AP-42 Section 12.20
Reference
Report Sect. 4
Reference 83

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MEASUREMENT OF CHROMIUM EMISSIONS FROM CHROMIC ACID ANODIZING OPERATIONS IN BUILDING 2 AT NAVAL AVIATION DEPOT NORTH ISLAND, SAN DIEGO, CA

Oct 29, '91 = Rpt Date

DELIVERY ORDER NO. ED-31

PREPARED FOR
DEPARTMENT OF THE NAVY
ENVIRONMENTAL PLANNING AND COMPLIANCE
NAVAL AVIATION DEPOT
NAS NORTH ISLAND
SAN DIEGO, CA 92135-5112

PREPARED BY
BENMOL CORPORATION
AND
PACIFIC ENVIRONMENTAL SERVICES, INC.

OCTOBER 29, 1991

CONTRACT NO. N00123-88-D-5131

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INTRODUCTION

The North Island Naval Base operates chromic acid anodizing tanks (C3-12) in Building 472 at the Naval Aviation Depot and the tanks are served by the C2 scrubber. In addition, the Base also operates a Helo Blade anodizing unit in Building 2 which is served by the Helo Blade scrubber. Both of theses scrubbers were selected for source testing to develope emission factors for total and hexavalent chromium to assist the Benmol Corporation in preparing the AB2588 report for the Base.

Benmol Corporation, one of the Navy's environmental consultants, selected Pacific Environmental Services (PES), a participant in the CARB independent contractor program, to perform the source testing. PES and its analytical laboratory, West Coast Analytical Services, qualify as independent testing laboratories (no conflict of interest).

Section 2 of the report describes the tested emission control system for each anodizing opertion. Section 3 describes the testing procedures and analytical methods used. Section 4 provides a summary and discussion of the test results and Section 5 addresses the project quality assurance. Appendix A contains the process data records, field data sheets, and all subsequent calculations; Appendix B contains the lab report showing the resulting sample analyses and QA/QC; and Appendix C contains equipment calibration records.

EQUIPMENT AND PROCESS DESCRIPTI

The C2 wet scrubber is used to collect fumes from the chromic acid anodizing operations in the cleaning shop of Building 472. The anodizing tanks are manifolded together and routed underground to the wet scrubber which is equipped with an integral squirrel cage blower and a stub stack (see Figure 1). For each test on the C2 scrubber, six 4' x 5' aluminum sheets were processed in tank C3-12 for a total of 240 sq. ft. per test. The chromic acid anodizing tank (C3-12) is 14'6" long by 5'0" wide by 7'0" deep with a 2-inch slot type hood along one side of the tank. The tank has a capacity of 3400 gallons and an anti-mist additive (MSP-ST) manufactured by Harshaw is added to control fuming.

The Helo Blade scrubber is used to collect fumes from the chromic acid anodizing operations in Building 2. Two remote anodizing tanks are served by a central reservoir of chromic acid at room temperature. The tests were conducted with only one remote anodizing tank in operation. A helo blade is placed inside the remote tank (which is much shorter than blade), the tank is filled with chromic acid from the reservoir, and the anodizing takes place for one hour on small patches of the blade in need of repair. The blade passes through v-groves in each end of the remote tank which are pneumatically sealed against the blade. The level in the remote tank is maintained by a constant supply of chromic acid from the reservoir. Leakage and overflow from the remote tank is routed back to the reservoir. The remote tank is covered and ducted a short distance to the scrubber which is exhausted through a 12-inch diameter duct to a large stack with a rooftop blower (see Figures 2A and 2B). The large stack vents other process areas of Building 2. The reservoir is 24" wide by 34" deep by 168" long and has a capacity of 290 gallons. The remote tank is 24" wide by 12" deep by 188" long.

During the source tests, the tank parameters were recorded by Benmol engineers. Production data sheets are included in Appendix A.

