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SOURCE

EMISSION

EVALUATION

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Prepared For:

BOEING COMPANY
PLANT 2
CHROMIC ACID ANODIZING TANK 5A
SEATTLE, WASHINGTON
AUGUST-DECEMBER 1989

Submitted by:

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We certify that the information contained herein is accurate and complete to the best of our knowledge.

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INTRODUCTION

The purpose of this testing program performed at the Boeing Company's Plant No. 2 in Seattle, Washington was to quantify the hexavalent chromium (Cr^{+6}) and total chromium (Cr) emissions exhausted from the #5A chromic acid anodizing tank which is one of the tanks in the 80 anodic tank line located in the 210 Building. The fumes which result from the plating process are controlled by blowing air horizontally across the top of the tank and pulling off the fumes through ductwork with an axial fan to the exhaust stack. The plating cycle takes 55 minutes during which the vat is heated to a temperature of approximately 95° F. Samples were collected over a four (4) month period as coordination would allow.

Three (3) samples were collected while no parts were in the bath (passive or "blank" runs) on August 22, August 29, and September 19, 1989. Eight (8) samples were collected during anodizing cycles on August 22, August 31, September 19, November 30 and December 1, 1990. Three (3) particle size distribution (droplet size) samples were collected during anodizing cycles on August 31 and November 30, 1989. An ambient workroom sample was collected over a 6.5 hour period on August 31, 1989. Samples of the acid in the bath were collected on September 19 and December 1, 1989.

As part of this study, the ventilation system which pulls off air at the surface of the acid bath into vents along one side of the tank was evaluated by measuring the gas velocity at the individual air vents. The velocity was measured on August 22, August 31 and November 30, 1989.

The chromium sample method used is similar to EPA Method 5, which is detailed in the Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A. The sample train was modified to exclude the front-half filter and utilized 0.1 N sodium hydroxide (NaOH) solution in the first two (2) impingers, followed by an impinger containing 0.1 N nitric acid (HNO_3), followed by an empty impinger, a final back-half Teflon^R filter to collect any chromium which might break through the absorbing liquid, and a bubbler containing indicating silica gel desiccant. EPA Methods 1-4 were also performed during each chromium test. Methods 1 and 2 were performed to measure the stack gas velocity, temperature and volumetric flow rate. Method 3 was used to calculate the molecular weight of the stack gas. Method 4 was performed to measure the moisture content of the stack gas.

Mr. Kris A. Hansen, Mr. James A. Guenthoer, Mr. K. Steven Mackey, Ms. Jan M. Widmeyer and Ms. Angela F. Blaisdell of Am Test, Inc.'s Air Quality Division based in Redmond, Washington performed the field sampling, data reduction, and final report preparation. Am Test, Inc.'s Trace Metals Division performed the hexavalent chromium and chromium analysis. Mr. Paul Siebenaler coordinated this project for Boeing Aerospace & Electronics.

PRESENTATION OF RESULTS

This report is divided into separate sections for each type of test conducted. Please refer to the Table of Contents to locate information for a specific type of sample. Within each section a summary sheet is included for each run. On the summary sheet the chromium emission concentration is presented in units of milligrams per dry standard cubic meter (mg/dscm) and in parts per million (ppm). The chromium emission rate is presented in units of pounds per hour (lb/hr) and the chromium emission factor is presented in units of milligrams per amphere-hour (mg/amp-hr). Airflow is also presented in units of dry standard cubic feet per minute (dscf/min). The corresponding computer printout and field data sheet follow each summary sheet for each run. The run numbers indicate the run number on a particular test day, not the total number of runs of a particular sample type. The appropriate process information data sheet follows the field data sheet, where applicable. Laboratory analysis results are included in Appendix A of this report. Example calculations of results are included in Appendix B of this report.

In some cases the hexavalent chromium concentrations were greater than the total chromium concentrations. The explanation is that there is a difference in accuracy between the 2 analytical methods (colorimetric versus ICP). The ICP method would likely be the more accurate method.

A brief summary of the chromium tests conducted without parts in the bath and with parts in the bath is presented in Table 1 below.

Table 1. Summary of results from chromium emissions tests conducted at the #5A chromic acid anodizing tank at Boeing Plant 2.

Date	Time	Condition	Hex. Chromium mg/dscm	Hex. Chromium mg/amp-hr	Total Chromium mg/dscm	Total Chromium mg/amp-hr
8/22	1521-1722	Bath Off	0.109	--	0.094	--
8/29	1008-1209	Bath Off	0.105	--	0.096	--
9/19	1022-1223	Bath Off	0.008	--	0.018	--
8/22	1045-1148	Bath On	1.235	23.8	0.805	15.5
8/22	1401-1503	Bath On	1.389	25.7	0.759	14.0
8/31	1215-1315	Bath On	0.438	33.6	0.431	33.1
8/31	1558-1659	Bath On	0.457	36.4	0.418	33.3
9/19	1300-1401	Bath On	0.947	17.7	0.916	17.1
11/30	0803-0904	Bath On	0.261	6.19	0.280	6.64
11/30	1546-1649	Bath On	0.416	8.23	0.423	8.36
12/1	0729-0831	Bath On	0.263	5.94	0.273	6.17
Average			0.512	19.7	0.410	16.8

22.44 old solution

6.79 fresh solution

SECTION 1
"BLANK" RUNS
(NO PARTS IN BATH)

Sample Type:	**Bath Off - Blank Run 1**
Sampling Date:	**August 22, 1989**
Sample Times:	**15:21-17:22 (120 minutes)**
Run Number:	**3**
Lab Numbers:	**915092, 915095, 915099, 915102**
Airflow:	**20,499 dscf/min**
Hexavalent Chromium	
Concentration:	**0.109 mg/dscm**
Concentration:	**0.05 ppm**
Emission Rate:	**3802.6 mg/hr**
Total Chromium	
Concentration:	**0.094 mg/dscm**
Concentration:	**0.04 ppm**
Emission Rate:	**3261.7 mg/hr**

METHOD 1-5 - HEXAVALENT AND TOTAL CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	1BO#5CR3	LAB #:	915092
CLIENT:	BOEING PLANT #2	START TIME:	15:21 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	17:22 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	120.0 MINUTES
SAMPLE DATE:	AUGUST 22, 1989	CONDITION:	BATH OFF
RUN #:	3-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
905.2	890.8	14.4
381.9	379.7	2.2
473.1	470.2	2.9
745.0	725.6	19.4
TOTAL H2O GAIN:		38.9
TOTAL VOLUME (SCF)		1.83
PERCENT MOISTURE:		1.68
Bws:		0.0168

PITOT Cp:	0.84
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	90.9
BAROM. PRES. "HG:	30.04
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.04
ORIFICE PRES "H2O:	1.322
METER PRES. "HG:	30.14

INIT. METER VOL.:	475.221
FINAL METER VOL.:	587.407
VOLUME SAMPLED:	112.186
STD VOLUME (DSCF):	107.545
STD VOLUME (DSCM):	3.046
Y FACTOR:	0.993

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.67

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE 1	0.19	87	NW 1	0.18	87
2	0.27	87	2	0.28	88
3	0.28	87	3	0.32	89
4	0.28	88	4	0.28	88
5	0.26	87	5	0.27	88
6	0.19	87	6	0.21	88

PERCENT ISOKINETICS:	103 %		
STACK TEMPERATURE:	87.6 DEG. F.		547.6 DEG. R.
AVERAGE VELOCITY HEAD:	0.249 " OF H2O		
STACK GAS VELOCITY:			28.56 FT/SEC.
STACK GAS AIR FLOW:	21535.4 ACF/MIN.		20498.8 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	332.5
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.109
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.05
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	3802.6

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	285.2
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.15
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.094
TOTAL CHROMIUM IN SAMPLE (ppm):	0.04
TOTAL CHROMIUM EMISSION RATE (mg/hr):	3261.7

AT

TRAVERSE SAMPLING DATA

Page 1 of 1

1B0#5Cr3 915092

Client Boeing - Plnt 2
Date 8-22-89
Sample Location Bldg 2-10 Tank #5 Exhaust
Operators JAB - KSW
Sample Box # C
Run# 3

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm 1.01 / ____
Leak Test Vac 19 / ____
____ Pitots, Pretest
____ Pitots, Postest
____ Orsat Sampling System
____ Tedlar Bag
____ Thermocouple @ ____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter ____
Distance Upstream ____
Distance Downstream ____

Filter # ____ tare ____ mgs

	Final Wt.		Initial Wt.		Net Wt.
#1 Bubbler (NaOH)	905.2	-	890.8	=	____
#2 Impinger (HNO3)	381.9	-	379.7	=	____
#3 Bubbler (H2O)	473.1	-	470.2	=	____
#4 Silica Gel	745.0	-	725.6	=	____

TOTAL WATER VOLUME ____

Start Time 1521
Stop Time 1720
Barometric Pressure "Hg 29.63
Static Pres "H_2O ____
Production Rate BATHOFF

NOMOGRAPH SETUP

% Moisture ____
Meter Temp. ____
Stack Temp. ____
ΔH@ ____ Y ____
Pitot# ____ Side# ____
Cp ____
Nozzle Diameter ____
K Factor ____
Reference ΔP ____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp°F In	Gas Meter Temp°F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NW 1	0	575.221	.19	.99	.99	87	88	5"		68	87
2	10		.27	1.41	1.41	92	88	6"	NR	67	87
3	20		.28	1.48	1.48	95	88	7"		64	87
4	30		.28	1.48	1.48	92	88	7"		65	88
5	40		.24	1.27	1.27	92	89	6"		66	87
6	50		.19	1.00	1.00	92	89	6		67	87
NE 1	60		.18	.95	.95	94	89	6		68	87
2	70		.28	1.48	1.48	95	89	7"		66	88
3	80		.32	1.69	1.69	96	89	8"		66	89
4	90		.28	1.48	1.48	95	87	7"		67	88
5	100		.27	1.42	1.42	92	85	7		67	88
6	110		.21	1.11	1.11	91	82	6"		68	88
END	120	587.407									

1.322 90.9

Sample Type:	**Bath Off - Blank Run 2**
Sampling Date:	**August 29, 1989**
Sample Times:	**10:08-12:09 (120 minutes)**
Run Number:	**1**
Lab Numbers:	**915486, 915487, 915489, 915491**
Airflow:	**21,403 dscf/min**
Hexavalent Chromium	
Concentration:	**0.105 mg/dscm**
Concentration:	**0.05 ppm**
Emission Rate:	**3818.9 mg/hr**
Total Chromium	
Concentration:	**0.096 mg/dscm**
Concentration:	**0.04 ppm**
Emission Rate:	**3492.5 mg/hr**

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	2BO#5CR1	LAB #:	915486
CLIENT:	BOEING PLANT #2	START TIME:	10:08 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	12:09 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	120.0 MINUTES
SAMPLE DATE:	AUGUST 29, 1989	CONDITION:	BATH OFF
RUN #:	1-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1263.4	1251.8	11.6
634.2	631.9	2.3
478.7	473.9	4.8
772.8	746.1	26.7
TOTAL H2O GAIN:		45.4
TOTAL VOLUME (SCF)		2.14
PERCENT MOISTURE:		1.88
Bws:		0.0188

PITOT Cp:	0.840
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	78.5
BAROM. PRES. "HG:	30.04
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.04
ORIFICE PRES "H2O:	1.403
METER PRES. "HG:	30.14

INIT. METER VOL.:	734.162
FINAL METER VOL.:	847.802
VOLUME SAMPLED:	113.640
STD VOLUME (DSCF):	111.469
STD VOLUME (DSCM):	3.157
Y FACTOR:	0.993

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.65

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.22	81	NE 1	0.23	82
2	0.27	82	2	0.29	82
3	0.30	82	3	0.33	83
4	0.29	82	4	0.29	84
5	0.26	82	5	0.29	84
6	0.21	83	6	0.27	85

PERCENT ISOKINETICS:	102 %	
STACK TEMPERATURE:	82.7 DEG. F.	542.7 DEG. R.
AVERAGE VELOCITY HEAD:	0.270 " OF H2O	
STACK GAS VELOCITY:		29.62 FT/SEC.
STACK GAS AIR FLOW:	22330.2 ACF/MIN.	21402.8 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	331.5
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.105
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.05
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	3818.9

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	301.2
TOTAL CHROMIUM CONC. ON FILTER (ug):	2.0
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.096
TOTAL CHROMIUM IN SAMPLE (ppm):	0.04
TOTAL CHROMIUM EMISSION RATE (mg/hr):	3492.5

AT

2B [illegible] 4154 TRAVERSE SAMPLING DATA

Page 1 of 1

Client BOEING
Date 8-29-89
Sample Location BLDG 2-10
[illegible] STACK
Operators [illegible]
Sample Box # 17
Run# [illegible]

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter
Distance Upstream
Distance Downstream

Start Time 1009
Stop Time 1207
Barometric Pressure "Hg 29.63
Static Pres "H_2O
Production Rate
BATH OFF

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm 4.01 / .007
Leak Test Vac 16 / 17
[illegible] Pitots, Pretest
[illegible] Pitots, Postest
[illegible] Orsat Sampling System
[illegible] Tedlar Bag
[illegible] Thermocouple @ [illegible] °F

Filter # [illegible] tare [illegible] mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 NaCl Bubbler	1263.4	1251.2	
#2 H2O Impinger	634.2	631.9	
#3 MT Bubbler	478.7	473.9	
#4 Silica Gel	772.8	746.1	

TOTAL WATER VOLUME

NOMOGRAPH SETUP

% Moisture 2
Meter Temp. 75
Stack Temp. 80
ΔH@ .942 Y .993
Pitot# AG Side# A
Cp .840
Nozzle Diameter .313
K Factor 5.18
Reference ΔP

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NOZ	0	734.162	.22	1.14	1.14	66	64	6½		67	81
2	10		.27	1.40	1.40	74	64	7		61	82
3	20		.30	1.56	1.56	80	70	8½	N/A	61	82
4	30		.29	1.50	1.50	83	72	8½		58	82
5	40		.26	1.35	1.35	85	74	7		59	82
6	50		.21	1.09	1.09	85	76	6		59	83
WE 1	60		.23	1.19	1.19	83	76	6½		60	82
2	70		.29	1.50	1.50	85	77	8		61	82
3	80		.33	1.71	1.71	88	79	9½		62	83
4	90		.29	1.50	1.50	89	79	8		64	84
5	100		.29	1.50	1.50	88	80	8		60	84
6	110		.27	1.40	1.40	88	80	7½		65	85
EXP	120	847.802									

1403 78.5

Sample Type:	**Bath Off - Blank Run 3**
Sampling Date:	**September 19, 1989**
Sample Times:	**10:22-12:23 (120 minutes)**
Run Number:	**1**
Lab Numbers:	**917067, 917068, 917069, 917077**
Airflow:	**20,651 dscf/min**
Hexavalent Chromium	
Concentration:	**0.008 mg/dscm**
Concentration:	**0.004 ppm**
Emission Rate:	**272.0 mg/hr**
Total Chromium	
Concentration:	**0.018 mg/dscm**
Concentration:	**0.009 ppm**
Emission Rate:	**645.4 mg/hr**

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	4BO#5CR1	LAB #:	917077
CLIENT:	BOEING PLANT #2	START TIME:	10:22 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	12:23 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	120.0 MINUTES
SAMPLE DATE:	SEPTEMBER 19, 1989	CONDITION:	BATH OFF
RUN #:	1-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
448.5	454.9	-6.4
480.5	464.0	16.5
434.9	429.1	5.8
320.1	318.0	2.1
686.0	669.9	16.1
TOTAL H2O GAIN:		34.1
TOTAL VOLUME (SCF)		1.61
PERCENT MOISTURE:		1.51
Bws:		0.0151

PITOT Cp:	0.84
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	74.6
BAROM. PRES. "HG:	30.24
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.24
ORIFICE PRES "H2O:	1.255
METER PRES. "HG:	30.33

INIT. METER VOL.:	444.328
FINAL METER VOL.:	550.148
VOLUME SAMPLED:	105.820
STD VOLUME (DSCF):	105.212
STD VOLUME (DSCM):	2.980
Y FACTOR:	0.993

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.69

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.20	78	NE 1	0.21	78
2	0.23	78	2	0.27	79
3	0.27	78	3	0.31	80
4	0.27	79	4	0.27	81
5	0.24	79	5	0.26	82
6	0.20	79	6	0.24	83

PERCENT ISOKINETICS:	100 %	
STACK TEMPERATURE:	79.5 DEG. F.	539.5 DEG. R.
AVERAGE VELOCITY HEAD:	0.246 " OF H2O	
STACK GAS VELOCITY:		28.11 FT/SEC.
STACK GAS AIR FLOW:	21196.6 ACF/MIN.	20651.0 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	23.1
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.008
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.004
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	272.0

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	54.6
TOTAL CHROMIUM CONC. ON FILTER (ug):	0.175
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.018
TOTAL CHROMIUM IN SAMPLE (ppm):	0.009
TOTAL CHROMIUM EMISSION RATE (mg/hr):	645.4

AT

TRAVERSE SAMPLING DATA

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4BOA-SCR 1 917077

Client Boeing Plant 2
Date 9/19/89
Sample Location Tank #5 Vent Stack (Bath Off Test)
Operators RSM/JAG
Sample Box # Blue 1
Run # 1 — Chromium/Hex Chrome Sampler Train

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .005 / .004
Leak Test Vac 20 / 15"
✓ Pitots, Pretest
✓ Pitots, Postest
✓ Orsat Sampling System
✓ Tedlar Bag
✓ Thermocouple @ ____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter ____
Distance Upstream ____
Distance Downstream ____

Filter # N/A tare ____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 NaOH Bubbler	448.5	454.9	- ____
#2 NaOH Impinger	460.5	464.0	- ____
#3 HNO3 Bubbler	434.9	429.1	- ____
#4 MT Silica Gel	320.1	318.0	
	6886.0	6869.9	= ____

TOTAL WATER VOLUME ____

Start Time 10:22
Stop Time 12:23
Barometric Pressure "Hg 30.24 / 768 mm
Static Pres "H_2O -0.02
Production Rate ____
BATH - OFF

NOMOGRAPH SETUP

% Moisture ____
Meter Temp. ____
Stack Temp. 78
ΔH@ .993 Y .993
Pitot # 4' Glass Side # ____
Cp .84
Nozzle Diameter .313
K Factor ____
Reference ΔP ____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
West 1	0	444.328	.20	1.01	1.01	60	59	2.8	—	55	78
2	10		.23	1.17	1.17	66	60	3.1	—	49	78
3	20		.27	1.37	1.37	70	62	3.1	—	51	78
4	30		.27	1.37	1.37	75	65	3.1	—	50	79
5	40		.24	1.22	1.22	79	68	3.0	—	51	79
6	50		.20	1.01	1.01	81	71	2.9	—	52	79
North 1	60		.21	1.06	1.06	81	73	2.9	—	55	78
2	70		.27	1.37	1.37	84	75	3.1	—	53	79
3	80		.31	1.57	1.57	86	77	3.4	—	54	80
4	90		.27	1.37	1.37	88	78	3.3	—	52	81
5	100		.26	1.32	1.32	87	79	3.2	—	53	82
6	110		.24	1.22	1.22	87	79	3.1		200	83
	120	550.148									

1.255 / 74.6 ✓

SECTION 2
BATH ON RUNS
(PARTS IN BATH)

Sample Type:	**Bath On - Run 1**
Sampling Date:	**August 22, 1989**
Sample Times:	**10:45-11:48 (60 minutes)**
Run Number:	**1**
Lab Numbers:	**915089, 915090, 915093, 915097 915100**
Airflow:	**20,704 dscf/min**
Process Data	
Bath Amperage:	**1825 amp-hr/hr**
Voltage:	**22.7 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**74° F**
Hexavalent Chromium	
Concentration:	**1.235 mg/dscm**
Concentration:	**0.57 ppm**
Emission Rate:	**43,457 mg/hr**
Emission Factor:	**23.8 mg/amp-hr**
Total Chromium	
Concentration:	**0.805 mg/dscm**
Concentration:	**0.37 ppm**
Emission Rate:	**28,305 mg/hr**
Emission Factor:	**15.5 mg/amp-hr**

METHOD 1-5 - HEXAVALENT AND TOTAL CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	1BO#5CR1	LAB #:	915090
CLIENT:	BOEING PLANT #2	START TIME:	10:45 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	11:48 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	AUGUST 22, 1989	CONDITION:	BATH ON
RUN #:	1-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1252.3	1246.9	5.4
628.3	628.2	0.1
472.5	471.4	1.1
722.0	711.9	10.1
TOTAL H2O GAIN:		16.7
TOTAL VOLUME (SCF)		0.79
PERCENT MOISTURE:		1.45
Bws:		0.0145

PITOT Cp:	0.84
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	75.0
BAROM. PRES. "HG:	30.04
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.04
ORIFICE PRES "H2O:	1.278
METER PRES. "HG:	30.13

INIT. METER VOL.:	364.682
FINAL METER VOL.:	418.957
VOLUME SAMPLED:	54.275
STD VOLUME (DSCF):	53.570
STD VOLUME (DSCM):	1.517
Y FACTOR:	0.993

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.20	78	NE 1	0.19	78
2	0.25	79	2	0.27	78
3	0.27	78	3	0.31	78
4	0.28	78	4	0.28	79
5	0.26	78	5	0.26	80
6	0.20	78	6	0.23	80

PERCENT ISOKINETICS:	101 %		
STACK TEMPERATURE:	78.5 DEG. F.		538.5 DEG. R.
AVERAGE VELOCITY HEAD:	0.249 " OF H2O		
STACK GAS VELOCITY:			28.30 FT/SEC.
STACK GAS AIR FLOW:	21340.7 ACF/MIN.		20704.1 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	1874.0
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	1.235
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.57
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	43456.5
AMPHERE HOURS PER HOUR (amp-hr/hr):	1825
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	23.8

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	1220.6
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.15
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.805
TOTAL CHROMIUM IN SAMPLE (ppm):	0.37
TOTAL CHROMIUM EMISSION RATE (mg/hr):	28304.7
AMPHERE HOURS PER HOUR (amp-hr/hr):	1825
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	15.5

(BOATCr) 915090 TRAVERSE SAMPLING DATA Page 1 of 1

Client BOEING - PLT #2
Date 8-22-89
Sample Location Bldg 2-10 TANK #5 Exhaust
Operators JAG - KSM
Sample Box # H
Run # 1 - Cr

SCHEMATIC TRAVERSE LAYOUT

Start Time 1045
Stop Time 11:48
Barometric Pressure "Hg 30.04 - 723mm
Static Pres "H_2O
Production Rate
BATH ON

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm 2.02 / <.01
Leak Test Vac 5 / 11"
Pitots, Pretest
Pitots, Postest
Orsat Sampling System
Tedlar Bag
Thermocouple @ °F

Stack Diameter 48" ø
Distance Upstream
Distance Downstream

Filter # tare mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (NaOH)	1252.3	1246.9	
#2 Impinger (HNO_3)	628.3	628.2	
#3 Bubbler (MT)	472.5	471.4	
#4 Silica Gel	722.0	711.9	

TOTAL WATER VOLUME 16.7

NOMOGRAPH SETUP

% Moisture 2
Meter Temp. 70
Stack Temp. 80
ΔH@ .943 Y .993
Pitot # 4 Side # A
Cp .84
Nozzle Diameter .313
K Factor 5.14
Reference ΔP

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NW 1	0	369.682	.20	1.03	1.03	66	66	5½		66	78
2	5		.25	1.28	1.28	72	66	6½	N/A	58	79
3	10		.22	1.39	1.39	74	67	7		61	78
4	15		.28	1.43	1.43	78	68	7½		61	78
5	20		.26	1.34	1.34	80	69	7		61	78
6	25		.20	1.03	1.03	81	70	5.5		60	78
NE 1	30		.19	.98	.98	78	72	5		59	78
2	35		.27	1.39	1.39	82	73	7.0		58	79
3	40		.31	1.59	1.59	84	74	8.5		58	78
4	45		.28	1.43	1.43	85	74	7.5		60	79
5	50		.26	1.34	1.34	85	75	7.0		60	80
6	55		.23	1.18	1.18	85	76	6.0		60	80
END	60	418.957									

1.278 75.0

August 22, 1989

	Time	Amps
Run 1:	1050	200
	1055	1820
	1100	1820
	1105	1820
	1110	1820
	1115	1820
	1120	1820
	1145	1820

Cycle is 55 minutes

1825 $\frac{\text{amp-hr}}{\text{hr}}$

ambient temp 74°F

	Time	Amps	
Run 2:	1400	0	
	1401	200	3 min.
	1403	1820	
	1405	1820	
	1407	1820	
	1410	1820	
	1415	1820	
	1420	1820	52 min.
	1425	1820	
	1430	1820	
	1435	1820	
	1440	1820	
	1445	1820	
	1450	1820	
	1455	1820	

Sample Calculation - Run 2

$(3\text{min} * 200\text{amps} + 52\text{min} * 1820\text{amps}) / 55\text{min} * \frac{60\text{min/hr}}{55\text{min}}$

$= 1889$ amp-hr/hr

Sample Type:	**Bath On - Run 2**
Sampling Date:	**August 22, 1989**
Sample Times:	**14:01-15:03 (60 minutes)**
Run Number:	**2**
Lab Numbers:	**915091, 915094, 915098, 915101**
Airflow:	**20,555 dscf/min**
Process Data	
Bath Amperage:	**1889 amp-hr/hr**
Voltage:	**22.7 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**83° F**
Hexavalent Chromium	
Concentration:	**1.389 mg/dscm**
Concentration:	**0.64 ppm**
Emission Rate:	**48,503 mg/hr**
Emission Factor:	**25.7 mg/amp-hr**
Total Chromium	
Concentration:	**0.759 mg/dscm**
Concentration:	**0.35 ppm**
Emission Rate:	**26,494 mg/hr**
Emission Factor:	**14.0 mg/amp-hr**

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	1BO#5CR2	LAB #:	915091
CLIENT:	BOEING PLANT #2	START TIME:	14:01 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	15:03 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	AUGUST 22, 1989	CONDITION:	BATH ON
RUN #:	2-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1253.0	1247.1	5.9
624.8	623.6	1.2
532.0	531.5	0.5
833.0	822.8	10.2
TOTAL H2O GAIN:		17.8
TOTAL VOLUME (SCF)		0.84
PERCENT MOISTURE:		1.55
Bws:		0.0155

PITOT Cp:	0.84
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	85.9
BAROM. PRES. "HG:	30.04
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.04
ORIFICE PRES "H2O:	1.294
METER PRES. "HG:	30.14

INIT. METER VOL.:	419.767
FINAL METER VOL.:	474.771
VOLUME SAMPLED:	55.004
STD VOLUME (DSCF):	53.208
STD VOLUME (DSCM):	1.507
Y FACTOR:	0.993

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE 1	0.21	86	NW 1	0.18	86
2	0.27	86	2	0.26	86
3	0.31	85	3	0.28	86
4	0.27	85	4	0.27	85
5	0.26	85	5	0.25	85
6	0.24	86	6	0.20	84

PERCENT ISOKINETICS:	102 %		
STACK TEMPERATURE:	85.4 DEG. F.		545.4 DEG. R.
AVERAGE VELOCITY HEAD:	0.249 " OF H2O		
STACK GAS VELOCITY:			28.49 FT/SEC.
STACK GAS AIR FLOW:	21482.2 ACF/MIN.		20555.4 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	2092.5
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	1.389
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.642
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	48502.8
AMPHERE HOURS PER HOUR (amp-hr/hr):	1889
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	25.7

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	1143.0
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.18
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.759
TOTAL CHROMIUM IN SAMPLE (ppm):	0.35
TOTAL CHROMIUM EMISSION RATE (mg/hr):	26494.0
AMPHERE HOURS PER HOUR (amp-hr/hr):	1889
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	14.0

AT

1BO#5Cr1 9/5091 TRAVERSE SAMPLING DATA Page 1 of _____

Client BOEING-PLNT #2
Date 8-22-89
Sample Location BLDG 2-10
TANK #5 Exhaust
Operators JAG-RSM
Sample Box # B
Run # 2 - Cr

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter _____
Distance Upstream _____
Distance Downstream _____

Start Time 14:01
Stop Time 1505
Barometric Pressure "Hg 763
Static Pres "H_2O _____
Production Rate _____
BATH - ON

