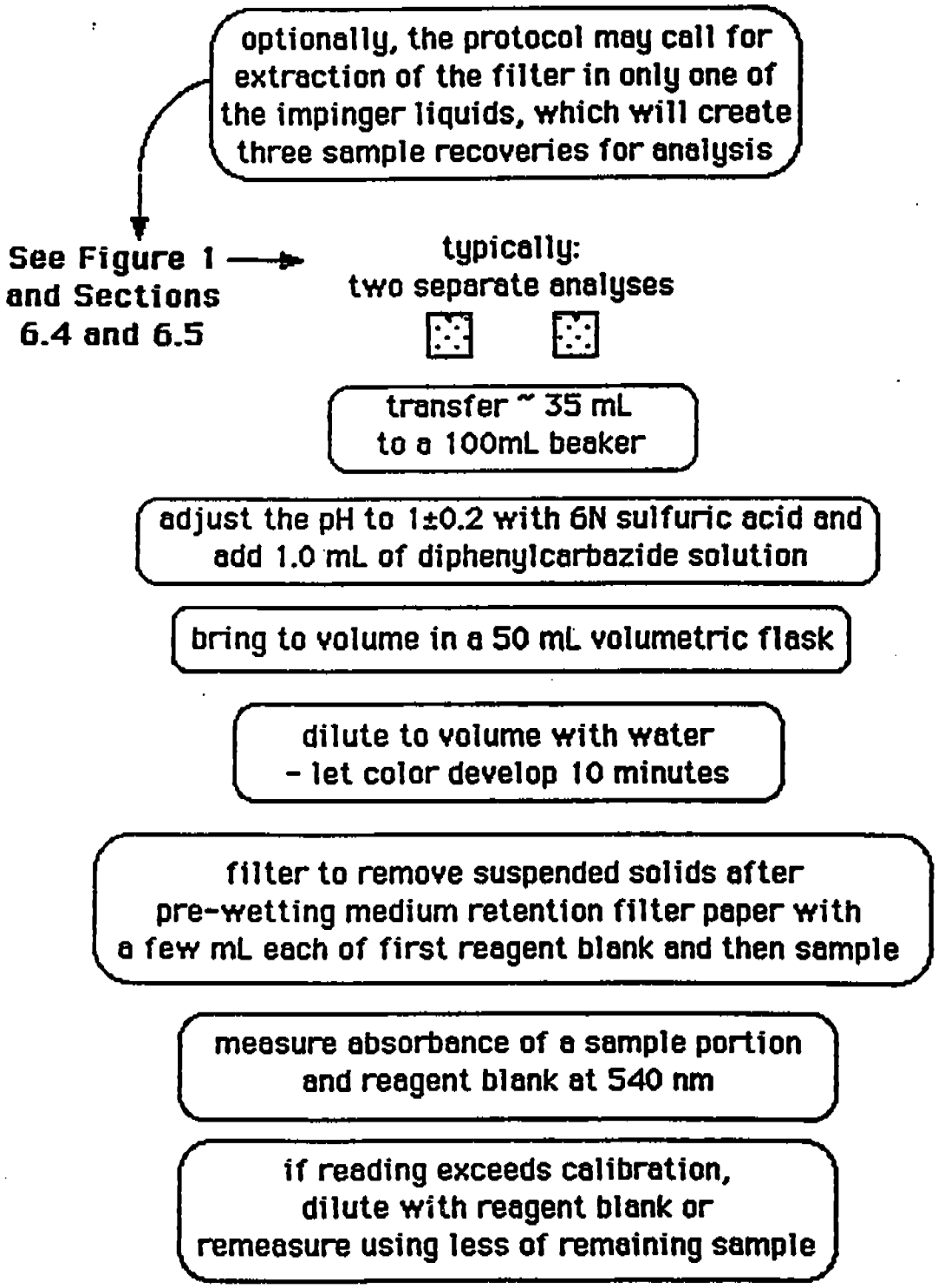
1. 3. 1 Figure 1.

Sample Collection and Recovery for Hexavalent and Total Chromium



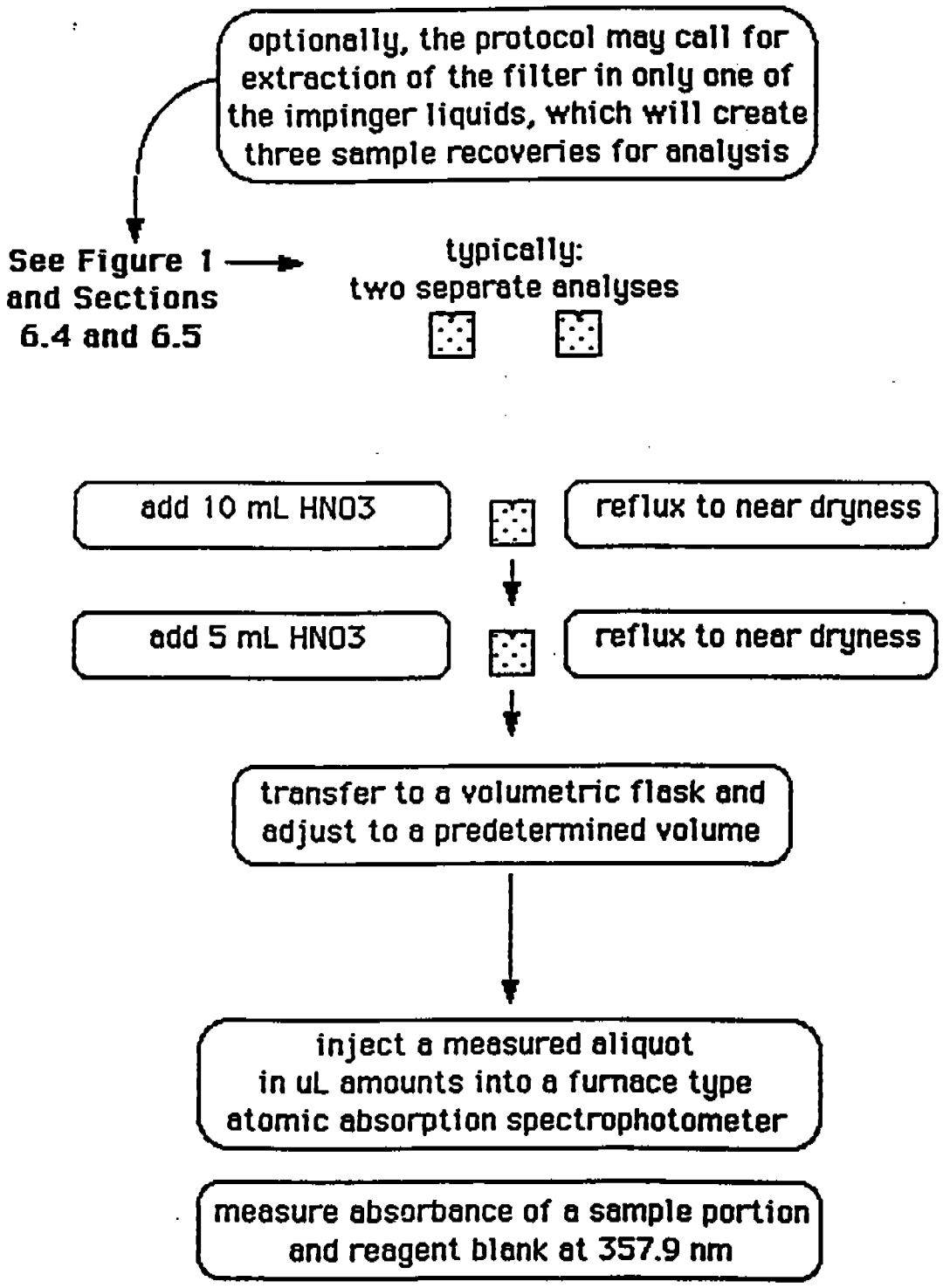
1. 3. 2 Figure 2.