CLEANING SHOP
C-2 SCRUBBER
BUILDING 472

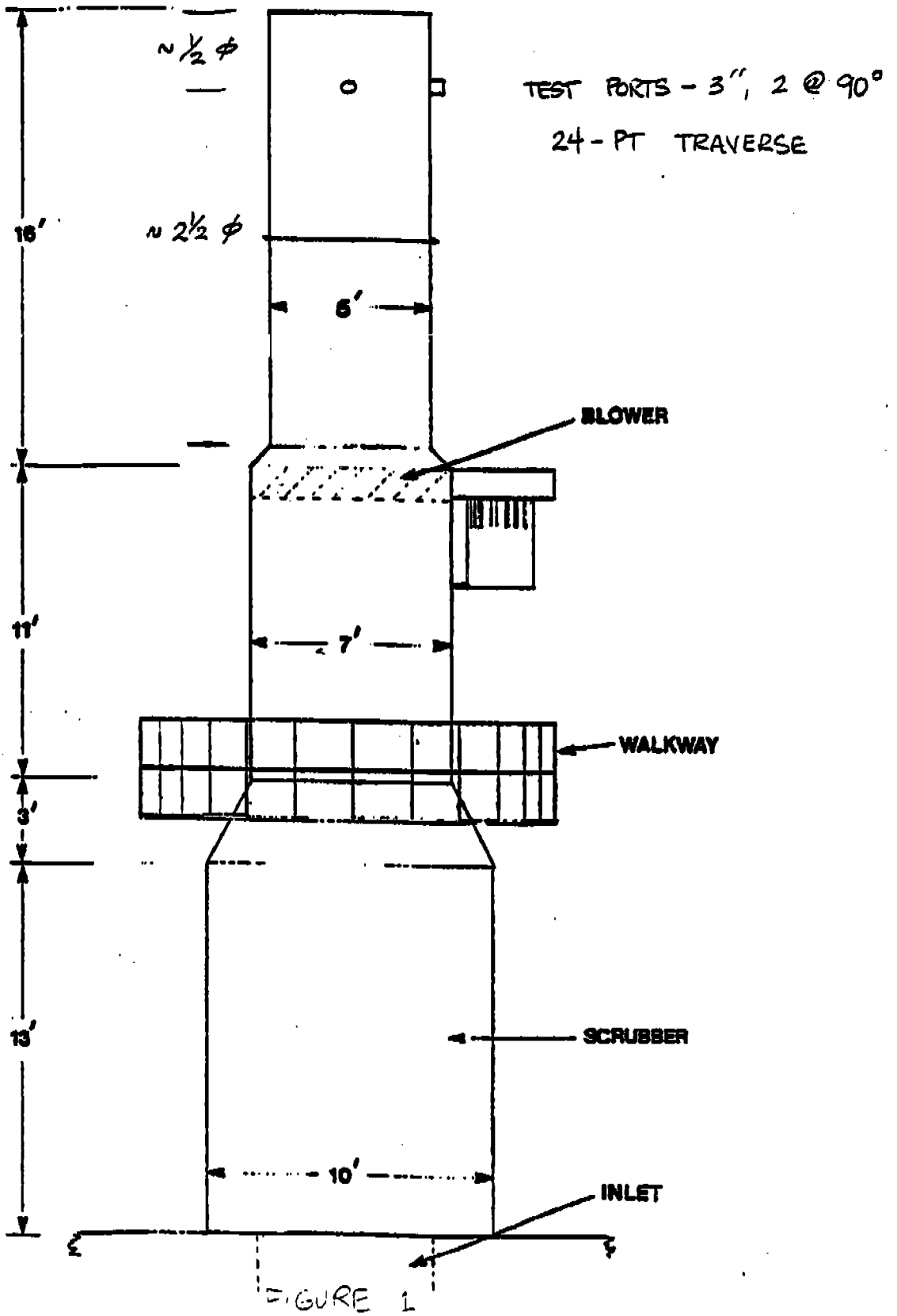


FIGURE 1

HELO BLADE ANODIZING UNIT
PROCESS OVERVIEW
BUILDING 2

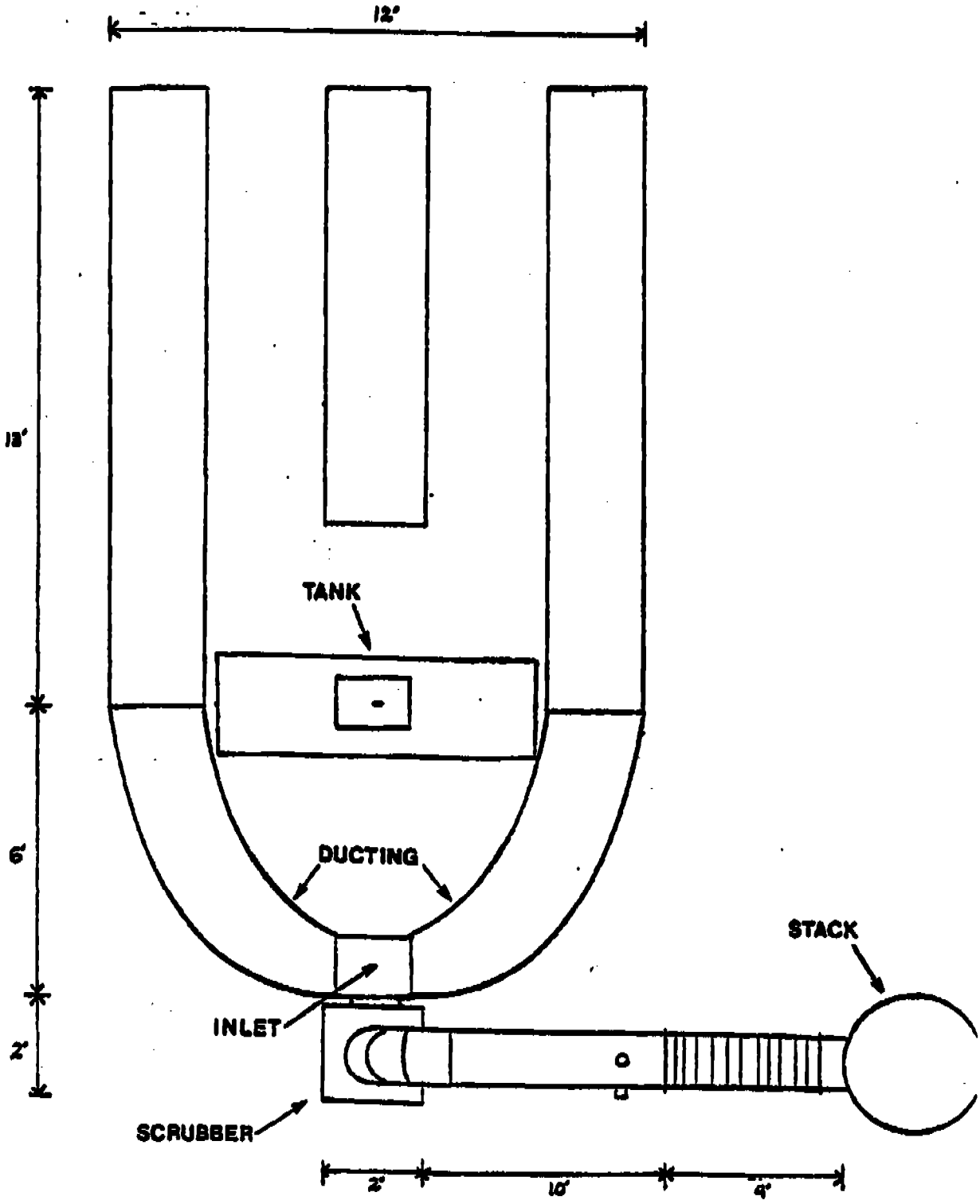


FIGURE 2A

HELO BLADE ANODIZING UNIT
EMISSIONS CONTROL SYSTEM

BUILDING 2

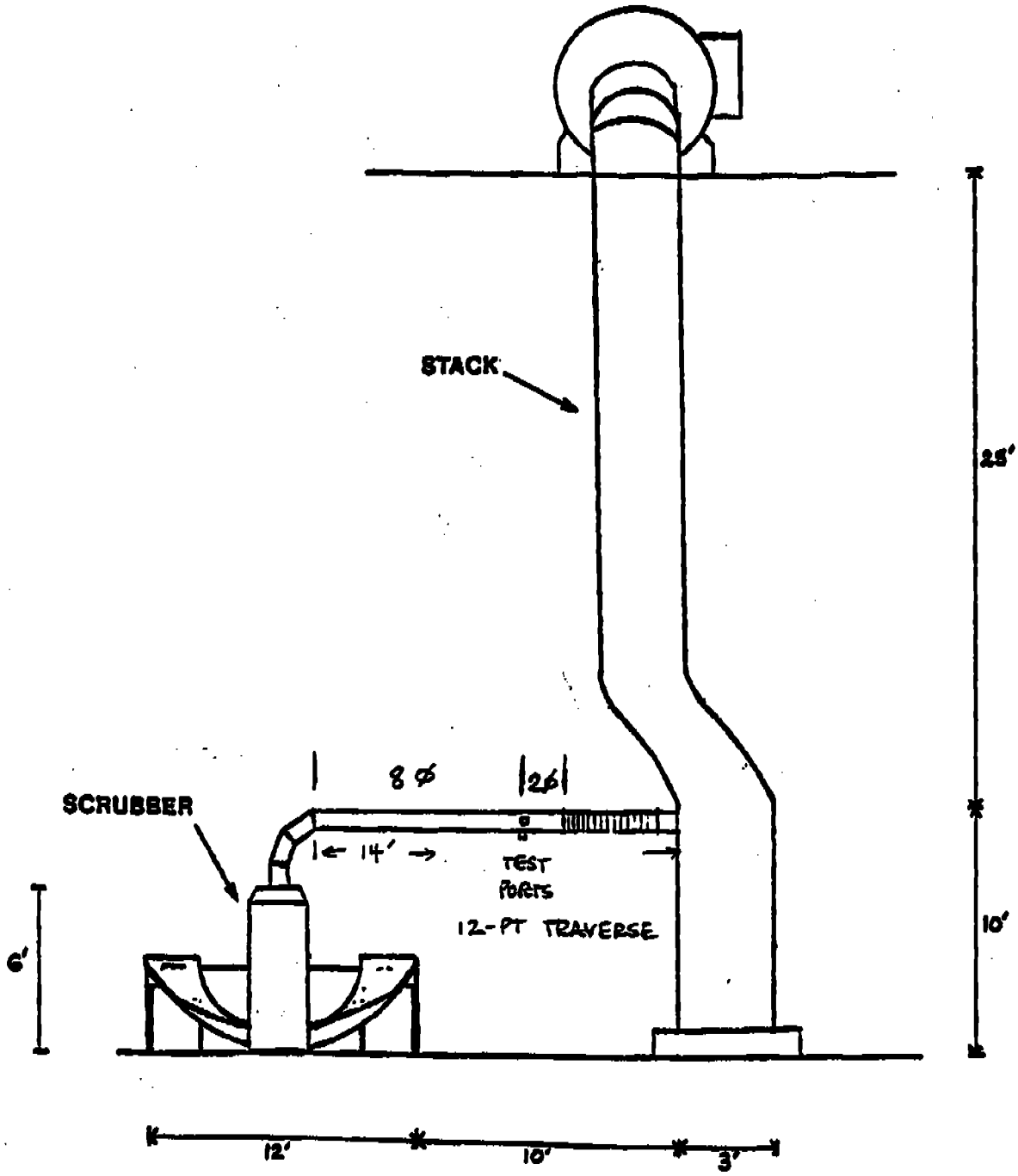


FIGURE 2B

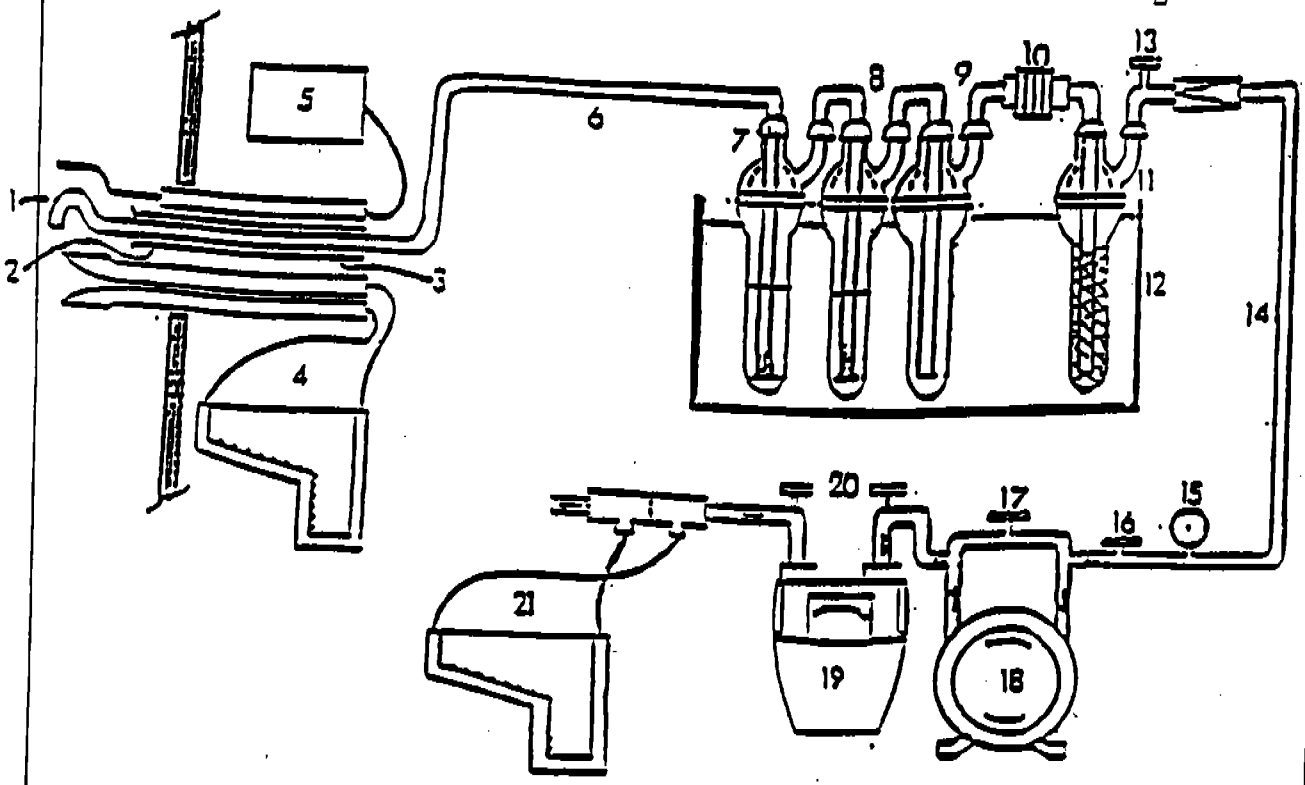
TESTING METHODOLOGY

The sampling locations, number of traverse points, and location of traverse points were determined as described in CARB Method 1. The sampling was conducted for 2 hours at 24 traverse points on the C2 scrubber exhaust (5 minutes per point), and at 12 traverse points on the Helo scrubber exhaust (10 minutes per point). The production interval for each operation was about 1 hour. Three sub-tests were conducted on each scrubber exhaust. Each sub-test was coordinated so that the 1-hour sampling traverse for each of the two ports coincided exactly with 1 hour of production. The sampling locations for the C2 scrubber are shown in Figure 1, and the sampling locations for the Helo scrubber are shown in Figure 2.

Prior to sampling, the duct velocity, static pressure and temperature were measured to define an estimated average duct velocity for nozzle size selection in order to sample isokinetically. A cyclonic flow check was made during previous testing and therefore not repeated for these tests.

The samples for chromium were collected by CARB Method 425 modified to utilize 0.02N sodium bicarbonate in the impingers and allow analysis of the hexavalent chromium by ion chromatography. The sampling train was manufactured by Nutech and configured as shown in Figure 3. The sample train consisted of a glass nozzle, a teflon union, a glass-lined stainless steel probe (72-inch for the C2 scrubber, and 18-inch for Helo scrubber), a short length of 1/2-inch Teflon tubing, two Greenburg-Smith impingers each charged with 100 mls of 0.02N sodium bicarbonate solution, an empty impinger used as a water trap, a glass filter holder, an impinger filled with silica gel, a 30-foot umbilical line, a vacuum pump, a dry gas meter, and a calibrated orifice connected to an inclined manometer. Teflon-coated glass fiber filters with 0.3, 0.1, and 0.035 micron pore layers were used in the filter holders.

Pitot and sampling train leak checks were performed before and after each test. Prior to beginning the source test program, a 10-minute dry gas meter check was conducted on each sampling train at an orifice delta P of 1.0 inches of water, and the metered volume was checked against that of the calibration run at the same delta P. The sampling trains met the performance criteria of +/-3%.



1. Glass sampling nozzle with teflon union
2. Stainless steel probe sheath
3. Glass-lined probe
4. Type S pitot tube and manometer for velocity determinations
5. Stack temperature sensor
6. 15 ft. teflon probe line with ball and socket connectors
7. Greenburg-Smith impinger with 100 ml. of 0.02 $NaHCO_3$ sol.
8. Greenburg-Smith impinger with 100 ml. of " " " "
9. Modified Greenburg-Smith impinger (dry)
10. Filter holder with teflon-coated glass fiber filter
11. Modified Greenburg-Smith impinger filled with 200 grams of silica gel
12. Impinger case filled with ice
13. Impinger exit gas temperature sensor
14. Umbilical line to meter box
15. Vacuum gauge
16. Coarse adjustment valve
17. Bypass valve to adjust sample volume
18. Leak free vacuum pump
19. Dry gas meter
20. Dry gas meter inlet and outlet temperature sensors
21. Orifice with manometer sample volume metering

Figure 3: Diagram of sampling train.

The source test data was recorded during the tests by PES personnel on the field data sheets which are included in Appendix A. The weights of the impingers were recorded on sample retrieval sheets before and after the tests in order to obtain the moisture content of the stack gas stream. Process data was recorded simultaneously by Benmol engineers.

After the tests, the contents of the first three impingers were placed in a 1000 ml. polyethylene container. The filters were removed from the filter holder with plastic forceps and placed in the same sample bottle. The sampling train from the nozzle to the filter holder was then rinsed 3 times with the charging solution (0.02N sodium bicarbonate solution) and these rinses were added to the same container. Some 0.1 normal nitric acid solution was then used as a final rinse and these rinses were collected in a separate sample bottle and analyzed for total chromium. The sampling train was kept at 68 degrees Fahrenheit or less during the tests in order to induce condensation in the impingers. The samples remained chilled until analysis.

Laboratory analyses were conducted by West Coast Analytical Service in Sante Fe Springs, California. The total chromium concentration in each sample was measured by inductively coupled plasma (ICP) with detection by mass spectrometry (MS). The hexavalent chromium concentrations were measured by ion chromatography. The detection levels of the analytical procedures for total chromium, Cr T, and hexavalent chromium, Cr^{+6} were 0.5 and 0.01 ug/l respectively. The hexavalent chromium analyses were performed within 48 hours of the end of sampling for each individual sample.

RESULTS

Calculations were made from the field data sheets to determine sample volume, molecular weight, velocities, flow rate, and isokinetic variation for the test. These calculations are shown on the emission test calculation sheets in Appendix A.

Table 1 summarizes the results of the source tests on the C2 scrubber. There is a significant difference between the total chromium and the hexavalent chromium on all three source tests. This same difference was also evident during previous testing on this scrubber but not evident on the Helo scrubber sampled with the same equipment and procedures on subsequent days. No explanation can be found for this observation other than the total chromium detected was very close to the blank/detection level, or it might just be the nature of this scrubbing equipment and operation. The hexavalent chromium results are relatively consistant for all three tests and are assumed to be the most representative of the two chromium measurements. The mist suppressant/scrubber combination achieved very good hexavalent chromium reduction.

Tables 2 and 3 summarize the results of the source tests on the Helo Blade scrubber. During tests 1 and 2, production problems arose causing sampling interruptions and also a few minutes of operation without scrubber water. For this reason, a fourth test was performed. The results of all four tests, however, indicated that the scrubber was not performing properly.

The blank sample from each scrubber test set exhibited essentially no hexavalent chromium (<0.1 ug) and very little total chromium (<1 ug).

The scrubber water analyses indicated relatively clean scrubber water.

Isokinetic sampling rates all fell within 95 to 100%.