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .02/.01
Leak Test Vac 12/18
_____ Pitots, Pretest
_____ Pitots, Postest
_____ Orsat Sampling System
_____ Tedlar Bag
_____ Thermocouple @ _____ °F

Filter # _____ tare _____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (NaOH)	1253.0	- 1247.1 =	
#2 Impinger (HNO_3)	624.8	- 623.6 =	
#3 Bubbler (MT)	532.0	- 531.5 =	
#4 Silica Gel	833.0	- 822.8 =	

TOTAL WATER VOLUME _____

NOMOGRAPH SETUP

% Moisture 2
Meter Temp. _____
Stack Temp. _____
ΔH@ .993 Y .993
Pitot # _____ Side # _____
Cp .84
Nozzle Diameter .313
K Factor _____
Reference ΔP _____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NE 1	0	474.767	.21	1.08	1.08	77	77	7		60	86
2	5		.27	1.39	1.39	81	78	8		55	86
3	10		.31	1.59	1.59	83	79	10	N/A	57	85
4	15		.27	1.39	1.39	87	79	8		59	85
5	20		.26	1.34	1.34	90	81	8		59	85
6	25		.24	1.23	1.23	91	82	7.5		59	86
NW 1	30		.18	.92	.92	89	83	5½		64	86
2	35		.26	1.36	1.36	91	84	8		59	86
3	40		.28	1.46	1.46	94	85	9		60	86
4	45		.27	1.41	1.41	96	86	8½		62	85
5	50		.25	1.31	1.31	97	87	8		62	85
6	55		.20	1.05	1.05	98	88	7		63	84
END	60	474.771									

1.294 85.9

August 22, 1989

	Time	Amps
Run 1:	1050	200
	1055	1820
	1100	1820
	1105	1820
	1110	1820
	1115	1820
	1120	1820
	1145	1820

Cycle is 55 minutes

1825 amp-hr / hr

	Time	Amps	
Run 2:	1400	0	3 min.
	1401	200	
	1403	1820	52 min.
	1405	1820	
	1407	1820	
	1410	1820	
	1415	1820	
	1420	1820	
	1425	1820	
	1431	1820	
	1435	1820	
	1440	1820	
	1445	1820	
	1450	1820	
	1455	1820	

Sample Calculation - Run 2

(3 min * 200 amps + 52 min * 1820 amps) / 55 min * 60 min/hr / 55 min

= 1889 amp-hr/hr

ambient temp 83°F
bath temp 94°F
temp. above tank 86°F

Sample Type:	**Bath On - Run 3**
Sampling Date:	**August 31, 1989**
Sample Times:	**12:15-13:15 (60 minutes)**
Run Number:	**2**
Lab Numbers:	**915750, 915751, 915752, 915753 915754**
Airflow:	**21,546 dscf/min**
Process Data	
Bath Amperage:	**477 amp-hr/hr (small load)**
Voltage:	**21.8 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**82° F**
Hexavalent Chromium	
Concentration:	**0.438 mg/dscm**
Concentration:	**0.20 ppm**
Emission Rate:	**16,029 mg/hr**
Emission Factor:	**33.6 mg/amp-hr**
Total Chromium	
Concentration:	**0.431 mg/dscm**
Concentration:	**0.20 ppm**
Emission Rate:	**15,775 mg/hr**
Emission Factor:	**33.1 mg/amp-hr**

METHOD 1-5 - HEXAVALENT AND TOTAL CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	3BO#5CR2	LAB #:	915750
CLIENT:	BOEING PLANT #2	START TIME:	12:15 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	13:15 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	AUGUST 31, 1989	CONDITION:	BATH ON
RUN #:	2-CR+6		
OPERATORS:	GUENTHOER/WIDMEYER		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1188.1	1180.1	8.0
570.0	570.2	-0.2
480.6	480.8	-0.2
736.2	724.7	11.5
TOTAL H2O GAIN:		19.1
TOTAL VOLUME (SCF)		0.90
PERCENT MOISTURE:		1.59
Bws:		0.0159

INIT. METER VOL.:	2.263
FINAL METER VOL.:	58.832
VOLUME SAMPLED:	56.569
STD VOLUME (DSCF):	55.594
STD VOLUME (DSCM):	1.574
Y FACTOR:	0.993

PITOT Cp:	0.840
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	77.5
BAROM. PRES. "HG:	30.04
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.04
ORIFICE PRES "H2O:	1.418
METER PRES. "HG:	30.14

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.68

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.24	80	NE 1	0.24	83
2	0.30	80	2	0.28	83
3	0.33	81	3	0.31	83
4	0.29	82	4	0.31	84
5	0.26	83	5	0.29	84
6	0.24	83	6	0.19	83

PERCENT ISOKINETICS:	101 %	
STACK TEMPERATURE:	82.4 DEG. F.	542.4 DEG. R.
AVERAGE VELOCITY HEAD:	0.272 " OF H2O	
STACK GAS VELOCITY:		29.71 FT/SEC.
STACK GAS AIR FLOW:	22402.8 ACF/MIN.	21545.8 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	689.3
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.438
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.203
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	16028.6
AMPHERE HOURS PER HOUR (amp-hr/hr):	477
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	33.6

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	678.4
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.30
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.431
TOTAL CHROMIUM IN SAMPLE (ppm):	0.20
TOTAL CHROMIUM EMISSION RATE (mg/hr):	15774.9
AMPHERE HOURS PER HOUR (amp-hr/hr):	477
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	33.1

AT

115730 TRAVERSE SAMPLING DATA

Page 1 of _____

Client Boeing
Date 8.31.87
Sample Location T3 Leg 2-10
Tank #'s Exhaust
Operators JAG - JMW
Sample Box # C
Run # 2 Cr+6/Cr

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter _____
Distance Upstream _____
Distance Downstream _____

Start Time 1215
Stop Time 1315
Barometric Pressure "Hg 27.4
Static Pres "H_2O _____
Production Rate _____

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .027 .008
Leak Test Vac 15 / 20
✓ Pitots, Pretest
✓ Pitots, Postest
✓ Orsat Sampling System
✓ Tedlar Bag
_____ Thermocouple @ _____ °F

Filter # _____ tare _____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler	602.8 (585.3)	1180.1	= _____
#2 Impinger	570.2	570.2	= _____
#3 Bubbler	480.6	480.8	= _____
#4 Silica Gel	736.2	724.7	= _____

TOTAL WATER VOLUME _____

NOMOGRAPH SETUP

% Moisture _____
Meter Temp. _____
Stack Temp. _____
ΔH@ .942 Y .995
Pitot # _____ Side # _____
Cp .840
Nozzle Diameter .313
K Factor _____
Reference ΔP _____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NW 1	0	2,263	.24	1.20	1.28	70	70	6		64	80
2	5		.30	1.54	1.54	74	70	7		58	80
3	10		.33	1.69	1.69	79	71	7 W	N/A	63	81
4	15		.27	1.09	1.09	80	72	7		62	82
5	20		.26	1.34	1.34	82	73	6 1/4		60	82
6	25		.24	1.25	1.25	83	74	6		60	83
NE 1	30		.24	1.25	1.25	82	75	6		61	83
2	35		.28	1.46	1.46	84	76	7		58	83
3	40		.31	1.61	1.61	85	76	7 1/4		58	83
4	45		.31	1.61	1.61	86	77	7 1/4		60	84
5	50		.29	1.51	1.51	86	77	7		60	84
6	55		.19	.99	.99	85	77	6		60	83
END	60	8.832									

1.418 / 77.7

8/31/84

Run 7 (Method 6 for Al)

Parts into bath @ 12:13
Parts removed @ 1:09

Material into load is 3 rows of ~3/8" Tubing (6 tubes total)
Called Relatively Small Load ± this is why Amps —

55 min cycle

1	12:14	5 V	200 Amps
1 min	15	5 V	250 Amps
3 min	12:16	12.0 V	550 Amps
7 min	12:19	22.3 V	650 Amps
	12:26	22.9 V	450 Amps
	12:33	23.2 V	400 Amps
43 min	12:45	23.2 V	400 Amps
	12:53	23.2 V	400 Amps
	1:02	23.3 V	400 Amps
	1:09	0.5 V (off)	0 Amps

(1×200 + 1×250 + 3×550 + 8×650 + 43×400) / 55 × 60/55

94.0°F Bath Temp

82°F Ambient

477 Amp-hr / hr

1×5 + 1×5 + 3×12 + 7×22.3 + 7×22.9 + 36×23.2

21.9 volts

Third Anodizing Bath without stack testing:

Parts into bath @ 1:19
Parts removed from bath @ 2:14

23.2V 1820 Amps
94.0°F 84°F Ambient

Velocity Measurements after this Bath & Before Run #7:

Measured 2:40 - 2:50 PM

Opening #	Ft/min
1	2380
6	2230
11	1650
16	1700
21	1610
26	1390
31	720
36	1000
41	820
46	790
51	720
56	280

Sample Type:	**Bath On - Run 4**
Sampling Date:	**August 31, 1989**
Sample Times:	**15:58-16:59 (60 minutes)**
Run Number:	**3**
Lab Numbers:	**915755, 915756, 915757, 915758 915759**
Airflow:	**21,746 dscf/min**
Process Data	
Bath Amperage:	**464 amp-hr/hr (small load)**
Voltage:	**21.5 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**82° F**
Hexavalent Chromium	
Concentration:	**0.457 mg/dscm**
Concentration:	**0.21 ppm**
Emission Rate:	**16,873 mg/hr**
Emission Factor:	**36.4 mg/amp-hr**
Total Chromium	
Concentration:	**0.418 mg/dscm**
Concentration:	**0.19 ppm**
Emission Rate:	**15,463 mg/hr**
Emission Factor:	**33.3 mg/amp-hr**

METHOD 1-5 - HEXAVALENT AND TOTAL CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	380#5CR3	LAB #:	915755
CLIENT:	BOEING PLANT #2	START TIME:	15:58 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	16:59 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	AUGUST 31, 1989	CONDITION:	BATH ON
RUN #:	3-CR+6		
OPERATORS:	GUENTHOER/WIDMEYER		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
641.6	636.9	4.7
627.4	624.5	2.9
1162.8	1161.6	1.2
812.5	798.6	13.9
TOTAL H2O GAIN:		22.7
TOTAL VOLUME (SCF)		1.07
PERCENT MOISTURE:		1.85
Bws:		0.0185

PITOT Cp:	0.840
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	79.6
BAROM. PRES. "HG:	30.20
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.20
ORIFICE PRES "H2O:	1.447
METER PRES. "HG:	30.31

INIT. METER VOL.:	59.658
FINAL METER VOL.:	117.286
VOLUME SAMPLED:	57.628
STD VOLUME (DSCF):	56.717
STD VOLUME (DSCM):	1.606
Y FACTOR:	0.993

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.65

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.22	83	NE 1	0.24	83
2	0.29	83	2	0.31	84
3	0.31	81	3	0.33	84
4	0.31	82	4	0.31	84
5	0.26	83	5	0.29	84
6	0.22	83	6	0.25	84

PERCENT ISOKINETICS:	102 %	
STACK TEMPERATURE:	83.2 DEG. F.	543.2 DEG. R.
AVERAGE VELOCITY HEAD:	0.277 " OF H2O	
STACK GAS VELOCITY:		29.95 FT/SEC.
STACK GAS AIR FLOW:	22581.0 ACF/MIN.	21745.4 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	733.5
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.457
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.21
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	16873.4
AMPHERE HOURS PER HOUR (amp-hr/hr):	464
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	36.4

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	672.2
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.30
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.418
TOTAL CHROMIUM IN SAMPLE (ppm):	0.19
TOTAL CHROMIUM EMISSION RATE (mg/hr):	15463.3
AMPHERE HOURS PER HOUR (amp-hr/hr):	464
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	33.3

3 BOI#SCr3 915755 TRAVERSE SAMPLING DATA Page 1 of 1

Client Boeing
Date 8-31-89
Sample Location Bldg 2-10 Tank 5 Exhaust Stack
Operators
Sample Box # B
Run# 3

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter
Distance Upstream
Distance Downstream

Start Time 1558
Stop Time 1659
Barometric Pressure "Hg 30.20 / 767
Static Pres "H_2O
Production Rate
Bath On

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .01 / .004
Leak Test Vac 20 / 19
/ Pitots, Pretest
/ Pitots, Postest
Orsat Sampling System
Tedlar Bag
Thermocouple @ °F

Filter # 3 tare mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (Next 1HNO3)	641.6	636.9	
#2 Impinger (Next 1HNO3)	627.4	624.5	
#3 Bubbler	626.2	626.1	
#4 Silica Gel	536.6 / 812.5	535.5 / 799.6	

TOTAL WATER VOLUME

NOMOGRAPH SETUP

% Moisture
Meter Temp.
Stack Temp.
ΔH@ .993 Y .993
Pitot# Side#
Cp .840
Nozzle Diameter .313
K Factor
Reference ΔP

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
NW 1	0	54.658	.27	1.14	1.14	79	71	6½		65	83
2	5		.29	1.51	1.51	74	72	9	n/a	54	83
3	10		.31	1.61	1.61	77	72	9½		56	81
4	15		.31	1.61	1.61	79	74	9½		57	82
5	20		.26	1.35	1.35	84	76	8		59	83
6	25		.22	1.14	1.10	86	77	7		60	83
NE 1	30		.24	1.25	1.25	85	77	7½		60	83
2	35		.31	1.61	1.61	84	78	9½		58	84
3	40		.33	1.72	1.72	88	79	10		59	84
4	45		.31	1.61	1.61	89	79	9½		61	84
5	50		.29	1.51	1.51	88	80	9		61	84
6	55		.25	1.30	1.30	88	80	8		61	84
END	60	117.286									

1.447 79.6

1.2

8/31/81 Boeing Plant 2

Run 3

(Method 6 Cr⁺⁶) Parts Dipped into Tank 5 @ 3:58 PM

Power On @ 3:59 PM

Parts Removed from Tank @ 4:54 PM

Same Exact Type Load as Run 2 table

(46 tubes: 3X22@ 2 3/8)

93.5°F Bath

82°F Ambient

	3:59		
3 min	4:00	5.1 V	180 amps
4 min	4:02	17.0 V	750 amps
2 min	4:06	22.5 V	500 amps
26	4:08	22.7 V	420 amps
	4:10	22.8 V	420 amps
	4:34	23.0 V	400 amps
6 min	4:37	23.0 V	400 amps
7 min	4:40	23.0 V	390 amps
7 min	4:47	23.0 V	400 amps
	4:54		

$(3*180+4*750+2*500+26*420+13*400+7*390)/55 * 60/55 = 464$

$(3*5.1+4*17+2*22.5+2*22.7+24*22.8+20*23)/55 = 21.5\ V$

Sample Type:	**Bath On - Run 5**
Sampling Date:	**September 19, 1989**
Sample Times:	**13:00-14:01 (60 minutes)**
Run Number:	**2**
Lab Numbers:	**917070, 917071, 917072, 917078**
Airflow:	**20,402 dscf/min**
Process Data	
Bath Amperage:	**1853 amp-hr/hr**
Voltage:	**21.1 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**80° F**
Hexavalent Chromium	
Concentration:	**0.947 mg/dscm**
Concentration:	**0.44 ppm**
Emission Rate:	**32,818 mg/hr**
Emission Factor:	**17.7 mg/amp-hr**
Total Chromium	
Concentration:	**0.916 mg/dscm**
Concentration:	**0.42 ppm**
Emission Rate:	**31,747 mg/hr**
Emission Factor:	**17.1 mg/amp-hr**

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	4BO#5CR2	LAB #:	917078
CLIENT:	BOEING PLANT #2	START TIME:	13:00 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	14:01 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	SEPTEMBER 19, 1989	CONDITION:	BATH ON
RUN #:	2-CR+6		
OPERATORS:	GUENTHOER/MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
477.8	445.5	32.3
447.4	442.6	4.8
380.4	378.7	1.7
320.4	319.1	1.3
608.3	599.6	8.7
TOTAL H2O GAIN:		48.8
TOTAL VOLUME (SCF)		2.30
PERCENT MOISTURE:		4.06
Bws:		0.0406

PITOT Cp:	0.84
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	78.8
BAROM. PRES. "HG:	30.24
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.24
ORIFICE PRES "H2O:	1.336
METER PRES. "HG:	30.34

INIT. METER VOL.:	550.430
FINAL METER VOL.:	605.566
VOLUME SAMPLED:	55.136
STD VOLUME (DSCF):	54.402
STD VOLUME (DSCM):	1.541
Y FACTOR:	0.993

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE 1	0.20	82	NW 1	0.22	84
2	0.25	82	2	0.26	84
3	0.31	83	3	0.29	84
4	0.28	83	4	0.29	84
5	0.25	83	5	0.28	84
6	0.20	84	6	0.22	84

PERCENT ISOKINETICS:	105 %		
STACK TEMPERATURE:	83.4 DEG. F.		543.4 DEG. R.
AVERAGE VELOCITY HEAD:	0.253 " OF H2O		
STACK GAS VELOCITY:			28.72 FT/SEC.
STACK GAS AIR FLOW:	21654.3 ACF/MIN.		20402.1 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	1458.5
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.947
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.44
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	32818.1
AMPHERE HOURS PER HOUR (amp-hr/hr):	1853
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	17.7

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	1410.6
TOTAL CHROMIUM CONC. ON FILTER (ug):	0.275
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.916
TOTAL CHROMIUM IN SAMPLE (ppm):	0.42
TOTAL CHROMIUM EMISSION RATE (mg/hr):	31747.4
AMPHERE HOURS PER HOUR (amp-hr/hr):	1853
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	17.1

AT

TRAVERSE SAMPLING DATA

4B0 #5Cr2-917078

Client [redacted] (Plant #2)
Date 7-16-91
Sample Location [redacted]
#5 Chrome Tank Exhaust
Operators JMG - RSM
Sample Box # Blue 2
Run # 2-1

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .005 / .002
Leak Test Vac 15 / 15
Pitots, Pretest
Pitots, Postest
Orsat Sampling System
Tedlar Bag
Thermocouple @ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter
Distance Upstream
Distance Downstream

Filter # tare mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (NaOH)	447.8	445.5	
#2 Impinger (NaOH)	447.1	442.6	
#3 Bubbler (HNO3)	380.4	378.7	
#4 Silica Gel (MT)	608.3	599.6	
	320.4	319.1	

TOTAL WATER VOLUME

Start Time 1300
Stop Time 1401
Barometric Pressure "Hg 30.24" 768mm
Static Pres "H_2O -0.02
Production Rate

NOMOGRAPH SETUP

% Moisture
Meter Temp.
Stack Temp.
ΔH@ .943 Y .993
Pitot # Side #
Cp .84
Nozzle Diameter .313
K Factor
Reference ΔP

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
N 1	0	550.430	.20	1.04	1.04	73	44	4	N/A	63	82
2	5		.25	1.30	1.30	76	74	5		58	82
3	10		.31	1.62	1.62	80	75	6		57	83
4	15		.28	1.46	1.46	83	76	5½		57	83
5	20		.25	1.30	1.30	84	76	5		61	83
6	25		.20	1.15	1.15	84	77	4½		57	84
W 1	30		.22	1.15	1.15	83	78	4½		56	84
2	35		.26	1.36	1.36	86	76	5		56	84
3	40		.29	1.52	1.52	86	79	5½		58	84
4	45		.29	1.52	1.52	87	79	5½		56	84
5	50		.28	1.46	1.46	88	80	5½		58	84
6	55		.27	1.15	1.15	88	80	4½		58	84
END	60	605.566									

1.336 78.8

Boeing Plant 2 9/19/89 Mod-Smith
Chromic Acid Bath Tank #5 (Amps Amodized in Bath) Ambient Temp = 82°F
Parts into tank @ 12:59:30 Bath Temp 72.5°F
Out @ 1:55 PM (55 minute Anodize Cycle)

Time	Volts	Amps	Time	Volts	Amps
12:58	0.3	0	1:16	22.9	1810
12:59	0.3	0	1:17	22.9	1800
1:00PM	1.6	150	1:18	22.9	1800
1:01	6.8	1420	1:19	22.9	1810
1:02	11.8	1820	1:20	22.9	1810
1:03	17.0	1820	1:21	23.0	1810
1:04	21.3	1820	1:22	23.0	1810
1:05	22.4	1800	1:23	23.0	1810
1:06	22.5	1760	1:24	23.0	1810
1:07	22.6	1750	1:25	23.0	1820
1:08	22.7	1740	1:26	23.0	1810
1:09	22.7	1740	1:27	23.0	1810
1:10	22.7	1740	1:28	23.1	1810
1:11	22.7	1740	1:29	23.1	1820
1:12	22.8	1760	1:30	23.1	1810
1:13	22.9	1800	↓	↓	↓
1:14	22.8	1800	1:52	23.1	1810
1:15	22.8	1800			

22

1853 amp-hr / hr
21.1 volts

Sample Type:	**Bath On - Run 6**
Sampling Date:	**November 30, 1989**
Sample Times:	**08:03-09:04 (60 minutes)**
Run Number:	**1**
Lab Numbers:	**922093, 922094, 922095**
Airflow:	**22,740 dscf/min**
Process Data	
Bath Amperage:	**1628 amp-hr/hr**
Voltage:	**21.6 volts D.C.**
Bath Temperature:	**94° F**
Ambient Temperature:	**76° F**
Hexavalent Chromium	
Concentration:	**0.261 mg/dscm**
Concentration:	**0.12 ppm**
Emission Rate:	**10,077 mg/hr**
Emission Factor:	**6.19 mg/amp-hr**
Total Chromium	
Concentration:	**0.280 mg/dscm**
Concentration:	**0.13 ppm**
Emission Rate:	**10,813 mg/hr**
Emission Factor:	**6.64 mg/amp-hr**

Note: Acid in bath was drained and replaced prior to this test.

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	5BO#5CR1	LAB #:	922094
CLIENT:	BOEING PLANT #2	START TIME:	8:03 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	9:04 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	NOVEMBER 30, 1989	CONDITION:	BATH ON
RUN #:	1-CR+6		
OPERATORS:	S. MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1225.8	1245.5	-19.7
558.2	565.3	-7.1
515.4	514.0	1.4
756.9	749.7	7.2
TOTAL H2O GAIN:		-18.2
TOTAL VOLUME (SCF)		-0.86
PERCENT MOISTURE:		-1.47
Bws:		-0.0147

PITOT Cp:	0.842
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	74.5
BAROM. PRES. "HG:	30.40
STATIC PRES. "H2O:	-0.02
STACK PRES. "HG:	30.40
ORIFICE PRES "H2O:	3.078
METER PRES. "HG:	30.63

INIT. METER VOL.:	843.639
FINAL METER VOL.:	901.593
VOLUME SAMPLED:	57.954
STD VOLUME (DSCF):	59.304
STD VOLUME (DSCM):	1.680
Y FACTOR:	1.012

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	29.01

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.20	72	NE 1	0.18	73
2	0.28	73	2	0.30	74
3	0.31	73	3	0.35	74
4	0.31	73	4	0.31	74
5	0.30	73	5	0.30	74
6	0.25	73	6	0.28	74

PERCENT ISOKINETICS:	102 %	
STACK TEMPERATURE:	73.3 DEG. F.	533.3 DEG. R.
AVERAGE VELOCITY HEAD:	0.279 " OF H2O	
STACK GAS VELOCITY:		29.55 FT/SEC.
STACK GAS AIR FLOW:	22281.0 ACF/MIN.	22740.0 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	438
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.261
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.121
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	10077.1
AMPHERE HOURS PER HOUR (amp-hr/hr):	1628
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	6.19

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	470
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.15
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.280
TOTAL CHROMIUM IN SAMPLE (ppm):	0.129
TOTAL CHROMIUM EMISSION RATE (mg/hr):	10813.3
AMPHERE HOURS PER HOUR (amp-hr/hr):	1628
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	6.64

AT

92 2094 TRAVERSE SAMPLING DATA

Page 1 of 1

Client [illegible]
Date [illegible]
Sample Location [illegible]
Operators [illegible]
Sample Box # [illegible]
Run # 1 Cr⁺⁶/Total Cr

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .015/[illegible]
Leak Test Vac [illegible]/[illegible]
[illegible] Pitots, Pretest
[illegible] Pitots, Postest
n/a Orsat Sampling System
n/a Tedlar Bag
✓ Thermocouple @ [illegible] °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter 48"
Distance Upstream [illegible]
Distance Downstream [illegible]

Filter # [illegible] tare [illegible] mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (2 N NaOH)	1225.8	1245.5	[illegible]
#2 Impinger (1 N HNO₃)	558.2	565.3	[illegible]
#3 Bubbler	515.4	514.0	[illegible]
#4 Silica Gel	756.9	749.7	[illegible]

TOTAL WATER VOLUME [illegible]

Start Time [illegible]
Stop Time [illegible]
Barometric Pressure "Hg [illegible]
Static Pres "H_2O −.
Production Rate [illegible]
Box C

NOMOGRAPH SETUP

% Moisture [illegible]
Meter Temp. [illegible]
Stack Temp. [illegible]
ΔH@ 1.[illegible] Y 1.[illegible]
Pitot # C1 Side # [illegible]
Cp .84
Nozzle Diameter .[illegible]
K Factor 13.9
Reference ΔP [illegible]

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	
1	0	843.639	.20	2.19	2.19	51	47	11	n/a	36	72	
2	5		.28	3.[illegible]	3.[illegible]	76	49	12		38	73	
3	10		.31	3.[illegible]	3.4[illegible]	85	42	13		37	73	
4	15		.31	3.[illegible]	3.[illegible]	9[illegible]	[illegible]	12		40	74	
5	20		.20	[illegible]	[illegible]	9[illegible]	[illegible]	11		40	73	
6	25		.25	2.74	2.74	102	52	11		41	73	
1	30		.18	1.97	1.97	100	51	10		41	73	
2	35		.30	3.29	3.29	109	56	12		43	74	
3	40		.35	3.83	3.83	109	59	13		43	74	
4	45		.31	3.40	3.40	111	60	12		42	74	
5	50		.30	3.29	3.29	113	61	12		42	74	
6	55		.28	3.07	3.07	116	66	12		42	71	
	60	901.593										

3.078 74.5 ✓

Prime Vendor — [illegible]
Arthur Holm

11/30/89
Chromic Acid Bath 5
Bath Temp. — 94°
Parts descrip. — Clips, Fittings, fillers, Angles, Channels

	Time	Volts	Amperes		(Velometer) (FPM) Velocity	
Path ON						
Run 1						
Parts in —	0806	23.0	100	1 min	Pt.5	2400
	0807	2.6	500	1		
	08	20	950	1	10	1790
	09	13.0	1000	1		
	0810	17.5	1800	3	15	1690
	11	20.0	1600			
	12	22.0	1800		20	1560
	13	22.0	1500	2		
	14	22.5	1500		25	960
	0815	22.5	1550	1		
	16	22.5	1500	9	30	1010
	17	22.5	1500			
	18				35	970
	19	22.5	1500			
	0820	22.5	1500		40	750
	25	22.5	1550	26	45	950
	0830	22.5	1550		50	460
	35	22.6	1550			
	40	22.6	1550		55	260
	45					
	50	22.6	1575	11	60	600
	55	22.9	1575			
	0900	22.9	1575		Amb. Temp. 76°F	
Path OFF	0901				1100 – 1105	
Parts out	0902	21.6 V	1628 Amp-hr/hr		(Oven turned)	

Sample Type:	**Bath On - Run 7**
Sampling Date:	**November 30, 1989**
Sample Times:	**15:46-16:49 (60 minutes)**
Run Number:	**4**
Lab Numbers:	**922106, 922107, 922108**
Airflow:	**22,084 dscf/min**
Process Data	
Bath Amperage:	**1896 amp-hr/hr**
Voltage:	**21.2 volts D.C.**
Bath Temperature:	**94.5° F**
Ambient Temperature:	**77° F**
Hexavalent Chromium	
Concentration:	**0.416 mg/dscm**
Concentration:	**0.19 ppm**
Emission Rate:	**15,601 mg/hr**
Emission Factor:	**8.23 mg/amp-hr**
Total Chromium	
Concentration:	**0.423 mg/dscm**
Concentration:	**0.20 ppm**
Emission Rate:	**15,853 mg/hr**
Emission Factor:	**8.36 mg/amp-hr**

Note: Acid in bath was drained and replaced prior to this test.