Hexavalent Chromium Analysis



1. 3. 3 Figure 3.

Total Chromium Analysis



2 RANGE, SENSITIVITY, PRECISION, AND INTERFERENCES

2. 1 RANGE

2. 1. 1 Hexavalent Chromium

A straight line response curve was obtained in the range 0.5 ug Cr(VI)/50 mL to 3.0 ug Cr(VI)/50 mL. For a minimum analytical accuracy of 100 ± 10 percent, the lower limit of the range is 2 ug/100mL. The upper limit can be extended by appropriate dilution or by using a smaller cell path length after recalibration for the smaller cell. (Reference 8.3)

2. 2 SENSITIVITY

The minimum sampling volume should be calculated for each test and should be based upon [1] the targeted minimum detectable concentration at the source, [2] the expected minimum detection limit achievable at the laboratory, and [3] the sampling time limitations at the source.

2. 2. 1 Hexavalent Chromium

A minimum detection limit, of 0.2 ug Cr(VI)/50mL using a 5 cm cell, has been observed. (Reference 8.3)

2. 3 PRECISION FOR HEXAVALENT CHROMIUM

The overall precision for sample collection and analysis for Cr(VI) will be determined after data are collected from a test protocol which includes multiple simultaneous sampling techniques.

2. 4 INTERFERENCES

2. 4. 1 Interferences of Hexavalent Chromium

Molybdenum, mercury and vanadium react with diphenylcarbazide to form a color; however, approximately 20 mg of elements can be present in a sample without creating a problem. Iron produces a yellow color, but this effect is not measured photometrically at 540 nm.

2. 4. 2 Interferences for Total Chromium

2. 4. 2. 1 The long residence time and high concentrations of the atomized sample in the optical path of the graphite furnace can result in severe physical and chemical interferences. Furnace parameters must be optimized to minimize these effects. If the analyte is not completely volatilized and removed from the furnace during atomization, memory effects will occur. If this situation is detected, the tube should be cleaned by operating the furnace at higher atomization temperatures.

2. 4. 2. 2 Nitrogen should not be used as the purge gas because of a possible CN band interference.

2. 4. 2. 3 Low concentrations of calcium may cause interferences; at concentrations above 200 mg/L calcium's effect is constant. Calcium nitrate is therefore added to ensure a known constant effect. This step may be omitted if the sample is known to be free of calcium or no analytical interferences are expected.

2. 5 ALTERNATIVE METHODS

Direct Measurement of Gas Volumes through Pipes and Small Ducts

Air Resources Board Method 2A may be used, where applicable, as an alternative to pitot tube methods specified in Method 5, as referenced herein.

Hexavalent Chromium Determination by Ion Chromatography

For hexavalent chromium concentrations which are within the detection range of ion chromatography, this analytical method may be used instead of the colorimetry method specified in these pages. This option applies only to the analysis of hexavalent chromium. The remainder of the test method shall be performed as specified.

Total Chromium Determination by Flame Atomic Absorption Spectroscopy

For high total chromium concentrations which are within the detection range of flame atomic absorption spectroscopy, this analytical method may be used instead of the furnace type method specified in these pages. This option applies only to the analysis of total chromium. The remainder of the test method shall be performed as specified.

Other Methods

The Executive Officer or authorized representative may approve an alternative test method (including other techniques or conditions) for the determination of hexavalent and/or total chromium emissions from stationary sources. To approve an alternative method, the Executive Officer or authorized representative may require the submission of test data demonstrating that the alternative method is equivalent to Method 425.

3 APPARATUS

All surfaces which may come in contact with sample must be glass, Teflon, or other similarly non-metallic (stainless steel may be a source of chromium contamination) inert material. See Section 5.2.

Any other sampling apparatus which, after review by the Executive Officer, is deemed equivalent for the purposes of this test method, may be used.

3. 1 SAMPLING TRAIN

Except where otherwise noted in this method, same as CARB Method 5, Section 2.1. Exceptions include a glass nozzle, a glass lined stainless steel probe, 0.1 N NaOH in the first two impingers, a Teflon-coated glass fiber filter, and a silica gel moisture trap after the filter. As shown in Figure 1, sample flow should be through the probe first, then the impingers, and then the filter.

3. 2 SAMPLE RECOVERY

Except where otherwise noted in this method, same as CARB Method 5, Section 2.2. Also, see Section 6. 2 of this method.

3. 3 ANALYSIS

The following apparatus and materials are needed:

3. 3. 1 Analysis of Hexavalent Chromium

3. 3. 1. 1 100 mL beakers

3. 3. 1. 2 Filtration Apparatus

Vacuum unit constructed of glass, to accommodate sintered glass funnels. Medium porosity filter paper is optional. Wherever filtering is specified, centrifuging may also be performed at the analyst's option.

3. 3. 1. 3 Volumetric Flasks

100-mL and other appropriate volumes.

3. 3. 1. 4 Hot Plate

3. 3. 1. 5 Pipettes

Assorted sizes, as needed.

3. 3. 1. 6 Spectrophotometer

To measure absorbance at 540nm.

3. 3. 2 Analysis of Total Chromium

3. 3. 2. 1 Philips Beakers

Borosilicate, 125mL, with digestion covers.

3. 3. 2. 2 Chromium Hollow Cathode Lamp or Electrodeless Discharge Lamp.

3. 3. 2. 3 Graphite Furnace

Any graphite furnace device with the appropriate temperature and timing controls.

3. 3. 2. 4 Strip Chart Recorder

A recorder is recommended for furnace work so that there will be a permanent record and so that any problems with the analysis such as drift, incomplete atomization, losses during charring, changes in sensitivity, etc., can easily be recognized.

4 REAGENTS

Unless otherwise indicated, all reagents must conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society. Where such specifications are not available, use the best available grade.

4. 1 SAMPLING

Except where otherwise noted in this method, same as CARB method 5, Section 3.1, except Teflon-coated glass fiber filters are used, and 0.1 N NaOH is used in the first two impingers. See section 4.3.2 below.

4. 2 SAMPLE RECOVERY

Except where otherwise noted in this method, same as CARB Method 5, Section 3.2.