BLDG 472 RESULTS

TABLE 1

NADEP BUILDING 472
C2 SCRUBBER EMISSIONS

Date:	10/22/91	10/23/91	10/23/91
Test Conditions:	372 AH	392 AH	447 AH
Test Number:	1	2	3
Flue Gas			
Temperature, oF	70	68	71
Velocity, ft/sec	28.2	29.3	27.8
Static Pressure, in. H_2O	-0.12	+0.12	+0.10
Duct Dimension, in.	72	72	72
Duct Area, sq. ft.	28.3	28.3	28.3
Flow Rate, ACFM	47,880	49,750	47,200
, DSCFM	46,840	48,950	46,140
Moisture, % v/v	2.0	1.8	1.9
Chromium			
Sample Start	10:30	08:02	11:50
Sample Stop	12:50	10:24	14:03
Sampling Time, min.	120	120	120
Sample Volume, DSCF	95.0	101.8	94.9
Isokinetic Rate, %	97.4	99.9	98.8
Concentration, mg/m³			
Total Cr	0.00026	0.00040	0.00018
Cr+6	0.000039	0.000049	0.000043
Emission Rate, mg/hr			
Total Cr	20.4	33.5	14.0
Cr+6	3.25	4.04	3.21
Emission Rate, mg/amp-hr			
Total Cr	0.055	0.085	0.031
Cr+6	0.0088	0.010	0.0072
Scrubber Water		.0087 average	
Concentration, ppm			
Total Cr		3.8	
Cr+6		3.4	

TABLE 2

NADEP BUILDING 2
HELO SCRUBBER EMISSIONS

Date:	10/24/91	10/24/91	6/20/91
Test Conditions:	19 AH	16 AH	18 AH
Test Number:	1	2	3
Flue Gas			
Temperature, oF	65	65	62
Velocity, ft/sec	21.8	20.6	20.6
Static Pressure, in. H_2O	-0.79	-0.79	-0.79
Duct Dimension, in.	12	12	12
Duct Area, sq. ft.	0.785	0.785	0.785
Flow Rate, ACFM	1030	970	970
, DSCFM	1018	963	968
Moisture, % v/v	1.6	1.5	1.5
Chromium			
Sample Start	08:49	11:14	18:13
Sample Stop	13:08*	16:57**	20:23
Sampling Time, min.	120	120	120
Sample Volume, DSCF	124.7	103.7	106.9
Isokinetic Rate, %	99.7	95.3	97.7
Concentration, mg/m^3			
Total Cr	0.0067	0.0058	0.0016
Cr+6	0.0061	0.0040	0.0011
Emission Rate, mg/hr			
Total Cr	11.6	9.47	2.61
Cr+6	10.6	6.63	1.84
Emission Rate, mg/amp-hr			
Total Cr	0.62	0.58	0.14
Cr+6	0.57	0.41	0.10
Scrubber Water			
Concentration, ppm			
Total Cr		29.0	
Cr+6		22.4	

* Sampling interrupted for 98 min. by blown air seal.
** Sampling interrupted for 17 min. by fan down.

TABLE 3

NADEP BUILDING 2
HELO SCRUBBER EMISSIONS

Date:	10/25/91
Test Conditions:	22 AH
Test Number:	4
Flue Gas	
Temperature, oF	60
Velocity, ft/sec	21.4
Static Pressure, in. H_2O	-0.83
Duct Dimension, in.	12
Duct Area, sq. ft.	0.785
Flow Rate, ACFM	1010
, DSCFM	1010
Moisture, % v/v	1.5
Chromium	
Sample Start	07:49
Sample Stop	10:46*
Sampling Time, min.	120
Sample Volume, DSCF	113.7
Isokinetic Rate, %	99.8
Concentration, mg/m^3	
Total Cr	0.0136
Cr+6	0.0095
Emission Rate, mg/hr	
Total Cr	23.4
Cr+6	16.3
Emission Rate, mg/amp-hr	
Total Cr	1.08
Cr+6	0.75

* Approximately 1 hour between blades due to crane inaccessible.

QUALITY ASSURANCE/QUALITY CONTROL

Source tests are performed to determine the types and amounts of pollutants emitted by a source. Information form this source test program may be used for obtaining permits, evaluating control equipment performance, updating emission inventories, and determining compliance with present and future emission regulations. For these purposes, reliable data are required. PES provides this reliability by using the following work practices:

Use Of Standard Test Procedures

CARB Method 425 was utilized to determine the chromium emission rates. A procedure must be thoroughly studied under various conditions in order to be designated as a CARB Method. Results of many executions of the procedure are compared to demonstrate accuracy and repeatability before adoption of the procedure as a source testing method. Method 425 normally specifies hexavalent chromium analysis by the diphenylcarbazide colorimetric method but can be adapted to achieve maximum sensitivity for hexavalent chromium through the utilization of ion chromatography for analysis.

Use Of Trained Test Personnel

Because of the complexity of typical source testing methods, testers should be trained and experienced with the test procedures in order to assure reliable results. PES personnel have had professional training and routinely conduct hexavalent chromium source tests.

Knowledge Of Source's Operation

The source testing team should have sufficient knowledge of the process to be tested in order to properly document the process parameters during the tests. Without documentation of the process parameters used, results are much less meaningful. PES has previously tested many chrome platers and is familiar with the plating process.

Equipment Maintenance and Calibration

Use of properly maintained and calibrated test equipment is essential for minimizing systematic errors in results. All sampling devices were constructed, maintained, and calibrated as suggested in EPA documents APTD-0576, and APTD-0581 (These are commonly accepted construction and maintenance manuals for source testing equipment.). The dry gas meters were calibrated before and after the tests using a transfer gas meter with NBS traceability. All equipment calibrations are included in Appendix C of this report.

Systematic Data Reduction

Data reduction was accomplished by the use of step by step calculation sheets. All calculations are shown in Appendix A.

Thorough Record Keeping

All data relating to the operation of the sampling train must be immediately recorded to ensure that it is not lost or misinterpreted. PES accomplishes thorough record keeping by use of field data sheets. The PES test team is familiar with these sheets and the information required to complete them. Any unusual occurrences in the process operation, unusual test instrument readings, or any other items that could have affected the test results were noted.

Proper Sample Handling Procedures

Inaccurate source test results can be caused by delays in retrieving samples, contamination of the samples, insufficient sample identification, tampering, and mishandling of samples. The chances of these errors are greatly increased when too many people are permitted to handle the samples. The samples were retrieved immediately after each test and returned to the PES lab within a few hours after each test. A sample submittal/chain of custody form (See Appendix B) was completed and submitted with all samples to document that the sample analyzed was taken under the conditions reported.

Use Of Thoroughly Cleaned Glassware

All glassware was cleaned prior to the tests with 0.1 normal nitric acid solution. The trains were then cleaned with 0.02N sodium carbonate solution and laboratory grade distilled water, air dried, and sealed until the next tests.

Submission Of Blank Samples

During each test set, a sample from an unused charged sampling train was carried to the field (train blank), submitted to the laboratory and analyzed with the other samples to detect any possible contamination of sampling media or equipment or problems with lab analyses. Corrections were not made to the measured concentrations of the collected samples. In addition, an audit sample submitted to PES by the SDAPCD, and a sample of each scrubber water were analyzed along with the source test samples. The audit sample analysis yielded 80 ug/L hexavalent chromium, and 75 ug/L total chromium.

Analytical Checks

The analyses of each batch of samples included calibration curves, duplicate analyses, spike recoveries, and standard additions. A complete QA/QC package from the analytical lab is included in Appendix B.

The field testing described in this report was conducted by S. Hugh Brown and Steve Hernandez of PES. Study direction and report preparation were under the supervision of S. Hugh Brown, Director of Air Quality of Pacific Environmental Services, Incorporated.

Approved: S. Hugh Brown
S. Hugh Brown

APPENDIX A

Field Data, Calculations, and Process Data

PES

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT NADEP
DATE 10-22-91
SAMPLING LOCATION C2 SCRUBBER EXHAUST
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE. (DISTANCE A) 72"
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE. (DISTANCE B) 0
STACK I.D., (DISTANCE A - DISTANCE B) 72"
NEAREST UPSTREAM DISTURBANCE 61"
NEAREST DOWNSTREAM DISTURBANCE 110"
CALCULATOR

SCHEMATIC OF SAMPLING LOCATION

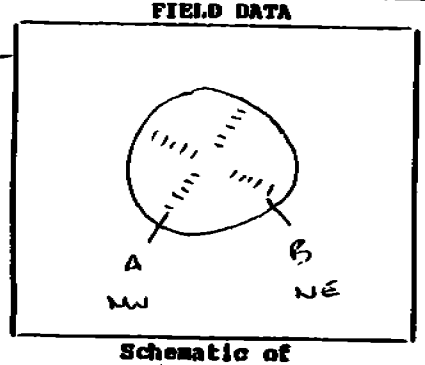
TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
(1)	2.1	72"	(1.5)		
2	6.7	↓	4.8		
3	11.8		8.5		
4	17.7		12.7		
5	25.0		18.0		
6	35.6		25.6		
7	64.4		46.4		
8	75.0		54.0		
9	82.3		59.3		
10	88.2		63.5		
11	93.3		67.2		
(12)	97.9		(70.5)		

(1), (12) MOVED TO NEXT NEAREST POINT.

14

Plant: NADEP
Date: 10-22-91
Sampling Location: C2 SCRUBBER EXHAUST
Sample Type: C6
Run Number: C2-1
Operator: BROWN/HERNANDEZ
Ambient Temperature: 70
Barometric Pressure: 30.0
Static Pressure (P_s): -0.15-0.115
Filter Number(s):
Pretest Leak Rate = 0.009 cfm @ 10 in. Hg
Pretest Pitot Leak Check: ✓
Pretest Orsat Leak Check: —
Read and Record all Data Every 5 Minutes

FIELD DATA



Schematic of Traverse Point Layout

Probe Length and Type: 6' SS W GLASS LINER
Pitot Tube I.D. No.: 1A "S" TYPE
Nozzle I.D. No. & Diameter: OLP 0.30
Assumed Moisture, %: 2%

Meter Box Number: 2A
Meter $\Delta H_@$: 1.778
C Factor: 1.10
Meter Gamma: 1.002
Heater Box Setting: —
Reference Δp: 0.119 Δp_a 0.09
Post Test Leak Rate = 0.000 cfm @ 15 in. Hg
Post Test Pitot Leak Check: ✓
Post Test Orsat Leak Check:

Impinger Box No. 58 ; Blank Box No. 1B

Traverse Point Number	Sampling Time, (min)	/Clock / Time /(24-hour clock)	Gas Meter Reading (V_m) ft^3	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F
—	0	/10:30	344.675	0.23	1.90	1.90	70	84	82	9.0	—	67
A1 2	5	/10:35	348.370	0.24	2.10	2.10	70	87	82	9.0	—	59
A2 1 2	10	/10:40	352.265	0.25	2.20	2.20	70	89	82	11.0	—	65
A3 2 3	15	/10:45	356.325	0.29	2.50	2.50	70	90	83	11.5	—	68
A4 3 4	20	/10:50	360.585	0.29	2.50	2.50	70	91	83	11.5	—	70
A5 4 5	25	/10:55	364.900	0.27	2.35	2.35	70	91	84	11.5	—	70
A6 5 6	30	/11:00	369.180	0.29	2.50	2.50	70	92	85	11.5	—	68
A7 6 7	35	/11:05	373.480	0.23	1.90	1.90	70	92	85	11.0	—	68
A8 7 8	40	/11:10	377.410	0.26	2.30	2.30	70	92	85	11.0	—	65
A9 8 9	45	/11:15	381.490	0.27	2.35	2.35	70	92	85	11.0	—	64
A10 9 10	50	/11:20	385.680	0.31	2.60	2.60	70	92	86	12.0	—	64
A10 10 11	55	/11:25	390.120	0.31	2.60	2.60	70	93	86	12.0	—	65
A10 11	60	/11:30	393.576	0.17	1.45	1.45	70	84	83	7.0	—	59
B1	65	/11:55	397.850	0.16	1.45	1.45	70	85	83	7.0	—	50
B2	70	/12:00	401.155	0.18	1.60	1.60	70	86	83	8.0	—	52
B3	75	/12:05	404.610	0.19	1.70	1.70	70	87	83	8.0	—	53
B4	80	/12:10	408.150	0.20	1.80	1.80	70	88	83	8.0	—	54
B5	85	/12:15	411.680	0.19	1.70	1.70	70	89	83	8.0	—	54
B6	90	/12:20	415.250	0.20	1.80	1.80	70	89	83	8.5	—	54
B7	95	/12:25	419.010	0.28	2.40	2.40	70	89	83	12.0	—	55
B8	100	/12:30	423.100	0.30	2.80	2.80	69	89	83	13.0	—	55
B9	105	/12:35	427.525	0.33	3.00	3.00	70	88	82	14.0	—	55
B10	110	/12:40	432.260	0.34	3.10	3.10	70	87	82	14.5	—	55
B11	115	/12:45	437.020	0.34 0.35	3.15	3.15	70	87	82	15.0	—	56
B11	120	12:50	441.996									

START @ 11:50

15

D=17.0 $\sqrt{T}$ = 97.321 $\sqrt{\Delta P}$=0.502 ΔH=2.24 T_s=530 T_m=546 ≤68

PACIFIC ENVIRONMENTAL SERVICES, INC.