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	5BO#5CR4	LAB #:	922107
CLIENT:	BOEING PLANT #2	START TIME:	15:46 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	16:49 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	NOVEMBER 30, 1989	CONDITION:	BATH ON
RUN #:	4-CR+6		
OPERATORS:	S. MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1255.5	1254.3	1.2
570.1	568.3	1.8
518.0	517.6	0.4
771.7	762.6	9.1
TOTAL H2O GAIN:		12.5
TOTAL VOLUME (SCF)		0.59
PERCENT MOISTURE:		1.01
Bws:		0.0101

PITOT Cp:	0.842
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	91.8
BAROM. PRES. "HG:	30.48
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.48
ORIFICE PRES "H2O:	2.977
METER PRES. "HG:	30.70

INIT. METER VOL.:	946.900
FINAL METER VOL.:	1004.859
VOLUME SAMPLED:	57.959
STD VOLUME (DSCF):	57.586
STD VOLUME (DSCM):	1.631
Y FACTOR:	1.012

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.74

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE 1	0.21	79	NW 1	0.22	78
2	0.30	79	2	0.27	78
3	0.33	80	3	0.30	78
4	0.30	79	4	0.30	78
5	0.29	79	5	0.29	78
6	0.26	78	6	0.24	77

PERCENT ISOKINETICS:	102 %	
STACK TEMPERATURE:	78.4 DEG. F.	538.4 DEG. R.
AVERAGE VELOCITY HEAD:	0.275 " OF H2O	
STACK GAS VELOCITY:		29.58 FT/SEC.
STACK GAS AIR FLOW:	22299.1 ACF/MIN.	22051.3 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	679
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.416
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.193
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	15600.6
AMPHERE HOURS PER HOUR (amp-hr/hr):	1896
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	8.23

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	690
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.15
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.423
TOTAL CHROMIUM IN SAMPLE (ppm):	0.196
TOTAL CHROMIUM EMISSION RATE (mg/hr):	15853.3
AMPHERE HOURS PER HOUR (amp-hr/hr):	1896
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	8.36

AT

TRAVERSE SAMPLING DATA

922107

Client Boeing
Date 11/30/89
Sample Location Test @ Vent Stack Boeing Plant 2 Renton, WA
Operators MSH
Sample Box # C
Run # 4 - Cr^{+6} / Total Chromium

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .015 / .014
Leak Test Vac 15" / 15"
✓ Pitots, Pretest
✓ Pitots, Postest
N/A Orsat Sampling System
N/A Tedlar Bag
✓ Thermocouple @ ____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter 42" ϕ
Distance Upstream
Distance Downstream

Filter # Teflon tare ____ mgs

	Final Wt.		Initial Wt.		Net Wt.
#1 Bubbler (2-NaOH)	1255.5	-	1254.3	=	
#2 Impinger (1-HNO_3)	570.1	-	568.3	=	
#3 Bubbler	518.0	-	517.6	=	
#4 Silica Gel	771.7	-	762.6	=	

TOTAL WATER VOLUME

Start Time 15:46
Stop Time 16:49
Barometric Pressure "Hg 30.48
Static Pres "H_2O
Production Rate Both On

NOMOGRAPH SETUP

% Moisture 2
Meter Temp. 93
Stack Temp. 78
ΔH@ 1.92 Y 1.01
Pitot # 4 Side # A
Cp .842
Nozzle Diameter .313
K Factor 10.2
Reference ΔP N/A

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
North 1	0	946.900	.21	2.27	2.27	99	66	10	N/A	43	79
2	5		.30	3.24	3.24	99	66	12		42	79
3	10		.33	3.56	3.56	108	67	12		42	80
4	15		.30	3.24	3.24	113	69	12		42	79
5	20		.29	3.13	3.13	117	70	12		41	79
6	25		.26	2.80	2.80	120	72	11		43	78
West 1	30		.22	2.37	2.37	113	72	10		46	78
2	35		.27	2.91	2.91	120	73	11		47	78
3	40		.30	3.24	3.24	121	73	11		45	78
4	45		.30	3.24	3.24	122	74	12		44	78
5	50		.29	3.13	3.13	123	75	12		46	78
6	55		.24	2.59	2.59	122	77	11		48	77
	60	1004.859									

2.977 91.8

11/30/89
Chromic Acid Bath 5
R4-MS Bath Temp. 94.5 Ambient Temp. 77°
Parts descrip. —

Time	Volts	Amperes	Amperes
Parts In — 1554	0.5		
~~Bath Off 1555~~	~~2.1~~	~~100~~	
Bath On — 1556	5.0	100	
1557	8.5	1800	53
1558	13.5	1800	
1559	17.7	1800	
1600	21.5	1800	
1601	22.0	1800	
1602	22.0	1800	
1603	22.0		
1604			
1605			
1606			
1607			
1608			
1609			
1610			
1615	22.5	1800	
~~Bath Off — 1618~~			
~~Parts out 1620~~			
1625			
1630			
1640			
1650	22.5	1800	
Bath OFF 1657			
Parts out 1653			

13

36

21.2 V

1896 amp-hr/hr

Sample Type:	**Bath On - Run 8**
Sampling Date:	**December 1, 1989**
Sample Times:	**07:29-08:31 (60 minutes)**
Run Number:	**5**
Lab Numbers:	**922114, 922115, 922116**
Airflow:	**22,318 dscf/min**
Process Data	
Bath Amperage:	**1680 amp-hr/hr**
Voltage:	**20.8 volts D.C.**
Bath Temperature:	**93.5° F**
Ambient Temperature:	**70° F**
Hexavalent Chromium	
Concentration:	**0.263 mg/dscm**
Concentration:	**0.12 ppm**
Emission Rate:	**9,982 mg/hr**
Emission Factor:	**5.94 mg/amp-hr**
Total Chromium	
Concentration:	**0.273 mg/dscm**
Concentration:	**0.13 ppm**
Emission Rate:	**10,371 mg/hr**
Emission Factor:	**6.17 mg/amp-hr**

Note: Acid in bath was drained and replaced prior to this test.

METHOD 1-5 - HEXAVALENT CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	5BOM5CR5	LAB #:	922114	
CLIENT:	BOEING PLANT #2	START TIME:	07:29	O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	08:31	O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	60.0	MINUTES
SAMPLE DATE:	DECEMBER 1, 1989	CONDITION:	BATH ON	
RUN #:	5-CR+6			
OPERATORS:	S. MACKEY			
CONTACT:	P. SIEBENALER			

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1176.0	1175.6	0.4
628.0	627.2	0.8
479.2	478.5	0.7
801.9	791.0	10.9
TOTAL H2O GAIN:		12.8
TOTAL VOLUME (SCF)		0.60
PERCENT MOISTURE:		1.01
Bws:		0.0101

PITOT Cp:	0.842
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	72.5
BAROM. PRES. "HG:	30.50
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.50
ORIFICE PRES "H2O:	3.045
METER PRES. "HG:	30.72

INIT. METER VOL.:	5.482
FINAL METER VOL.:	63.027
VOLUME SAMPLED:	57.545
STD VOLUME (DSCF):	59.295
STD VOLUME (DSCM):	1.679
Y FACTOR:	1.012

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.74

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.20	71	NE 1	0.22	71
2	0.27	72	2	0.30	72
3	0.30	73	3	0.34	72
4	0.31	72	4	0.30	72
5	0.30	72	5	0.30	72
6	0.24	71	6	0.27	72

PERCENT ISOKINETICS:	104 %	
STACK TEMPERATURE:	71.8 DEG. F.	531.8 DEG. R.
AVERAGE VELOCITY HEAD:	0.278 " OF H2O	
STACK GAS VELOCITY:		29.55 FT/SEC.
STACK GAS AIR FLOW:	22277.4 ACF/MIN.	22318.3 DSCF/MIN.

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	442.00
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.263
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.122
HEXAVALENT CHROMIUM EMISSION RATE (mg/hr):	9982.0
AMPHERE HOURS PER HOUR (amp-hr/hr):	1680
HEX. CHROMIUM EMISSION FACTOR (mg/amp-hr):	5.94

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	459.2
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.15
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.273
TOTAL CHROMIUM IN SAMPLE (ppm):	0.127
TOTAL CHROMIUM EMISSION RATE (mg/hr):	10370.5
AMPHERE HOURS PER HOUR (amp-hr/hr):	1680
TOTAL CHROMIUM EMISSION FACTOR (mg/amp-hr):	6.17

AT

922114 TRAVERSE SAMPLING DATA

Page 1 of 1

Client Boo
Date 12/[illegible]
Sample Location Tan[illegible]
Operators [illegible]
Sample Box # B
Run# 5 / [illegible] C

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .01 / .0
Leak Test Vac [illegible] / [illegible]
_____ Pitots, Pretest
_____ Pitots, Postest
_____ Orsat Sampling System
_____ Tedlar Bag
_____ Thermocouple @ _____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter _____
Distance Upstream _____
Distance Downstream _____

Filter # _____ tare _____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler	1176.0	1175.6	
#2 Impinger	628.0	627.2	
#3 Bubbler	479.2	478.5	
#4 Silica Gel	801.9	791.0	

TOTAL WATER VOLUME _____

Start Time 07:[illegible]
Stop Time [illegible]
Barometric Pressure "Hg [illegible]
Static Pres "H_2O _____
Production Rate _____

NOMOGRAPH SETUP

% Moisture _____
Meter Temp. _____
Stack Temp. _____
ΔH@ _____ Y _____
Pitot# _____ Side# _____
Cp _____
Nozzle Diameter _____
K Factor _____
Reference ΔP _____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
1	0	005.487	.20	2.18	2.18	42	42	11	N/A	38	71
2	5		.27	[illegible]	[illegible]	6[illegible]	4[illegible]	12		36	72
3	10		.30	3.27	3.2[illegible]	9[illegible]	4[illegible]	12		3[illegible]	7[illegible]
4	15		.31	3.38	3.39	90	47	13		40	72
5	[illegible]		.[illegible]	[illegible]	[illegible]	95	4[illegible]	13		4[illegible]	7[illegible]
	25		.24	[illegible]	2.62	10[illegible]	5[illegible]	.12		4[illegible]	[illegible]
	[illegible]		.27	2.[illegible]	2.4[illegible]	9[illegible]	54	12		4[illegible]	71
	35		.30	3.27	3.27	105	5[illegible]	12		[illegible]	[illegible]
	[illegible]		.34	[illegible]	[illegible]	106	5[illegible]	14		4[illegible]	7[illegible]
6	45		.3[illegible]	[illegible]	[illegible]	105	6[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	109	[illegible]	[illegible]		[illegible]	7[illegible]
[illegible]	[illegible]		.27	2.[illegible]	[illegible]	11[illegible]	[illegible]	1[illegible]		46	72
	[illegible]	063.027									

3.045 72.5

12-1-89

Chromic Acid Bath #5

Bath Temp. 93.5°F Ambient – 70°F

Parts Descrip. – supports, stiffeners

Run 5

	Time	Volts	Amperes
Parts In – [redacted]	0730	0.6	0
[redacted]	0731	0.4	0
Switch ON →	0732	3.0	100 1
	0733	6.0	100 1
	0734	11.5	800 1
	0735	15.5	1800 2
	0736	21.8	1800
	0737	21.8	1600 28+25
	0738	22.0	1600
	0739	22.0	1600
	0740	22.0	1600
	0741	22.2	1600
	0742	22.5	1600
	0743	22.6	1600
	0744	22.6	1600
	0745	22.6	1600
	0750	10	
[redacted]	[redacted]		
	0753	22.7	1600
	0800	10	
	0805	22.6	1600
	0810	20	
	0820		
	0825	22.6	1650 2
Bath off	0827	1.0	0
Parts out	0828	0.8	0

(2 * 100 + 800 + 48 * 1600 + 2 * 1650)

Set B 11760.0
6280.0
Runs → 479.2
find 8019

20.8 V

1680 amp-hr/hr

SECTION 3
PARTICLE SIZE DISTRIBUTION RUNS
BATH ON

The results of the particle size distribution tests are presented graphically in Figures 1 and 2. Figure 1 is a plot of the distribution based on chemical analysis for total chromium of each filter which lined each stage of the Cascade impactor. Figure 2 is a plot of the distribution based on the gravimetric weight gain on each filter prior to chemical analysis. The detailed results are presented on computer printouts titled "Pilat (U of W) Mark 5 Particle Size Analysis Results" and computer printouts titled "Particle Size Analysis" which are included for each run. The column titled "aerodynamic diameter" (in micrometers) was plotted against the column titled "percent less than" on semi-log versus probability graph paper to illustrate the particle size distributions.

The aerodynamic mass mean diameter (MMD) value represents the size (in micrometers - microns) at which fifty percent of the particulate matter collected was composed of particles of less than that value. The average MMD based on chemical analysis of the progressive size ranges was 4.9 microns. The average MMD based on gravimetric (weight) analysis of the cut sizes was 3.0 microns.

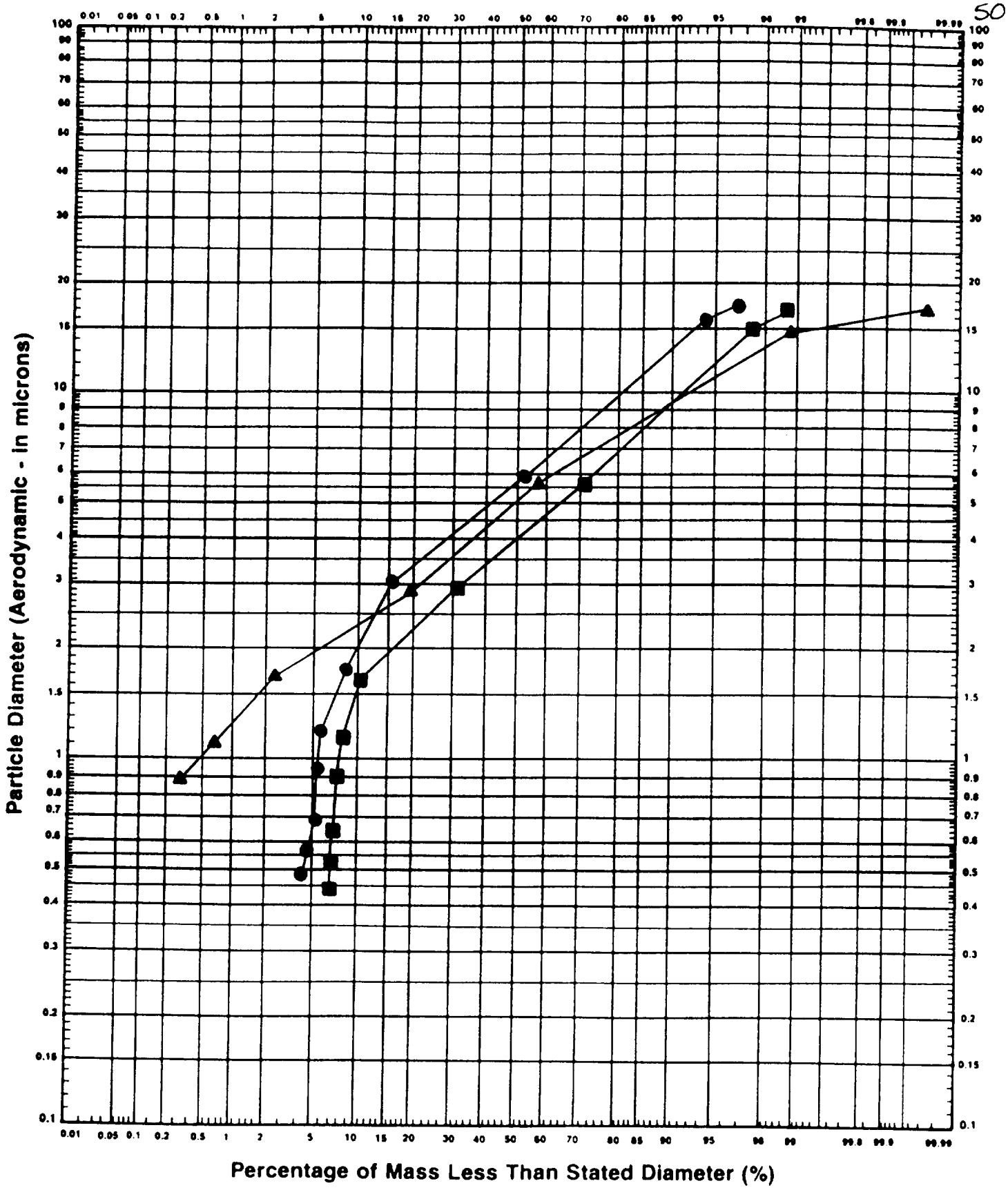

Figure 1. Plot of particle size versus chromium concentration at the #5A chromic acid anodizing tank at Boeing Plant 2 in Seattle, Washington.

Symbol	Run #	MMD microns
●	1	5.7
■	2	4.0
▲	3	5.1
	Average	4.9

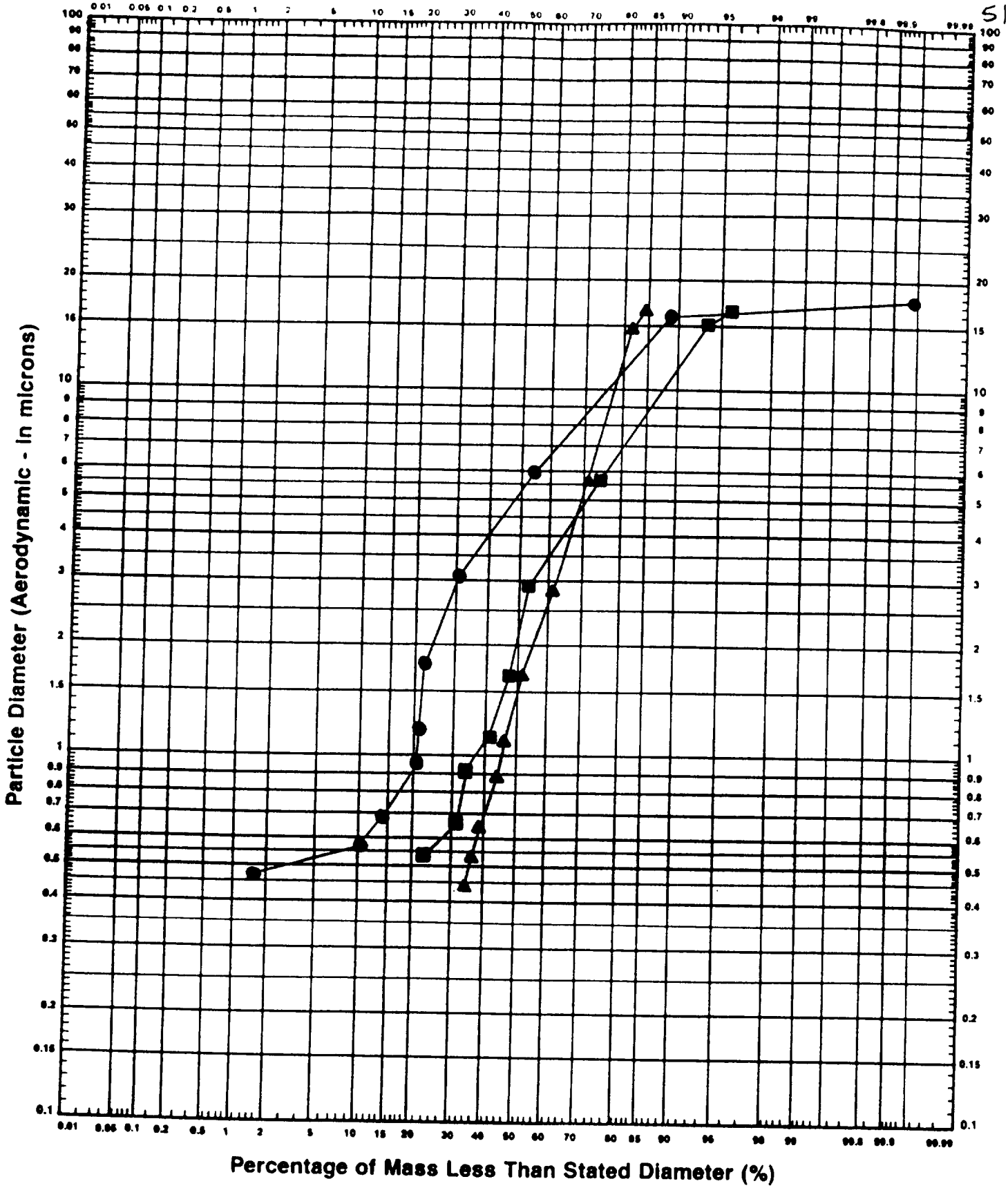

Figure 2. Plot of particle size versus particle mass (weight) at the #5A chromic acid anodizing tank at Boeing Plant 2 in Seattle, Washington.

Symbol	Run #	MMD microns
●	1	5.3
■	2	2.2
▲	3	1.5
	Average	3.0

Sample Type:	**Particle Size Distribution Bath On - Run 1**
Sampling Date:	**August 31, 1989**
Sample Times:	**10:26-11:26 (60 minutes)**
Run Number:	**1**
Lab Numbers:	**915962-915976, 915744-915749**
Airflow:	**21,696 dscf/min**
Process Data	
Bath Amperage:	**1892 amp-hr/hr**
Voltage:	**22.4 volts D.C.**
Bath Temperature:	**94.5° F**
Ambient Temperature:	**78° F**

Stage #	Distribution d50's (microns)	Cumulative Cr % Less Than Stated Diameter	Chromium Concentration (mg/dscm)
1	17.54	96.85	0.009
2	15.87	94.54	0.007
3	5.90	52.90	0.117
4	3.07	15.90	0.104
5	1.76	7.93	0.022
6	1.18	5.74	0.006
7	0.95	5.29	0.001
8	0.68	5.01	0.001
9	0.56	4.72	0.001
10	0.47	4.45	0.001
final	<0.47	0.00	0.013
TOTAL			0.280

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOMK5CR1		Y FACTOR	0.993		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10 CHROMIC TANK #5 EXHAUST		PERCENT MOISTURE	0.81	%	STACK GAS MW DRY	28.85	gm/mole
SAMPLE DATE	AUGUST 31, 1989		METER TEMP	67.5	Deg. F.	STACK GAS MW WET	28.76	gm/mole
OPERATOR	GUENTHOER/WIDMEYER		STACK TEMP	80.2	Deg. F.	PITOT Cp	0.84	
			MARK 5 TEMP	80.2	Deg. F.	NOZZLE DIAMETER	0.188	inches
RUN #	1-MK5/Cr		BAROMETRIC PRESSURE	30.16	" of Hg	NOZZLE AREA	0.0002	sq. ft.
LAB #	915744		STATIC PRESSURE	0.00	" of H20	STACK DIAMETER	48.00	inches
START TIME	10:26	O'CLOCK	STACK PRESSURE	30.16	" of Hg	STACK AREA	12.566	sq. ft.
STOP TIME	11:26	O'CLOCK	ORIFICE PRESSURE	0.17	" of H20	VELOCITY HEAD	0.27	" H20
SAMPLE TIME	60.00	MINUTES	MK5 OUTLET ABS. PRES	29.16	" of Hg	STACK GAS VELOCITY	29.4	ft/sec
INITIAL METER VOL	982.904	CU FEET	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1766.7	ft/min
FINAL METER VOL	1001.815	CU FEET	AVG. MARK 5 PRESSURE	30.06	" of Hg	STACK GAS AIRFLOW	22201.2	acf/min
VOLUME SAMPLED	18.911	CU FEET	SAMPLE RATE	0.32	cf/min	STACK GAS AIRFLOW	21695.7	dscf/min
VOLUME (STACK COND)	19.40	ACTUAL CU FT	SAMPLE RATE (STD)	0.32	dscf/min	% ISOKINETICS	95	%
STD VOLUME	18.955	DSCF	SAMPLE RATE (MK5)	0.32	acf/min			
STD VOLUME	0.537	DSCM	SAMPLE RATE (MK5)	8.95	liter/min			

SET ID # HH-QUARTZ B:T1R1-TANK 5.OUT
CONFIGURATION: 1,6,12,90,110,110,110,105,105,78,FINAL FILTER

STAGE #	CHROMIUM ON FILTERS micrograms	CHROMIUM ON FILTERS milligrams	FRACTIONAL %	PERCENT < than	AERODYNAMIC DIAMETER microns	CHROMIUM CONC. mg/dscm
NOZZLE:	0.00	0.00000				
1	4.75	0.00475	3.15	96.85	17.54	0.0088
2	3.47	0.00347	2.30	94.54	15.87	0.0065
3	62.70	0.06270	41.64	52.90	5.90	0.1168
4	55.70	0.05570	37.00	15.90	3.07	0.1037
5	12.00	0.01200	7.97	7.93	1.76	0.0223
6	3.30	0.00330	2.19	5.74	1.18	0.0061
7	0.67	0.00067	0.45	5.29	0.95	0.0012
8	0.42	0.00042	0.28	5.01	0.68	0.0008
9	0.45	0.00045	0.30	4.72	0.56	0.0008
10	0.40	0.00040	0.27	4.45	0.47	0.0007
FILTER	6.70	0.00670	4.45	0.00	<.47	0.0125
TOTAL:	150.56	0.15056	100.00			0.2804

BACKHALF ANALYSIS

RINSE OF SUBSTRATES	0.75
POST IMPACTOR RINSE	4.45
IMPINGER #1	< 0.90
IMPINGER #2	< 0.79
IMPINGER #3 & 4	< 0.83
FILTER	< 0.30
TOTAL:	5.20 ug

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOEMK5R1		Y FACTOR	0.993		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10 CHROMIC TANK #5 EXHAUST		PERCENT MOISTURE	0.81	%	STACK GAS MW DRY	28.85	gm/mole
SAMPLE DATE	AUGUST 31, 1989		METER TEMP	67.5	Deg. F.	STACK GAS MW WET	28.76	gm/mole
OPERATOR	GUENTHOER/WIDMEYER		STACK TEMP	80.2	Deg. F.	PITOT Cp	0.84	
			MARK 5 TEMP	80.2	Deg. F.	NOZZLE DIAMETER	0.188	inches
RUN #	1-MK5/Cr		BAROMETRIC PRESSURE	30.16	" of Hg	NOZZLE AREA	0.0002	sq. ft.
LAB #	915744		STATIC PRESSURE	0.00	" of H2O	STACK DIAMETER	48.00	inches
START TIME	10:26	O'CLOCK	STACK PRESSURE	30.16	" of Hg	STACK AREA	12.566	sq. ft.
STOP TIME	11:26	O'CLOCK	ORIFICE PRESSURE	0.17	" of H2O	VELOCITY HEAD	0.27	" H2O
SAMPLE TIME	60.00	MINUTES	MK5 OUTLET ABS. PRES	29.16	" of Hg	STACK GAS VELOCITY	29.4	ft/sec
INITIAL METER VOL	982.904	CU FEET	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1766.7	ft/min
FINAL METER VOL	1001.815	CU FEET	AVG. MARK 5 PRESSURE	30.06	" of Hg	STACK GAS AIRFLOW	22201.2	acf/min
VOLUME SAMPLED	18.911	CU FEET	SAMPLE RATE	0.32	cf/min	STACK GAS AIRFLOW	21695.7	dscf/min
VOLUME (STACK COND)	19.40	ACTUAL CU FT	SAMPLE RATE (STD)	0.32	dscf/min	% ISOKINETICS	95	%
STD VOLUME	18.955	DSCF	SAMPLE RATE (MK5)	0.32	acf/min			
STD VOLUME	0.537	DSCM	SAMPLE RATE (MK5)	8.95	liter/min			