4. 3 REAGENTS FOR HEXAVALENT CHROMIUM

4. 3. 1 Type II Water

Type II water is deionized and distilled, meeting American Society for Testing and Materials (ASTM) specification for type reagent - ASTM Test Method D 1193-77. The water should be monitored for impurities.

4. 3. 2 Batch of 0.1% NaOH Solution, Analytical Reagent Grade

The same batch of 0.1N NaOH solution should be used for impinger sampling, sample recovery, preparation, extraction, and analysis. Therefore, sampling and analytical personnel should coordinate their plans so that all steps in sampling

and analysis use the same batch of solution which will be prepared fresh for each source test. Typically, dissolve 4.0 g NaOH in water in a 1 liter volumetric flask and dilute to the mark. Repeat, as necessary, so that a single batch of sufficient volume is prepared to serve all of the needs of sampling and analysis. Store the solution in a tightly capped polyethylene bottle.

4. 3. 3 Potassium Dichromate Stock Solution

Dissolve 2.829 g of analytical reagent grade potassium dichromate ($K_2Cr_2O_7$) in water, and dilute to 1 liter (1 mL = 1000 ug Cr(VI)).

4. 3. 4 Potassium Dichromate Standard Solution

Dilute 10.00 mL potassium dichromate stock solution to 100 mL (1 mL = 100 ug Cr(VI) with water.

4. 3. 5 Sulfuric Acid, 6N, Analytical Reagent Grade

Dilute 166 mL sulfuric acid to 1000 mL in water.

4. 3. 6 Diphenylcarbazide Solution, Analytical Reagent Grade

Dissolve 0.5 g of 1,5-diphenylcarbazide in 100 mL acetone. Store in a brown bottle. Discard when the solution becomes discolored.

4. 3. 7 0.1% Potassium Permanganate Solution

Analytical Reagent Grade

4. 3. 8 0.01% Potassium Permanganate Solution

Analytical Reagent Grade

4. 3. 9 Removal of Reducing Agents in the Reagents

The 0.1 N NaOH extraction solution (4.3.2) and the 6N sulfuric acid solution (4.3.5) may contain small amounts of reducing agents that can react with the hexavalent chromium. Potassium permanganate is added to these reagents in order to neutralize these reducing agents. Pipette 3 mL of the extraction solution into cuvettes A and B. Use cuvette A as a sample cell and cuvette B as a reference cell. Zero the instrument at 528 nm with both cuvettes. Wait 10 minutes. Add an adequate amount (uL) of 0.01% potassium permanganate solution (4.3.8) to cuvette A. Enough should be added so that after 10 minutes a slight change in absorbance is observed. This step may have to be repeated a number of times in order to determine the required amount of potassium permangante that is required. From the change in absorbance, calculate the amount of potassium permanganate that is needed to nuetralize the

reducing agents found in the reagents. Then pipette the proper volume of higher concentration 0.1% potassium permanganate solution (4.3.7) into the reagents. This is done by assuming that the number of milliequivalents of reducing agents in the reagents are equal to the number of milliequivalents of 0.1% potassium permanganate pipetted.

This procedure is repeated with the 6N sulfuric acid solution.

4. 4 REAGENTS FOR TOTAL CHROMIUM

4. 4. 1 ASTM Type II Water (ASTM D1193)

Refer to section 4.3.1.

4. 4. 2 Concentrated Nitric Acid

4. 4. 2. 1 Reagent preparation should use Ultrex or equivalent grade HNO_3.

4. 4. 2. 2 Glassware cleaning should use ACS reagent grade HNO_3.

4. 4. 3 Hydrogen Peroxide (30%) (Optional), Analytical Reagent Grade

4. 4. 4 Matrix Modifier

Follow manufacturer's recommendations, when interferences are suspected.

4. 4. 5 Total Chromium Standard Stock Solution (1000mg/L)

Either procure a certified aqueous standard from a supplier (Spex Industries, Alpha Products, or Fisher Scientific) and verify by comparison with a second standard, or dissolve 2.829 g of Potassium Dichromate ($K_2Cr_2O_7$, analytical reagent grade) in Type II water and dilute to 1 liter.

4. 4. 6 Total Chromium Working Standards

All total chromium preparations injected for analysis shall be prepared to contain 1.0% (v/v) HNO_3. The zero standard shall be 1.0 % (v/v) HNO_3.

5 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

5. 1 SAMPLE COLLECTION

Except where otherwise indicated in this method, all samples are collected from the source by use of CARB Method 5. Exceptions include a glass nozzle, a glass lined stainless steel probe, 0.1 N NaOH in the first two impingers, and a Teflon-coated glass fiber filter. As shown in Figure 1, sample flow should be through the probe first, then the impingers, and then the filter.

5. 2 SAMPLE HANDLING AND PRESERVATION

All surfaces which may come in contact with sample must be glass, Teflon, or other similarly non-metallic (even stainless steel may be a source of chromium contamination) inert material and must be prewashed with detergents, soaked in 1:1 HNO_3 for several hours, rinsed with Type II water, and finally rinsed with 0.1 N NaOH batch solution. For awkward objects, such as long glass probes, soaking may be replaced by careful wiping.

5. 2. 1 Probes are generally the most difficult sampling apparatus to clean. Therefore, before use in sampling, to ensure that sampling equipment is clean and free of chromium contamination, apparatus which may come in contact with sample must be cleaned until a sample of final rinse for each probe has been analyzed as below the detection limit for total chromium. The procedures of Section 6 shall be followed for this contamination check.

If the specified glass probes are in short supply, the cleaning protocol required above could double the number of days necessary to complete a series of tests. Two options exist which reduce mid-course delays in a sampling effort:

5. 2. 1. 1 Another cleaning procedure may be used if it is tested and documented as achieving the objective of no detectable chromium in the last probe cleaning rinse. Testing and documentation shall include: a pre-test visit to the intended site, collection of samples from an intended test point with the highest expected concentration of chromium, trials of other cleaning procedures, and documentation of those which pass the analytical tests and are used instead of the cleaning procedures in Section 5.2.1 above.

5. 2. 1. 2 The risk of mid-course cleaning delays may be reduced by the use of a sufficient number of probes which have been pre-cleaned and contamination checked by the procedures of Sections 5.2.1 or 5.2.1.1. Extra probes should be included to allow for breakage.

6 PROCEDURES FOR SAMPLE RECOVERY, PREPARATION, AND ANALYSIS

6. 1 SILICA GEL WEIGHING

For stack gas moisture determination, weigh the spent silica gel or silica gel plus impinger to the nearest 0.5 g using a balance. This step may be conducted in the field.

6. 2 SAMPLE COLLECTION AND RECOVERY

The sample is collected using probe, impingers, and filter.

6. 2. 1 Probe

The probe is rinsed with 0.1 N NaOH. The total rinse volume should exceed 100 mL and be stored in container 1. (Measure the volume.) The probe rinse is transported to a clean room or to a site with laboratory conditions where it is split with half saved for hexavalent chromium analysis and half saved for total chromium analysis. Each sample split is ~50mL. (Measure the volumes.)