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-21-91

Sampling Location: C2 SCRUBBER EXHAUST

Sample Type: Cr^{+6}

Run Number: C2-1

Sample Box Number: 5B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 695.4 - 138.4 = 557.0
(B) 271.2 - 58.5 = 212.7

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1		#2		#3	
Impingers						
Final Volume:	SHB 688.3	ml	586.8	ml	484.0	ml
Initial Volume:	590.5	ml	586.6	ml	482.4	ml
Net Volume:	17.8	ml	0.2	ml	1.6	ml
Total H_2O:	17.8 →		18.0 →		19.6 →	

Silica Gel			
Final Volume:	688.9	g	Cumulative Sums.
Initial Volume	668.4	g	
Net Volume	20.5	g	← ∴ 6% net H2O.
Total Moisture:	40.1		

Description of Impinger Catch: CLEAR

Plant: NADEP

Date: 10-22-91

Source/Sample Number: C2-1

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(97.321)(1.002)\left[\frac{(30.0) + (2.24/13.6)}{(546)}\right]$

$Vm(std) =$ 95.0 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 40.1 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(40.1)$

$Vw(std) =$ 1.89 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.89)}{(1.89) + (95.0)} =$ _____

$Bw_s =$ 0.020 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.020)(18 - 29)$

$Ms =$ 28.78 lb/lb-mole. ✓ Quick. OK.

Plant: NADEP

Date: 10-22-91

Source/Sample Number: C2-1

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.502)\left[\sqrt{\frac{(530)}{(29.99)(28.78)}}\right]$$

Vs(avg) = 28.2 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(28.2)(28.3)$$ ft². 6" Dia $= \frac{6^2 \times \pi}{4} = 28.27$. OK.

Qs = 47884 OK. acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(47884)(1-0.020)\left[\frac{(29.99)}{(530)}\right]$$

Q(std) = 46840 OK dscfm. Use on next pg.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(530)(95.0)}{(29.99)(28.2)(0.00491)(120)(1-0.020)}\right]$$

%I = 97.4 %

CLIENT: BENMOL/NAVY

Project No. 4321.003

Sampling Location: C2 SCRUBBER EXH Test Date: 10-22-91

Sample Volume: 95.0 DSCF Stack Flow Rate: 46,840 DSCFM

Chromium Test No. 1

Blank: Sample No. C2-4

A Total Cr: <0.0005 ug/ml x 428.5 mls = <0.21 ug Cr
B acid wash: <0.0005 ug/ml x 171.3 mls = <0.09 ug Cr
Total = <0.3 ug Cr

Cr^{+6}: 0.00012 ug/ml x 428.5 mls = <0.051 ug Cr^{+6}

Total Chromium

Source: Sample No. C2-1

A Total Cr: 0.00098 ug/ml x 557.0 mls = 0.55 ug Cr
B acid wash: 0.00067 ug/ml x 212.7 mls = 0.14 ug Cr
Total = 0.69 OK ug Cr

↓ OK.

$$\frac{(0.69)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(95.0)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0002$$ #1 Sol

$$\frac{(0.69)\ \text{ug} \times 60\ \text{min/hr} \times (46840)\ \text{DSCFM}}{(95.0)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 20.4\ \text{mg/hr Cr}$$ OK

$$\frac{(20.4)\ \text{mg/hr}}{(371.5)\ \text{amp-hr/hr}} = 0.055\ \text{mg/amp-hr Cr}$$ OK

transferred to 1st col, Table 1, pg 6.

Hexavalent Chromium

Source: Sample No. C2-1

A Cr^{+6}: 0.00019 ug/ml x 557.0 mls = 0.11 ug Cr^{+6} OK

$$\frac{(0.11)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(95.0)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.000039\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(0.11)\ \text{ug} \times 60\ \text{min/hr} \times (46840)\ \text{DSCFM}}{(95.0)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 3.25\ \text{mg/hr}\ Cr^{+6}$$ OK

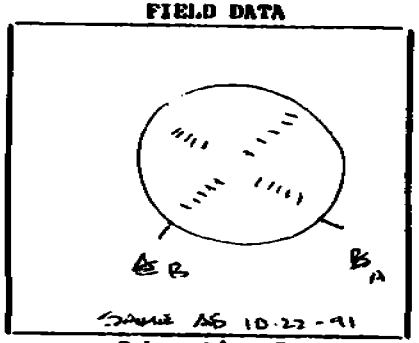
$$\frac{(3.25)\ \text{mg/hr}}{(371.5)\ \text{amp-hr/hr}} = 0.0088\ \text{mg/amp-hr}\ Cr^{+6}$$ OK

SAME ← OK.

(355 + 388)/2 = 371.5
1st 2nd transfer

Plant NAVY NASSP
Date 10-23-91
Sampling Location C2 SCRUBBER EXH
Sample Type 425
Run Number C2-2
Operator BROWN / HERNANDEZ
Ambient Temperature 65
Barometric Pressure -0.115
Static Pressure (P_g) -0.115
Filter Number(s)
Pretest Leak Rate = 0.004 cfm @ 15 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check –
Read and Record all Data Every 5 Minutes

FIELD DATA



Schematic of Traverse Point Layout

Probe Length and Type 6' SS W GLASS LINER
Pitot Tube I.D. No. 1A
Nozzle I.D. No. & Diameter OLP 0.30
Assumed Moisture, % 2%

Meter Box Number 2A
Meter $\Delta H_@$ 1.778
C Factor 1.10
Meter Gamma 1.002
Heater Box Setting –
Reference Δp 0.119 ΔP_a = 0.09
Post Test Leak Rate = 0.000 cfm @ 10 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

Impinger Box No. 3B ; Blank Box No.

Traverse Point Number	Sampling Time, (min)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft^3	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F
0	0	/08:02	~~443.60~~	0.19	1.70	1.70	69	72	69	6.0	–	~~56~~
B2	5	/08:07	446.652	0.19	1.70	1.70	68	78	70	6.0	–	52
B2	10	/08:12	450.68	0.20	1.80	1.80	68	79	71	6.0	–	53
B3	15	/08:17	453.78	0.22	1.95	1.95	68	81	72	6.2	–	53
B4	20	/08:22	457.565	0.23	2.05	2.05	67	82	73	6.7	–	52
B5	25	/08:27	461.450	0.25	2.25	2.25	68	83	74	7.0	–	53
B6	30	/08:32	465.560	0.24	2.15	2.15	67	84	75	7.0	–	53
B7	35	/08:37	470.000	0.30	2.70	2.70	67	84	76	8.0	–	53
B8	40	/08:42	473.980	0.33	3.00	3.00	67	85	76	8.5	–	53
B9	45	/08:47	478.670	0.37	3.30	3.30	67	84	76	9.0	–	54
B10	50	/08:52	483.625	0.36	3.30	3.30	67	84	77	9.0	–	54
B11	55	/08:57	488.610	0.35	3.25	3.25	67	85	77	9.0	–	53
B11	60	/09:02	493.586	0.25	2.20	2.20	69	80	78	7.5	–	48
A2	65	/09:29	497.645	0.25	2.20	2.20	68	84	78	7.5	–	58
A2	70	/09:34	501.166	0.30	2.70	2.70	69	85	78	8.0	–	53
A3	75	/09:39	506.280	0.30	2.70	2.70	69	85	78	8.0	–	54
A4	80	/09:44	510.830	0.31	2.80	2.80	68	85	78	8.5	–	55
A5	85	/09:49	515.435	0.28	2.50	2.50	69	85	78	8.0	–	55
A6	90	/09:54	519.865	0.22	2.00	2.00	69	85	78	6.5	–	55
A7	95	/09:59	523.840	0.25	2.20	2.20	69	85	78	6.5	–	54
A8	100	/10:04	527.890	0.27	2.40	2.40	69	85	78	8.0		54
A9	105	/10:09	532.950	0.30	2.70	2.70	69	86	79	8.0	–	55
A10	110	/10:14	536.665	0.32	2.90	2.90	69	87	79	8.5	–	55
A11	115	/10:19	541.285	0.32	2.90	2.90	69	88	80	8.5	–	55
A11	120	10:24	546.015									

START 443.0 ~~444.60~~ (444.50)

START 09:29

A=120 V_m=103.015 $\sqrt{\Delta P}$=0.522 ΔH=2.47 T_s=528 T_m=540 ≤68

PACIFIC ENVIRONMENTAL SERVICES, INC.

6.1

20

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-21-91

Sampling Location: C2 SCRUBBER EXHAUST

Sample Type: Cr^{+6}

Run Number: C2-2

Sample Box Number: 3B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 810.6 - 138.2 = 672.4
(B) 190.0 - 59.2 = 130.8

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1		#2		#3	
Impingers						
Final Volume:	624.8	ml	516.8	ml	469.0	ml
Initial Volume:	570.7	ml	551.2	ml	468.2	ml
Net Volume:	54.1	ml	-34.4	ml	0.8	ml
Total H_2O:	54.1	→	19.7	→	20.5	→
Silica Gel						
Final Volume:	731.9	g				g
Initial Volume	712.9	g				g
Net Volume	19.0	g				g
Total Moisture:	39.5					

Description of Impinger Catch: CLEAR

K ? Why may cont? These are cumulative amts. OK ∴ vol % same as on p 16 of subtest #1

E r r r ? — g g g — — —

Plant: NADEP

Date: 10-23-91

Source/Sample Number: C2-2

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(103.015)(1.002)\left[\frac{(30.0) + (2.47/13.6)}{(540)}\right]$

$Vm(std) =$ 101.8 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 39.5 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(39.5)$

$Vw(std) =$ 1.86 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.86)}{(1.86) + (101.8)} =$ _____

$Bw_s =$ 0.018 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

$Md = 0.440\ (___) + 0.320(___) + 0.280(___)$

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.018)(18 - 29)$

$Ms =$ 28.80 lb/lb-mole.

Plant: NADEP

Date: 10-23-91

Source/Sample Number: C2-2

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.522)\left[\sqrt{\frac{(528)}{(29.99)(28.80)}}\right]$$

Vs(avg) = 29.3 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(29.3)(28.3)$$

Qs = 49751 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(49751)(1-0.018)\left[\frac{(29.99)}{(528)}\right]$$

Q(std) = 48950 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(528)(101.8)}{(29.99)(29.3)(0.00049)(120)(1-0.018)}\right]$$

%I = 99.9 %

CLIENT: BENMOL/NAVY

Project No. 4321.003

Sampling Location: C2 SCRUBBER EXH Test Date: 10-23-91

Sample Volume: 101.8 DSCF Stack Flow Rate: 48,950 DSCFM

Chromium Test No. 2

Blank: Sample No. C2-4

A Total Cr: <0.0005 ug/ml x 428.5 mls = <0.21 ug Cr
B ~~acid wash: <0.0005~~ ug/ml x 171.3 mls = <0.09 ug Cr
Total = <0.3 ug Cr

Transferred from end of Part 2, 32 page from end.