CONFIGURATION: 1,6,12,90,110,110,110,105,105,78,FINAL FILTER
SET ID # HH-QUARTZ B:T1R1-TANK 5.OUT

STAGE #	TARE WT. Gms.	FINAL WT. Gms.	NET WT. Gms.	NET WT. Mgs.	FRACTIONAL %	PERCENT < than	AERODYN. DIAMETER um	PARTIC. CONC. Gr/DSCF	PARTIC. CONC. @ STACK CONDITIONS Gr/ACF	PARTIC. CONC. Mg/DSCM
NOZZLE:	0.00000	0.00000	0.00000	0.00						
1	0.85776	0.85777	0.00001	0.01	0.56	99.44	17.54	8.1E-06	8.0E-06	0.02
2	1.28918	1.28940	0.00022	0.22	12.36	87.08	15.87	1.8E-04	1.8E-04	0.41
3	1.29306	1.29363	0.00057	0.57	32.02	55.06	5.90	4.6E-04	4.5E-04	1.06
4	1.30218	1.30261	0.00043	0.43	24.16	30.90	3.07	3.5E-04	3.4E-04	0.80
5	1.29894	1.29908	0.00014	0.14	7.87	23.03	1.76	1.1E-04	1.1E-04	0.26
6	1.29425	1.29428	0.00003	0.03	1.69	21.35	1.18	2.4E-05	2.4E-05	0.06
7	1.29866	1.29867	0.00001	0.01	0.56	20.79	0.95	8.1E-06	8.0E-06	0.02
8	1.26340	1.26352	0.00012	0.12	6.74	14.04	0.68	9.8E-05	9.5E-05	0.22
9	1.16257	1.16263	0.00006	0.06	3.37	10.67	0.56	4.9E-05	4.8E-05	0.11
10	1.17138	1.17154	0.00016	0.16	8.99	1.69	0.47	1.3E-04	1.3E-04	0.30
FILTER	0.35832	0.35835	0.00003	0.03	1.69	0.00	<.47	2.4E-05	2.4E-05	0.06
TOTAL:			0.00178	1.78	100.00			0.0014	0.0014	3.31

BLANK #1:	1.30168	1.30168	0.00000	PM10:	74.6 % < 10 Microns
BLANK #2:	1.28174	1.28176	0.00002	MMD:	3.08 Microns @ 50%
AVERAGE BLANK:			0.00001		

***** PARTICLE SIZE ANALYSIS *****

**** INPUT DATA ****

DATE OF TEST	AUGUST 31, 1989
TIME OF TEST	10:26-11:26
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
PART. DIAM. TYPE	C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)
TEST TYPE	OUTLET
RUN NUMBER	1-TANK 5 - FILE NAME: B:T1R1-TANK 5.OUT
REMARKS:	
IMPACTOR TYPE	MK5-78
	MARK 5 IMPACTOR WITH A 78 HOLE FINAL STAGE
WATER VAPOR	0.81%
CARBON DIOXIDE	0.10%
CARBON MONOXIDE	0.00%
OXYGEN	20.90%
SULFUR DIOXIDE	0.00%
NITROGEN	79.00%
PARTICLE DENSITY	1.00 GRAMS/CM^3

GAS METER VOLUME	18.911	CUBIC FEET
IMPACTOR DELTA P	1.00	INCHES HG
ORIFICE DELTA P	0.17	INCHES H2O
STACK PRESS. (BELOW ATMOS.)	0.00	INCHES H2O
BAROMETRIC PRESS.	30.16	INCHES HG
STACK TEMPERATURE	80.2	DEGREES F
METER TEMPERATURE	67.5	DEGREES F
IMPACTOR TEMPERATURE	80.2	DEGREES F
SAMPLE TIME	60.00	MINUTES
AV. VELOCITY OF STACK GAS	1766.70	FEET/MINUTE
GAS METER PRESSURE	0.00	IN HG
NOZZLE DIAMETER	0.19	INCHES
MAXIMUM AERODYN. DIAMETER	60.00	MICRONS

MASS GAIN ON STAGE 1	0.01 MG
MASS GAIN ON STAGE 2	0.22 MG
MASS GAIN ON STAGE 3	0.57 MG
MASS GAIN ON STAGE 4	0.43 MG
MASS GAIN ON STAGE 5	0.14 MG
MASS GAIN ON STAGE 6	0.03 MG
MASS GAIN ON STAGE 7	0.01 MG
MASS GAIN ON STAGE 8	0.12 MG
MASS GAIN ON STAGE 9	0.06 MG
MASS GAIN ON STAGE 10	0.16 MG
MASS GAIN ON FINAL FILTER	0.03 MG

**** RESULTS ****

DATE OF TEST AUGUST 31, 1989
TIME OF TEST 10:26-11:26
LOCATION OF TEST BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER 1 -
RUN NUMBER 1-TANK 5
ACTUAL FLOW RATE (STACK CONDITIONS) 0.325 CFM
FLOW RATE (STANDARD CONDITIONS) 0.318 CFM
PERCENT ISOKINETIC SAMPLING 95.55 %

VISCOSITY OF GAS STREAM 0.0001830 GRAMS/CM-SEC

STAGE	CCF	DP(CLAS AERO)	DP(IMP AERO)	CUM FRACTION
1	1.009	17.538	17.621	0.9944
2	1.010	15.865	15.948	0.8708
3	1.028	5.896	5.978	0.5506
4	1.054	3.074	3.155	0.3090
5	1.094	1.758	1.839	0.2303
6	1.140	1.179	1.259	0.2135
7	1.175	0.952	1.031	0.2079
8	1.248	0.676	0.755	0.1404
9	1.306	0.555	0.634	0.1067
10	1.372	0.467	0.547	0.0169

TOTAL MASS PER DRY NORMAL CUBIC METER 3.2958 MG/CUBIC METER

PART. DIAM. TYPE C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)

PARTICLE SIZE (MICRONS)	CUMFR (STD. DEV.)	CUMFR (PER CENT)	CUM.MASS (MG/DRY N.CU.METER)	dM/dLOG D
0.20	-9.8170	0.0	0.000	0.000
0.25	-7.7933	0.0	0.000	0.000
0.40	-3.5306	0.0	0.001	0.054
0.50	-1.7166	4.3	0.142	3.926
0.75	-1.0210	15.4	0.506	1.489
1.00	-0.7962	21.3	0.702	0.488
1.50	-0.7653	22.2	0.732	0.444
2.00	-0.7254	23.4	0.772	0.213
2.50	-0.6733	25.0	0.825	1.127
4.00	-0.0619	47.5	1.567	5.061
5.00	0.1987	57.9	1.908	1.252
7.50	0.3707	64.5	2.124	2.865
10.00	0.6623	74.6	2.459	2.464
15.00	1.0733	85.8	2.829	1.725
20.00	4.9321	100.0	3.296	0.000
25.00	9.0597	100.0	3.296	0.000
40.00	19.2740	100.0	3.296	0.000
50.00	29.4350	100.0	3.296	0.000

**** RESULTS (CONTINUED) ****

TIME OF TEST	10:26-11:26
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
RUN NUMBER	1-TANK 5

*** INHALABLE PARTICULATE MATTER ***

CUM.	MASS LESS THAN 2.5 MICRON:	0.83	MG/DRY NORMAL CU.METER	(25.0 %)
CUM.	MASS LESS THAN 5.0 MICRON:	1.91	MG/DRY NORMAL CU.METER	(57.9 %)
CUM.	MASS LESS THAN 10.0 MICRON:	2.46	MG/DRY NORMAL CU.METER	(74.6 %)
CUM.	MASS LESS THAN 15.0 MICRON:	2.83	MG/DRY NORMAL CU.METER	(85.8 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE ARE CLASSICAL AERODYNAMIC DIAMETERS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE :	Y =	-1.04 +	2.13X
MASS GEOMETRIC MEAN DIAMETER		3.077	
GEOMETRIC STANDARD DEVIATION		2.942	
CORRELATION COEFFICIENT		0.875	

AT

TRAVERSE SAMPLING DATA

Page 1 of _____

Client Boeing
Date 8-31-87
Sample Location Bldg 2-10
Chromic Tank #5 exhaust
Operators JAG - JMW
Sample Box # B
Run # 1 - PS. Marks

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm 1.024 /
Leak Test Vac 15 / 1
/ Pitots, Pretest
/ Pitots, Postest
Orsat Sampling System
Tedlar Bag
Thermocouple @ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter
Distance Upstream
Distance Downstream

Filter # HH tare mgs

	Final Wt.		Initial Wt.		Net Wt.
#1 Bubbler (NaOH)	634.8	-	1253.7	=	0.8
#2 Impinger (HNO3)	625.5	-	626.1	=	-.6
#3 Bubbler	535.6	-	535.7	=	0.4
#4 Silica Gel	798.6	-	795.9	=	2.7

TOTAL WATER VOLUME 3.3

Start Time 10:26
Stop Time 11:26
Barometric Pressure "Hg 30.16
Static Pres "H_2O 0.0
Production Rate
Bath On

NOMOGRAPH SETUP

% Moisture 2
Meter Temp.
Stack Temp. 80
ΔH@ .91 Y .99
Pitot # Side #
Cp .84
Nozzle Diameter .188
K Factor
Reference ΔP .27
ΔH = .17

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
PAV	0	982.904	.27	.17	.17	63	63	5		61	79
	10					65	63	5	N/A	58	79
	20					68	65	5		58	81
	30					71	68	3		60	80
	40					72	70	3 1/2		63	81
	50					72	70	3 1/2		64	81
PAV	60	1001.815									
								1" HKS			

61.5 80.2

8/31/89 Brewing Plant 2

Run 1 — Started with Parts into bath @ 10:26 AM
(Particle Sizing) Removed Parts 11:21 AM

Readings during Test:

10:26	5	1		0	1		
10:27	12	2		200	2		
10:29	23.0			1830			
10:45	23.0	Volts	26	1830	Amps	34	94.5° Bath Temperature
10:55	23.0	Volts		1830	Amps		
11:03	23.1	Volts	8	1830	Amps		
11:11	23.2	Volts	18	1820	Amps	18	78°F ambient
11:20	23.2	Volts		1820	Amps		
11:21	23.2	Volts		1820	Amps		
11:22	0.5 V	(Off Range Reading)		0	Amps		

Velocity Measurements between Runs 1 & 2:

Opening #	ft/min reading
1	2270
6	1810
11	1740
16	1640
21	1650
26	1220
31	730
36	1060
41	730
46	820
51	680
56	340
Ctr	620

(Reading from 11:35 - 11:50
(Empty Bath)

(1*0 + 2*200 + 34*1830 + 18*1820)/55 * 60/55

1892 amps/hr
22.4 volt

← Workroom Air Sampler Here; Wet Surfaces Too

Sample Type:	**Particle Size Distribution Bath On - Run 2**
Sampling Date:	**November 30, 1989**
Sample Times:	**12:02-13:07 (65 minutes)**
Run Number:	**2**
Lab Numbers:	**922208-922219, 922096-922100**
Airflow:	**22,576 dscf/min**
Process Data	
Bath Amperage:	**1883 amp-hr/hr**
Voltage:	**21.5 volts D.C.**
Bath Temperature:	**93.0° F**
Ambient Temperature:	**73° F**

Stage #	Distribution d50's (microns)	Cumulative Cr % Less Than Stated Diameter	Chromium Concentration (mg/dscm)
1	16.58	98.61	0.003
2	15.00	97.65	0.002
3	5.57	70.65	0.052
4	2.91	30.51	0.077
5	1.66	11.16	0.037
6	1.11	8.26	0.006
7	0.90	7.79	0.001
8	0.64	7.54	0.001
9	0.52	7.25	0.001
10	0.44	7.25	0.000
final	<0.44	0.00	0.014
TOTAL			0.196

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOMK5CR2		Y FACTOR	1.012		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10 CHROMIC TANK #5 EXHAUST		PERCENT MOISTURE	3.54	%	STACK GAS MW DRY	28.85	gm/mole
SAMPLE DATE	NOVEMBER 30, 1989		METER TEMP	88.7	Deg. F.	STACK GAS MW WET	28.47	gm/mole
OPERATOR	MACKEY		STACK TEMP	76.8	Deg. F.	PITOT Cp	0.842	
			MARK 5 TEMP	76.8	Deg. F.	NOZZLE DIAMETER	0.188	inches
RUN #	2-MK5/Cr		BAROMETRIC PRESSURE	30.42	" of Hg	NOZZLE AREA	0.0002	sq. ft.
LAB #	922208		STATIC PRESSURE	-0.02	" of H2O	STACK DIAMETER	48.00	inches
START TIME	12:02	O'CLOCK	STACK PRESSURE	30.42	" of Hg	STACK AREA	12.566	sq. ft.
STOP TIME	13:07	O'CLOCK	ORIFICE PRESSURE	0.43	" of H2O	VELOCITY HEAD	0.30	" H2O
SAMPLE TIME	65.00	MINUTES	MK5 OUTLET ABS. PRES	29.42	" of Hg	STACK GAS VELOCITY	31.0	ft/sec
INITIAL METER VOL	902.199	CU FEET	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1862.5	ft/min
FINAL METER VOL	925.122	CU FEET	AVG. MARK 5 PRESSURE	30.32	" of Hg	STACK GAS AIRFLOW	23405.2	acf/min
VOLUME SAMPLED	22.923	CU FEET	SAMPLE RATE	0.35	cf/min	STACK GAS AIRFLOW	22575.7	dscf/min
VOLUME (STACK COND)	23.55	ACTUAL CU FT	SAMPLE RATE (STD)	0.35	dscf/min	% ISOKINETICS	101	%
STD VOLUME	22.719	DSCF	SAMPLE RATE (MK5)	0.36	acf/min			
STD VOLUME	0.644	DSCM	SAMPLE RATE (MK5)	9.90	liter/min			

SET ID # RB-QUARTZ B:T1R2-TANK 5.OUT
CONFIGURATION: 1,6,12,90,110,110,110,105,105,78,FINAL FILTER

STAGE #	CHROMIUM ON FILTERS micrograms	CHROMIUM ON FILTERS milligrams	FRACTIONAL %	PERCENT < than	AERODYNAMIC DIAMETER microns	CHROMIUM CONC. mg/dscm
NOZZLE:	0.00	0.00000				
1	1.72	0.00172	1.39	98.61	16.58	0.0027
2	1.20	0.00120	0.97	97.65	15.00	0.0019
3	33.50	0.03350	27.00	70.65	5.57	0.0521
4	49.80	0.04980	40.14	30.51	2.91	0.0774
5	24.00	0.02400	19.34	11.16	1.66	0.0373
6	3.60	0.00360	2.90	8.26	1.11	0.0056
7	0.58	0.00058	0.47	7.79	0.90	0.0009
8	0.32	0.00032	0.26	7.54	0.64	0.0005
9	0.35	0.00035	0.28	7.25	0.52	0.0005
10	0.00	0.00000	0.00	7.25	0.44	0.0000
FILTER	9.00	0.00900	7.25	0.00	<.44	0.0140
TOTAL:	124.07	0.12407	100.00			0.1928

BACKHALF ANALYSIS

RINSE OF SUBSTRATES	1.62
RINSE OF IMPACTOR	24.2
IMPINGER #1 & #2	6.08
IMPINGER #3 & 4	< 0.8
FILTER	< 0.15
TOTAL:	31.9 ug

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOEMK5R2		Y FACTOR	1.012		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10 CHROMIC TANK #5 EXHAUST		PERCENT MOISTURE	3.54	%	STACK GAS MW DRY	28.85	gm/mole
SAMPLE DATE	NOVEMBER 30, 1989		METER TEMP	88.7	Deg. F.	STACK GAS MW WET	28.47	gm/mole
OPERATOR	S. MACKEY		STACK TEMP	76.8	Deg. F.	PITOT Cp	0.842	
			MARK 5 TEMP	76.8	Deg. F.	NOZZLE DIAMETER	0.188	inches
RUN #	2-MK5/Cr		BAROMETRIC PRESSURE	30.42	" of Hg	NOZZLE AREA	0.0002	sq. ft.
LAB #	922208		STATIC PRESSURE	-0.02	" of H2O	STACK DIAMETER	48.00	inches
START TIME	12:02	O'CLOCK	STACK PRESSURE	30.42	" of Hg	STACK AREA	12.566	sq. ft.
STOP TIME	13:07	O'CLOCK	ORIFICE PRESSURE	0.43	" of H2O	VELOCITY HEAD	0.30	" H2O
SAMPLE TIME	65.00	MINUTES	MK5 OUTLET ABS. PRES	29.42	" of Hg	STACK GAS VELOCITY	31.0	ft/sec
INITIAL METER VOL	902.199	CU FEET	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1862.5	ft/min
FINAL METER VOL	925.122	CU FEET	AVG. MARK 5 PRESSURE	30.32	" of Hg	STACK GAS AIRFLOW	23405.2	acf/min
VOLUME SAMPLED	22.923	CU FEET	SAMPLE RATE	0.35	cf/min	STACK GAS AIRFLOW	22575.7	dscf/min
VOLUME (STACK COND)	23.55	ACTUAL CU FT	SAMPLE RATE (STD)	0.35	dscf/min	% ISOKINETICS	101	%
STD VOLUME	22.719	DSCF	SAMPLE RATE (MK5)	0.36	acf/min			
STD VOLUME	0.644	DSCM	SAMPLE RATE (MK5)	9.90	liter/min			

CONFIGURATION: 1,6,12,90,110,110,110,105,105,78,FINAL FILTER
SET ID # RB-QUARTZ B:T1R2-TANK 5.OUT

STAGE #	TARE WT. Gms.	FINAL WT. Gms.	NET WT. Gms.	NET WT. Mgs.	FRACTIONAL %	PERCENT < than	AERODYN. DIAMETER um	PARTIC. CONC. Gr/DSCF	PARTIC. CONC. @ STACK CONDITIONS Gr/ACF	PARTIC. CONC. Mg/DSCM
NOZZLE:	0.00000	0.00000	0.00000	0.00						
1	0.79516	0.79520	0.00004	0.04	4.08	95.92	16.58	2.7E-05	2.6E-05	0.06
2	1.20263	1.20265	0.00002	0.02	2.04	93.88	15.00	1.4E-05	1.3E-05	0.03
3	1.19687	1.19705	0.00018	0.18	18.37	75.51	5.57	1.2E-04	1.2E-04	0.28
4	1.27910	1.27931	0.00021	0.21	21.43	54.08	2.91	1.4E-04	1.4E-04	0.33
5	1.19856	1.19862	0.00006	0.06	6.12	47.96	1.66	4.1E-05	3.9E-05	0.09
6	1.19888	1.19894	0.00006	0.06	6.12	41.84	1.11	4.1E-05	3.9E-05	0.09
7	1.29744	1.29751	0.00007	0.07	7.14	34.69	0.90	4.8E-05	4.6E-05	0.11
8	1.29010	1.29013	0.00003	0.03	3.06	31.63	0.64	2.0E-05	2.0E-05	0.05
9	1.29562	1.29570	0.00008	0.08	8.16	23.47	0.52	5.4E-05	5.2E-05	0.12
10	1.28629	1.28652	0.00023	0.23	23.47	0.00	0.44	1.6E-04	1.5E-04	0.36
FILTER	0.43523	0.43523	0.00000	0.00	0.00	0.00	<.44	0.0E+00	0.0E+00	0.00
TOTAL:			0.00098	0.98	100.00			0.0007	0.0006	1.52

BLANK #1:	1.20388	1.20393	0.00005		
BLANK #2:	1.23287	1.23290	0.00003		
AVERAGE BLANK:			0.00004		

PM10: 85.3 % < 10 Microns
MMD: 2.19 Microns @ 50%

***** PARTICLE SIZE ANALYSIS *****

**** INPUT DATA ****

DATE OF TEST	NOVEMBER 30, 1989
TIME OF TEST	12:02-13:07
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
PART. DIAM. TYPE	C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)
TEST TYPE	OUTLET
RUN NUMBER	2-TANK 5 - FILE NAME: B:T1R2-TANK 5.OUT
REMARKS:	
IMPACTOR TYPE	MK5-78
	MARK 5 IMPACTOR WITH A 78 HOLE FINAL STAGE

WATER VAPOR	3.54%
CARBON DIOXIDE	0.10%
CARBON MONOXIDE	0.00%
OXYGEN	20.90%
SULFUR DIOXIDE	0.00%
NITROGEN	79.00%
PARTICLE DENSITY	1.00 GRAMS/CM^3

GAS METER VOLUME	22.923	CUBIC FEET
IMPACTOR DELTA P	1.00	INCHES HG
ORIFICE DELTA P	0.43	INCHES H2O
STACK PRESS. (BELOW ATMOS.)	-0.02	INCHES H2O
BAROMETRIC PRESS.	30.42	INCHES HG
STACK TEMPERATURE	76.8	DEGREES F
METER TEMPERATURE	88.7	DEGREES F
IMPACTOR TEMPERATURE	76.8	DEGREES F
SAMPLE TIME	65.00	MINUTES
AV. VELOCITY OF STACK GAS	1862.50	FEET/MINUTE
GAS METER PRESSURE	0.00	IN HG
NOZZLE DIAMETER	0.19	INCHES
MAXIMUM AERODYN. DIAMETER	60.00	MICRONS

MASS GAIN ON STAGE 1	0.04 MG
MASS GAIN ON STAGE 2	0.02 MG
MASS GAIN ON STAGE 3	0.18 MG
MASS GAIN ON STAGE 4	0.21 MG
MASS GAIN ON STAGE 5	0.06 MG
MASS GAIN ON STAGE 6	0.06 MG
MASS GAIN ON STAGE 7	0.07 MG
MASS GAIN ON STAGE 8	0.03 MG
MASS GAIN ON STAGE 9	0.08 MG
MASS GAIN ON STAGE 10	0.23 MG
MASS GAIN ON FINAL FILTER	0.00 MG

**** RESULTS ****

DATE OF TEST NOVEMBER 30, 1989
TIME OF TEST 12:02-13:07
LOCATION OF TEST BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER 1 -
RUN NUMBER 2-TANK 5
ACTUAL FLOW RATE (STACK CONDITIONS) 0.358 CFM
FLOW RATE (STANDARD CONDITIONS) 0.345 CFM
PERCENT ISOKINETIC SAMPLING 99.62 %

VISCOSITY OF GAS STREAM 0.0001798 GRAMS/CM-SEC

STAGE	CCF	DP(CLAS AERO)	DP(IMP AERO)	CUM FRACTION
1	1.010	16.580	16.659	0.9592
2	1.011	14.998	15.077	0.9388
3	1.029	5.573	5.652	0.7554
4	1.055	2.905	2.983	0.5413
5	1.096	1.661	1.738	0.4801
6	1.143	1.113	1.191	0.4190
7	1.178	0.898	0.975	0.3476
8	1.253	0.638	0.714	0.3170
9	1.312	0.524	0.600	0.2355
10	1.380	0.440	0.517	0.0010

TOTAL MASS PER DRY NORMAL CUBIC METER 1.5454 MG/CUBIC METER

PART. DIAM. TYPE C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)

PARTICLE SIZE (MICRONS)	CUMFR (STD. DEV.)	CUMFR (PER CENT)	CUM.MASS (MG/DRY N.CU.METER)	dM/dLOG D
0.20	-23.0317	0.0	0.000	0.000
0.25	-17.3927	0.0	0.000	0.000
0.40	-5.5153	0.0	0.000	0.000
0.50	-1.1746	12.0	0.186	8.410
0.75	-0.5342	29.7	0.458	0.472
1.00	-0.2907	38.6	0.596	1.209
1.50	-0.0709	47.2	0.729	0.352
2.00	-0.0213	49.2	0.760	0.225
2.50	0.0317	51.3	0.792	0.504
4.00	0.3785	64.7	1.001	1.324
5.00	0.5984	72.5	1.121	1.093
7.50	0.8744	80.9	1.250	0.519
10.00	1.0497	85.3	1.318	0.620
15.00	1.5456	93.9	1.451	0.790
20.00	2.1875	98.6	1.523	0.318
25.00	2.7887	99.7	1.541	0.089
40.00	5.6261	100.0	1.545	0.000
50.00	12.3087	100.0	1.545	0.000

**** RESULTS (CONTINUED) ****

TIME OF TEST	12:02-13:07
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
RUN NUMBER	2-TANK 5

*** INHALABLE PARTICULATE MATTER ***

UM.	MASS LESS THAN 2.5 MICRON:	0.79	MG/DRY NORMAL CU.METER	(51.3 %)
UM.	MASS LESS THAN 5.0 MICRON:	1.12	MG/DRY NORMAL CU.METER	(72.5 %)
CUM.	MASS LESS THAN 10.0 MICRON:	1.32	MG/DRY NORMAL CU.METER	(85.3 %)
UM.	MASS LESS THAN 15.0 MICRON:	1.45	MG/DRY NORMAL CU.METER	(93.9 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE ARE CLASSICAL AERODYNAMIC DIAMETERS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE :	Y =	-0.69 +	2.02X
MASS GEOMETRIC MEAN DIAMETER		2.193	
GEOMETRIC STANDARD DEVIATION		3.124	
CORRELATION COEFFICIENT		0.763	

AT

TRAVERSE SAMPLING DATA

922208

Client [illegible]
Date 11/[illegible]/8[illegible]
Sample Location [illegible] 3A [illegible]

Operators K[illegible]
Sample Box # [illegible]
Run# 2 - [illegible]
~~[illegible]~~

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm [illegible] / ____

Leak Test Vac [illegible] / ____

✓ Pitots, Pretest

✓ Pitots, Postest

N/A Orsat Sampling System

N/A Tedlar Bag

✓ Thermocouple @ ____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter 45 [illegible]
Distance Upstream ____
Distance Downstream ____

Filter # RB tare ____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (Z-N[illegible])	1177.1	117[illegible].2	
#2 Impinger (H[illegible])	623.1	621.0	
#3 Bubbler	478.1	475.[illegible]	
#4 Silica Gel	717.4	711.2	
TOTAL WATER VOLUME			17.7

Start Time 12:0[illegible]
Stop Time 13:07
Barometric Pressure "Hg 30.4[illegible]
Static Pres "H_2O -[illegible]
Production Rate 6[illegible]

NOMOGRAPH SETUP

% Moisture [illegible]
Meter Temp. [illegible]
Stack Temp. 7[illegible]
ΔH@ 1.9[illegible] Y 1.[illegible]
Pitot# [illegible] Side# [illegible]
Cp .8[illegible]
Nozzle Diameter .1[illegible]
K Factor 1.4[illegible]
Reference ΔP n/[illegible]

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	Gas Meter Temp °F In	Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F
North 2	0	902.199	.30	.43	.44	56	58	9	N/A	46	76
"	5		.30	.43	.43	84	57	9		46	76
"	10		.30	.43	.44	95	58	9		46	76
"	15		.30	.43	.43	105	59	9		46	7[illegible]
"	20		.30	[illegible]	.42	114	60	9		[illegible]	[illegible]
"	25		.30	[illegible]	.43	12[illegible]	6[illegible]	[illegible]		[illegible]	77
"	30		.30	.43	.43	12[illegible]	64	9		4[illegible]	77
"	35		.30	[illegible]	.43	129	67	9		45	77
"	40		[illegible]	[illegible]	.43	130	70	[illegible]		45	77
"	45		.30	.43	.42	132	72	[illegible]		45	77
"	50		.30	.43	.42	13[illegible]	7[illegible]	[illegible]		4[illegible]	7[illegible]
"	55		.30	.43	.43	133	72	[illegible]		4[illegible]	77
"	60										
"	65	925.122									

65 .428 88.7 76.8

11/30/89
Chromic Acid Bath 5
Bath Temp. 93 °F Ambient 73°F
Parts descrip. - fittings etc., stringers mostly
Run 1 - Particle Sizing

Time	Volts	Amperes
~~1200~~		
~~1201~~		
~~1202~~		
~~1203~~		
~~1204~~		
~~1205~~		
~~1206~~		
~~1207~~		
~~1208~~		
1209		
Put Ti In Bath ON 1210		
1211	2.5 1	150 2
1212	7.0 1	1100 1
1213	11.0 1	1750 1
1214	14.0 1	1800
1215	19.0 1	1800
1216	21.5 1	1800
1217	22.0 1	1800
1218	22.2 1	1800
1219	22.2 1	1800
1220	22.2 1	1800
1221	22.3 1	1800
1222	22.3 1	1800
1223	22.3 1	1800
1224		
1225		
1230	22.4 5	1800
1235	22.6 5	1800
1240	22.6 5	1800
1245	22.7 5	1800
1255	22.8 10	1800
1300	22.8 5	1800
1305	22.8 5	1800
Parts out & ATH OFF 1306	0.7	0

12*150+1100+1750+51*1800)/55

1883 amp-hr/hr
21.5 Volts

Note: Chromic Acid has been drained & replaced with new since last testing (Because of repairs)

Sample Type:	**Particle Size Distribution Bath On - Run 3**
Sampling Date:	**November 30, 1990**
Sample Times:	**14:15-15:15 (60 minutes)**
Run Number:	**3**
Lab Numbers:	**922220, 922223-922233, 922101-922105**
Airflow:	**22,433 dscf/min**
Process Data	
Bath Amperage:	**1920 amp-hr/hr**
Voltage:	**20.8 volts D.C.**
Bath Temperature:	**94.0° F**
Ambient Temperature:	**78° F**