6. 2. 2 Impingers and Filter

The sampling and analytical personnel shall discuss the expected sample concentrations and the analytical limits of detection for hexavalent and total chromium. The impinger catch and filter should be handled one of two ways depending on these expectations as directed in Sections 6.2.2.1 and 6.2.2.2 below.

6. 2. 2. 1 Higher Concentrations

If it <u>is not</u> considered important to minimize the dilution of any sample component, then the contents of both impingers (~200mL total) shall be combined and stored in container 2. (Measure the volume.) As soon as possible, the filter is transported in a filter container to a site with laboratory conditions where it should be extracted in all of the impinger solution from container 2. The extraction should include shaking for a minimum of 30 minutes. The alkaline impinger medium will retard reduction of hexavalent chromium. The extract solution is split with half saved for hexavalent chromium analysis and half saved for total chromium analysis. Each sample split is ~100 mL. (Measure the volumes.)

6. 2. 2. 2 Lower Concentrations

If it <u>is</u> considered important to minimize the dilution of any sample component, then the contents of each impinger (~100mL each) may be stored in containers 2 and 3. (Measure the volumes.) The filter shall be extracted in only one of the impinger contents, whichever is suspected to have the higher concentration. The extraction shall include shaking for a minimum of 30 minutes. The contents of the first impinger are stored in container 2 and those of the second impinger in container 3. Whichever impinger contents are not used for extraction must be handled as a third sample recovery requiring separate analyses. Both sample recoveries are split as described above. Each sample split is ~50 mL. (Measure the volumes.)

6.3 REAGENT BLANK PREPARATION

Hexavalent Chromium Reagent Blank

For each preparation, transfer 35 mL of solution to a 100mL beaker, adjust the pH to 1.0 ± 0.2 with 6N sulfuric acid, add 1.0 mL of diphenylcarbazide solution, dilute to volume with water in a 50 mL volumetric flask, and let color develop for 10 minutes.

Total Chromium Reagent Blank

For total chromium, the reagent blank is simply 1 % HNO_3.

6.4 SAMPLE PREPARATION

6.4.1 Hexavalent Chromium Sample Preparation

For each preparation, transfer 35 mL of solution to a 100mL beaker, adjust the pH to 1.0 ± 0.2 with 6N sulfuric acid, add 1.0 mL of diphenylcarbazide solution, dilute to volume with water in a 50 mL volumetric flask, and let color develop for 10 minutes. (This leaves at least 15 mL of sample split for further analyses. The total volume of sample split must be known at this point.)

6.4.2 Total Chromium Sample Preparation

In a beaker, add 10ml of concentrated nitric acid to the sample aliquot taken for analysis. Cover the beaker with a digestion cover. Place the beaker on a hot plate and reflux the sample down to near dryness. Add another 5mL nitric acid to complete digestion. Reflux the sample volume down to near dryness.

Wash down the beaker walls and digestion cover with distilled water and filter the sample to remove silicates and other insoluble material that could clog the nebulizer. Filtration should be done only if there is concern that insoluble materials may clog the nebulizer. Adjust the volume to 50 mL or a predetermined value based on the expected metal concentrations. The final concentration of HNO_3 in the solution should be 1 % (v/v). The sample is now ready for analysis. The applicability of a sample preparation technique must be demonstrated by analyzing spiked samples and/or relevant standard reference materials.

6.5 ANALYSIS

6.5.1 Hexavalent Chromium Analysis

The analyst must filter the preparation for clarity at this point. Medium retention filter paper should be used. The filter paper shall be pre-wetted with a few mL of reagent blank and sample preparation. This will prime the filter so that it won't absorb color complex.

Transfer a portion of the filtered preparation into a 5 cm absorption cell.

Measure the absorbance at the optimum wavelength of 540 nm.

Subtract the sample blank absorbance reading to obtain a net reading.

If the absorbance reading of a sample preparation exceeds the calibration range, dilute with reagent blank or re-measure using less of the sample preparation. (There should be about 15mL remaining at this point. See Sections 6.2.1, 6.2.2.1, and 6.2.2.2.)

6.5.2 Check for Matrix Effects on the Cr(VI) Results

As the analysis for Cr(VI) 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 following method: Obtain two equal volume aliquots of the same sample solution. The aliquots should each contain between 6 and 10 ug of Cr(VI) (less if not possible). Spike one of the aliquots with an aliquot of standard solution that contains between 6 and 10 ug of Cr(VI). Now treat both the spiked and unspiked sample aliquots as described in Section 6.4.1 above. Next, calculate the Cr(VI) mass Cs, in ug in the aliquot of the unspiked sample solution by using the following equation:

$$Cs = Ca \frac{As}{At-As} \qquad \text{Eq. 1}$$

where:

Ca = Cr(VI) in the standard solution, ug.

As = Absorbance of the unspiked sample solution.

At = Absorbance of the spiked sample solution.

Volume corrections will not be required since the solutions as analyzed have been made to the same final volume. If the results of this method used on the single source sample do not agree to within 10 percent of the value obtained by the

routine spectrophotometric analysis, then reanalyze all samples from the source using the method of standard additions procedure.

6. 5. 3 Total Chromium Analysis

The 357.9-nm wavelength line shall be used.

Follow the manufacturer's operating instructions for all other spectrophotometer parameters.

Furnace parameters suggested by the manufacturer should be employed as guidelines. Since temperature-sensing mechanisms and temperature controllers can vary between instruments or with time, the validity of the furnace parameters must be periodically confirmed by systematically altering the furnace parameters while analyzing a standard. In this manner, losses of analyte due to higher than necessary temperature settings or losses in sensitivity due to less than optimum settings can be minimized. Similar verification of furnace parameters may be required for complex sample matrices.

Inject a measured uL aliquot of preparation into the furnace and atomize. If the concentration found exceeds the calibration range, the sample should be diluted in the same acid matrix and reanalyzed. The use of multiple injections can improve accuracy and help detect furnace pipetting errors.

Subtract a sample blank reading from a sample reading to obtain a net reading.

7 CALIBRATION, QUALITY CONTROL, AND DATA REPORTING

7. 1 GENERAL

Perform all of the calibrations described in CARB Method 5, Section 5, with any modifications appropriate for this method.

7. 2 CALIBRATION AND QUALITY CONTROL FOR HEXAVALENT CHROMIUM

7. 2. 1 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 Institute of Standards and Technology. 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.

7. 2. 2 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 50 ug Cr(VI) standard solution in the sample cell and a reagent 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 reagent blank and standard solutions shall be scanned separately. The optimum wavelength shall be the wavelength at which the maximum differences in absorbance between the standard and the reagent blank occurs.

7. 2. 3 Either (1) run a series of chromium standards and construct a calibration curve by plotting the concentrations of the standards against the absorbances or (2) if necessary, for the method of standard additions, plot added concentration versus absorbance.