/ml x 428.5 mls = 0.051 ug Cr^{+6}

Total C

Source: OK Sample No. C2-2

A Total Cr: 0.00158 ug/ml x 672.4 mls = 1.06 ug Cr
B acid wash: 0.0008 ug/ml x 130.8 mls = 0.10 ug Cr
Total = 1.16 ug Cr

$$\frac{(1.16)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(101.8)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.00040\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(1.16)\ \text{ug} \times 60\ \text{min/hr} \times (48{,}950)\ \text{DSCFM}}{(101.8)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 33.5\ \text{mg/hr Cr}$$

$$\frac{(33.5)\ \text{mg/hr}}{(392)\ \text{amp-hr/hr}} = 0.085\ \text{mg/}$$

#2 Sor C-2

These results look OK unless or unless #1, or OK.

Hexavalent Chromium

Source: Sample No. C2-2

A Cr^{+6}: 0.00021 ug/ml x 672.4 mls = 0.14 ug Cr^{+6}

$$\frac{(0.14)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(101.8)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.000049\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(0.14)\ \text{ug} \times 60\ \text{min/hr} \times (48{,}950)\ \text{DSCFM}}{(101.8)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 4.04\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(4.04)\ \text{mg/hr}}{(392)\ \text{amp-hr/hr}} = 0.010\ \text{mg/amp-hr}\ Cr^{+6}$$

(379 + 405)/2 = 357 not 392, but is small.

Plant NAVY NADEP
Date 10-23-91
Sampling Location C2 SCRUBBER EXHAUST
Sample Type 425
Run Number C2-3
Operator BROWN / HERNANDEZ
Ambient Temperature 69
Barometric Pressure 30.0
Static Pressure (P_s) -0.10
Filter Number(s)
Pretest Leak Rate = 0.03 cfm @ 10 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check —
Read and Record all Data Every 5 Minutes

FIELD DATA

SAME AS C2-2

Schematic of Traverse Point Layout

Probe Length and Type 6' SS W/ GLASS LINER
Pitot Tube I.D. No. 1A S TYPE
Nozzle I.D. No. & Diameter 02P 0.30
Assumed Moisture, % 2%

Meter Box Number 2A
Meter $\Delta H_@$ 1.778
C Factor 1.10
Meter Gamma 1.002
Heater Box Setting -
Reference Δp 0.117 Δp_c = 0.09
Post Test Leak Rate = 0.04 cfm @ 14 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

IMPINGER BOX No. 5B ; BLANK Box No.

Traverse Point Number	Sampling Time, (min)	/Clock / Time / (24-hour clock)	Gas Meter Reading (V_m) ft^3	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F
—	—	/ 11:50	546.935	0.22	1.95	1.95	70	87	84	9.0	—	60
A2	5	/ 11:55	550.850	0.22	1.95	1.95	70	88	84	9.0	—	60
A2	10	/ 12:00	554.500	0.27	2.40	2.40	69	90	84	10.5	—	62
A3	15	/ 12:05	558.655	0.27	2.40	2.40	69	90	84	10.5	—	62
A4	20	/ 12:10	562.890	0.29	2.60	2.60	69	91	85	11.5	—	62
A5	25	/ 12:15	567.280	0.29	2.60	2.60	69	92	85	11.5	—	62
A6	30	/12:20	571.740	0.20	1.85	1.85	70	92	86	8.5	—	62
A7	35	/12:25	575.530	0.22	1.95	1.95	70	93	86	8.5	—	61
A8	40	/12:30	579.350	0.25	2.30	2.30	70	93	87	10.0	—	61
A9	45	/12:35	583.420	0.28	2.50	2.50	70	93	87	11.0	—	61
A10	50	/12:40	587.750	0.30	2.70	2.70	71	94	87	11.5	—	62
A11	55	/12:45	592.205	0.30	2.70	2.70	71	95.	88	11.5	—	62
A12	60	/12:50	596.710	0.16	1.40	1.40	71	87	86	7.0	—	56
B2	65	/13:08	599.900	0.16	1.40	1.40	71	89	86	7.0	—	58
B2	70	/ 13:13	603.185	0.17	1.50	1.50	72	91	87	7.0	—	59
B3	75	/ 13:18	606.540	0.17	1.50	1.50	72	92	87	7.0	—	61
B4	80	/ 13:23	609.925	0.19	1.70	1.70	71	92	87	8.0	—	61
B5	85	/13:28	613.455	0.21	1.90	1.90	72	92	87	8.5	—	60
B6	90	/13:33	617.205	0.20	1.80	1.80	72	91	86	10.0	—	61
B7	95	/13:38	621.350	0.25	2.25	2.25	72	92	86	12.0	—	62
B8	100	/13:43	625.810	0.29	2.60	2.60	71	91	86	12.0	—	62
B9	105	/13:48	630.350	0.32	2.90	2.90	71	91	86	12.0	—	62
B10	110	/13:53	634.965	0.34	3.10	3.10	71	92	86	13.5	—	62
B11	115	/13:58	639.775	0.34	3.10	3.10	71	93	86		—	63
B12	120	14:03	644.644									

θ=120 47.709 $\Delta H_@$ = 0.493 ΔH=2.21 T_s=531 T_m=549

PACIFIC ENVIRONMENTAL SERVICES, INC.

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-22-91

Sampling Location: C2 SCRUBBER EXHAUST

Sample Type: Cr6

Run Number: C2-3

Sample Box Number: 1B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 767.1 - 131.3 = 635.8

(B) 196.1 - 60.1 = 136

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	653.7 ml	534.7 ml	483.2 ml
Initial Volume:	588.2 ml	585.6 ml	482.0 ml
Net Volume:	65.5 ml	-50.9 ml	1.2 ml
Total H_2O:	65.5	14.6	15.8
Silica Gel			
Final Volume:	711.0 g	g	g
Initial Volume	687.8 g	g	g
Net Volume	23.2 g	g	g
Total Moisture:	39.0		

Description of Impinger Catch: CLEAR

Plant: NADEP

Date: 10-23-91

Source/Sample Number: C2-3

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(97.709)(1.002)\left[\frac{(30.0) + (2.21/13.6)}{(549)}\right]$

$Vm(std) =$ 94.9 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 39.0 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(39.0)$

$Vw(std) =$ 1.84 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.84)}{(1.84) + (94.9)} =$ _____

$Bw_s =$ 0.019 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.019)(18 - 29)$

$Ms =$ 28.79 lb/lb-mole.

Plant: NADEP

Date: 10-23-91

Source/Sample Number: C2-3

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.493)\left[\sqrt{\frac{(531)}{(29.99)(28.79)}}\right]$$

Vs(avg) = 27.8 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(27.8)(28.3)$$

Qs = 47204 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(47204)(1-0.019)\left[\frac{(29.99)}{(531)}\right]$$

Q(std) = 46135 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(531)(94.9)}{(29.99)(27.8)(0.00049)(120)(1-0.019)}\right]$$

%I = 98.8 %

CLIENT: BENMOL/NAVY

Project No. 4321.003

Sampling Location: C2 SCRUBBER EXH Test Date: 10-23-91

Sample Volume: 94.9 DSCF Stack Flow Rate: 46,135 DSCFM

Chromium Test No. 3

Blank: Sample No. C2-4

A Total Cr: <0.0005 ug/ml x 428.5 mls = <0.21 ug Cr
B acid wash: <0.0005 ug/ml x 171.3 mls = <0.09 ug Cr
Total = <0.3 ug Cr

Cr^{+6}: 0.00012 ug/ml x 428.5 mls = 0.051 ug Cr^{+6}

Total Chromium

Source: Sample No. C2-3

A Total Cr: 0.00065 ug/ml x 635.8 mls = 0.41 ug Cr
B acid wash: 0.00053 ug/ml x 136.0 mls = 0.07 ug Cr
Total = 0.48 ug Cr

$$\frac{(0.48)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(94.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.00018\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(0.48)\ \text{ug} \times 60\ \text{min/hr} \times (46{,}135)\ \text{DSCFM}}{(94.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 14.0\ \text{mg/hr Cr}$$

$$\frac{(14.0)\ \text{mg/hr}}{(447)\ \text{amp-hr/hr}} = 0.031\ \text{mg/amp-}$$

#3 C2 Dcr

Hexavalent Chromium

These numbers look ok, anyhow vs ~~[illegible]~~ outlet #1, or OK

Source: Sample No. C2-3

A Cr^{+6}: 0.00018 ug/ml x 635.8 mls = 0.11 ug Cr^{+6}

$$\frac{(0.11)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(94.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.000043\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(0.11)\ \text{ug} \times 60\ \text{min/hr} \times (46{,}135)\ \text{DSCFM}}{(94.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 3.21\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(3.21)\ \text{mg/hr}}{(447)\ \text{amp-hr/hr}} = 0.0072\ \text{mg/amp-hr}\ Cr^{+6}$$

(436 + 458) / 2 = 449 → OK

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-21-91

Sampling Location: C2 SCRUBBER EXHAUST

Sample Type: Cr^{+6}

Run Number: C2-4 (BLANK TRAIN)

Sample Box Number: 1B

Clean-up Man: BROWN

Job Number: H321.003

Comments: (A) 567.2 - 138.7
(B) 229.6 - 58.3

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE	#1	#2	#3
Impingers			
Final Volume:	563.6 ml	583.7 ml	490.2 ml
Initial Volume:	563.6 ml	584.3 ml	490.4 ml
Net Volume:	0 ml	0 ml	0 ml
Total H_2O:			
Silica Gel			
Final Volume:	619.5 g	g	g
Initial Volume	619.8 g	g	g
Net Volume	0 g	g	g
Total Moisture:			

Description of Impinger Catch: CLEAR

First Test
first traverse

C-2 SCRUBBER TEST DATE 10/22/91

	TIME	AMPS	VOLTS	Amp-Hours
	10:20	MIN		1271
Test Begin	10:26	3 600	42	1271
	10:29	1 500	42	1292
	10:30	4 450	42	1300
	10:34	18 400	42	1333
	10:52	34 350	42	1436
Test End	11:26	350	41	1632
	11:29			1633
	AVG	60 → 387		~~369~~ 355

C-2 SCRUBBER TEST DATE 10/22/91

First test
Second traverse

	TIME	AMPS	VOLTS	Amp-Hours
	1155			1633
Test Begin	1156	.5 500	15	
	1156.30	.5 700	22	
	1157	.5 600	25	
	1157.30	.5 800	40	1653
	1158	1 550	43	
	1159	1 425	43	
	1200	5 400	42.5	1671
	1205	5 400	42.5	1705
	1210	5 390	43	1740
	1215	15 375	42.5	1768
	1230	10 375	42.5	1861
	1240	10 375	42	1922
	1250	3 390	42	1984
	1253	1 390	42	2003
	1254	1 390	42	2009
	1255	1 390	42	2015
Test End	1256	1 390	42	2021
	1257	390	42	2028
		60 → 395		~~395~~ 388

C-2 SCRUBBER TEST DATE 10-23-91

Second test
first traverse

	TIME	AMPS		VOLTS	Amp-Hours
	8:05				2028
Test begin	8:08	.5	800	15	
	8:08:30	.5	1000	35	2031.
	8:09	.5	900	43	2038
	8:09:30	.5	550	42	2045
	8:10	.5	450	42	2049
	8:10:30	.5	400	42	2052
	~~8:12~~ 8:11	1	400	42	2055
	8:12	3	400	42	2063
	8:15	5	400	42	2082
	8:20	10	375	42.5	2113
	8:30	15	375	42.5	2173
	8:45	15	375	42.5	2267
	9:00	5	390	42.5	2357
	9:05	3	390	42.3	2388
Test Ends	9:08		390	42.5	2407
	9:10		390	42.5	2419
		60	396		~~391~~ 379

Second Test
Second traverse

C-2 SCRUBBER TEST DATE 10-23-91

	TIME	AMPS	VOLTS	Amp-Hours
Before test	9:15			2419
Test Begin	9:29	.5 900	15	2419
	9:29:30	.5 900	35	2425
	9:30	.5 700	42	2433
	9:30:30	.5 550	42	2440
	9:31	1 490	42	2444
	9:32	1 450	42	2450
	9:33	3 425	42.5	2457
	9:36	17 450	42.5	2479
	9:53	21 400	42.5	2592
	10:14	11 400	42.5	2725
	10:25	4 400	42.5	2797
Test End	10:29	400	42.5	2824
	10:30	400	42.5	2831
		60 430		~~412~~ 405