Stage #	Distribution d50's (microns)	Cumulative Cr % Less Than Stated Diameter	Chromium Concentration (mg/dscm)
1	16.44	99.67	0.001
2	14.87	98.84	0.002
3	5.52	56.28	0.096
4	2.88	19.09	0.084
5	1.65	2.22	0.038
6	1.10	0.69	0.004
7	0.89	0.31	0.001
8	0.63	0.00	0.001
9	0.52	0.00	0.000
10	0.44	0.00	0.000
final	<0.44	0.00	0.000
TOTAL			0.229

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOMK5CR3		Y FACTOR	1.012		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10		PERCENT MOISTURE	4.00	%	STACK GAS MW DRY	28.85	gm/mole
	CHROMIC TANK #5 EXHAUST		METER TEMP	92.3	Deg. F.	STACK GAS MW WET	28.42	gm/mole
SAMPLE DATE	NOVEMBER 30, 1989		STACK TEMP	80.0	Deg. F.	PITOT Cp	0.842	
OPERATOR	MACKEY		MARK 5 TEMP	80.0	Deg. F.	NOZZLE DIAMETER	0.188	inches
			BAROMETRIC PRESSURE	30.45	" of Hg	NOZZLE AREA	0.0002	sq. ft.
RUN #	3-MK5/Cr		STATIC PRESSURE	-0.02	" of H2O	STACK DIAMETER	48.00	inches
LAB #	922223		STACK PRESSURE	30.45	" of Hg	STACK AREA	12.566	sq. ft.
START TIME	14:15	O'CLOCK	ORIFICE PRESSURE	0.43	" of H2O	VELOCITY HEAD	0.30	" H2O
STOP TIME	15:15	O'CLOCK	MK5 OUTLET ABS. PRES	29.45	" of Hg	STACK GAS VELOCITY	31.1	ft/sec
SAMPLE TIME	60.00	MINUTES	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1868.8	ft/min
INITIAL METER VOL	925.298	CU FEET	AVG. MARK 5 PRESSURE	30.35	" of Hg	STACK GAS AIRFLOW	23483.6	acf/min
FINAL METER VOL	946.778	CU FEET	SAMPLE RATE	0.36	cf/min	STACK GAS AIRFLOW	22433.1	dscf/min
VOLUME SAMPLED	21.480	CU FEET	SAMPLE RATE (STD)	0.35	dscf/min	% ISOKINETICS	103	%
VOLUME (STACK COND)	22.16	ACTUAL CU FT	SAMPLE RATE (MK5)	0.37	acf/min			
STD VOLUME	21.171	DSCF	SAMPLE RATE (MK5)	9.99	liter/min			
STD VOLUME	0.600	DSCM						
SET ID # H-QUARTZ	B:T1R3-TANK 5.OUT							
CONFIGURATION:	1,6,12,90,110,110,110,105,105,78,FINAL FILTER							

STAGE #	CHROMIUM ON FILTERS micrograms	CHROMIUM ON FILTERS milligrams	FRACTIONAL %	PERCENT < than	AERODYNAMIC DIAMETER microns	CHROMIUM CONC. mg/dscm
NOZZLE:	0.00	0.00000				
1	0.45	0.00045	0.33	99.67	16.44	0.0008
2	1.12	0.00112	0.82	98.84	14.87	0.0019
3	57.80	0.05780	42.57	56.28	5.52	0.0964
4	50.50	0.05050	37.19	19.09	2.88	0.0842
5	22.90	0.02290	16.86	2.22	1.65	0.0382
6	2.08	0.00208	1.53	0.69	1.10	0.0035
7	0.52	0.00052	0.38	0.31	0.89	0.0009
8	0.42	0.00042	0.31	0.00	0.63	0.0007
9	0.00	0.00000	0.00	0.00	0.52	0.0000
10	0.00	0.00000	0.00	0.00	0.44	0.0000
FILTER	0.00	0.00000	0.00	0.00	<.44	0.0000
TOTAL:	135.79	0.13579	100.00			0.2264

BACKHALF ANALYSIS

RINSE OF SUBSTRATES	< 0.006
RINSE OF IMPACTOR	26.1
IMPINGER #1 & #2	<2.2
IMPINGER #3 & 4	1.34
FILTER	0.15
TOTAL:	27.59 ug

PILAT (U of W) MARK 5 PARTICLE SIZE ANALYSIS RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME	A:BOEMK5R3		Y FACTOR	1.012		AVERAGE % CO2	0.1	Percent
CLIENT	BOEING AEROSPACE		VOLUME H2O	N/A	mls	AVERAGE % O2	20.9	Percent
LOCATION	SEATTLE, WASHINGTON		VOLUME H2O	N/A	SCF	AVERAGE CO	0.0	Percent
SAMPLE SITE	PLANT NO. 2, BLDG. 2-10		PERCENT MOISTURE	4.00	%	STACK GAS MW DRY	28.85	gm/mole
	CHROMIC TANK #5 EXHAUST		METER TEMP	92.3	Deg. F.	STACK GAS MW WET	28.42	gm/mole
SAMPLE DATE	NOVEMBER 30, 1989		STACK TEMP	80.0	Deg. F.	PITOT Cp	0.842	
OPERATOR	S. MACKEY		MARK 5 TEMP	80.0	Deg. F.	NOZZLE DIAMETER	0.188	inches
			BAROMETRIC PRESSURE	30.45	" of Hg	NOZZLE AREA	0.0002	sq. ft.
RUN #	3-MK5/Cr		STATIC PRESSURE	-0.02	" of H2O	STACK DIAMETER	48.00	inches
LAB #	922223		STACK PRESSURE	30.45	" of Hg	STACK AREA	12.566	sq. ft.
START TIME	14:15	O'CLOCK	ORIFICE PRESSURE	0.43	" of H2O	VELOCITY HEAD	0.30	" H2O
STOP TIME	15:15	O'CLOCK	MK5 OUTLET ABS. PRES	29.45	" of Hg	STACK GAS VELOCITY	31.1	ft/sec
SAMPLE TIME	60.00	MINUTES	MK5 DELTA P	1.00	" of Hg	STACK GAS VELOCITY	1868.8	ft/min
INITIAL METER VOL	925.298	CU FEET	AVG. MARK 5 PRESSURE	30.35	" of Hg	STACK GAS AIRFLOW	23483.6	acf/min
FINAL METER VOL	946.778	CU FEET	SAMPLE RATE	0.36	cf/min	STACK GAS AIRFLOW	22433.1	dscf/min
VOLUME SAMPLED	21.480	CU FEET	SAMPLE RATE (STD)	0.35	dscf/min	% ISOKINETICS	103	%
VOLUME (STACK COND)	22.16	ACTUAL CU FT	SAMPLE RATE (MK5)	0.37	acf/min			
STD VOLUME	21.171	DSCF	SAMPLE RATE (MK5)	9.99	liter/min			
STD VOLUME	0.600	DSCM						

CONFIGURATION: 1,6,12,90,110,110,110,105,105,78,FINAL FILTER
SET ID # M-QUARTZ B:T1R3-TANK 5.OUT

STAGE #	TARE WT. Gms.	FINAL WT. Gms.	NET WT. Gms.	NET WT. Mgs.	FRACTIONAL %	PERCENT < than	AERODYN. DIAMETER um	PARTIC. CONC. Gr/DSCF	PARTIC. CONC. @ STACK CONDITIONS Gr/ACF	PARTIC. CONC. Mg/DSCM
NOZZLE:	0.00000	0.00000	0.00000	0.00						
1	0.85909	0.85955	0.00046	0.46	15.49	84.51	16.44	3.4E-04	3.2E-04	0.77
2	1.28809	1.28818	0.00009	0.09	3.03	81.48	14.87	6.6E-05	6.3E-05	0.15
3	1.28863	1.28894	0.00031	0.31	10.44	71.04	5.52	2.3E-04	2.2E-04	0.52
4	1.28424	1.28456	0.00032	0.32	10.77	60.27	2.88	2.3E-04	2.2E-04	0.53
5	1.29960	1.29986	0.00026	0.26	8.75	51.52	1.65	1.9E-04	1.8E-04	0.43
6	1.28682	1.28696	0.00014	0.14	4.71	46.80	1.10	1.0E-04	9.7E-05	0.23
7	1.28585	1.28595	0.00010	0.10	3.37	43.43	0.89	7.3E-05	7.0E-05	0.17
8	1.27794	1.27808	0.00014	0.14	4.71	38.72	0.63	1.0E-04	9.7E-05	0.23
9	1.27916	1.27922	0.00006	0.06	2.02	36.70	0.52	4.4E-05	4.2E-05	0.10
10	1.28418	1.28423	0.00005	0.05	1.68	35.02	0.44	3.6E-05	3.5E-05	0.08
FILTER	0.41443	0.41547	0.00104	1.04	35.02	0.00	<.44	7.6E-04	7.2E-04	1.73
TOTAL:			0.00297	2.97	100.00			0.0022	0.0021	4.95

BLANK #1:	1.27938	1.27941	0.00003	PM10:	73.9 % < 10 Microns
BLANK #2:	1.27952	1.27957	0.00005	MMD:	1.33 Microns @ 50%
AVERAGE BLANK:			0.00004		

***** PARTICLE SIZE ANALYSIS *****

**** INPUT DATA ****

DATE OF TEST	NOVEMBER 30, 1989
TIME OF TEST	14:15-15:15
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
PART. DIAM. TYPE	C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)
TEST TYPE	OUTLET
RUN NUMBER	3-TANK 5 - FILE NAME: B:T1R3-TANK 5.OUT
REMARKS:	
IMPACTOR TYPE	MK5-78
	MARK 5 IMPACTOR WITH A 78 HOLE FINAL STAGE
WATER VAPOR	4.00%
CARBON DIOXIDE	0.10%
CARBON MONOXIDE	0.00%
OXYGEN	20.90%
SULFUR DIOXIDE	0.00%
NITROGEN	79.00%
PARTICLE DENSITY	1.00 GRAMS/CM^3

GAS METER VOLUME	21.480	CUBIC FEET
IMPACTOR DELTA P	1.00	INCHES HG
ORIFICE DELTA P	0.43	INCHES H2O
STACK PRESS. (BELOW ATMOS.)	-0.02	INCHES H2O
BAROMETRIC PRESS.	30.45	INCHES HG
STACK TEMPERATURE	80.0	DEGREES F
METER TEMPERATURE	92.3	DEGREES F
IMPACTOR TEMPERATURE	80.0	DEGREES F
SAMPLE TIME	60.00	MINUTES
AV. VELOCITY OF STACK GAS	1868.80	FEET/MINUTE
GAS METER PRESSURE	0.00	IN HG
NOZZLE DIAMETER	0.19	INCHES
MAXIMUM AERODYN. DIAMETER	60.00	MICRONS

MASS GAIN ON STAGE 1	0.46 MG
MASS GAIN ON STAGE 2	0.09 MG
MASS GAIN ON STAGE 3	0.31 MG
MASS GAIN ON STAGE 4	0.32 MG
MASS GAIN ON STAGE 5	0.26 MG
MASS GAIN ON STAGE 6	0.14 MG
MASS GAIN ON STAGE 7	0.10 MG
MASS GAIN ON STAGE 8	0.14 MG
MASS GAIN ON STAGE 9	0.06 MG
MASS GAIN ON STAGE 10	0.05 MG
MASS GAIN ON FINAL FILTER	1.04 MG

**** RESULTS ****

DATE OF TEST NOVEMBER 30, 1989
TIME OF TEST 14:15-15:15
LOCATION OF TEST BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER 1 -
RUN NUMBER 3-TANK 5
ACTUAL FLOW RATE (STACK CONDITIONS) 0.365 CFM
FLOW RATE (STANDARD CONDITIONS) 0.348 CFM
PERCENT ISOKINETIC SAMPLING 101.21 %

VISCOSITY OF GAS STREAM 0.0001802 GRAMS/CM-SEC

STAGE	CCF	DP(CLAS AERO)	DP(IMP AERO)	CUM FRACTION
1	1.010	16.438	16.518	0.8451
2	1.011	14.870	14.949	0.8148
3	1.029	5.524	5.604	0.7104
4	1.055	2.879	2.958	0.6027
5	1.097	1.646	1.724	0.5152
6	1.145	1.103	1.180	0.4680
7	1.180	0.890	0.967	0.4343
8	1.256	0.631	0.708	0.3872
9	1.316	0.518	0.595	0.3670
10	1.385	0.436	0.513	0.3502

TOTAL MASS PER DRY NORMAL CUBIC METER 5.0209 MG/CUBIC METER

PART. DIAM. TYPE C (I=IMP AERO, C=CLAS AERO, P=PHYSICAL)

PARTICLE SIZE (MICRONS)	CUMFR (STD. DEV.)	CUMFR (PER CENT)	CUM.MASS (MG/DRY N.CU.METER)	dM/dLOG D
0.20	-0.5795	28.1	1.412	0.977
0.25	-0.5236	30.0	1.508	1.007
0.40	-0.4059	34.2	1.719	1.064
0.50	-0.3487	36.4	1.826	1.125
0.75	-0.2300	40.9	2.054	1.596
1.00	-0.1177	45.3	2.275	1.838
1.50	0.0114	50.5	2.533	1.276
2.00	0.1027	54.1	2.716	1.683
2.50	0.1934	57.7	2.895	2.018
4.00	0.4290	66.6	3.344	2.065
5.00	0.5246	70.0	3.515	1.394
7.50	0.5958	72.4	3.637	0.343
10.00	0.6416	73.9	3.713	1.069
15.00	0.9054	81.7	4.104	3.446
20.00	1.3140	90.6	4.547	3.116
25.00	1.7271	95.8	4.810	2.309
40.00	4.1752	100.0	5.021	0.009
50.00	10.6763	100.0	5.021	0.000

**** RESULTS (CONTINUED) ****

TIME OF TEST	14:15-15:15
LOCATION OF TEST	BOEING PLANT NO. 2, BLDG. 2-10
TEST NUMBER	1
RUN NUMBER	3-TANK 5

*** INHALABLE PARTICULATE MATTER ***

CUM. MASS LESS THAN 2.5 MICRON:	2.90 MG/DRY NORMAL CU.METER	(57.7 %)
CUM. MASS LESS THAN 5.0 MICRON:	3.51 MG/DRY NORMAL CU.METER	(70.0 %)
CUM. MASS LESS THAN 10.0 MICRON:	3.71 MG/DRY NORMAL CU.METER	(73.9 %)
CUM. MASS LESS THAN 15.0 MICRON:	4.10 MG/DRY NORMAL CU.METER	(81.7 %)

NOTE: DIAMETERS FOR INHALABLE PARTICULATE ARE CLASSICAL AERODYNAMIC DIAMETERS.

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE :	Y = -0.11 + 0.88X
MASS GEOMETRIC MEAN DIAMETER	1.329
GEOMETRIC STANDARD DEVIATION	13.741
CORRELATION COEFFICIENT	0.996

922223

TRAVERSE SAMPLING DATA

Page 1 of 1

Client Boeing
Date 11/30/93
Sample Location Test #31 Vent Stack 2-19
Operators KSH
Sample Box # A
Run # 3 - Particle Sizing Mode 7

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm .009 / ____
Leak Test Vac 10" / ____
____ Pitots, Pretest
____ Pitots, Postest
N/A Orsat Sampling System
N/A Tedlar Bag
____ Thermocouple @ ____ °F

SCHEMATIC TRAVERSE LAYOUT

Stack Diameter 48"
Distance Upstream ____
Distance Downstream ____

Filter # A tare ____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler (2 NaOH)	1267.3	1259.1	____
#2 Impinger (HNO3)	619.7	617.5	____
#3 Bubbler	495.8	493.9	____
#4 Silica Gel	725.2	718.8	____
TOTAL WATER VOLUME			18.7

Start Time 14:15
Stop Time 15:15
Barometric Pressure "Hg 30.45
Static Pres "H_2O ____
Production Rate Baseline

NOMOGRAPH SETUP

% Moisture 2
Meter Temp. 95
Stack Temp. 75
ΔH@ 1.92 Y 1.018
Pitot # C Side # A
Cp .82
Nozzle Diameter .188
K Factor ____
Reference ΔP ____

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O		Orifice Setting (ΔH), In H_2O Ideal	Actual	Gas Meter Temp °F In	Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F	Imp. Exit Temp °F	Stack Temp °F	
North 3	0	926.298	.30		.43	.43	63	64	9	N/A	45	80	
"	5		.30		.43	.43	86	64	9		45	80	
"	10		.30		.43	.43	105	64	9		45	80	
"	15		.30		.43	.43	115	65	9		46	80	
"	20		.30		.43	.43	121	66	9		45	80	
"	25		.30		.43	.43	124	68	9		45	80	
"	30		.30		.43	.43	127	69	9		46	80	
"	35		.30		.43	.43	129	70	9		45	80	
"	40		.30		.43	.43	130	71	9		45	80	
"	45		.30		.43	.43	131	72				80	
"	50		.30		.43	.43	132	73				80	
"	55		.30		.43	.43	133	74				80	
	60	946.778											
	60				.430		92.3					80	

Particle Sizing

11/30/89

Chromic Acid Bath 5

Temp. (Bath) 94°F Part Descrip. - Supports

Run 3 P.S.	Time	Volts	Amperes
Bath on →	1415	2.0	200 |
	1416	3.5	1200 |
	1417	8.0	1800 53
	1418	13.5	1800
	1419	18.0	1800
	1420	21.5	
	1421	21.8	
	1422	22.0	
	1423	22.0	
	1424	22.0	
	1425	22.0	
	1430	22.0	
	1435		
	1440	22.0	
	1445		
	1450	22.0	
	1455		
	1500	22.0	
	1505	22.0	1800
Bath off	1510		

(20 × 1200 + 53 × 1800)

1920 amp-hr/hr

20.8 volts

SECTION 4
AMBIENT WORKROOM SAMPLE

Sample Type:	**Ambient Workroom Sample 1**
Sampling Date:	**August 31, 1989**
Sample Times:	**10:22-16:52 (390 minutes)**
Run Number:	**1**
Lab Numbers:	**915740, 915741, 915743**
Process Data	
Bath Status:	**Bath On and Off During Test**
Ambient Temperature:	**80° F**
Hexavalent Chromium	
Concentration:	**0.295 mg/dscm**
Concentration:	**0.14 ppm**
Total Chromium	
Concentration:	**0.249 mg/dscm**
Concentration:	**0.12 ppm**
Description of sampling set-up: Sampling site was 53 inches above ground, 7 feet from the north end on tank #5, 10 inches away from east edge of tank, adjacent to ventilation opening #56. The top edge of the tank is 43 inches above the ground. The acid liquid level was approximately 6 inches below the top of the tank.	

METHOD 1-5 - HEXAVALENT AND TOTAL CHROMIUM EMISSIONS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	3BO#5WR1	LAB #:	915740
CLIENT:	BOEING PLANT #2	START TIME:	10:22 O'CLOCK
LOCATION:	SEATTLE, WASHINGTON	STOP TIME:	16:52 O'CLOCK
SAMPLE SITE:	BLDG 210/TANK #5	SAMPLE TIME:	390.0 MINUTES
SAMPLE DATE:	AUGUST 31, 1989	CONDITION:	BATH ON & OFF
RUN #:	1-CR+6		
OPERATORS:	S. MACKEY		
CONTACT:	P. SIEBENALER		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
1274.9	1250.4	24.5
629.0	629.9	-0.9
475.3	473.4	1.9
817.4	783.8	33.6
TOTAL H2O GAIN:		59.1
TOTAL VOLUME (SCF)		2.79
PERCENT MOISTURE:		1.45
Bws:		0.0145

PITOT Cp:	NA
NOZZLE DIA INCHES:	NA
NOZZLE AREA FT^2:	NA
STACK DIA. INCHES:	NA
STACK AREA FT^2:	NA
METER TEMP. DEG F:	147.1
BAROM. PRES. "HG:	30.20
STATIC PRES. "H2O:	0.00
STACK PRES. "HG:	30.20
ORIFICE PRES "H2O:	1.0
METER PRES. "HG:	30.27

INIT. METER VOL.:	830.633
FINAL METER VOL.:	1045.964
VOLUME SAMPLED:	215.331
STD VOLUME (DSCF):	189.298
STD VOLUME (DSCM):	5.361
Y FACTOR:	0.999

AVERAGE % CO2:	0.1
AVERAGE % O2:	20.9
AVERAGE % CO:	0
STACK GAS MW. DRY:	28.85
STACK GAS MW. WET:	28.69

HEXAVALENT CHROMIUM

HEXAVALENT CHROMIUM CONCENTRATION (ug):	1581.3
HEXAVALENT CHROMIUM CONCENTRATION (mg/dscm):	0.295
HEXAVALENT CHROMIUM IN SAMPLE (ppm):	0.14

TOTAL CHROMIUM

TOTAL CHROMIUM CONCENTRATION (ug):	1336.7
TOTAL CHROMIUM CONC. ON FILTER (ug):	< 0.30
TOTAL CHROMIUM CONCENTRATION (mg/dscm):	0.249
TOTAL CHROMIUM IN SAMPLE (ppm):	0.12

*Note: Slight differences in total chromium and hexavalent chromium concentrations are due to different methods of analysis.

AT

3B045WR4

TRAVERSE SAMPLING DATA

Page 1 of 1

Client Boeing Plant 2
Date 8/31/87
Sample Location Workroom Air NE of Bath #5
Operators KSM
Sample Box # A
Run # 1 Workroom (Total Cr/Cr+6 Sample Train)

Stack Diameter N/A
Distance Upstream
Distance Downstream

Start Time 10:22
Stop Time 16:52
Barometric Pressure "Hg 30.20 "Hg
Static Pres "H_2O 0
Production Rate

EQUIPMENT CHECKS

Initial/Final

Leak Rate Cfm <.02 / .005
Leak Test Vac 15" / 11"
_____ Pitots, Pretest
_____ Pitots, Postest
_____ Orsat Sampling System
_____ Tedlar Bag
_____ Thermocouple @ _____ °F

SCHEMATIC TRAVERSE LAYOUT

Filter # Teflon tare _____ mgs

	Final Wt.	Initial Wt.	Net Wt.
#1 Bubbler	657.1	- 1250.4	=
#2 Impinger	629.0	- 629.9	=
#3 Bubbler	475.3	- 473.4	=
#4 Silica Gel	817.4	- 783.8	=

TOTAL WATER VOLUME

NOMOGRAPH SETUP

% Moisture N/A
Meter Temp.
Stack Temp.
ΔH@ _____ Y _____
Pitot # _____ Side # _____
Cp
Nozzle Diameter
K Factor
Reference ΔP

Sample Point	Elap Time Min.	Dry Gas Meter Reading Cu. Ft.	Pitot Reading (ΔP), In. H_2O	Orifice Setting (ΔH), In H_2O Ideal	Orifice Setting (ΔH), In H_2O Actual	(5) Gas Meter Temp °F In	(6) Gas Meter Temp °F Out	Pump Vacuum In. Hg Gauge	Filter Box Temp °F (N/A)	(2) Imp. Exit Temp °F	(1) Stack Temp °F (Workroom Air Temp)
Start Point	0	830.633	N/A	1.00	1.00	106	72	7.5		65	77
Workroom Air	15				1.0	155	78	7.4		54	77
	30				1.0	170	86	7.3		60	77
	45				1.0	178	94	7.0		60	78
1 Hour	60				1.0	183	100	7.0		60	78
	75				1.0	18	103	7.0		61	78
	90				1.0	188	107	7.0		61	78
	105				1.0	187	108	7.0		61	79
2 Hours	120				1.0	190	109	7.0		61	79
	135				1.0	190	110	7.0		63	79
	150				1.0	192	111	7.0		61	81
	165				1.0	192	113	7.0		60	82
3 Hours	180				1.0	193	113	7.0		58	81
	195				1.0	194	114	7.0		58	80
	210				1.0	194	114	7.0		59	80
	225				1.0	194	114	7.0		58	81
4 Hours	240				1.0	194	115	7.0		57	81
	255				1.0	195	115	7.0		57	82
	270				1.0	195	116	7.0		57	81
	285				1.0	195	116	7.0		58	81
5 Hrs	300				1.0	195	116	7.0		59	80
	315				1.0	195	116	7.0		59	78
	330				1.0	195	116	7.0		61	81
	345				1.0	196	116	7.0		61	81
6 Hrs	360				1.0	196	116	7.0		63	82

3/31/21 Brewing Plant 2

Run 1 (Private Steig) — Started with Parts into bath @ 10:26 AM
Removed Parts 11:21 AM

Readings during Test:

10:45	23.0 Volts	1830 Amps	94.5° Bath Temperature
10:55	23.0 Volts	1830 Amps	
11:03	23.1 Volts	1830 Amps	
11:11	23.2 Volts	1820 Amps	78°F ambient
11:20	23.2 Volts	1820 Amps	
11:22	0.5 V (Off Over Relay)	0 Amps	

Velocity Measurements between Rung 1 & 2:

Opening #	Ft/min reading
1	2270
2	1810
11	1740
16	1640
21	1650
26	1270
31	730
36	1060
41	730
46	820
51	680
56	340
61	620

(Readings from 11:35 - 11:50)
(Empty Bath)

← Workroom Air Sampler is Here; Wet Surfaces Too

SECTION 5
VENTILATION SYSTEM EVALUATION

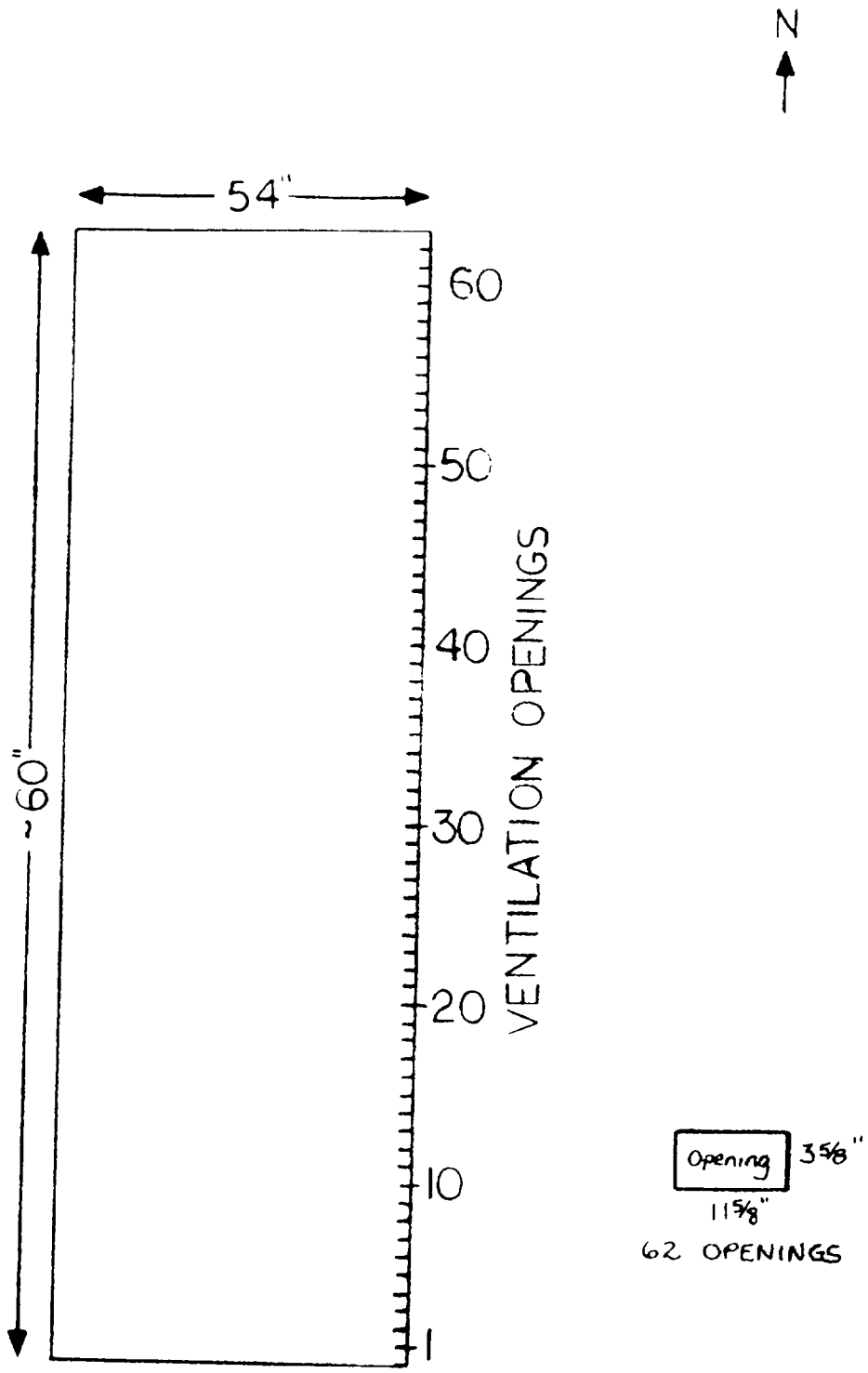

Figure 3. **Diagram of the #5A chromic acid anodizing tank and ventilation system at Boeing Plant 2 in Seattle, Washington.**

Sample Type:	**Ventilation Opening Velocities**
Sampling Dates:	**August 22, August 31, November 30, 1989**

Description of sampling procedure: A Kurz velometer with a digital readout in feet per minute was used to measure the velocity at each vent opening along the east side of the #5 chromic anodize aluminum tank. There are 62 openings along the east side. The measurement was taken at the centroid of each 3.375 by 11.625 inch opening. The velocity was lowest from openings 54-58, therefore, the ambient workroom sample was taken at that point.