7. 2. 4 Each standard for hexavalent chromium is made up fresh in a separate 50mL volumetric flask starting with 35 mL of the same batch of NaOH solution reserved for its sample set. Then an appropriate amount of hexavalent chromium is added to each calibration standard, starting with none for the zero standard. Then 6N sulfuric acid and diphenylcarbazide solution are added in the same manner as in sample preparation.

7. 3 CALIBRATION AND QUALITY CONTROL FOR TOTAL CHROMIUM

7. 3. 1 Either (1) run a series of chromium standards and reagent blanks and construct a calibration curve by plotting the concentrations of the standards against the absorbances or (2) for the method of standard additions, plot added concentration versus absorbance. For instruments that read directly in concentration, set the curve corrector to read out the proper concentration.

Calibration standards for total chromium should start with 1% v/v HNO_3 with no chromium for the zero standard with appropriate increases in total chromium concentration in the other calibration standards. The calibration standards should be prepared following the steps outlined in sample preparation.

7. 3. 2 Run a check standard after approximately every 10 sample injections. Standards are run in part to monitor the life and performance of the graphite tube. Lack of reproducibility or a significant change in the signal for the standards indicates that the tube should be replaced.

7. 3. 3 Duplicates, spiked samples, and check standards should be routinely analyzed.

7. 3. 4 Calculate metal concentrations (1) by the method of standard additions, or (2) from a calibration curve, or (3) directly from the instrument's concentration readout. All dilution or concentration factors must be taken into account. Concentrations reported for multiphased or wet samples must be appropriately qualified (e.g., 5 ug/g dry weight).

7. 3. 5 Calibration curves must be composed of a minimum of a reagent blank and three total chromium standards. A calibration curve should be made for every batch of samples, unless check standards remain within 10% of the last calibration curve.

7. 3. 6 Dilute samples with reagent blank solution if they are more concentrated than the highest standard or if they fall on the plateau of a calibration curve.

7. 3. 7 Employ a minimum of one matrix-matched sample blank per sample batch to determine if contamination or any memory effects are occurring.

7. 3. 8 Test the system with check standards after approximately every 15 samples.

7. 3. 9 Run one duplicate sample for every 10 samples, providing there is enough sample for duplicate analysis. A duplicate sample is a sample brought through the whole sample preparation.

7. 3.10 Spiked samples or standard reference materials shall be used daily to ensure that correct procedures are being followed and that all equipment is operating properly. This will serve as a check on calibration standards, too.

7. 3.11 Whenever sample matrix problems are suspected, the method of standard additions shall be used for the analysis of all extracts, or whenever a new sample matrix is being analyzed.

7. 3.12 The concentration of all calibration standards should be verified against a quality control check sample obtained from an outside source.

7. 3.13 All quality control data should be maintained and available for easy reference or inspection.

7. 4 DATA REPORTING

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

7. 4. 1 Total Cr(VI) in Sample

Calculate and report m_h, the total ug Cr(VI) in the sample. This can be obtained from the calibration curve or from the method of standard additions. Note that m_h is the sum of the masses of hexavalent chromium analyses performed on all sample splits. Also take in account the dilutions when calculating m_h.

Report these calculations based on net readings, but report all sample blank data, too.

7. 4. 2 Total Chromium in the Sample

Calculate and report m_t, the total ug of chromium in the sample. This can be obtained from the calibration curve or from the method of standard additions. Note that m_t is the sum of the masses of total chromium analyses performed on all sample splits. Also take into account the necessary dilutions when calculating out m_t.

Report these calculations based on net readings, but report all sample blank data, too.

7. 4. 3 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop

Except where otherwise noted in this method, same as Method 5, Section 6.2.

7. 4. 4 Dry Gas Volume, Volume of Water Vapor, Moisture Content

Except where otherwise noted in this method, same as Method 5, Sections 6.3, 6.4, and 6.5, respectively.

7. 4. 5 Cr(VI) Emission Concentration

Calculate and report $[h]_s$ (g/dscm), the Cr(VI) concentration in the stack gas, dry basis, corrected to standard conditions, as follows:

$$[h]_s = (10^{-6} g/ug)(m_h/V_{m(std)})$$

7. 4. 6 Total Chromium Emission Concentration

Calculate and report $[t]_s$ (g/dscm), the total chromium concentration in the stack gas, dry basis, corrected to standard conditions as follows:

$$[t]_s = (10^{-6} g/ug)(m_t/V_{m(std)})$$

7. 4. 7 Isokinetic Variation, Acceptable Results

Except where otherwise noted in this method, same as Method 5, Sections 6.11 and 6.12, respectively.

8 REFERENCES

8. 1 US. Environmental Protection Agency/Office of Solid Waste, Washington, D.C., "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, "SW-846 (1986), Third Edition.

8. 2 Same as in Bibliography of Method 5, Citations 2 to 6 and 7.

8. 3 California Air Resources Board, Inorganic Analysis Section. (1988)

APPENDIX G

EQUIPMENT CALIBRATION DATA

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-5-91 Thermocouple number 3A

Ambient temperature 73.8 °~~C~~F Barometric pressure 29.53 in. Hg

Calibrator G.G. Reference: mercury-in-glass ASTM 3F 3F67Y

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		73.8	73.8	
2. BOILING H2O		209.4	209.4	
3. ICE H2O		41.0	41.0	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-5-91 Thermocouple number 3B

Ambient temperature 73.5 °C Barometric pressure 27.53 in. Hg

Calibrator [illegible] Reference: mercury-in-glass ASTM 3F 34078

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		73	73	
2. BOILING H2O		[illegible]	[illegible]	
3. ICE H2O		[illegible]	[illegible]	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-6-91 Thermocouple number 49

Ambient temperature 74 °C F Barometric pressure 29.65 in. Hg

Calibrator [illegible] Reference: mercury-in-glass ASTM 3F 34078

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		74.0	74.0	
2. BOILING H2O		208.6	208.6	
3. ICE H2O		40.2	44.4	

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

[b]Type of calibration system used.

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

PES

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-6-91 Thermocouple number 4c

Ambient temperature 73.4 °C Barometric pressure 29.65 in. Hg

Calibrator [illegible] Reference: mercury-in-glass ASTM 3 E 34C78

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		73.[illegible]	73.4	
2. BOILING H2O		[illegible]	[illegible]	
3. ICE H2O		4[illegible]	4[illegible]	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-6-91 Thermocouple number 5A

Ambient temperature 73.4 °~~C~~F Barometric pressure 28.65 in. Hg

Calibrator GGW Reference: mercury-in-glass ASTM 3F 34C78

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		73.4	73.4	
2. BOILING H2O		208.4	208.4	
3. ICE H2O		40.4	40.4	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-5-91 Thermocouple number 53

Ambient temperature 71.4 °C/F Barometric pressure 29.53 in. Hg

Calibrator GC Reference: mercury-in-glass ASTM 3F 34673

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		71.4	71.4	
2. BOILING H2O		[illegible]	210	
3. ICE H2O		[illegible]	37.2	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 11-19-90 Thermocouple number 5-6-C