Third Test
first traverse

C-2 SCRUBBER TEST DATE 10-23-91

	TIME	AMPS	VOLTS	Amp-Hours
	11:38			2831
Test Begin	~~11:32~~ 11:51:30			2831
	11:52:[illegible]	.5 1100	15	2833
	11:52:30	.5 1000	25	2836
	11:53	.5 1100	42	2841
	11:53:30	.5 650	42	2850
	11:54	1 550	42.5	2854
	11:55	1 450	42.5	2862
	11:56	4 450	42.5	2870
	12:00	12 450	43	2895
	12:12	22 425	43	2981
	12:34	10 450	43	3139
	12:44	7 450	43	3216
	12:51	1[illegible] 450	43	3262
	12:53	[illegible] 450	43	3277
	12:54	[illegible] 450	43	3284
	12:55	450	43	3291
	12:56	450	43	3298
	12:57	450	43	3306
				~~475~~ 436
		60 460		

~~Seco~~ Third Test
Second Traverse

C-2 SCRUBBER TEST DATE 10-23-91

	TIME	AMPS	VOLTS	Amp-Hours
	1305			3317
Test Start	13:07	.5 500	10	3317
	13:07:30	.5 700	23	3322
	13:08	.5 800	30	3328
	13:08:30	.5 650	40	3337
	13:09	.5 550	42	3342
	13:09:30	.5 500	42	3345
	13:10	1 450	42	3349
	13:11	4 450	42	3357
	13:15	13 450	42	3395
	13:28	12 450	42	3484
	13:40	10 450	42	3570
	13:50	10 450	42	3645
	14:00	6 450	42	3720
	14:06	1 450	42	3766
	14:07	450	42	3775
	14:08	450	42	3782
	14:09	450	42	3790
		60 458		~~473~~ 458

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

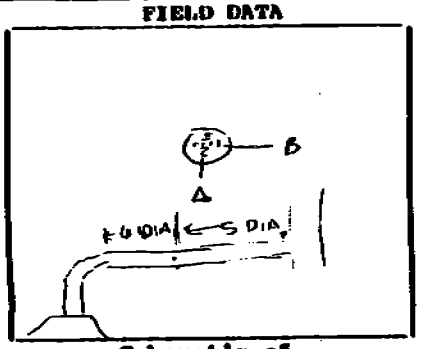
PLANT NADEP
DATE
SAMPLING LOCATION HELD BLADE SCRUBBER EXHAUST
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE. (DISTANCE A) 12"
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE. (DISTANCE B) 0
STACK I.D., (DISTANCE A - DISTANCE B) 12"
NEAREST UPSTREAM DISTURBANCE 82"
NEAREST DOWNSTREAM DISTURBANCE 69"
CALCULATOR

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	4.4	12"	0.5 (1.0)		
2	14.6	↓	1.8		
3	29.6		3.6		
4	70.4		8.5		
5	85.4		10.3		
6	95.6		11.5 (11.0)		

Plant NAVY NADEP
Date 10-24-91
Sampling Location HILO BLADE SCRUBBER
Sample Type 425
Run Number HB 1
Operator BROWN/HERNANDEZ
Ambient Temperature 70
Barometric Pressure 30.05
Static Pressure (P_s) -0.79
Filter Number(s)
Pretest Leak Rate = 0.04 cfm @ 10 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check —
Read and Record all Data Every 10 Minutes

FIELD DATA



Schematic of Traverse Point Layout

Probe Length and Type 24" GLASS LINED
Pitot Tube I.D. No. ~~4688~~ S-3B ~~0.3841~~
Nozzle I.D. No. & DIAMETER 4688 0.3841
Assumed Moisture, % 2%

Meter Box Number 2A
Meter $\Delta H_@$ 1.778
C Factor
Meter Gamma 1.002
Heater Box Setting —
Reference Δp 0.075
Post Test Leak Rate = 0.35 cfm @ 14 in. Hg
Post Test Pitot Leak Check ✓
Post Test Orsat Leak Check

IMPINGER BOX No. 3B ; BLANK BOX No. 1B

Traverse Point Number	Sampling Time, (min)	Clock Time (24-hour clock)	Gas Meter Reading (V_m) ft^3	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F	
—	0	08:49	645.635	0.12	3.10	3.10	70	76	76	9.0	—	48	SCRUBBER TURNED ON AT 08:58
A1	10	08:59	656.160	0.13	3.40	3.40	65	85	77	9.0	—	57	
A2	20	09:09	666.155	0.15	3.60	3.60	64	88	79	9.5	—	54	
A3	30	09:19	676.460	0.16	3.80	3.80	63	90	80	10.0	—	54	
A4	40	09:29	687.150	0.22	5.30	5.30	63	93	82	13.0	—	53	
A5	50	09:39	699.300	0.21	5.10	5.10	63	94	84	13.0	—	54	
A6	60	09:49	711.710	0.13	3.15	3.15	68	82	82	9.0	—	53	10:31 START
B1	70	10:41	724.010	0.10	2.45	2.45	65	89	83	7.5	—	53	~~START AT 10:31~~
B2	80	10:51	729.750	0.10	2.45	2.45	66	91	83	7.5	—	53	
B3	90	11:01	738.500	0.13	3.40	3.40	65	92	84	9.0	—	53	
B4	100	11:11	747.775	0.19	4.70	4.70	64	80	77	12.0	—	54	@ 11:10:35 blew dirt hose (brown)
B5	110	12:58	759.995	0.21	5.10	5.10	64	85	78	3.0	—	55	STOPPED TEST. STARTED AT 12:48
B6	120	13:08	772.184										

$\theta = 120$ $V_m = 126.190$ $\sqrt{\Delta P} = .389$ $\Delta H = 3.8$ $T_s = 65$ $T_m = 83.75$ $T_m = 84.4$ 168

PACIFIC ENVIRONMENTAL SERVICES, INC.

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-23-91

Sampling Location: HELO BLADE SCRUBBER EXHAUST

Sample Type: Cr6

Run Number: HB-1

Sample Box Number: 3B

Clean-up Man: BROWN

Job Number: 4321-003

Comments: A 670.9 − 129.7 = 541.2
B 213.6 − 60.0 = 153.6

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	576.1 ml	566.7 ml	467.8 ml
Initial Volume:	558.0 ml	563.5 ml	466.6 ml
Net Volume:	18.1 ml	3.2 ml	1.2 ml
Total H_2O:	18.1 →	21.3 →	22.5 →
Silica Gel			
Final Volume:	713.4 g	g	g
Initial Volume	693.1 g	g	g
Net Volume	20.3 g	g	g
Total Moisture:	42.8		

Description of Impinger Catch: CLEAR

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-1

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(126.549)(1.002)\left[\frac{(30.05) + (3.80/13.6)}{(544)}\right]$

$Vm(std) =$ 124.7 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 42.8 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(42.8)$

$Vw(std) =$ 2.01 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(2.01)}{(2.01) + (124.7)} =$ _____

$Bw_s =$ 0.016 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.016)(18 - 29)$

$Ms =$ 28.82 lb/lb-mole.

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-1

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.389)\left[\sqrt{\frac{(525)}{(29.99)(28.82)}}\right]$$

Vs(avg) = 21.8 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(21.8)(0.785)$$

Qs = 1027 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(1027)(1-0.016)\left[\frac{(29.99)}{(525)}\right]$$

Q(std) = 1018 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(525)(124.7)}{(29.99)(21.8)(0.000804)(120)(1-0.016)}\right]$$

%I = 99.7 %

CLIENT: BENMOL/NAVY

Project No. 4321.003

Sampling Location: HELO SCRUBBER EXH Test Date: 10-24-91

Sample Volume: 124.7 DSCF Stack Flow Rate: 1018 DSCFM

Test No. 1

Chromium

Blank: Sample No. HB-4

A Total Cr: 0.0012 ug/ml x 432.1 mls = 0.52 ug Cr
B acid wash: 0.0015 ug/ml x 112.1 mls = 0.17 ug Cr
Total = 0.69 ug Cr

Cr^{+6}: 0.00018 ug/ml x 432.1 mls = 0.078 ug Cr^{+6}

HB-1 #1 rates

Total Chromium

Source: Sample No. HB-1

A Total Cr: 0.0412 ug/ml x 541.2 mls = 22.3 ug Cr
B acid wash: 0.0091 ug/ml x 153.6 mls = 1.4 ug Cr
Total = 23.7 ug Cr

$$\frac{(23.7)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(124.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0067\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(23.7)\ \text{ug} \times 60\ \text{min/hr} \times (1018)\ \text{DSCFM}}{(124.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 11.6\ \text{mg/hr Cr}$$

$$\frac{(11.6)\ \text{mg/hr}}{(18.7)\ \text{amp-hr/hr}} = 0.62\ \text{mg/amp-hr Cr}$$

Hexavalent Chromium

Source: Sample No. HB-1

A Cr^{+6}: 0.040 ug/ml x 541.2 mls = 21.6 ug Cr^{+6}

$$\frac{(21.6)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(124.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0061\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(21.6)\ \text{ug} \times 60\ \text{min/hr} \times (1018)\ \text{DSCFM}}{(124.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 10.6\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(10.6)\ \text{mg/hr}}{(18.7)\ \text{amp-hr/hr}} = 0.57\ \text{mg/amp-hr}\ Cr^{+6}$$

Plant NAVY NADEP
Date 10-24-91
Sampling Location HELO BLADE SCRUBBER
Sample Type 425
Run Number HB-2
Operator BROWN / HERNANDEZ
Ambient Temperature
Barometric Pressure 30.05
Static Pressure (P_s)
Filter Number(s)
Pretest Leak Rate 0.005 cfm @ 15 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check
Read and Record all Data Every 10 Minutes

FIELD DATA

SAME AS HB-1

Schematic of Traverse Point Layout

Probe Length and Type 24" GLASS LINED
Pitot Tube I.D. No. 3-36
Nozzle I.D. No. & Diameter CRP 0.368
Assumed Moisture, % 2%

Meter Box Number 2A
Meter $\Delta H_@$ 1.778
C Factor 0.119
Meter Gamma 1.002
Heater Box Setting –
Reference Δp 0.090
Post Test Leak Rate = 0.006 cfm @ 19 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

IMPINGER BOX No. 5B ; BLANK BOX No. 1B

Traverse Point Number	Sampling Time, (min)	/Clock / Time /(24-hour / clock)	Gas Meter Reading (V_m) ft^3	Velocity Head (ΔP_s) in. H_2O	Orifice Pres. Differential (ΔH) in. H_2O Desired	Actual	Stack Temp. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F
–	0	/14:14	772.412	0.07	1.80	1.80	71	80	80	9.0	–	65
B1	10	/14:24	778.975	0.10	2.00	2.00	69	85	80	10.0	–	63
B2	20	/14:34	786.660	0.10	2.00	2.00	66	88	81	10.0	–	64
B3	30	/14:44	794.430	0.16	3.15	2.95	66	89	81	15.0	–	58
B4	40	/14:54	803.740	0.16	3.15	3.00	65	82	82	15.0	–	58
B5	50	/15:04	813.2	0.21	3.80	3.60	64	85	81	19.0	–	61
B6	60	/15:14	823.515	0.12	2.40	2.40	64	78	78	11.5	–	58
A1	70	/16:02	831.925	0.12	2.40	2.40	65	86	79	11.5	–	60
A2	80	/16:12	840.480	0.10	2.00	2.00	65	89	80	10.5	–	60
A3	90	/16:22	848.500	0.12	2.40	2.40	64	91	82	11.5	–	60
A4	100	/16:32	857.030	0.20	4.20	3.60	63	93	83	19.0	–	59
A5	110	/16:42	867.230	0.18	3.70	3.60	62	91	84	19.0	–	59
A6	120	/16:52	877.955								–	
		/										
		/										
		/t_f=1200			ΔH=2.65							
		/										
		/										<68
		/										
		/										
		/										
		/										
		/										
		/										

– FAN LOST ON @14:45 & 15:02 RESTART

PACIFIC ENVIRONMENTAL SERVICES, INC.