Velocity Traverse

Boeing - Plant 2 - #5A Chromic Anodize Aluminum Tank
Date: August 22, 1989
Time: 11:55 - 12:15

Vent #	Velocity (ft/min)	Vent #	Velocity ft/min
1	2050	32	1330
2		33	
3	2060	34	980
4		35	
5	2450	36	970
6		37	
7	1830	38	460
8		39	
9	1810	40	730
10		41	
11	1720	42	790
12		43	
13	1800	44	690
14		45	
15	1700	46	630
16		47	
17	1740	48	
18		49	810
19	1570	50	
20		51	1090
21	1560	52	
22		53	1020
23	1560	54	
24		55	240
25	930	56	
26		57	340
27	1110	58	
28		59	620
29	960	60	
30		61	470
31	810	62	

Ambient Temperature 74°F

Velocity Traverse

Boeing - Plant 2 - #5A Chromic Anodize Aluminum Tank
Date: August 22, 1989
Time: 16:55 - 17:15

Vent #	Velocity (ft/min)	Vent #	Velocity ft/min
1		32	1060
2	1780	33	
3		34	1090
4	1690	35	
5		36	1080
6	2140	37	
7		38	1130
8	1800	39	
9		40	830
10	1690	41	
11		42	860
12	1640	43	
13		44	780
14	1770	45	
15		46	820
16	1560	47	
17		48	730
18	1420	49	
19		50	690
20	1500	51	
21		52	690
22	1470	53	
23		54	700
24	1220	55	
25		56	320
26	1390	57	
27		58	620
28	1190	59	
29		60	550
30	990	61	
31		62	510

Ambient Temperature 83°F

Velocity Traverse

Boeing - Plant 2 - #5A Chromic Anodize Aluminum Tank
Date: August 31, 1989
Time: 11:35 - 11:50

Vent #	Velocity (ft/min)	Vent #	Velocity ft/min
1	2270	32	
2		33	
3		34	
4		35	
5		36	1060
6	1810	37	
7		38	
8		39	
9		40	
10		41	730
11		42	
12	1740	43	
13		44	
14		45	
15		46	820
16	1640	47	
17		48	
18		49	
19		50	
20		51	680
21	1650	52	
22		53	
23		54	
24		55	
25		56	340
26	1220	57	
27		58	
28		59	
29		60	
30		61	620
31	730	62	

Ambient Temperature 78°F

Velocity Traverse

Boeing - Plant 2 - #5A Chromic Anodize Aluminum Tank
Date: August 31, 1989
Time: 14:20-14:50

Vent #	Velocity (ft/min)	Vent #	Velocity ft/min
1	2380	32	
2		33	
3		34	
4		35	
5		36	1060
6	2230	37	
7		38	
8		39	
9		40	
10		41	820
11	1650	42	
12		43	
13		44	
14		45	
15		46	
16	1700	47	
17		48	
18		49	
19		50	
20		51	720
21	1610	52	
22		53	
23		54	
24		55	
25		56	280
26	1390	57	
27		58	
28		59	
29		60	
30		61	500
31	720	62	

Ambient Temperature 81°F

Velocity Traverse

Boeing - Plant 2 - #5A Chromic Anodize Aluminum Tank
Date: November 30, 1989
Time: 11:00 - 11:05

Vent #	Velocity (ft/min)	Vent #	Velocity ft/min
1		32	
2		33	
3		34	
4		35	970
5	2400	36	
6		37	
7		38	
8		39	
9		40	750
10	1790	41	
11		42	
12		43	
13		44	
14		45	950
15	1690	46	
16		47	
17		48	
18		49	
19		50	460
20	1560	51	
21		52	
22		53	
23		54	
24		55	260
25	960	56	
26		57	
27		58	
28		59	
29		60	600
30	1010	61	
31		62	

Ambient Temperature 76°F

SECTION 6
CHROMIC ACID SAMPLES
TAKEN FROM THE BATH

Sample Type:	Acid Sample
Sampling Date:	September 19, 1989
Lab Number:	917176
Hexavalent Chromium:	5,292,000 micrograms/sample 5.3 grams/sample
Total Chromium:	48,470,000 micrograms/sample 48.5 grams/sample

Sample Type:	Acid Sample
Sampling Date:	November 30, 1989
Lab Number:	922117
Hexavalent Chromium:	6,578,000 micrograms/sample 6.6 grams/sample
Total Chromium:	6,325,000 micrograms/sample 6.3 grams/sample

METHODOLOGY REFERENCES

Hexavalent chromium testing and analysis methods detailed in a paper titled "Method Development and Testing for Measurement of Source Levels of Hexavalent and Total Chromium" by Daniel G. Bivens and W.G. DeWees were utilized for this project. Sampling procedures specified in the July 1, 1988 Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A, Methods 1-5 were also used. Quality assurance procedures for source testing are outlined in the EPA's reference manual titled Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 3, EPA-600/4-77-027b.

The specific sampling and analysis procedures utilized for the particle size distribution tests detailed in the operations manual for the Mark 3-5 impactor by Dr. Michael J. Pilat and the "Procedures for Cascade Impactor Calibration and Operation in Process Streams - Revised 1983 to Include PM_{10} Source Sampling" prepared by Mr. D. Bruce Harris for the U.S. EPA, February 1984. Methodology and procedures specified in "Recommended Methodology for the Determination of Particle Size Distributions in Ducted Sources" prepared by the Southern Research Institute for the California Air Resources Board, ARB Contract A3-092-32, May 1986 were also referenced for sampling strategies.

SAMPLING AND ANALYSIS PROCEDURES

CHROMIUM SAMPLES

The sample train used for collecting chromium (Cr) and hexavalent chromium (Cr^{+6}) samples was an EPA Method 5 design with modifications. A typical Method 5 sample train schematic is included as Figure 5 in Appendix B of this report. The sample train did not include a heated front-half filter. A quartz probe with an attached nozzle was inserted into the stack to draw a sample into the impingers. The probe was equipped with "S" type pitot tubes to measure velocity and a thermocouple sensor to measure the stack temperature at each sample point. The thermocouple probe was connected to a Fluke^{R} digital thermocouple indicator which is accurate to within $\pm$1 degree Fahrenheit. The condenser section of the sample train consisted of a modified Greenburg-Smith bubbler containing 100 milliliters (ml) of 0.1 N sodium hydroxide (NaOH) absorbing solution, a second impinger containing 100 ml of NaOH absorbing solution, a third impinger containing 100 ml of 0.1 N nitric acid (HNO_3), an empty bubbler, a back-half filter holder containing a Teflon^{R} filter, and a final bubbler containing indicating silica gel desiccant. The condenser section was maintained at a temperature below 68° F by adding ice to the condenser section throughout sampling.

The sample train was connected to a control box by means of an umbilical cord which contains a vacuum hose, pitot lines, thermocouple wires and a 4-wire electrical cord. The control box (meter box) was used to monitor stack conditions and to facilitate isokinetic sampling. The control box consists of a diaphragm pump which is used to pull the stack gas through the sample train, fine and coarse metering valves to control the sampling rate, a vacuum gauge which measures the pressure drop from the sampling nozzle to the metering valves, and a calibrated

dry gas meter. At the outlet of the dry gas meter is a calibrated orifice which is used to isokinetically control the flow of gas through the metering system. The pressure drop across the orifice was monitored with both low and high range magnehelic gauges. The pitot tubes utilized to measure stack gas velocity are connected to the control box via the umbilical cord. The control box contains low and high range magnehelic gauges which are used for the velocity measurement.

The chrome anodizing tank ventilation system exhausts to a a 48 inch diameter circular stack with two (2) sampling ports available 90 degrees apart. The sampling ports are located 2 feet upstream and 6 feet downstream from the nearest flow disturbance. Two (2) traverses of six (6) points each were performed during each chromium test. Figure 4 located in Appendix B of this report is a schematic of the stack and the point locations selected. The sample probe was marked with felt pen to indicate the proper point location.

Stack condition measurements were made prior to collecting a sample. The appropriate sample nozzle was selected and isokinetic operating parameters were established utilizing a Hewlett-Packard programmable calculator. The sampling nozzle, probe and condenser section glassware were all cleaned and rinsed with dilute nitric acid and deionized water prior to assembling the sample train. The sample train was assembled and leak tested following the procedures outlined in Method 5. Before each test, a final check was made to assure that the process was operating at the desired production rate and the desired operating parameters (e.g. whether parts were in the bath or not). Ice was added to the condenser section. The sample nozzle was positioned in the stack at the first sample point. The sample pump was then turned on and the gas sampling rate was adjusted for isokinetic sampling. Sampling proceeded isokinetically at each of the 6 traverse

points. The pump was then turned off and the sample train was carefully moved to the second port. The nozzle was then positioned at the first point of the second traverse, the pump was again turned on and isokinetic sampling was performed at the 6 traverse points. Upon completion of the second traverse the sample probe was removed from the stack and a post-test leak check was performed according to Method 5 procedures.

Following sample collection, the samples were transferred to a temporary laboratory area for clean up. The back-half filters were transferred to glass petri dishes labeled with the sample date, client name and run number. These filters, along with an unused filter to be analyzed as a blank, were submitted to the Am Test laboratory for washing and chromium analysis.

The contents of the nozzle, probe liner and connective glassware were quantitatively transferred to a glass storage container using 0.1 N NaOH. An iodine flask with a female ball joint end was attached to the male ball joint end of the probe to assure that no material collected inside the glassware was lost during the rinsing and brushing of the probe. The contents of the iodine flask were quantitatively transferred to the storage container labeled with sample date, client name, and run number. A portion of the reagent was placed in a glass storage container and submitted with the samples to the Am Test laboratory for analysis for chromium.

The bubblers and impingers utilized for the condenser section of the sample train were weighed with a readability of $\pm$0.1 grams before and after sampling on a Mettler PE3000 electronic top loading balance. The difference between the initial and final weights of the condenser section constitute the amount of moisture gain

during the run. The contents of the first two (2) impingers containing sodium hydroxide absorbing solution were then transferred to a 1000 ml glass graduated cylinder. The bubblers and impingers were rinsed with 0.1 N NaOH reagent into the graduated cylinder, and the liquid level was recorded. The liquid was then transferred to the corresponding sample container for each run which contained the probe wash. For some samples, the solutions from the probe rinse, 1st impinger and 2nd impinger were analyzed separately to evaluate collection efficiency for this method. The liquid in the 3rd and 4th impingers containing HNO_3 were transferred to a 1000 ml glass graduated cylinder. The bubblers and impingers were rinsed with 0.1 N HNO_3 reagent into the graduated cylinder, and the liquid level was recorded. The sample was then transferred to a labeled sample container. The samples were then transferred to the Am Test, Inc. laboratory for chromium analysis. The sodium hydroxide solutions were analyzed for both hexavalent chromium and total chromium. The nitric acid solutions and the teflon filter were analyzed for total chromium only. Hexavalent chromium (Cr^{+6}) analysis was performed using EPA Method 7176, which is a diphenylcarbazide colorimetric method. The hexavalent chromium analyses were completed within 48 hours after collecting the samples. Total chromium (Cr) analysis was performed using EPA Method 200.7, which utilizes inductively coupled plasma (ICP) spectroscopy. The laboratory results were presented in units of micrograms per sample. Those units were converted to concentrations in air.

PARTICLE SIZE DISTRIBUTION SAMPLES

Cascade impactors separate the sampled aerosol particles into size increments by inertial impaction of the particles onto a collection surface, in this case ultrapure microfiber quartz filter paper. This occurs at successive stages through the impactor, hence the name "Cascade". The resulting index of the measured particle

size is traditionally separated by the particle diameter collected with 50% collection efficiency by each jet stage, and this diameter is usually called the "cut diameter" and is characterized by the symbol "D_{50}". The aerodynamic cut diameter is the diameter of a unit density sphere which will be collected with 50% efficiency by the specific impactor jet stage.

For these tests Am Test used straight nozzles at the inlet to a Pilat (U of W) Mark 5 source test Cascade impactor. A photograph of the Mark 5 impactor with a straight nozzle is illustrated in Figure 6 in Appendix B of this report. A complete Cascade impactor sampling train is illustrated in Figure 7 in Appendix B of this report. The Mark 5 impactors were assembled using the jet stages listed for configuration #78, which has a 78 hole final stage. In this configuration, the Mark 5 impactor provided eleven (11) aerodynamic particle size cut diameters, of sizes between 0.25 and 20 microns in diameter.

Whatman QM-A ultra-pure quartz microfiber filter substrates which were mounted on stainless steel inserts and baked at 500° F for 2 hours, desiccated for 24 hours and weighed to a constant weight on a Mettler AE163 electronic balance (set to a time integrating mode with a readability of 0.01 milligrams) were used to line each collection plate. Following the impactor run, the substrates were desiccated for 24 hours and weighed again.

The impactor probe was connected to a condenser section identical to the chromium samples. The sample train was connected to a control box as described for the chromium samples. The impingers were weighed before and after each test for calculating the percent moisture in the gas stream. The condenser section was leak-checked prior to staring a test. The flow rate through the impactor was pre-

set to the rate necessary for isokinetic sampling at the specific velocity point. The particle size distribution samples were collected at a point of average velocity in the stack. The impactor was positioned in the stack at the sample point with the nozzle facing away from the gas stream and was allowed to come to stack temperature for approximately one-half (1/2) hour. Ice was added to the condenser section of the particle size sample train. The nozzle was then turned to face the flow and the sample pump was turned on and the sampling rate was maintained at the pre-set rate necessary for isokinetic sampling.

After a sample had been collected the pump was then turned off and the impactor was removed from the stack, taking care that the nozzle tip did not touch the port nipple. The impactor was detached from the probe and carefully transferred to Am Test's temporary laboratory. The impactor was allowed to cool and was carefully disassembled and inspected. Each stage was inspected for proper particulate matter deposition. All interior impactor surfaces were checked for wall loss. The stainless steel inserts, onto which the substrates are mounted, were transferred to individual petri dishes and placed into a Labconco^{R} desiccator. Two (2) substrate blanks for each sample set were kept with the sample to audit desiccation and weighing techniques. To obtain final weights, the substrates were desiccated for 24 hours and weighed. The weights were recorded on the data sheet and in a bound laboratory notebook. The total weight of each substrate and stainless steel insert is approximately 1 gram. The low tare weight and simple donut-like shape of the Pilat (U of W) Mark 5 Cascade impactor insert-substrate combination allows for a great degree of weighing accuracy.

Once final weights were obtained for the substrates, each filter which lines the substrates was placed in a separate glass jar for submittal to the laboratory for

chromium analysis. The substrates were collectively rinsed into a separate jar. The appropriate blank filters and reagents were submitted along with the samples.

QUALITY ASSURANCE

A strict quality assurance program was followed throughout preparation, sampling, analysis, data reduction, and report preparation. This program includes recent equipment calibrations, careful chain-of-custody procedures, the use of ACS quality or better reagents, analysis of control samples, and "by-hand" calculation checks of computerized results.

The sample nozzles used to collect isokinetic samples were calibrated on-site before sampling using inside calipers readable to 0.001 inches. The dry gas meters used to accurately measure sample volumes have been recently calibrated using a spirometer at the Washington State Department of Ecology (DOE) laboratory in Redmond, Washington. The "S" type pitot tubes used for velocity measurement have also been recently calibrated utilizing a wind tunnel and a standard "P" type pitot tube and are inspected regularly for proper alignment. The digital Fluke thermocouple indicators used to obtain temperature measurements are accurate to ± 1 degree Fahrenheit. Each thermocouple probe used to monitor temperatures is checked quarterly at 3 different temperature settings.

In addition to quantitative clean-up and analysis procedures, filter and reagent blanks, as well as standard solutions were carried throughout the analysis procedures. The samples were weighed to constant weights of ± 0.05 milligrams following desiccation in a Labconco "Autodry Cabinet" desiccator. This desiccator is an electronic dehumidifier which automatically maintains the humidity inside the desiccator. The dehumidifier automatically recharges the internal desiccant every 5.5 hours with a small heater and fan inside the chamber. An Airguide humidity indicator accurate to $\pm 1\%$ is used to check the humidity inside the

desiccator when obtaining tare and final weights. Indicating silica gel desiccant is added to the chamber as necessary to maintain the humidity at the desired level. The Mettler AE163 electronic balance used to obtain weights was set to a time integrating mode (100,000 readings per minute) with a readability of 0.01 milligrams. The balance was calibrated prior to every use. The calibration of Am Test's Mettler balances is checked by the manufacturer on a yearly basis.

Each stage of the Mark 5 cascade impactor has been calibrated using a polydispersed aerosol and optical size analyzer at a range of temperatures and flow rates to determine the inertial impaction parameter for that particular stage. This parameter is intrinsic for each stage being controlled by the physical configuration of the stage and other pertinent aerodynamic values. The stages are periodically examined for wear and corrosion and are replaced as necessary.

Additional information with respect to Am Test, Inc.'s laboratory quality assurance and quality control protocol programs is included in the Appendix of this report.

CALCULATION OF RESULTS

The velocity, airflow, molecular weight, and moisture results were calculated using EPA 40 CFR 60 Method 1-5 criteria. Copies of pertinent equations are included in the Appendix of this report. Final results calculations were performed using spreadsheet programs run on a Hewlett-Packard Vectra computer system. Sample "by-hand" calculations of results were completed using a Hewlett-Packard calculator, and may be found in the Appendix of this report.

The particle size distribution results were computer generated in the Am Test Air Quality Division office utilizing a Cascade impactor data reduction program. This computer program is considered as "state-of-the-art" by particle sizing experts throughout the United States. Computer printouts of the particle size distribution results are included in Appendix A. To plot the particle size distribution, the column titled "aerodynamic diameter" (in micrometers) was plotted against the column titled "percent less than" on semi-log versus probability graph paper to illustrate the particle size distribution for each Mark 5 run.

APPENDIX A

AMTEST

ANALYSIS REPORT

CLIENT: Am Test, Inc. - Air Quality Division DATE RECEIVED: 8/23/89

REPORT TO: Kris Hansen DATE REPORTED: 9/11/89

BOEING PLANT #2

Laboratory Sample Numbers	Client Identification	Total Chromium (ug)	Hexavalent Chromium (ug)	Volume (ml)
915088	Blank (0.1N NaOH)	<0.60	0.036	100.
915089	Run 1 Probe	1,040.	1,670. 1,650.] 1660	215.
915090	Run 1 First Impinger	78.6	94.	130.
915091	Run 2 Probe & First Impinger	1,030.	1,970.	285.
915092	Run 3 Probe & First Impinger	283.	321.	329.
915093	Run 1 Second Impinger	102.	120.	130.
915094	Run 2 Second Impinger	113.	122. 123.] 122.5	139.
915095	Run 3 Second Impinger	2.2	11.5	144.
DETECTION LIMIT*		0.006	0.025	-
EPA Method used		200.7	7176	-

< = less than
*Values reported in mg/l.

JTD/pb

REPORTED BY John T. Dailey
John T. Dailey

AMTEST

AmTest Inc 104

Professional
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Redmond WA
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Fax: 206 883 3495

Tel: 206 885 1664

ANALYSIS REPORT

CLIENT: Am Test, Inc. - Air Quality Division

DATE RECEIVED: 8/23/89

REPORT TO: Kris Hansen

DATE REPORTED: 8/31/89

BOEING PLANT #2

Laboratory Sample Nos.	Client Identification	Total Chromium	Volume (ml)
915096	Blank Filter	<0.15*	-
915097	Run 1 Filter	<0.15*	-
915098	Run 2 Filter	<0.18*	-
915099	Run 3 Filter	<0.15*	-
915100	Run 1 HNO_3 Solution	<1.00**	166.
915101	Run 2 HNO_3 Solution	<1.02**	170.
915102	Run 3 HNO_3 Solution	<0.894**	149.
915103	Blank Solution (0.1 N HNO_3)	<0.600**	100.
DETECTION LIMIT		0.006	-
EPA Method used		200.7 (ICP)	-

*Reported in ug/filter.
**Reported in ug.

KF/pb

REPORTED BY Kathy Fugiel

AMTEST

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ANALYSIS REPORT

CLIENT: Air Quality Division

DATE RECEIVED: 8/30/89

REPORT TO: Kris Hansen

DATE REPORTED: 9/7/89

BOEING PLANT 2

Laboratory Sample No.	Client Identification	Total Chromium (ug)*	Hexavalent Chromium (ug)
915486	Run 1 1st Impinger & Probe	297.	324.
915487	Run 1 2nd Impinger	4.16	7.49
915488	0.1 N NaOH Blank	0.70	2.2
915489	Run 1 HNO_3 3rd & 4th Inp	<1.06	-
915490	0.1 N HNO_3 Blank	<0.60	-
915491	Run 1 Teflon Filter*	2.0	-
915492	Teflon Filter Blank*	<0.30	-
EPA Method		200.7	7196

*Filter samples reported as (ug/filter).

REPORTED BY: Kathy Fugiel

KF/ja

ANALYSIS REPORT

CLIENT: Am Test, Inc. - Air Quality Division DATE RECEIVED: 9/1/89

REPORT TO: Kris Hansen DATE REPORTED: 9/12/89

BOEING PLANT #2 - BUILDING 210

Laboratory Sample Numbers	Client Identification	Hexavalent Chromium	Total Chromium	Volume (ml)
Blank				
915737	0.1N NaOH	<2.5	<0.60	100.
915738	0.1N HNO_3	-	<0.60	100.
915739	Teflon Filter	-	<0.30	-
R1 Workroom (Bath #5)				
915740	NaOH Imp #1	1,553.	1,311.	187.
915741	NaOH Imp #2	28.3	25.7	133.
915742	NHO_3 Imp #3 & #4	-	<0.87	145.
915743	Filter	-	<0.30	-
R1-PS				
915744	Impactor Rinse NaOH	156.	162.	183.
915745	Probe Rinse	1.16	4.45	89.
915746	Imp #1	<3.7	<0.90	150.
915747	Imp #2	<3.3	<0.79	132.
915748	Imp #3 & #4	-	<0.83	138.
915749	Filter	-	<0.30	-
R2				
915750	Probe Rinse	620.	603.	178.
915751	Imp #1	26.1	32.0	130.
915752	Imp #2	43.2	42.3	137.
915753	Imp #3 & #4	-	1.09	121.
915754	Filter	-	<0.30	-

CLIENT: Am Test, Inc. - Air Quality Division DATE RECEIVED: 9/1/89

REPORT TO: Kris Hansen DATE REPORTED: 9/12/89

BOEING PLANT #2 - BUILDING 210

Laboratory Sample Numbers	Client Identification	Hexavalent Chromium	Total Chromium	Volume (ml)
R3				
915755	Probe	654.	596.	143.
915756	Imp #1	35.3	34.0	141.
915757	Imp #2	44.2	42.2	141.
915758	Imp #3 & #4	-	<0.96	160.
915759	Filter	-	<0.30	-

Liquid Solutions are reported in units of ug.
Filter Samples are reported in units of ug/filter.
Volumes are reported in units of ml.

REPORTED BY Kathy Fuggiel

KF/pb

ANALYSIS REPORT

CLIENT: Am Test, Inc. - Air Quality Division

DATE RECEIVED: 9/6/89

REPORT TO: Kris Hansen

DATE REPORTED: 9/18/89

BOEING PLANT #2

Laboratory Sample Nos.	Client Identification	Total Chromium	Volume (ml)
915962	Rinse of Substrates	0.75 ug	50.
915963	Blank Solution	<0.60 ug	100.
915965	Blank Filters	0.65*	-
915966	1	4.75*	-
915967	2	3.47*	-
915968	3	62.7*	-
915969	4	55.7*	-
915970	5	12.*	-
915971	6	3.3*	-
915972	7	0.67*	-
915973	8	0.42*	-
915974	9	0.45*	-
915975	10	0.40*	-
915976	12	6.7*	-
Filter Reagent Blank		0.20 ug	-
EPA Method No.		200.7 (ICP)	-

*Reported in ug/filter.

KF/pb

REPORTED BY Kathy Fugiel

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ANALYSIS REPORT

CLIENT: Air Quality Division

REPORT TO: Kris Hansen

DATE RECEIVED: 9/20/89

DATE REPORTED: 9/29/89

BOEING PLANT 2

Laboratory Sample No.	Client Identification	Chromic Acid Bath #5 Total Chromium	Hexavalent Chromium
917067	Run 1 Imp 1 & 2 (.1N NaOH)	24.5	<6.25
917068	Run 1 Imp 3 & 4 (0.1 HNO_3)	1.33	-
917069	Run 1 Teflon Filter	0.175	-
917070	Run 2 Imp 1 & 2 (0.1 NaOH)	268.	247. 246.]
917071	Run 2 Imp 3 & 4 (0.1 HNO_3)	1.64	-
917072	Run 2 Teflon Filter	0.275	-
917073	Blank Solution (0.1 NaOH)	<1.00	<2.5
917074	Blank Solution (0.1 $NHCO_3$)	1.2	-
917075	Blank Teflon Filter	0.175	-
917076	Bath #5 Sample	48,470,000.	5,292,000.
917077	Run 1 Probe (0.1 N NaOH)	28.8	23.1
917078	Run 2 Probe (0.1 N NaOH)	1,141.	1,212.
Detection Limit (ug/ml)		0.006	0.025
EPA Method		200.7 (ICP)	7196

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Solutions reported in ug, filter reported as ug/filter.

KF/ja

REPORTED BY: Kathy Fugiel

ANALYSIS REPORT

CLIENT: AM TEST, INC. - AIR QUALITY DIVISION

REPORT TO: Kris Hansen

DATE RECEIVED: 12/4/89
DATE REPORTED: 12/11/89
DATE REVISED: 1/30/90

BOEING PLANT #2

Laboratory Sample Nos.	Client Identification	Chromium (ug/filter)	Volume (ml)
922208	Stage RB-1	1.72	-
922209	Stage RB-2	1.20	-
922210	Stage RB-3	33.5	-
922211	Stage RB-4	49.8	-
922212	Stage RB-5	24.0	-
922213	Stage RB-6	3.60	-
922214	Stage RB-7	0.58	-
922215	Stage RB-8	0.32	-
922216	Stage RB-9	0.35	-
922217	Stage RB-10	<0.15	-
922218	Stage RB-12	9.0	-
922219	Rinse of RB Substrates	1.62*	116.
922220	Rinse of H Substrates	<0.6*	100.
922221	Blank Sol.	<0.6*	130.
922222	Blank Filters**	<0.15	-
922223	Stage H-1	0.45	-
922224	Stage H-2	1.12	-
922225	Stage H-3	57.8	-

*Results are in ug.
**4 Mark 5 filters.
Filters were brought to 25 mls. total volume.

CLIENT: AM TEST, INC. - AIR QUALITY DIVISION

DATE RECEIVED: 12/4/89
DATE REPORTED: 12/11/89
DATE REVISED: 1/30/90

REPORT TO: Kris Hansen

BOEING PLANT #2

Laboratory Sample Nos.	Client Identification	Chromium (ug/filter)	Volume (ml)
922226	Stage H-4	50.5	-
922227	Stage H-5	22.9	-
922228	Stage H-6	2.08	-
922229	Stage H-7	0.52	-
922230	Stage H-8	0.42	-
922231	Stage H-9	<0.15	-
922232	Stage H-10	<0.15	-
922233	Stage H-12	<0.15	-
BLANK 1		<0.15	-
BLANK 2		<0.15	-

Filters were brought to 25 mls. total volume.