Ambient temperature 73 °C Barometric pressure 29.96 in. Hg

Calibrator G Gw Reference: mercury-in-glass ASTM 3F 34C 72

other TSC - LAB

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR	73	73	73	N.A
2. BOILING H2O	203	95	95	N.A
3. ICE H2O	36	36	36	N.A

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-5-91 Thermocouple number 6A

Ambient temperature 71.4 °~~C~~F Barometric pressure 29.53 in. Hg

Calibrator G.Gne Reference: mercury-in-glass ASTM 3F 34078

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		71.4	71.4	
2. BOILING H2O		209.6	209.6	
3. ICE H2O		40.4	40.4	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 3-5-91 Thermocouple number 66

Ambient temperature 74.4 °F Barometric pressure 29.53 in. Hg

Calibrator GGW Reference: mercury-in-glass ASTM 3F 34078

other TSC LAB

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[c] %
1. AMBIENT AIR		74.4	74.4	
2. BOILING H2O		209.8	209.8	
3. ICE H2O		43.2	43.2	

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 2/16/91 Thermocouple number S14-1

Ambient temperature 75 °~~C~~F Barometric pressure 29.58 in. Hg

Calibrator R. Walde Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °~~C~~F	Thermocouple potentiometer temperature, °~~C~~F	Temperature difference,[c] %
Ambient		75	76	-.19
ICE H_2O Bath		34	35	-.20
Warm H_2O Bath		210	209	.15

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °}\cancel{C}^{F} + \cancel{273}^{460}) - (\text{test thermom temp, °}\cancel{C}^{F} + \cancel{273}^{460})}{\text{ref temp, °}\cancel{C}^{F} + \cancel{273}^{460}}\right] 100 \leq 1.5\%.$

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number S14-2

Ambient temperature 75 °~~C~~F Barometric pressure 29.53 in. Hg

Calibrator R. Kelly Reference: mercury-in-glass ASTM-31F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °~~C~~F	Thermocouple potentiometer temperature, °~~C~~F	Temperature difference,[c] %
Ambient		75	75	0
ICE H_2O Bath		33	33	0
Warm H_2O Bath		210	210	0

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, } °\cancel{C}^{F} + \cancel{273}^{460}) - (\text{test thermom temp, } °\cancel{C}^{F} + \cancel{273}^{460})}{\text{ref temp, } °\cancel{C}_{F} + \cancel{273}^{460}}\right] 100 \leq 1.5\%.$

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number SH-3

Ambient temperature 75 °~~C~~F Barometric pressure 29.58 in. Hg

Calibrator R. Kolch Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °~~C~~F	Thermocouple potentiometer temperature, °~~C~~F	Temperature difference,[c] %
Ambient		75	74	.19
Ice H_2O Bath		34	34	0
Warm H_2O Bath		210	208	.30

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °}\cancel{C}^{F} + \overset{460}{273}) - (\text{test thermom temp, °}\cancel{C}^{F} + \overset{460}{273})}{\text{ref temp, °}\cancel{C} + \cancel{273}\,460}\right] 100 \leq 1.5\%.$

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number SH-4

Ambient temperature 75 °C/F Barometric pressure 29.58 in. Hg

Calibrator R. Kolb Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C/F	Thermocouple potentiometer temperature, °C/F	Temperature difference,[c] %
Ambient		75	76	-.19
Ice H_2O Bath		33	34	-.20
Warm H_2O Bath		210	211	-.15

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number SH-5

Ambient temperature 75 °C/F Barometric pressure 29.58 in. Hg

Calibrator R. Kolb Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[c] %
Ambient		75	75	0
Ice H_2O Bath		34	34	0
Warm H_2O Bath		210	209	.15

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

[b]Type of calibration system used.

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

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number S/H-6

Ambient temperature 75 °F Barometric pressure 29.58 in. Hg

Calibrator R. Kolde Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[c] %
Ambient		75	74	.19
Ice H_2O Bath		34	35	-.20
Warm H_2O Bath		210	208	.30

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number SA-7

Ambient temperature 75 °~~C~~F Barometric pressure 29.58 in. Hg

Calibrator A. Klde Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[c] %
Ambient		75	76	-.19
Ice H_2O Bath		33	34	-.20
Warm H_2O Bath		210	211	-.15

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, } °\cancel{C}^{F} + \cancel{273}^{460}) - (\text{test thermom temp, } °\cancel{C}^{F} + \cancel{273}^{460})}{\text{ref temp, } °\cancel{C}^{F} + \cancel{273}^{460}}\right] 100 \leq 1.5\%.$

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB- 3 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6-7-91 PERFORMED BY : R KOLDE

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	485.307	491.165	501.471	512.230	522.381	534.895
FINAL WTM	490.380	501.163	511.920	522.090	533.914	544.795
INITIAL DGM	539.300	545.200	555.600	566.502	576.800	589.500
FINAL DGM	544.400	555.300	566.200	576.501	588.502	599.500
TEMP. WTM (F)	74.0	74.0	74.0	74.0	74.0	74.0
TEMP. DGM (F)	81.0	83.000	86.0	89.0	92.0	95.0
TEST TIME (MIN.)	13.6	21.1	20.3	15.3	16.0	9.3

****

NET VOLUME WTM	5.073	9.998	10.449	9.860	11.533	9.900
NET VOLUME DGM	5.100	10.100	10.600	9.999	11.702	10.000
Y	1.006	1.005	1.005	1.010	1.014	1.019
dH@	2.014	1.882	2.103	2.017	2.140	1.942

****

AVERAGE Y = 1.010

ACCEPTABLE Y RANGE = 0.990 TO 1.030

AVERAGE dH@ = 2.016

ACCEPTABLE dH@ RANGE = 1.816 TO 2.216

Y = (Vw x Pb x (
(Tw + 460)

[illegible]

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB-3 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6/7/91 PERFORMED BY : R. [illegible]

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	485.307	491.165	501.471	512.230	522.381	534.895
FINAL WTM	490.380	501.163	511.920	522.090	533.914	544.7[illegible]
INITIAL DGM	539.300	545.200	555.600	566.502	576.800	589.500
FINAL DGM	544.400	555.300	566.200	576.501	588.502	599.500
TEMP. WTM (F)	74/74	74/74	74/74	74/74	74/74	74/74
TEMP. DGM (F)	80/82	82/85	85/88	88/90	90/94	94/96
TEST TIME (MIN.)	13.54.67	21.12.30	20.26.14	18.33.38	16.03.62	9.30.13

****

NET VOLUME WTM

NET VOLUME DGM

Y

dH@

****

AVERAGE Y =

ACCEPTABLE Y RANGE = TO

AVERAGE dH@ =

ACCEPTABLE dH@ RANGE = TO

Y = (Vw x Pb x (
(Tw + 460)

dH@ = 0.0317 x dHd / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/7/91 Thermocouple number MB-3 Inlet Outlet

Ambient temperature 74 °~~C~~F Barometric pressure 29.60 in. Hg

Calibrator R. Kolch Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °~~C~~F	Thermocouple potentiometer temperature, °~~C~~F	Temperature difference,[c] %
Ambient	Inlet	74	74	0
	Outlet	74	73	.19
Ice H_2O Bath	Inlet	34	33	.20
	Outlet	34	34	0
Warm H_2O Bath	Inlet	200	198	.30
	Outlet	200	199	.15

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

[b]Type of calibration system used.