PES

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-23-91

Sampling Location: HELO BLADE SCRUBBER EXHAUST

Sample Type: Cr^6

Run Number: HB-2

Sample Box Number: 5B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 646.5 - 129.6 = 516.9
(B) 221.7 - 59.2 = 162.5

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	581.3 ml	598.3 ml	484.6 ml
Initial Volume:	571.7 ml	602.8 ml	482.2 ml
Net Volume:	10.6 ml	-4.5 ml	2.4 ml
Total H_2O:	10.6 →	6.1 →	8.5 →
Silica Gel			
Final Volume:	696.7 g	g	g
Initial Volume	671.6 g	g	g
Net Volume	25.1 g	g	g
Total Moisture:	33.6		

Description of Impinger Catch: CLEAR

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-2

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(105.523)(1.002)\left[\frac{(30.05) + (2.65/13.6)}{(544)}\right]$

$Vm(std) =$ 103.7 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 33.6 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(33.6)$

$Vw(std) =$ 1.58 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.58)}{(1.58) + (103.7)} =$ _____

$Bw_s =$ 0.015 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.015)(18 - 29)$

$Ms =$ 28.84 lb/lb-mole.

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-2

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.368)\left[\sqrt{\frac{(525)}{(29.99)(28.84)}}\right]$$

Vs(avg) = 20.6 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(20.6)(0.785)$$

Qs = 970 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(970)(1-0.015)\left[\frac{(29.99)}{(525)}\right]$$

Q(std) = 963 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(525)(103.7)}{(29.99)(20.6)(0.000739)(120)(1-0.015)}\right]$$

%I = 95.3 %

CLIENT: BENMOL / NAVY

Project No. 4321.003

Sampling Location: HELO SCRUBBER EXH Test Date: 10-24-91

Sample Volume: 103.7 DSCF Stack Flow Rate: 963 DSCFM

Chromium Test No. 2

#2 Hole meter

Blank: Sample No. HB-4

A Total Cr: 0.0012 ug/ml x 432.1 mls = 0.52 ug Cr
B acid wash: 0.0015 ug/ml x 112.1 mls = 0.17 ug Cr
Total = 0.69 ug Cr

Cr^{+6}: 0.00018 ug/ml x 432.1 mls = 0.078 ug Cr^{+6}

Total Chromium

Source: Sample No. HB-2

A Total Cr: 0.0265 ug/ml x 516.9 mls = 13.7 ug Cr
B acid wash: 0.0202 ug/ml x 162.5 mls = 3.3 ug Cr
Total = 17.0 ug Cr

$$\frac{(17.0)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(103.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0058\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(17.0)\ \text{ug} \times 60\ \text{min/hr} \times (963)\ \text{DSCFM}}{(103.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 9.47\ \text{mg/hr Cr}$$

$$\frac{(9.47)\ \text{mg/hr}}{(16.2)\ \text{amp-hr/hr}} = 0.58\ \text{mg/amp-hr Cr}$$

Hexavalent Chromium

Source: Sample No. HB-2

A Cr^{+6}: 0.023 ug/ml x 516.9 mls = 11.9 ug Cr^{+6}

$$\frac{(11.9)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(103.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0040\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(11.9)\ \text{ug} \times 60\ \text{min/hr} \times (963)\ \text{DSCFM}}{(103.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 6.63\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(6.63)\ \text{mg/hr}}{(16.2)\ \text{amp-hr/hr}} = 0.41\ \text{mg/amp-hr}\ Cr^{+6}$$

Plant NAVY NADEP
Date 10-24-91
Sampling Location HILL BLADE SCRUBBER
Sample Type 425
Run Number HB 3
Operator BROWN / HERNANDEZ
Ambient Temperature 68
Barometric Pressure 30.05
Static Pressure (P_s) - 0.80
Filter Number(s) 0.01B
Pretest Leak Rate = 0.025 cfm @ 10 in. Hg
Pretest Pitot Leak Check ✓
Pretest Orsat Leak Check —
Read and Record all Data Every 10 Minutes

FIELD DATA

SAME AS HB-1

Schematic of Traverse Point Layout

Probe Length and Type 24" GLASS LINED
Pitot Tube I.D. No. & 3B
Nozzle I.D. No. & Diameter 08P 0.368
Assumed Moisture, % 2%

Meter Box Number 2A
Meter $\Delta H_@$ 1.778
C Factor
Meter Gamma 1.002
Heater Box Setting —
Reference Δp 0.09
Post Test Leak Rate = 0.002 cfm @ 10 in. Hg
Post Test Pitot Leak Check
Post Test Orsat Leak Check

Impinger Box No. 3B ; Blank Box No. 1B

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. (T_s) °F	Dry Gas Meter Temp. Inlet ($T_{m_{in}}$) °F	Outlet ($T_{m_{out}}$) °F	Pump Vacuum in. Hg	Sample Box Temp. Filter Temp. °F	Impinger Temp. °F
-	0	18:13	878.512	0.11	2.20	2.20	63	80	79	7.0	—	65
Δ_1	10	18:23	884.120	0.17	3.40	3.40	66	85	79	9.0	—	62
Δ_2	20	18:33	896.440	0.12	2.50	2.50	62	90	80	7.5	—	57
Δ_3	30	18:43	905.360	0.15	3.10	3.10	62	90	81	7.5	—	57
Δ_4	40	18:53	914.965	0.19	3.80	3.80	60	91	82	10.0	—	57
Δ_5	50	19:03	925.585	0.20	4.00	4.00	60	92	83	10.5	—	57
Δ_6	60	19:13	936.575	0.08	1.70	1.70	64	80	80	6.0	—	53
B_1	70	19:33	943.695	0.09	1.80	1.80	63	85	80	6.0	—	53
B_2	80	19:43	951.075	0.08	1.70	1.70	61	87	80	6.0	—	55
B_3	90	19:53	958.280	0.14	2.80	2.80	60	88	81	8.0	—	56
B_4	100	20:03	967.270	0.16	3.20	3.20	60	91	82	8.5	—	56
B_5	110	20:13	977.015	0.18	3.70	3.70	60	92	83	9.5	—	56
B_6	120	20:23	987.660									
		/										
		/										
	θ = 120	/	V_m = 108.748	$\bar{P}_s$ = 0.149	ΔH =	2.83	61.75	$\bar{T}$ =	= 79.4			≈ 66
		/						T_m				
		/					T_s = 622					
		/										
		/										
		/										
		/										
		/										

PACIFIC ENVIRONMENTAL SERVICES, INC.

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SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-24-91

Sampling Location: HELO BLADE SCRUBBER EXHAUST

Sample Type: Cr6

Run Number: HB-3

Sample Box Number: 3B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 722.6 - 138.2 = 584.4
(B) 228.7 - 60.1 = 168.6

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	576.0 ml	557.6 ml	467.7 ml
Initial Volume:	564.5 ml	554.7 ml	466.8 ml
Net Volume:	11.5 ml	2.9 ml	0.9 ml
Total H_2O:	11.5 →	14.4 →	15.3 →
Silica Gel			
Final Volume:	714.1 g	g	g
Initial Volume	694.2 g	g	g
Net Volume	19.9 g	g	g
Total Moisture:	35.2		

Description of Impinger Catch: CLEAR

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-3

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(108.748)(1.032)\left[\frac{(30.05) + (2.83/13.6)}{(544)}\right]$

$Vm(std) =$ 106.9 dscf.

2. Volume water vapor collected (standard conditions).

$V(lo) =$ 35.2 condensate from impingers and selica gel.

$Vw(std) = (0.04707)\ V(lo) = (0.04707)(35.2)$

$Vw(std) =$ 1.66 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.66)}{(1.66) + (106.9)} =$ _____

$Bw_s =$ 0.015 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

$Md =$ 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.015)(18 - 29)$

$Ms =$ 28.84 lb/lb-mole.

Plant: NADEP

Date: 10-24-91

Source/Sample Number: HB-3

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.369)\left[\sqrt{\frac{(522)}{(29.99)(28.84)}}\right]$$

Vs(avg) = 20.6 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(20.6)(0.785)$$

Qs = 970 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(970)(1-0.015)\left[\frac{(29.99)}{(522)}\right]$$

Q(std) = 968 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(522)(106.9)}{(29.99)(20.6)(0.000739)(120)(1-0.015)}\right]$$

%I = 97.7 %

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CLIENT: BENMOL/NAVY

Project No. 4321.003

#3 filter catch

Sampling Location: HELO SCRUBBER EXH Test Date: 10-24-91

Sample Volume: 106.9 DSCF Stack Flow Rate: 968 DSCFM

Chromium Test No. 3

Blank: Sample No. HB-4

A Total Cr: 0.0012 ug/ml x 432.1 mls = 0.52 ug Cr
B acid wash: 0.0015 ug/ml x 112.1 mls = 0.17 ug Cr
Total = 0.69 ug Cr

Cr^{+6}: 0.00018 ug/ml x 432.1 mls = 0.078 ug Cr^{+6}

Total Chromium

Source: Sample No. HB-3

A Total Cr: 0.0075 ug/ml x 584.4 mls = 4.38 ug Cr
B acid wash: 0.0025 ug/ml x 168.6 mls = 0.42 ug Cr
Total = 4.8 ug Cr

$$\frac{(4.8)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(106.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0016\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(4.8)\ \text{ug} \times 60\ \text{min/hr} \times (968)\ \text{DSCFM}}{(106.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 2.61\ \text{mg/hr Cr}$$

$$\frac{(2.61)\ \text{mg/hr}}{(18.2)\ \text{amp-hr/hr}} = 0.14\ \text{mg/amp-hr Cr}$$

Hexavalent Chromium

Source: Sample No. HB-3

A Cr^{+6}: 0.0058 ug/ml x 584.4 mls = 3.39 ug Cr^{+6}

$$\frac{(3.39)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(106.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0011\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(3.39)\ \text{ug} \times 60\ \text{min/hr} \times (968)\ \text{DSCFM}}{(106.9)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 1.84\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(1.84)\ \text{mg/hr}}{(18.2)\ \text{amp-hr/hr}} = 0.10\ \text{mg/amp-hr}\ Cr^{+6}$$

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-23-91

Sampling Location: HEO BLADE SCRUBBER EXHAUST

Sample Type: Cr6

Run Number: HB-4 (BLANK TRAIN)

Sample Box Number: 1B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 570.8 - 138.7 = 432.1
(B) 172.0 - 59.9 = 112.1

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	567.0 ml	581.9 ml	487.3 ml
Initial Volume:	567.0 ml	581.9 ml	487.5 ml
Net Volume:	~~0~~ ml	~~0~~ ml	-0.2 ml
Total H_2O:	~~0~~	~~0~~	-0.2 →
Silica Gel			
Final Volume:	662.6 g	g	g
Initial Volume	662.3 g	g	g
Net Volume	0.3 g	g	g
Total Moisture:	0.1		

Description of Impinger Catch: CLEAR

SAMPLE RECOVERY DATA

Plant: NADEP

Date: 10-24-91

Sampling Location: HELO BLADE SCRUBBER EXHAUST

Sample Type: Cr6

Run Number: HB-5

Sample Box Number: 5B

Clean-up Man: BROWN

Job Number: 4321.003

Comments: (A) 641.1 - 138.1 = 503.0
(B) 219.5 - 59.2 = 160.3

FRONT HALF

Filter Number: TEFLON

Description of Filter: CLEAN

MOISTURE

	#1	#2	#3
Impingers			
Final Volume:	580.5 ml	588.0 ml	483.5 ml
Initial Volume:	569.7 ml	586.2 ml	481.9 ml
Net Volume:	10.8 ml	1.8 ml	1.6 ml
Total H_2O:	10.8 →	12.6 →	14.2 →
Silica Gel			
Final Volume:	704.1 g	g	g
Initial Volume	680.5 g	g	g
Net Volume	23.6 g	g	g
Total Moisture:	37.8		

Description of Impinger Catch: CLEAR

Plant: NADEF

Date: 10-25-91

Source/Sample Number: HB-5

1. $Vm(std) = (17.64)(Vm)(Y)\left[\frac{P_{bar} + (\Delta H/13.6)}{Tm}\right]$

$Vm(std) = (17.64)(114.036)(1.062)\left[\frac{(30.0) + (3.05/13.6)}{(536)}\right]$

Vm(std) = 113.7 dscf.

2. Volume water vapor collected (standard conditions).

V(lo) = 37.8 condensate from impingers and selica gel.

Vw(std) = (0.04707) V(lo) = (0.04707)(37.8)

Vw(std) = 1.78 scf.