JTD/pb

REPORTED BY John T. Dailey

AMTEST

ANALYSIS REPORT

CLIENT: AM TEST, INC. - AIR QUALITY DIVISION

REPORT TO: Kris Hansen

DATE RECEIVED: 11/30/89
DATE REPORTED: 12/1/89
DATE REVISED: 1/30/90

BOEING PLANT #2

Laboratory Sample Numbers	Client Identification	Chromium (ug)	Hexavalent Chromium (ug)	Volume (ml)
922090	Blank 0.1 N NaOH	<0.6	<25.	100.
922091	Blank 0.1 N HNO_3	<0.6	-	100.
922092	Blank Teflon Filter	<0.15*	-	-
922093	Run 1 Teflon Filter	<0.15*	-	-
922094	Run 1 NaOH Imp 1 & 2	470.	438.	395.
922095	Run 1 HNO_3 Imp 3 & 4	<1.1	-	177.
922096	R2-PS Teflon Filter	<0.15*	-	-
922097	R2-PS NaOH Imp 1 & 2	6.08	<70.	380.
922098	R2-PS HNO_3 Imp 3 & 4	<0.8	-	133.
922099	R2 Impactor Stages Rinse	24.2	<53.	212.

*Results are in ug/filter.
Filters were brought to 25 mls. total volume.

CLIENT: AM TEST, INC. - AIR QUALITY DIVISION

DATE RECEIVED: 11/30/89
DATE REPORTED: 12/1/89
DATE REVISED: 1/30/90

REPORT TO: Kris Hansen

BOEING PLANT #2

Laboratory Sample Numbers	Client Identification	Chromium (ug)	Hexavalent Chromium (ug)	Volume (ml)
922100	R2 Straight Nozzle Rinse	86.6	68.4	38.
922101	R3-PS Teflon Filter	-	-	-
922102	R3-PS NaOH Imp 1 & 2	<2.16	<90.	360.
922103	R3-PS HNO_3 Imp 3 & 4	1.34	-	168.
922104	R3-PS Impactor Rinse	26.1	<32.	128.
922105	R3-PS Nozzle Rinse	30.2	22.6	20.
922106	R4 Teflon Filter	<0.15*	-	-
922107	R4 NaOH Imp 1 & 2	6.90	679.	350.
922108	R4 HNO_3 Imp 3 & 4	<0.9	-	157.

*Results are in ug/filter.
Filters were brought to 25 mls. total volume.

JTD/pb

REPORTED BY John T. Dailey

AMTEST

ANALYSIS REPORT

CLIENT: AM TEST, INC. - AIR QUALITY DIVISION

REPORT TO: Kris Hansen

DATE RECEIVED: 12/1/89
DATE REPORTED: 12/11/89
DATE REVISED: 1/30/90

BOEING PLANT #2

Laboratory Sample Nos.	Client Identification	Chromium (ug)	Hexavalent Chromium (ug)	Volume (ml)
922111	Blank 0.1 N NaOH	<0.6	25.	100.
922112	Blank 0.1 N HNO_3	<0.6	-	100.
922113	Blank Teflon Filter	<0.15*	-	-
922114	Run 5 NaOH Imp 1 & 2	458.	442.	409.
922115	Run 5 HNO_3 Imp 3 & 4	1.20	-	171.
922116	Run 5 Teflon Filter	<0.15*	-	-
922117	Chromic Acid Bath #5	6,325,000.	6,578,000.	253.

*Results are in ug/filter.
Filters were brought to 25 mls. total volume.

JTD/pb

REPORTED BY John T. Dailey

APPENDIX B

SAMPLE CALCULATION SHEET
METHODS 1-5

CLIENT: BOEING PLANT #2 DATE OF TEST: 8-22-89

LOCATION: Seattle, Wash. RUN #: 1 BO#5CR1 Lab # 915090
1-Bath On

Particulate Matter Emission Concentration - Equation 5-1

Vm_{std} =
17.647°R/"Hg*54.27 ft³*.993*(30.04"Hg + (1.278"H_2O/13.6))/(460 + 75.0 °F)

= 53.570 dscf

dscm = 53.570 dscf/35.31 ft³/m³

= 1.517 dscm

Substitution of Equation 5-4 into 5-5

W_a = _____mg * _____ml /_____ml

= _____mg

M_n = (net weight filter catch) + (net weight "B" section) - Wa + Back-half

= _____mg = _____mg + _____mg - _____mg +_____mg

C_s= (0.001 g/mg) * (15.43 grains/gram) * _____mg /_____dscf

= _____gr/dscf (Equation 5-6)

gr/dscf @7% O_2 = _____gr/dscf * (20.9% - 7%O_2)/(20.9% - _____%O_2)

= _____gr/dscf @ 7% O_2

gr/dscf @ 12% CO_2 = _____gr/dscf * 12% / _____%CO_2

= _____gr/dscf @ 12% CO_2

mg/dscm = _____mg/_____dscm

= _____mg/dscm

Particulate Matter Emission Rate

pounds/hour = _____gr/dscf * _____dscf/min * 60 min/hr * 1 lb/7000 grains

= _____lb/hr

Moisture - Equation 5-2 and 5-3

Vw_{std} = 0.04715 ft³/g * 16.7 grams of H_2O collected in impingers

= 0.787 scf

SAMPLE CALCULATION SHEET (continued)
METHODS 1-5

B_{ws} = (.787 scf)/(.787 scf + 53.570 dscf)

= 0.0145

%Moisture = 0.0145 * 100

= 1.45 %

Molecular weight - Equation 3-2

M_d = 0.440 * (0.1 $\%CO_2$) + 0.320 * (20.9 $\%O_2$) + 0.280 * (79.0 % CO + $\%N_2$)

M_d = 28.85 g/g-mole (dry)

M_s = 28.85 g/g-mole * (1 - .0145) + 18.0g/g-mole * .0145

M_s = 28.69 g/g-mole (wet)

Stack gas velocity and volumetric flow rate - Equation 2-9 and 2-10

V_s = 85.49 * .84 * .4987 * $\sqrt{538.5}$ ° R / 28.69 g/g-mole / 30.04 "Hg

V_s = 28.30 ft/sec (std)

Q_{sd} = 3600 * (1 - .0145) * 28.30 ft/sec * 12.566 ft^2 * (528 ° R/538.5° R) * (30.04 "Hg/29.92 "Hg)

= 1242249 dscf/hr / 60 min/hr

= 20704.1 dscf/min (dry standard cubic feet per minute)

acfm = 28.30 ft/sec * 12.566 ft^2 * 60 sec/min

= 21340.7 acfm (actual cubic feet per minute)

Isokinetic variation - Equation 5-8

I = 0.09450 * 53.570 dscf * 538.5 ° R/(30.04 "Hg * 28.30 ft/sec * 60 min * 0.005343 ft^2 *(1 - .0145))

I = 101 %

All of the above numbered equations are from the 40 CFR 60 and assume English units.

AMTEST

Example Calculations for Chromium
Boeing Plant 2, #5A Chrome Anodizing Tank
August 22, 1989, Run 1 with Bath On
Lab #'s 915089, 915090, 915093, 915097, 915100

Sample	ug Cr	ug Cr^{+6}
Probe	1040	1660
1st Impinger	78.6	94.
2nd Impinger	102	120
3rd Impinger	<1.00	—
Filter	<0.15	—
TOTAL	1220.6	1874.0

Hexavalent Chromium (Cr^{+6})

$$\frac{1874\ ug\ in\ sample}{1.517\ dscm\ of\ gas\ sampled} * \frac{1mg}{1000\ ug} = \boxed{1.235\ mg/dscm}$$

$$1.235\ mg/dscm * \frac{22.414\ l/m\text{-}mole}{51.996\ mg/m\text{-}mole} * \frac{293.15^{\circ}K}{273.15^{\circ}K} * \frac{1m^3}{10^6 ml} * 10^6 ppm$$

$$= \boxed{0.57\ ppm}$$

$$1.235\ mg/dscm * 60 min/hr * \frac{1m^3}{35.32\ ft^3} * 20704.1\ dscf/min = \boxed{43,456.5\ mg/hr}$$

$$43456.5\ mg/hr\ /\ 1825\ amp\text{-}hr/hr = \boxed{23.8\ mg/amp\text{-}hr}$$

Total Chromium

$$\frac{1220.6\ ug}{1.517\ dscm} * \frac{1mg}{1000 ug} = \boxed{0.805\ mg/dscm}$$

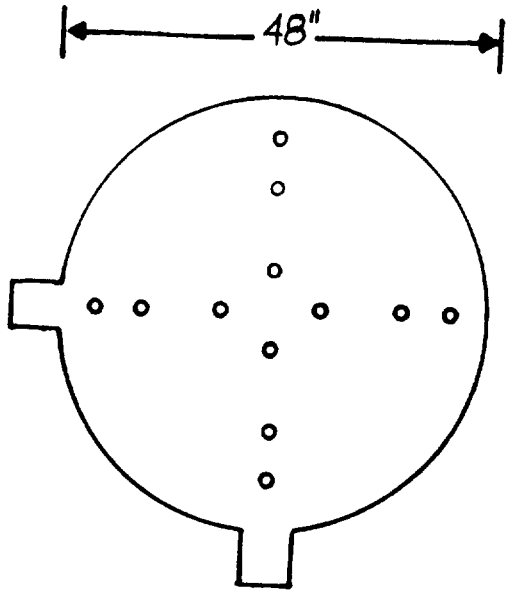
$$0.805\ mg/dscm * \frac{22.414\ l/m\text{-}mole}{51.996\ mg/m\text{-}mole} * \frac{293.15^{\circ}K}{273.15^{\circ}K} * \frac{1m^3}{10^6 ml} * 10^6 ppm = \boxed{0.37 ppm}$$

$$0.805\ mg/dscm * 60 min/hr * \frac{1m^3}{35.32\ ft^3} * 20704.1\ dscf/min = \boxed{28304.7\ mg/hr}$$

$$\frac{28304.7\ mg/hr}{1825\ amp\text{-}hr/hr} = \boxed{15.5\ mg/amp\text{-}hr}$$

CROSS SECTIONAL AREA

Traverse Point	Distance (inches)
1	2.11
2	7.01
3	14.21
4	33.79
5	40.99
6	45.89



STACK DIMENSIONS

48 inch diameter circular stack

2 ports

A = 2 feet

B = 6 feet

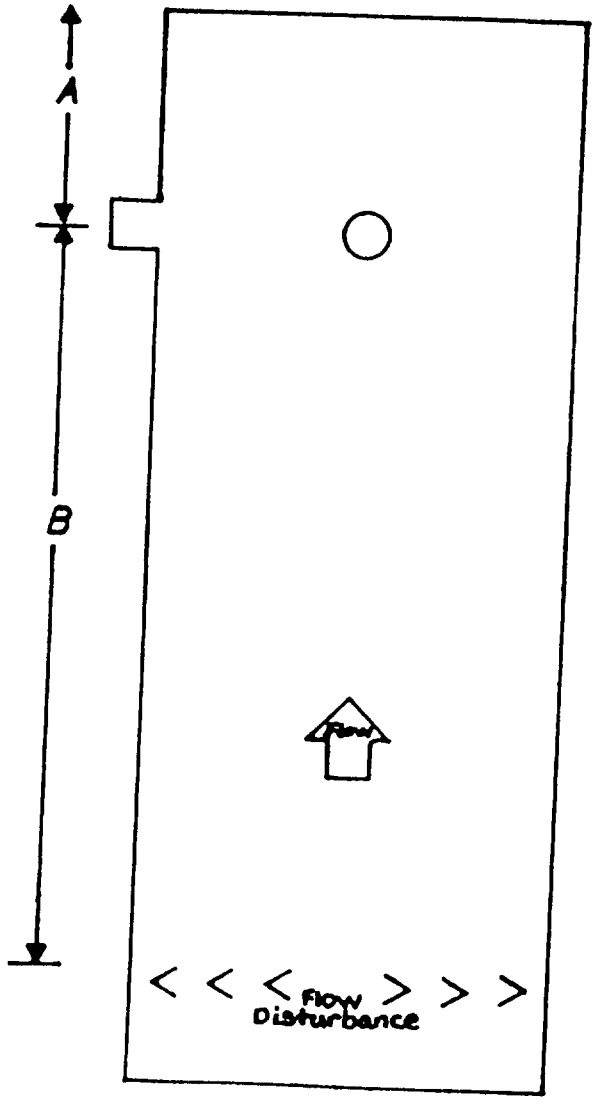


Figure 4. Location of sampling ports and traverse points.

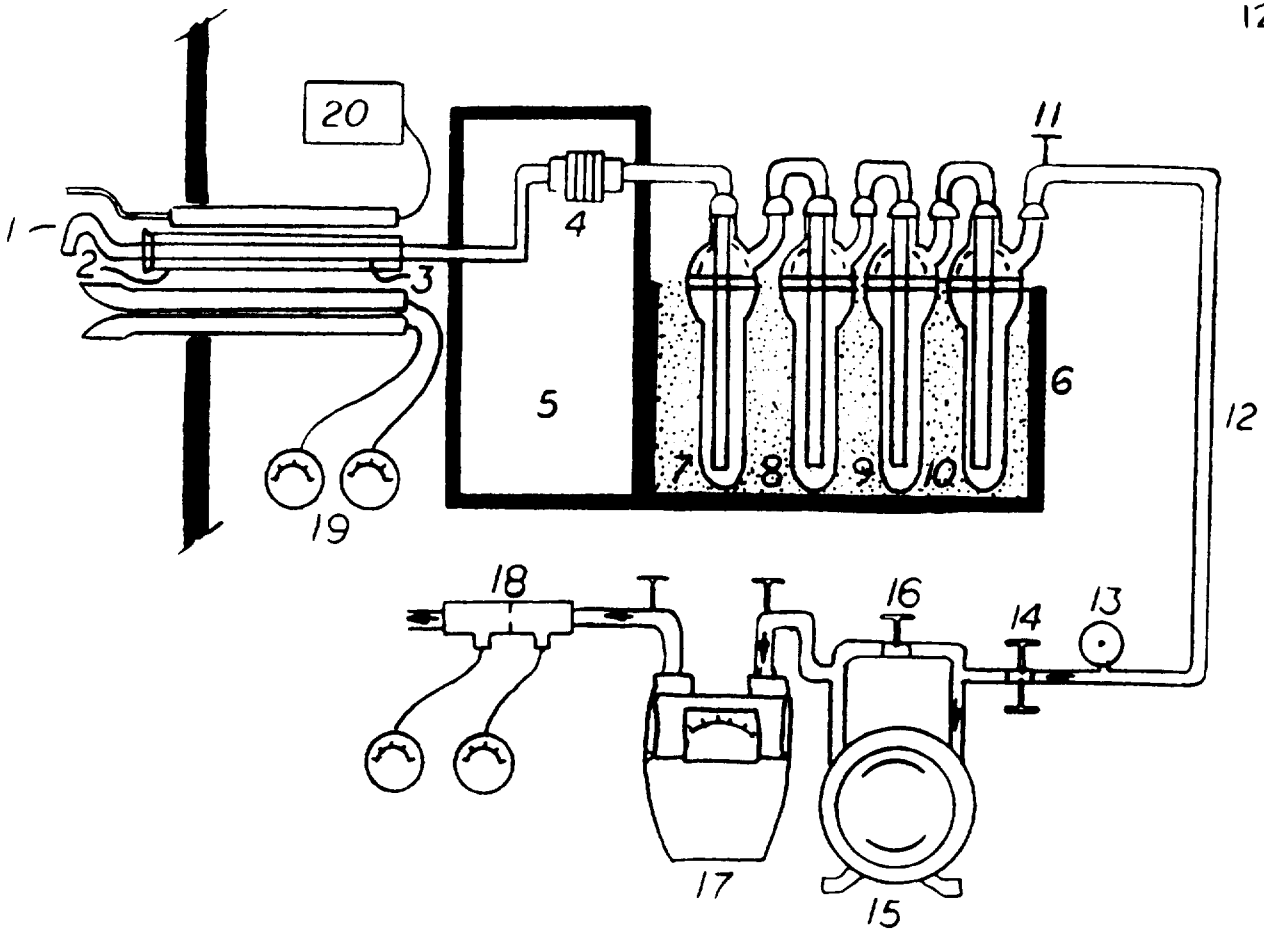
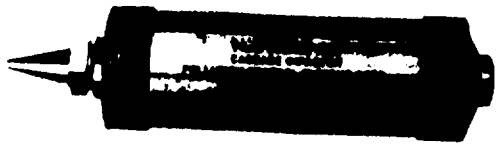


Figure 5. Method 5 Sample Train.

1. Sampling nozzle
2. Sampling probe sheath
3. Heated sample probe liner
4. Out of stack filter assembly
5. Heated filter compartment maintained at 248°F ± 25°F (or temperature specified in 40 CFR subpart)
6. Impinger case - contains ice during sampling
7. First impinger containing 100 ml H_2O
8. Modified Greenburg-Smith impinger containing 100 ml H_2O
9. Third impinger - empty
10. Fourth impinger containing indicating silica gel desiccant
11. Impinger exit gas temperature sensor
12. Umbilical cord - vacuum line
13. Vacuum gauge
14. Fine and coarse adjustment valves
15. Leak free pump
16. By-pass valve
17. Dry gas meter with inlet and outlet temperature sensors
18. Orifice meter with magnehelic gauges
19. S-type pitot tube with magnehelic gauges
20. Fluke multi-channel digital thermocouple indicator



Mark 5 with sampling nozzle

PCSC Precutter with Nozzle on Mark 3

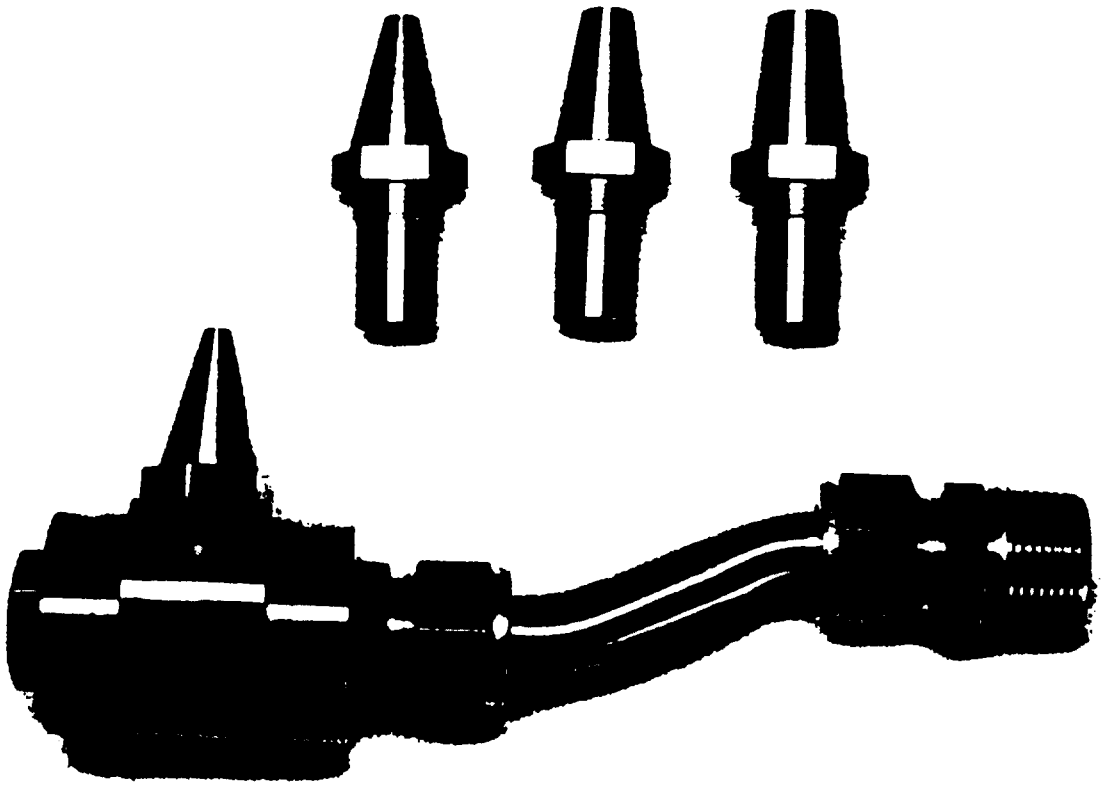


Figure 6. Illustration of Pilat (U of W) Mark 5 Cascade impactor, Mark 3 impactor equipped with a PCSC precutter attachment, and an enlargement of the PCSC precutter attachment.

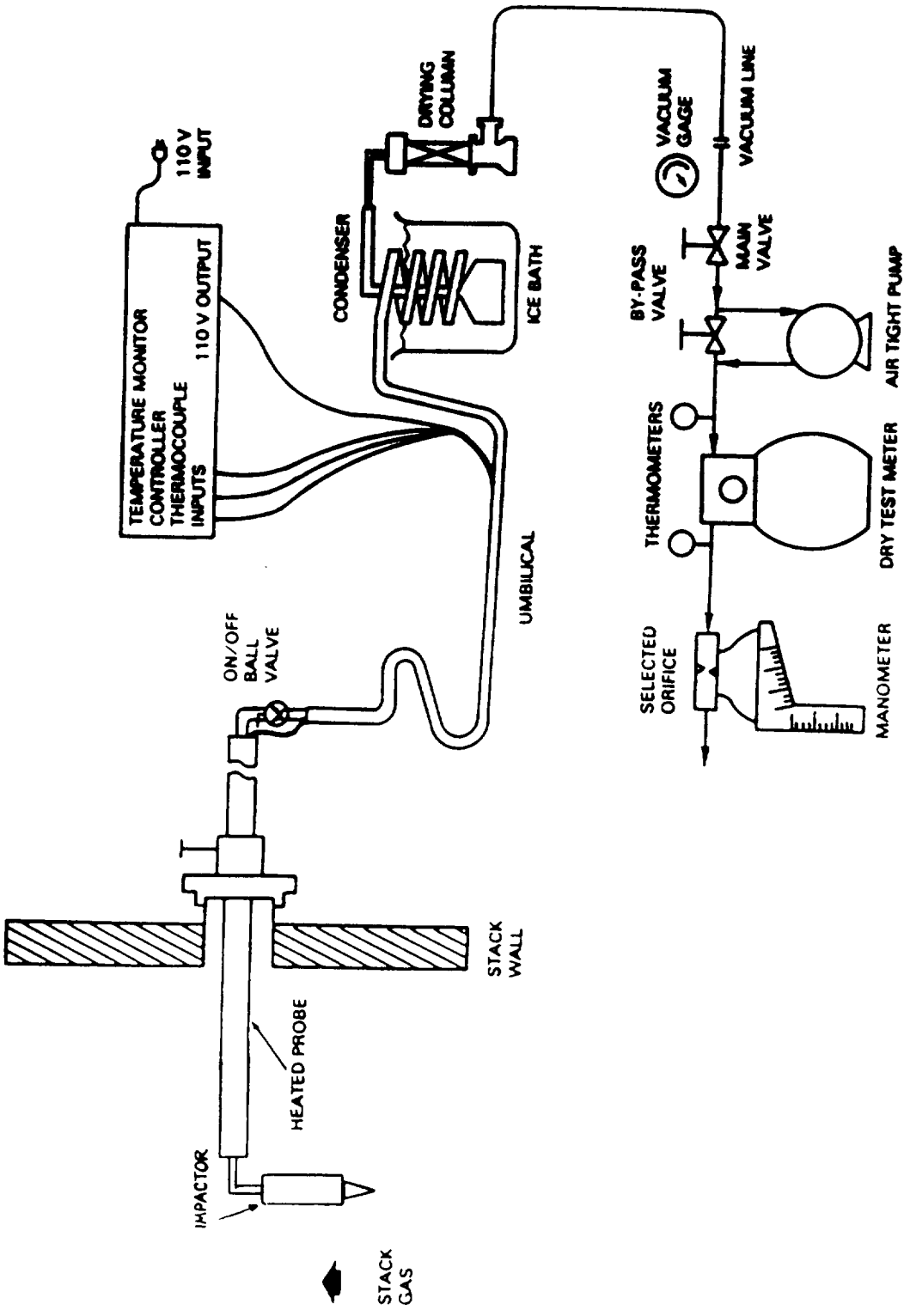


Figure 7. Cascade impactor particulate sampling train.

METHOD 1 - LOCATION OF TRAVERSE POINTS

Circular Stacks

TRAVERSE POINT	DISTANCE % of diameter
1	4 4
2	14 7
3	29 5
4	70 5
5	85 3
6	95 6

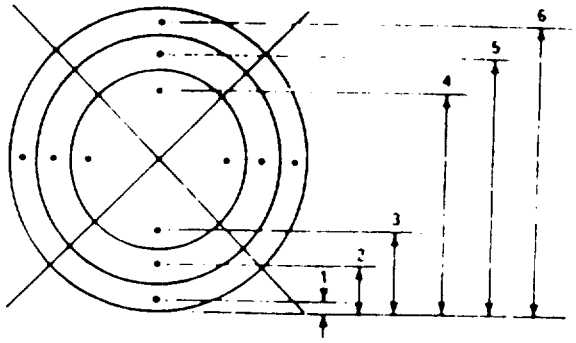


Figure 1-3. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points indicated.

TABLE 1-2. LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter—											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	78.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.8	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9

Rectangular Stacks

For a rectangular cross section, an equivalent diameter (D_e) shall be calculated from the following equation, to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{(L+W)}$$

where L = length and W = width.

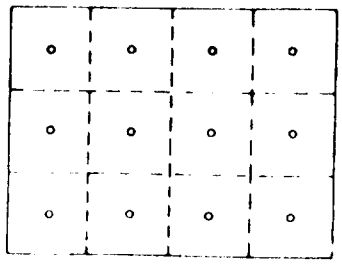


Figure 1-4. Example showing rectangular stack cross section divided into 12 equal areas, with a traverse point at centroid of each area.

METHOD 1 - MINIMUM NUMBER OF TRAVERSE POINTS

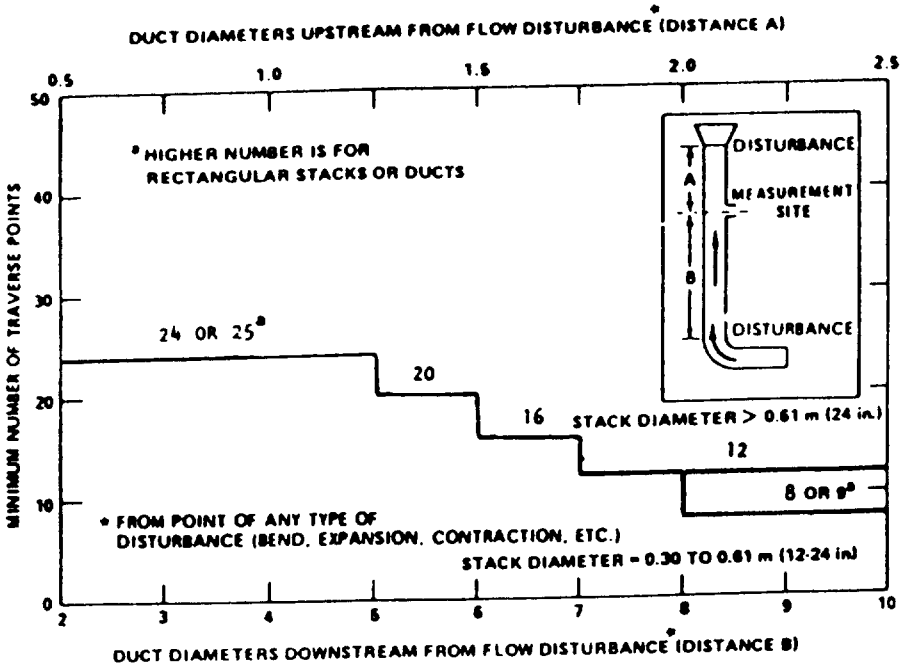


Figure 1-1. Minimum number of traverse points for particulate traverses.