[c] $\left[\frac{(\text{ref temp, } °\cancel{C}^{F} + \cancel{273}^{460}) - (\text{test thermom temp, } °\cancel{C}^{F} + \cancel{273}^{460})}{\text{ref temp, } °\cancel{C}^{F} + \cancel{273}^{460}}\right] 100 \leq 1.5\%.$

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. M2-10 BAROMETRIC PRESS. 29.58 IN. HG.

DATE: [illegible]-7-91 PERFORMED BY : R K

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
[illegible]	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WT1	234.464	240.737	251.624	262.298	272.892	284.644
FINAL WT1	240.480	251.019	261.892	272.676	283.165	296.726
INITIAL DG1	[illegible]	[illegible]	990.101	990.500	1000.800	1011.302
FINAL DG1	[illegible]	[illegible]	990.104	1000.600	1010.600	[illegible]
[illegible]	[illegible]	[illegible]	75.0	75.0	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	82.0	81.0	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	18.0	17.2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	10.268	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	10.004	10.100	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.014	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB-10 BAROMETRIC PRESS. 29.58 IN. HG.

DATE: 6/6/91 PERFORMED BY : R. [illegible]

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	234.463	240.924	251.624	262.248	272.892	283.68[illegible]
FINAL WTM	240.630	251.219	261.892	272.676	283.165	296.78[illegible]
INITIAL DGM	963.400	969.700	980.101	990.500	1000.800	1011.302
FINAL DGM	969.400	979.700	990.104	1000.6	1010.800	1024.0[illegible]
TEMP. WTM (F)	75/75	75/75	75/75	75/75	75/76	76/76
TEMP. DGM (F)	78/80	80/81	81/83	83/84	84/85	84/85
TEST TIME (MIN.)	15.05.94	20.46.52	18.01.00	15.15.19	13.02.87	11.43.79
**********	15.00					**********
NET VOLUME WTM	6.167 0.000	10.290 0.000	10.268 0.000	0.000	0.000	0.000
NET VOLUME DGM	6.000 0.000	10.000 0.000	10.003 0.000	0.000	0.000	0.000
Y	1.034 ERR	1.037 ERR	ERR	ERR	ERR	ERR
dH@	ERR	ERR	ERR	ERR	ERR	ERR
**********	1.71	1.74				**********

AVERAGE Y = ERR

ACCEPTABLE Y RANGE = ERR TO ERR

AVERAGE dH@ = ERR

ACCEPTABLE dH@ RANGE = ERR TO ERR

Y = (Vw x Pb x (
(Tw + 460)

dH@ = 0.0317 x dHd / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number MB10-Inlet / MB10-outlet

Ambient temperature 69 °~~C~~F Barometric pressure 29.58 in. Hg

Calibrator R. Holder Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °~~C~~ F	Thermocouple potentiometer temperature, °~~C~~ F	Temperature difference,[c] %
Ambient	Inlet	69	68	.19
	Outlet	69	68	.19
Ice H_2O Bath	Inlet	33	33	0
	Outlet	33	34	.20
Warm H_2O Bath	Inlet	204	205	.15
	Outlet	204	206	.30

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

[b]Type of calibration system used.

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

[illegible] METER AND ORIFICE CALIBRATION

[illegible] NO. ME-1 BAROMETRIC PRESS. 29.60 IN HG.

DATE [illegible]-7-91 PERFORMED BY : R BOLDE

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
[illegible]	[illegible]	[illegible]	10.00			
INITIAL WTP	[illegible]	[illegible]	464.102			
FINAL WTP	[illegible]	[illegible]	474.255			
INITIAL DGM	[illegible]	[illegible]	[illegible]			
FINAL DGM	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]			

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MG-11 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6/7/91 PERFORMED BY : R. Kolb

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	385.403	390.828	401.385	411.729	422.164	432.583
FINAL WTM	390.505	401.000	411.528	421.855	432.270	442.700
INITIAL DGM	979.000	984.300	994.700	1004.900	1015.200	1025.502
FINAL DGM	984.000	994.300	1004.700	1014.900	1025.200	1035.504
TEMP. WTM (F)	74/74	74/74	74/74	74/74	74/74	74/74
TEMP. DGM (F)	80/82	82/85	85/84	84/85	85/86	86/87
TEST TIME (MIN.)	12.43.59	21.12.13	18.30.20	15.06.91	13.09.07	9.20.33

****

NET VOLUME WTM

NET VOLUME DGM

Y

dH@

****

AVERAGE Y =

ACCEPTABLE Y RANGE = TO

AVERAGE dH@ =

ACCEPTABLE dH@ RANGE = TO

Y = (Vw x Pb x (
(Tw + 460)

dH@ = 0.0317 x dHd / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB-11 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6/7/91 PERFORMED BY :

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.80 ~~0.50~~	0.80 ~~0.75~~	0.80 ~~1.00~~	1.50	2.00	4.00
INITIAL WTM	443.204	453.957	464.62			
FINAL WTM	453.345	463.489	474.255			
INITIAL DGM	1036.000	1046.608	1056.608			
FINAL DGM	1046.007	1056.008	1066.609			
TEMP. WTM (F)	74/74	74/74	74/74			
TEMP. DGM (F)	87/88	88/84	89/90			
TEST TIME (MIN.)	7.39.90	6.14.79	5.59.52			

****

NET VOLUME WTM

NET VOLUME DGM

Y

dH@

****

AVERAGE Y =

ACCEPTABLE Y RANGE = TO

AVERAGE dH@ =

ACCEPTABLE dH@ RANGE = TO

Y = (Vw x Pb x (
(Tw + 460)

dH@ = 0.0317 x dHd / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/7/91 Thermocouple number MB-11 Inlet Outlet

Ambient temperature 73 °C Barometric pressure 29.60 in. Hg

Calibrator R. Kolde Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[c] %
Ambient	Inlet	72	72	0
	Outlet		73	
Ice H_2O Bath	Inlet	33	33	0
	Outlet		34	
Warm H_2O Bath	Inlet	202	202	0
	Outlet		204	

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

[b]Type of calibration system used.