3. Percent moisture, by volume.

$Bw_s = \frac{Vw(std)}{Vw(std) + Vm(std)} = \frac{(1.78)}{(1.78) + (113.7)} =$ _____

Bw_s = 0.015 .

4. Molecular weight, stack gas.

Dry molecular weight.

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

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

Md = 29.0 lb/lb-mole.

$Ms = Md + Bw_s\ (18 - Md) = (29) + (0.015)(18 - 29)$

Ms = 28.84 lb/lb-mole.

Plant: NADEP

Date: 10-25-91

Source/Sample Number: HB-5

5. Stack gas velocity average.

$$Vs(avg) = (85.49)(Cp)(\sqrt{\Delta P})\left[avg\sqrt{\frac{(Ts)}{(Ps)(Ms)}}\right]$$

$$Vs(avg) = (85.49)(0.84)(0.384)\left[\sqrt{\frac{(520)}{(29.94)(28.84)}}\right]$$

Vs(avg) = 21.4 ft/sec.

6. Stack volumetric flow rate, actual conditions (stack temperature and pressure).

$$Qs = (60)(Vs)(A) = (60)(21.4)(0.785)$$

Qs = 1008 acfm.

7. Stack volumetric flow rate, standard conditions (68 degrees F, 29.92 Hg).

$$Q(std) = (17.64)(Qs)(1-Bw_s)\left[\frac{(Ps)}{(Ts)}\right]$$

$$Q(std) = (17.64)(1008)(1-0.015)\left[\frac{(29.94)}{(520)}\right]$$

Q(std) = 1008 dscfm.

8. Isokinetic variation.

$$\%I = (K)\left[\frac{(Ts)(Vm(std))}{(Ps)(Vs)(An)(\theta)(1-Bw_s)}\right]$$

$$\%I = (0.0945)\left[\frac{(520)(113.7)}{(29.94)(21.4)(0.000739)(120)(1-0.015)}\right]$$

%I = 99.8 %

PES

CLIENT: BENMOL-/NAVY

#4 Hole filter

Project No. 4321.003

Sampling Location: HELO SCRUBBER EXH Test Date: 10-25-91

Sample Volume: 113.7 DSCF Stack Flow Rate: 1008 DSCFM

Chromium Test No. 4

Blank: Sample No. HB-4

A Total Cr: 0.0012 ug/ml x 432.1 mls = 0.52 ug Cr
B acid wash: 0.0015 ug/ml x 112.1 mls = 0.17 ug Cr
Total = 0.69 ug Cr

Cr^{+6}: 0.00018 ug/ml x 432.1 mls = 0.078 ug Cr^{+6}

Total Chromium

Source: Sample No. HB-5

A Total Cr: 0.0807 ug/ml x 503.0 mls = 40.6 ug Cr
B acid wash: 0.0208 ug/ml x 160.3 mls = 3.3 ug Cr
Total = 43.9 ug Cr

$$\frac{(43.9)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(113.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0136\ \text{mg/m}^3\ \text{Cr}$$

$$\frac{(43.9)\ \text{ug} \times 60\ \text{min/hr} \times (1008)\ \text{DSCFM}}{(113.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 23.4\ \text{mg/hr Cr}$$

$$\frac{(23.4)\ \text{mg/hr}}{(21.7)\ \text{amp-hr/hr}} = 1.08\ \text{mg/amp-hr Cr}$$

Hexavalent Chromium

Source: Sample No. HB-5

Cr^{+6}: 0.061 ug/ml x 503.0 mls = 30.7 ug Cr^{+6}

$$\frac{(30.7)\ \text{ug} \times 35.3\ \text{SCF/m}^3}{(113.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 0.0095\ \text{mg/m}^3\ Cr^{+6}$$

$$\frac{(30.7)\ \text{ug} \times 60\ \text{min/hr} \times (1008)\ \text{DSCFM}}{(113.7)\ \text{DSCF} \times 1000\ \text{ug/mg}} = 16.3\ \text{mg/hr}\ Cr^{+6}$$

$$\frac{(16.3)\ \text{mg/hr}}{(21.7)\ \text{amp-hr/hr}} = 0.75\ \text{mg/amp-hr}\ Cr^{+6}$$

First Test
First Traverse

HELO ANODIZE SCRUBBER TEST DATE 10-24-91

	TIME	AMPS	VOLTS	AMP-Hours
	8:07			2509.1
Test Begin	8:50	1 23	4	2509.1
	8:51	1 8	5	2509.2
	8:52	1 40	20	2509.4
	8:53	1 10	44	2510.1
	8:54	1 8	45	2510.3
	8:55	5 8	45	2510.6
	9:00	5 7	45	2511.6
	9:05	5 7	46	2512.6
	9:10	10 7	46	2513.5
	9:20	20 6.5	46	2515.4
	9:46	7 6.5	46	2519.2
	9:47	2 6.5	46	2520.5
	9:49	1 6.5	46	2520.9
	9:50	6.5	46	2521.0
	9:51	6.5	46	2521.2
	9:52	6.5	46	2521.4
	9:53	6.5	46	2521.6
	9:54	6.5	46	2521.8
		60 7.7		~~12.7~~ 11.9

First test
Second traverse

HELO ANODIZE SCRUBBER TEST DATE 10/24/91

	TIME	AMPS	VOLTS	Amp-Hours
				2521.8
	10:34			2522.0
Test Begin	10:36	.5 48	7	2522.6
	10:36:30	.5 44	7	2523.0
	10:37	1 42	7	2523.5
	10:38	1 32	8.5	2524.4
	10:39	1 30	8	2525.2
	10:40	1 30	10	2526.0
	10:41	2 32	16	2526.9
	10:43	2 26	17	2528.3
	10:45	3 24	23	2529.7
	10:48	3 22	28.5	2531.5
	10:51	4 28	34	2533.0
	10:55	1 16	36	2535.0
	10:56	4 15	42	2535.6
	11:00	5 14	42	2537.1
	11:05	10 14	42	2539.0
Test stop (Blown Hose)	11:14:40	~~4~~	~~30~~	2542.3
	12:52	2 4	30	2542.3
	12:54	1 5	40	2542.3
	12:55	1 10	40	2542.6
	12:56	4 11	40	2542.8
	13:00	5 12	40	2544.1
	13:05	5 11.5	40	2545.6
	13:10	3 11.5	40	2547.2
	13:12	11.5	40	2547.8
	13:13	11.5	40	2548.1

18.7

25.5

Second Test
first traverse

HELO ANODIZE SCRUBBER TEST DATE 10-24-91

	TIME	AMPS	VOLTS	Amp. Hours
	14:14			2548.3
Test Begin	14:18	.5 23	5	2548.3
	14:19:30	.5 24	15	2548.5
	14:20	1 16	18	2548.9
	14:21	1 14	20	2549.3
	14:22	1 15	28	2549.8
	14:23	1 22	38	2550.2
	14:24	2 12	41	2550.5
	14:26	4 10	41.5	2551.1
	1430	10 9	42	2552.2
	1440	10 9	42.5	2554.7
	1450	10 8	42.5	2557.2
	1500	1 9	42.5	2559.7
Rectifier OFF	1501	—	—	2559.9
	1506	2 12	43.	2560.1
	1505	7 9	45	2560.5
	1515	5 8	46	2562.2
	1520	4 8	46	2563.3
	1524	8	41	2564.3
	1525	8	41	2564.5
		60 9.7		15.8

Second test
Second traverse

HELO ANODIZE SCRUBBER TEST DATE 10-24-91

	TIME	AMPS		VOLTS	
	1550				2564.7
Test Begin	1557				2564.7
	1558	1	22	40	2565.5
	1559	1	10	44	2565.8
	1600	1	9	44	2566.1
	1602	1	9	44	2566.7
	1610	8	9	45	2569.5
	1620	10	8	45	2570.7
	1630	10	8	45	2573.3
	1640	10	8	44	2576.2
	1650	10	10	44	2579.0
	1655	5	12	43.5	2580.6
	1656	1	12	43.5	2580.9
	1657	1	12	43.5	2581.2
Test End	1658	1	12	43.5	2581.4
		60	9.3		16.5

Third Test
first Traverse

HELO ANODIZE SCRUBBER TEST DATE 10-24-91

	TIME	AMPS	VOLTS	
Test Begin	1817	1 25	40	2582.1
	1818	1 18	42	2582.5
	1819	1 12	44	2582.9
	1820	13 11	44	2583.2
	1833	12 8	45	2586.4
	1845	10 8	46	2589.0
	1855	10 7	46	2591.1
	1905	5 8	45	2593.3
	1910	5 8	45	2594.5
	1915	1 8	45	2595.8
	1916	1 8	45	2596.0
Test End	1917	8	45	2596.3
		60 9		14.2

Third Test
Second Traverse

HELO ANODIZE SCRUBBER TEST DATE 10-24-91

	TIME	AMPS	VOLTS	AMP-Hours
Test Start	1938	1 60	10	2596.4
	1939	1 24	42	2597.5
	1940	10 12	44	2597.8
	1950	10 10	45	2600.4
	2000	10 10	44	2603.0
	2010	10 10	41	2606.6
	2020	10 10	41	2610.7
	2030	7 16	40.5	2615.1
	2037	1 16	40.	2618.2
Test End	2038	16	40	2618.6
		60 12.2		22.2

Source category: Electroplating
Plant name : NAS North Island NADEP
Process : Chromic acid anodizing

Filename: REF_4-83.WQ1
Location: San Diego, CA
Test date: 10/22-10/24/91

Date: 04/17/96
Ref. No.: 4-83
Process rate basis: Tank surface area

Tank type	Type of control	Pollutant	Run No.	Test Meth.	Samp. time, min	Isokin. %	Gas volume, DSCF	Volum. flow rate, DSCFM	Mass, ug	Concen., gr/DSCF	Emission rate, lb/hr	Process rate, ft2	Emission factor g/hr-m2	Emission factor gr/hr-ft2	Rat.
Chromic acid anodizing (C2)	PBS/FS	total Cr	1	CARB 425	120	97.4	95.00	46,840	0.69	1.12E-07	4.5E-05	73	0.0030	0.0043	
		total Cr	2		120	99.9	101.80	48,950	1.16	1.76E-07	7.4E-05	73	0.0050	0.0071	
		total Cr	3		120	98.8	94.90	46,140	0.48	7.81E-08	3.1E-05	73	0.0021	0.0030	
		Average								1.22E-07			0.0034	0.0048	B
		Cr+6	1	CARB 425	120	97.4	95.00	46,840	0.11	1.79E-08	7.2E-06	73	0.00048	0.00069	
		Cr+6	2		120	99.9	101.80	48,950	0.14	2.12E-08	8.9E-06	73	0.00060	0.00086	
		Cr+6	3		120	98.8	94.90	46,140	0.11	1.79E-08	7.1E-06	73	0.00048	0.00068	
		Average								1.90E-08			0.00052	0.00075	B
Chromic acid anodizing (Helo Blade)	PBS/FS	total Cr	1	CARB 425	120	99.7	124.70	1,018	23.70	2.93E-06	2.6E-05	31	0.0040	0.0057	
		total Cr	2		120	95.3	103.70	963	17.00	2.53E-06	2.1E-05	31	0.0033	0.0047	
		total Cr	3		120	97.7	106.90	968	4.80	6.93E-07	5.7E-06	31	0.00090	0.0013	
		total Cr	4		120	99.8	113.70	1,010	43.90	5.96E-06	5.2E-05	31	0.0080	0.012	
		Average								3.03E-06			0.0040	0.0058	D
		Cr+6	1	CARB 425	120	99.7	124.70	1,018	21.60	2.67E-06	2.3E-05	31	0.0036	0.0052	
		Cr+6	2		120	95.3	103.70	963	11.90	1.77E-06	1.5E-05	31	0.0023	0.0033	
		Cr+6	3		120	97.7	106.90	968	3.39	4.89E-07	4.1E-06	31	0.00063	0.00091	
		Cr+6	4		120	99.8	113.70	1,010	30.70	4.17E-06	3.6E-05	31	0.0056	0.0081	
		Average								2.28E-06			0.0030	0.0044	D

Notes:
Helo Blade line data rated D because scrubber malfunction suspected.
Cr+6 analysis by ion chromatography.
Emissions controlled with packed bed scrubber and fume suppresant.