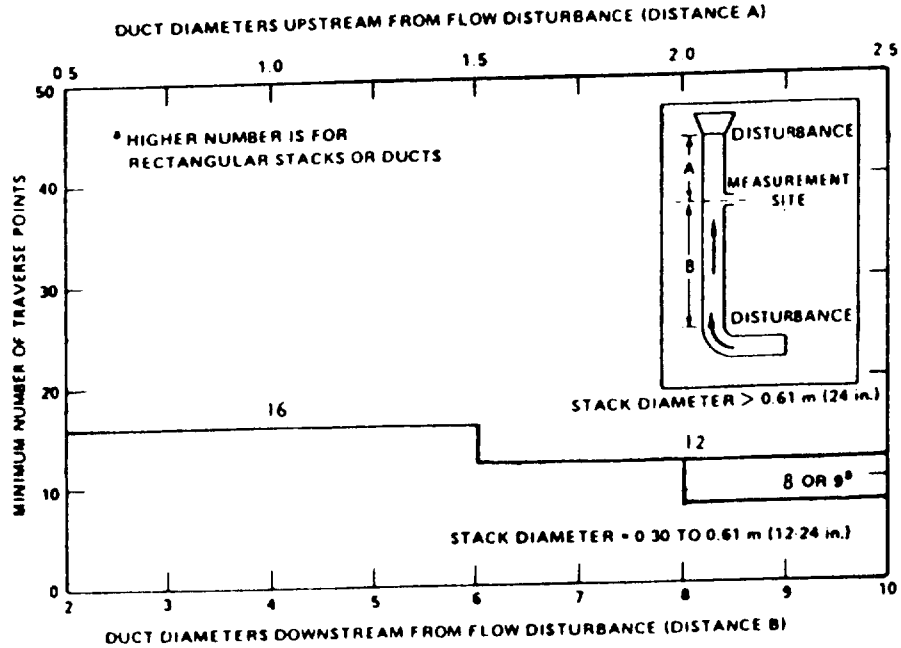


Figure 1-2. Minimum number of traverse points for velocity (nonparticulate) traverses.

METHOD 2 - STACK GAS VELOCITY AND VOLUMETRIC FLOW CALCULATIONS

5.1 Nomenclature.

A = Cross-sectional area of stack, m^2 (ft^2).
B_{ws} = Water vapor in the gas stream (from Method 5 or Reference Method 4), proportion by volume.
C_p = Pitot tube coefficient, dimensionless.
K_p = Pitot tube constant,

$$34.97 \frac{m}{sec}\left[\frac{(g/g\text{-mole})(mm\ Hg)}{(°K)(mm\ H_2O)}\right]^{1/2}$$

for the metric system and

$$85.49 \frac{ft}{sec}\left[\frac{(lb/lb\text{-mole})(in.\ Hg)}{(°R)(in.\ H_2O)}\right]^{1/2}$$

for the English system.

M_d = Molecular weight of stack gas, dry basis (see Section 3.6) g/g-mole (lb/lb-mole).
M_s = Molecular weight of stack gas, wet basis, g/g-mole (lb/lb-mole).

$$= M_d(1 - B_{ws}) + 18.0\ B_{ws}$$

Eq. 2-5

P_{bar} = Barometric pressure at measurement site, mm Hg (in. Hg).
P_g = Stack static pressure, mm Hg (in. Hg).
P_s = Absolute stack gas pressure, mm Hg (in. Hg).

$$= P_{bar} + P_g$$

Eq. 2-6

Eq. 2-6

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).
Q_{sd} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).
t_s = Stack temperature, °C (°F).
T_s = Absolute stack temperature, °K, (°R).

$$= 273 + t_s \text{ for metric.}$$

Eq. 2-7

$$= 460 + t_s \text{ for English.}$$

Eq. 2-8

T_{std} = Standard absolute temperature, 293 °K (528° R).
v_s = Average stack gas velocity, m/sec (ft/sec).
Δp = Velocity head of stack gas, mm H_2O (in. H_2O).
3,600 = Conversion factor, sec/hr.
18.0 = Molecular weight of water, g/g-mole (lb/lb-mole).

5.2 Average Stack Gas Velocity.

$$v_s = K_p C_p (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

Equation 2-9

5.3 Average Stack Gas Dry Volumetric Flow Rate.

$$Q_{sd} = 3{,}600(1 - B_{ws}) v_s A \left(\frac{T_{std}}{T_{s\ (avg)}}\right)\left(\frac{P_s}{P_{std}}\right)$$

Eq. 2-10

METHOD 3 - MOLECULAR WEIGHT AND EXCESS AIR CALCULATIONS

6.1 Nomenclature.

M_d = Dry molecular weight, g/g-mole (lb/lb-mole).
%EA = Percent excess air.
$\%CO_2$ = Percent CO_2 by volume (dry basis).
$\%O_2$ = Percent O_2 by volume (dry basis).
%CO = Percent CO by volume (dry basis).
$\%N_2$ = Percent N_2 by volume (dry basis).
0.264 = Ratio of O_2 to N_2 in air, v/v.
0.280 = Molecular weight of N_2 or CO, divided by 100.
0.320 = Molecular weight of O_2 divided by 100.
0.440 = Molecular weight of CO_2 divided by 100.

6.2 Percent Excess Air. Calculate the percent excess air (if applicable), by substituting the appropriate values of percent O_2, CO, and N_2 (obtained from Section 4.1.3 or 4.2.4) into Equation 3-1.

$$\%\ EA = \frac{\%O_2 - 0.5\%\ CO}{0.264\%\ N_2 (\%O_2 - 0.5\%\ CO)} \times 100$$

Eq. 3-1

NOTE: The equation above assumes that ambient air is used as the source of O_2, and that the fuel does not contain appreciable amounts of N_2 (as do coke oven or blast furnace gases). For those cases when appreciable amounts of N_2 are present (coal, oil, and natural gas do not contain appreciable amounts of N_2) or when oxygen enrichment is used, alternate methods, subject to approval of the Administrator, are required.

6.3 Dry Molecular Weight. Use Equation 3-2 to calculate the dry molecular weight of the stack gas.

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

Eq. 3-2

METHOD 4 - STACK GAS MOISTURE CALCULATIONS

2.3.1 Nomenclature.

B_{ws} = Proportion of water vapor, by volume, in the gas stream.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_m = Absolute pressure (for this method, same as barometric pressure) at the dry gas meter, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (°K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units.

T_m = Absolute temperature at meter, °K (°R).

T_{std} = Standard absolute temperature, 293° K (528°R).

V_m = Dry gas volume measured by dry gas meter, dcm (dcf).

ΔV_m = Incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf).

$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w(std)}$ = Volume of water vapor condensed corrected to standard conditions, scm (scf).

$V_{wg(std)}$ = Volume of water vapor collected in silica gel corrected to standard conditions, scm (scf).

V_f = Final volume of condenser water, ml.

V_i = Initial volume, if any, of condenser water, ml.

W_f = Final weight of silica gel or silica gel plus impinger, g.

W_i = Initial weight of silica gel or silica gel plus impinger, g.

Y = Dry gas meter calibration factor.

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

2.3.2 Volume of Water Vapor Condensed.

$$V_{w(std)} = \frac{(V_f - V_i)\rho_w R T_{std}}{P_{std} M_w}$$

$$= K_1 (V_f - V_i)$$

Eq. 4-1

K_1 = 0.001333 m^3/ml for metric units
= 0.04707 ft^3/ml for English units

2.3.3 Volume of Water Vapor Collected in Silica Gel

$$V_{wg(std)} = \frac{(W_f - W_i) R T_{std}}{P_{std} M_w}$$

$$= K_2 (W_f - W_i)$$

Eq. 4-2

Where:

K_2 = 0.001335 m^3/g for metric units
= 0.04715 ft^3/g for English units

2.3.4 Sample Gas Volume.

$$V_{m(std)} = V_m Y \frac{(P_m)(T_{std})}{(P_{std})(T_m)}$$

$$= K_3 Y \frac{V_m P_m}{T_m}$$

Eq. 4-3

Where:

K_3 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

NOTE: If the post-test leak rate (Section 2.2.6) exceeds the allowable rate, correct the value of V_m in Equation 4-3, as described in Section 6.3 of Method 5.

2.3.5 Moisture Content.

$$B_{ws} = \frac{V_{w(std)} + V_{wg(std)}}{V_{w(std)} + V_{wg(std)} + V_{m(std)}}$$

Eq. 4-4

NOTE: In saturated or moisture droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one using a value based upon the saturated conditions (see Section 1.2), and another based upon the results of the impinger analysis. The lower of these two values of B_{ws} shall be considered correct.

METHOD 5 - PARTICULATE EMISSION CALCULATIONS - (1)

6.1 Nomenclature.

A_n = Cross-sectional area of nozzle, m^2 (ft^2).

B_{ws} = Water vapor in the gas stream, proportion by volume.

C_a = Acetone blank residue concentration, mg/g.

c_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscm (g/dscf).

I = Percent of isokinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.0057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.

L_i = Individual leakage rate observed during the leak check conducted prior to the "i^{th}" component change ($i = 1, 2, 3....n$), m^3/min (cfm).

L_p = Leakage rate observed during the post-test leak check, m^3/min (cfm).

m_a = Mass of residue of acetone after evaporation, mg.

m_n = Total amount of particulate matter collected, mg.

M_w = Molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole).

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg).

P_s = Absolute stack gas pressure, mm Hg (in. Hg).

P_{std} = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

R = Ideal gas constant, 0.06236 mm Hg-m^3/°K-g-mole (21.85 in. Hg-ft^3/°R-lb-mole).

T_m = Absolute average dry gas meter temperature (see Figure 5-2), °K (°R).

T_s = Absolute average stack gas temperature (see Figure 5-2), °K (°R).

T_{std} = Standard absolute temperature, 293° K (528° R).

V_a = Volume of acetone blank, ml.

V_{aw} = Volume of acetone used in wash, ml.

V_{lc} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.

V_m = Volume of gas sample as measured by dry gas meter, dcm (dscf).

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf).

v_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec).

W_a = Weight of residue in acetone wash, mg.

Y = Dry gas meter calibration factor.

ΔH = Average pressure differential across the orifice meter (see Figure 5-2), mm H_2O (in. H_2O).

ρ_a = Density of acetone, mg/ml (see label on bottle).

ρ_w = Density of water, 0.9982 g/ml (0.002201 lb/ml).

θ = Total sampling time, min.

θ_1 = Sampling time interval, from the beginning of a run until the first component change, min.

θ_i = Sampling time interval, between two successive component changes, beginning with the interval between the first and second changes, min.

θ_p = Sampling time interval, from the final (n^{th}) component change until the end of the sampling run, min.

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

6.2 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop. See data sheet (Figure 5-2).

6.3 Dry Gas Volume. Correct the sample volume measured by the dry gas meter to standard conditions (20° C, 760 mm Hg or 68° F, 29.92 in. Hg) by using Equation 5-1.

$$V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m}\right)\left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{P_{std}}\right]$$

$$= K_1 V_m Y \frac{P_{bar} + (\Delta H/13.6)}{T_m}$$

Equation 5-1

Where:

K_1 = 0.3858 °K/mm Hg for metric units
= 17.64 °R/in. Hg for English units

NOTE: Equation 5-1 can be used as written unless the leakage rate observed during any of the mandatory leak checks (i.e., the post-test leak check or leak checks conducted prior to component changes) exceeds L_a. If L_p or L_i exceeds L_a, Equation 5-1 must be modified as follows:

(a) Case I. No component changes made during sampling run. In this case, replace V_m in Equation 5-1 with the expression:

$$[V_m - (L_p - L_a)\theta]$$

(b) Case II. One or more component changes made during the sampling run. In this case, replace V_m in Equation 5-1 by the expression:

$$\left[V_m - (L_1 - L_a)\theta_1 - \sum_{i=2}^{n} (L_i - L_a)\theta_i - (L_p - L_a)\theta_p\right]$$

and substitute only for those leakage rates (L_i or L_p) which exceed L_a.

6.4 Volume of Water Vapor.

METHOD 5 - PARTICULATE EMISSION CALCULATIONS - (2)

Equation 5-2

$$V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_3 V_{lc}$$

Where:

$K_3 = 0.001333$ m³/ml for metric units
$= 0.04707$ ft³/ml for English units.

6.5 Moisture Content.

$$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$$

Eq. 5-3

NOTE: In saturated or water droplet-laden gas streams, two calculations of the moisture content of the stack gas shall be made, one from the impinger analysis (Equation 5-3), and a second from the assumption of saturated conditions. The lower of the two values of B_w shall be considered correct. The procedure for determining the moisture content based upon assumption of saturated conditions is given in the Note of Section 1.2 of Method 4. For the purposes of this method, the average stack gas temperature from Figure 5-2 may be used to make this determination, provided that the accuracy of the in-stack temperature sensor is ±1° C (2° F).

6.6 Acetone Blank Concentration.

$$C_a = \frac{m_a}{V_a \rho_a}$$

Eq. 5-4

6.7 Acetone Wash Blank.

$$W_a = C_a V_{aw} \rho_a$$

Eq. 5-5

6.8 Total Particulate Weight. Determine the total particulate catch from the sum of the weights obtained from Containers 1 and 2 less the acetone blank (see Figure 5-3).

NOTE: Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

6.9 Particulate Concentration.

$$c_s = (0.001\ g/mg)\,(m_n / V_{m(std)})$$

Eq. 5-6

6.10 Conversion Factors:

From	To	Multiply by
acf	m³	0.02832
g/ft³	gr/ft³	15.43
g/ft³	lb/ft³	2.205×10^{-3}
g/ft³	g/m³	35.31

6.11 Isokinetic Variation.

6.11.1 Calculation From Raw Data

$$I = \frac{100\, T_s [K_3 V_{lc} + (P_m / T_m)(P_{bar} + \Delta H / 13.6)]}{60\theta v_s P_s A_n}$$

Eq. 5-7

Where:

$K_3 = 0.003454$ mm Hg - m³/ml - °K for metric units.
$= 0.002669$ in. Hg - ft³/ml - °R for English units.

6.11.2 Calculation From Intermediate Values.

$$I = \frac{T_s V_{m(std)} P_{std} 100}{T_{std} v_s \theta A_n P_s 60 (1 - B_{ws})}$$

$$= K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$$

Equation 5-8

where:

$K_4 = 4.320$ for metric units
$= 0.09450$ for English units.

6.12 Acceptable Results. If 90 percent ≤ I ≤ 110 percent, the results are acceptable. If the particulate results are low in comparison to the standard, and I is over 110 percent or less than 90 percent, the Administrator may accept the results.

NOMENCLATURE
METHOD 5 CALCULATIONS

Vm_{std} = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dscm (dscf).

Y = Dry gas meter calibration factor

P_b = Barometric pressure at the sampling site, mm Hg (in. Hg)

H = Average pressure differential across the orifice meter, mm H_2O (in. H_2O)

T_m = Absolute average dry gas meter temperature, ° K (° R)

dscm = Dry standard cubic meters

dscf = Dry standard cubic feet

W_a = Weight of residue in acetone wash

M_a = Mass of residue of acetone after evaporation, mg

C_a = Acetone blank residue concentration, mg/g

V_a = Volume of acetone blank

V_{aw} = Volume of acetone used in wash, ml

M_n = Total amount of particulate matter collected, mg

C_s = Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, mg/dscm (gr/dscf)

gr/dscf = grains per dry standard cubic foot

Vw_{std} = Volume of water vapor in the gas sample, corrected to standard conditions, scm (scf)

B_{ws} = Water vapor in the gas stream, proportion by volume

M_d = Molecular weight of stack gas, g/g-mole on dry basis

M_s = Molecular weight of stack gas, g/g-mole on wet basis

V_s = Stack gas velocity, calculated by Method 2, Equation 2-9, using data obtained from Method 5, m/sec (ft/sec)

C_p = Pitot tube coefficient, dimensionless

Δ_p = Velocity head of stack gas, mm H_2O (in. H_2O)

P_s = Absolute stack gas pressure, mm Hg (in. Hg)

NOMENCLATURE (continued)
METHOD 5 CALCULATIONS

Q_{std} = Dry volumetric stack gas flow rate corrected to standard conditions, dscm/hr (dscf/hr)

dscf/min = dry standard cubic feet per minute (also identified as dcfm or scfm)

acfm = actual cubic feet per minute

I = Percent of isokinetic sampling

A_n = Cross-sectional area of nozzle, m^2 (ft^2)

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SOURCE

EMISSION

EVALUATION

NOVEMBER 23, 1988

Prepared For:

BOEING COMPANY
#5 CHROMIC ACID ANODIZING TANK VENT
SEATTLE, WASHINGTON
NOVEMBER 1, 1988

Submitted by:

KRIS A. HANSEN
DIRECTOR, AIR QUALITY DIVISION

JAMES A. GUENTHOER
PROJECT ENGINEER

AM TEST, INC.
REDMOND, WASHINGTON

We certify that the information contained herein is accurate and complete to the best of our knowledge.

METHOD 1-5 - PARTICULATE EMISSION CONCENTRATION RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	BOECR6R3	LAB #:	822263
CLIENT:	BOEING PLANT #2	START TIME:	14:00 O'CLOCK
LOCATION:	SEATTLE, WASH	STOP TIME:	15:01 O'CLOCK
SAMPLE SITE:	CHROMIC ACID BATH #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	NOVEMBER 1, 1988	CONDITION:	BATH ON
RUN #:	3-CR+6		
OPERATORS:	GUENTHOER/WIDMEYER		
CONTACT:	TERRY LORDS		

HEXAVALENT CHROMIUM

MILLILITERS OF SOLUTION:	452
HEXAVALENT CHROMIUM CONCENTRATION (UG/ML):	4.8
HEXAVALENT CHROMIUM CONCENTRATION (MG/DSCM):	1.44
TOTAL HEXAVALENT CHROMIUM IN SAMPLE (PPM):	0.67
HEXAVALENT CHROMIUM EMISSION RATE (LBS/HR):	0.117

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
626.5	615.7	10.8
601.6	600.5	1.1
488.4	487.8	0.6
797.2	785.9	11.3
TOTAL H2O GAIN:		23.8
TOTAL VOLUME (SCF)		1.12
PERCENT MOISTURE:		2.07
Bws:		0.0207

PITOT Cp:	0.85
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	71.5
BAROM. PRES. "HG:	29.84
STATIC PRES. "H2O:	-0.09
STACK PRES. "HG:	29.83
ORIFICE PRES "H2O:	1.435
METER PRES. "HG:	29.95

INIT. METER VOL.:	101.307
FINAL METER VOL.:	155.848
VOLUME SAMPLED:	54.541
STD VOLUME (DSCF):	53.143
STD VOLUME (DSCM):	1.505
Y FACTOR:	0.98

AVERAGE % CO2:	0.0
AVERAGE % O2:	20.9
AVERAGE ppm CO:	0
STACK GAS MW. DRY:	28.84
STACK GAS MW. WET:	28.61

SAMPLE POINT		VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW	1	0.22	79
	2	0.27	79
	3	0.30	79
	4	0.30	78
	5	0.28	79
	6	0.22	79

SAMPLE POINT		VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE	1	0.28	78
	2	0.31	78
	3	0.32	78
	4	0.29	79
	5	0.25	79
	6	0.22	78

PERCENT ISOKINETICS:	96 %	
STACK TEMPERATURE:	78.6 DEG. F.	538.6 DEG. R.
AVERAGE VELOCITY HEAD:	0.271 " OF H2O	
STACK GAS VELOCITY:		30.02 FT/SEC.
STACK GAS AIR FLOW:	22636.1 ACF/MIN.	21669.8 DSCF/MIN.

METHOD 1-5 - PARTICULATE EMISSION CONCENTRATION RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	BOECR6R2	LAB #:	822262
CLIENT:	BOEING PLANT #2	START TIME:	11:08 O'CLOCK
LOCATION:	SEATTLE, WASH	STOP TIME:	13:09 O'CLOCK
SAMPLE SITE:	CHROMIC ACID BATH #5	SAMPLE TIME:	120.0 MINUTES
SAMPLE DATE:	NOVEMBER 1, 1988	CONDITION:	BATH OFF
RUN #:	2-CR+6		
OPERATORS:	GUENTHOER/WIDMEYER		
CONTACT:	TERRY LORDS		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
609.7	590.9	18.8
592.1	588.0	4.1
471.1	469.6	1.5
834.8	816.0	18.8
TOTAL H2O GAIN:		43.2
TOTAL VOLUME (SCF)		2.03
PERCENT MOISTURE:		1.88
Bws:		0.0188

PITOT Cp:	0.85
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	70.1
BAROM. PRES. "HG:	29.80
STATIC PRES. "H2O:	-0.09
STACK PRES. "HG:	29.79
ORIFICE PRES "H2O:	1.428
METER PRES. "HG:	29.91

INIT. METER VOL.:	990.700
FINAL METER VOL.:	1099.623
VOLUME SAMPLED:	108.923
STD VOLUME (DSCF):	106.268
STD VOLUME (DSCM):	3.010
Y FACTOR:	0.98

AVERAGE % CO2:	0.0
AVERAGE % O2:	20.9
AVERAGE ppm CO:	0
STACK GAS MW. DRY:	28.84
STACK GAS MW. WET:	28.63

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NE 1	0.28	75	NW 1	0.22	76
2	0.31	76	2	0.27	76
3	0.32	75	3	0.30	76
4	0.29	75	4	0.30	76
5	0.25	76	5	0.28	77
6	0.22	76	6	0.22	76

PERCENT ISOKINETICS:	96 %	
STACK TEMPERATURE:	75.8 DEG. F.	535.8 DEG. R.
AVERAGE VELOCITY HEAD:	0.271 " OF H2O	
STACK GAS VELOCITY:		29.95 FT/SEC.
STACK GAS AIR FLOW:	22585.3 ACF/MIN.	21744.5 DSCF/MIN.

HEXAVALENT CHROMIUM

MILLILITERS OF SOLUTION:	450
HEXAVALENT CHROMIUM CONCENTRATION (UG/ML):	0.15
HEXAVALENT CHROMIUM CONCENTRATION (MG/DSCM):	0.022
TOTAL HEXAVALENT CHROMIUM IN SAMPLE (PPM):	0.010
HEXAVALENT CHROMIUM EMISSION RATE (LBS/HR):	0.002

METHOD 1-5 - PARTICULATE EMISSION CONCENTRATION RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	BOECR6R1	LAB #:	822261
CLIENT:	BOEING PLANT #2	START TIME:	09:42 O'CLOCK
LOCATION:	SEATTLE, WASH	STOP TIME:	10:43 O'CLOCK
SAMPLE SITE:	CHROMIC ACID BATH #5	SAMPLE TIME:	60.0 MINUTES
SAMPLE DATE:	NOVEMBER 1, 1988	CONDITION:	BATH ON
RUN #:	1-CR+6		
OPERATORS:	GUENTHOER/WIDMEYER		
CONTACT:	TERRY LORDS		

FINAL WT. OF H2O G.	INIT.WT. OF H2O G	NET WT. OF H2O G.
589.4	581.4	8.0
594.4	591.9	2.5
485.5	484.7	0.8
771.8	762.7	9.1
TOTAL H2O GAIN:		20.4
TOTAL VOLUME (SCF)		0.96
PERCENT MOISTURE:		1.79
Bws:		0.0179

PITOT Cp:	0.85
NOZZLE DIA INCHES:	0.313
NOZZLE AREA FT^2:	0.0005
STACK DIA. INCHES:	48.00
STACK AREA FT^2:	12.566
METER TEMP. DEG F:	65.4
BAROM. PRES. "HG:	29.80
STATIC PRES. "H2O:	-0.09
STACK PRES. "HG:	29.79
ORIFICE PRES "H2O:	1.399
METER PRES. "HG:	29.90

INIT. METER VOL.:	937.063
FINAL METER VOL.:	990.517
VOLUME SAMPLED:	53.454
STD VOLUME (DSCF):	52.614
STD VOLUME (DSCM):	1.490
Y FACTOR:	0.98

AVERAGE % CO2:	0.0
AVERAGE % O2:	20.9
AVERAGE ppm CO:	0
STACK GAS MW. DRY:	28.84
STACK GAS MW. WET:	28.64

SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY " OF H2O	TEMPERATURE DEGREES F.
NW 1	0.22	76	NE 1	0.28	74
2	0.27	75	2	0.31	75
3	0.30	75	3	0.32	75
4	0.30	74	4	0.29	76
5	0.28	74	5	0.25	75
6	0.22	74	6	0.22	75

PERCENT ISOKINETICS:	95 %		
STACK TEMPERATURE:	74.8	DEG. F.	534.8 DEG. R.
AVERAGE VELOCITY HEAD:	0.271	" OF H2O	
STACK GAS VELOCITY:			29.92 FT/SEC.
STACK GAS AIR FLOW:	22560.6	ACF/MIN.	21780.2 DSCF/MIN.

HEXAVALENT CHROMIUM

MILLILITERS OF SOLUTION:	452
HEXAVALENT CHROMIUM CONCENTRATION (UG/ML):	5.4
HEXAVALENT CHROMIUM CONCENTRATION (MG/DSCM):	1.64
TOTAL HEXAVALENT CHROMIUM IN SAMPLE (PPM):	0.76
HEXAVALENT CHROMIUM EMISSION RATE (LBS/HR):	0.134

SUMMARY OF RESULTS

The results of the three (3) tests for determining hexavalent chromium (Cr^{+6}) emissions, collected at the #5 chromic acid bath exhaust on November 1, 1988 are summarized in Table 1 below:

Table 1. Summary of Cr^{+6} emissions tests performed November 1, 1988 at Boeing's Plant No. 2.

Sample Run #	AM Test Lab #	Cr^{+6} Emission Conc. mg/dscm	Cr^{+6} Emission Conc. ppm	Cr^{+6} Emission Rate lb/hr	Air Flow dscf/min
1	822261	1.64	0.76	0.134	21780
*2	822262	0.22	0.01	0.002	21745
3	822263	1.44	0.67	0.117	21670

* Run 2 occured over a 2-hr period while no parts were in the bath.

The hexavalent chromium emission concentration is presented in units of milligrams per dry standard cubic meter (mg/dscm) and in parts per million (ppm). The Cr^{+6} emission rate is presented in units of pounds per hour (lb/hr). Airflow is also presented in units of dry standard cubic feet per minute (dscf/min). An acceptable leak check of less than 0.02 cfm at the highest vacuum rate (or greater) used during the test preceded and followed each run. The average percentage isokinetics for each run were within the acceptable limits of 100 $\pm$ 10%. Computer printouts which detail the complete results may be found on the following pages.

analysis, data reduction, and final report preparation was performed by Mr. Kris A. Hansen, Ms. Angela F. Blaisdell, and Ms. Jan M. Widmeyer of Am Test. Am Test, Inc.'s Trace Metals Division performed the hexavalent chromium analysis using a diphenylcarbazide colorimetric method. Ms. Terry Lords and Mr. Chuck Strand represented the Boeing Company.

INTRODUCTION

The purpose of this testing program performed at the Boeing Company's Plant No. 2 in Seattle, Washington was to quantify the hexavalent chromium (Cr^{+6}) emissions exhausted from the #5 chromic acid anodizing tank which is one of the tanks in the 80 anodic tank line located in the 210 Building. The fumes which result from the plating process are controlled by blowing air horizontally across the top of the tank and sucking the fumes through ductwork with an axial fan to the exhaust stack. The plating cycle takes 55 minutes during which the vat is heated to a temperature of 95° C. Three (3) samples for determining hexavalent chromium were collected at this source on November 1, 1988. Two (2) of the samples were collected over one-hour periods during 2 anodizing cycles (run 1 and 3). One (1) sample was collected over a two-hour period while no parts were in the bath (run 2).

The sample method used is similar to EPA Method 5, which is detailed in the Title 40 Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A. The sample train was modified to exclude the front-half filter and utilized 0.1 N sodium hydroxide (NaOH) solution in the impingers. A final back-half Teflon^{R} filter was connected in series to collect any Cr^{+6} which might break through the absorbing liquid. EPA Methods 1-4 were also performed during this testing project. Methods 1 and 2 were performed to determine the stack gas velocity and volumetric flow rate, Method 3 was performed to determine the molecular weight of the stack gas, and Method 4 was performed to determine the moisture content of the stack gas.

Mr. James A. Guenthoer, and Ms. Jan M. Widmeyer of Am Test, Inc.'s Air Quality Division based in Redmond, Washington performed the field sampling. Laboratory