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

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB-13 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6-7-91 PERFORMED BY: R K

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
DHG ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	308.324	314.199	325.352	337.070	347.661	358.267
FINAL WTM	313.840	325.041	336.301	347.357	357.760	368.297
INITIAL DGM	641.100	649.100	649.200	660.300	671.300	681.302
FINAL DGM	647.300	660.700	660.500	671.001	681.300	691.302
AMB. TEMP (F)	73.0	71.0	73.0	73.0	74.0	75.0
TEMP. DGM (F)	78.0	82.000	85.0	87.0	88.0	91.0
TEST TIME (MIN.)	1[illegible]	[illegible]	20.0	15.2	13.1	[illegible]
[illegible]	[illegible]	[illegible]	10.[illegible]	10.297	[illegible]	10.[illegible]
[illegible]	[illegible]	10.400	11.900	10.201	10.000	10.000
[illegible]	1.0[illegible]	1.021	0.[illegible]	1.031	1.0[illegible]	[illegible]
[illegible]	1.[illegible]	1.[illegible]	1.[illegible]	1.[illegible]	1.[illegible]	1.[illegible]

[illegible] 1.02[illegible]

[illegible] 1.003 70 1.04[illegible]

[illegible] 1.[illegible]

[illegible] 1.[illegible] 7 1.07[illegible]

[illegible]

DRY GAS METER AND ORIFICE CALIBRATION

CONTROL BOX NO. MB-13 BAROMETRIC PRESS. 29.60 IN. HG.

DATE: 6/7/91 PERFORMED BY : RK

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
dHd ("H2O)	0.50	0.75	1.00	1.50	2.00	4.00
INITIAL WTM	308.326	314.109	325.352	337.070 ~~660.~~	347.661	358.267
FINAL WTM	313.84	325.041	336.301	347.357	357.760	368.397
INITIAL DGM	632.400	638.100	649.200	660.800	671.300	681.802
FINAL DGM	637.800	648.900 ~~638.100~~	660.500	671.001	681.300	691.802
TEMP. WTM (F)	73/73	73/73	73/74	73/74	74/75	75/74
TEMP. DGM (F)	76/80	80/84	84/87	87/87	87/90	90/93
TEST TIME (MIN.)	13.47.43	22.38.55	20.32.29	15.23.75	13.13.21	9.19.93

****

NET VOLUME WTM	0.000	0.000	0.000	0.000	0.000	0.000
NET VOLUME DGM	0.000	0.000	0.000	0.000	0.000	0.000
Y	ERR	ERR	ERR	ERR	ERR	ERR
dH@	ERR	ERR	ERR	ERR	ERR	ERR

****

AVERAGE Y = ERR

ACCEPTABLE Y RANGE = ERR TO ERR

AVERAGE dH@ = ERR

ACCEPTABLE dH@ RANGE = ERR TO ERR

Y = (Vw x Pb x (
(Tw + 460)

dH@ = 0.0317 x dHd / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 6/6/91 Thermocouple number MB-13 Inlet / MB-13 Outlet

Ambient temperature 69 °C Barometric pressure 29.58 in. Hg

Calibrator R. Kilde Reference: mercury-in-glass ASTM-3F

other

Reference point number[a]	Source[b] (specify)	Reference thermometer temperature, °C	Thermocouple potentiometer temperature, °C	Temperature difference,[c] %
Ambient	Inlet	69	70	.19
	Outlet	69	70	.19
Ice H_2O Bath	Inlet	34	34	0
	Outlet	34	35	.20
Warm H_2O Bath	Inlet	190	190	0
	Outlet	190	191	.15

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

[b]Type of calibration system used.

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

POSTTEST DRY GAS METER CALIBRATION

MB #:	10	BAROMETRIC PRESS.	29.12 (in. hg.)
DATE:	7-2-91	PERFORMED BY:	D MACHUGA
PLANT:	REMCO HYD	PRETEST Y :	1.042

	RUN 1	RUN 2	RUN 3
VACUUM ("Hg)	17.50	17.50	17.50
/\H ("H20)	1.75	1.75	1.75
INITIAL RTM	977.332	984.835	992.341
FINAL RTM	984.835	992.341	999.842
INITIAL DGM	832.596	839.755	847.024
FINAL DGM	839.755	847.024	854.310
TEMP. RTM (F)	76.0	76.0	77.0
TEMP. DGM (F)	78.0	81.0	82.0
TEST TIME (MIN.)	10.0	10.0	10.0

****

NET VOLUME RTM	7.503	7.506	7.501
NET VOLUME DGM	7.159	7.269	7.286
Y	1.047	1.038	1.035
/\H@	1.807	1.796	1.801

****

PRIOR Y = 1.042
RECHECK Y = 1.040
% DIFFERENCE = -0.208

AVERAGE /\H@ = 1.801

Y = (Vw x Pb x (Td + 460)) / (Vd (Pb + (dHd / 13.6))x(Tw + 460)

/\H@ = 0.0317 x /\H / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

POSTTEST DRY GAS METER CALIBRATION

MB #:	11	BAROMETRIC PRESS.	29.36 (in. hg.)
DATE:	6-24-91	PERFORMED BY:	R. Kolde
PLANT:	REMCO HYD.	PRETEST Y :	1.028

	RUN 1	RUN 2	RUN 3
VACUUM ("Hg)	6.00	6.00	6.00
/\H ("H20)	3.00	3.00	3.00
INITIAL RTM	885.766	895.206	904.615
FINAL RTM	895.206	904.615	914.014
INITIAL DGM	142.102	151.430	160.758
FINAL DGM	151.430	160.758	170.061
TEMP. RTM (F)	78.0	75.0	71.0
TEMP. DGM (F)	91.0	92.0	92.0
TEST TIME (MIN.)	10.0	10.0	10.0

****

NET VOLUME RTM	9.440	9.409	9.399
NET VOLUME DGM	9.328	9.328	9.303
Y	1.029	1.033	1.042
/\H@	1.909	1.897	1.873

****

PRIOR Y = 1.028
RECHECK Y = 1.035
% DIFFERENCE = 0.653

AVERAGE /\H@ = 1.893

Y = (Vw x Pb x (Td + 460)) / (Vd x (Pb + (dHd / 13.6) x (tw + 460))

/\H@ = 0.0317 x /\H / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2

POSTTEST DRY GAS METER CALIBRATION

MB #: 13

DATE: 6-24-91

PLANT: REMCO HYD.

BAROMETRIC PRESS. 29.63 (in. hg.)

PERFORMED BY: D. MACHUGA

PRETEST Y : 1.019

	RUN 1	RUN 2	RUN 3
VACUUM ("Hg)	6.00	6.00	6.00
/\H ("H20)	2.42	2.42	2.42
INITIAL RTM	915.034	923.620	936.440
FINAL RTM	923.620	936.440	945.065
INITIAL DGM	601.399	609.695	622.141
FINAL DGM	609.695	622.141	630.515
TEMP. RTM (F)	75.0	76.0	76.0
TEMP. DGM (F)	81.0	86.0	89.0
TEST TIME (MIN.)	10.0	15.0	10.0

****

NET VOLUME RTM	8.586	12.820	8.625
NET VOLUME DGM	8.296	12.446	8.374
Y	1.040	1.043	1.049
/\H@	1.858	1.865	1.821

****

PRIOR Y = 1.019
RECHECK Y = 1.044
% DIFFERENCE = 2.453

AVERAGE /\H@ = 1.848

Y = (Vw x Pb x (Td + 460)) / (Vd (Pb + (dHd / 13.6))x(Tw + 460)

/\H@ = 0.0317 x /\H / (Pb (Td + 460)) x ((Tw + 460) x time) / Vw)^2