AP42 Section:	13.4
Background Chapter	4
Reference:	18
Title:	Isokinetic Droplet Emission Measurements of Selected Induced Draft Cooling Towers (Revised 12/18/86). Kerr McGee Chemical Corporation, Trona, California, November. Environmental Systems Corporation (1986).

TIN 86-1143

Isokinetic Droplet Emission Measurements of Selected Induced Draft Cooling Towers

(Revised 12/18/86)

Prepared For:

Kerr McGee Chemical Corporation
P.O. Box 367
Trona, CA 93562

Prepared By:

Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

November, 1986

1.0 EXECUTIVE SUMMARY

As part of a program to assess/evaluate emissions trade-off options, Kerr McGee Chemical Corporation retained ESC to conduct specialized cooling tower emissions measurements. The goal of this test program was to determine the drift fraction for each tower. Drift fraction is the volumetric ratio of drift droplet emissions to design recirculating water flow rate, expressed as a percent. Table 1.1 presents the drift fractions determined during this project. Sodium was used as the tracer in this analysis.

Table 1.1

Summary of Drift Fractions Determined

Tower	Location	Drift Fraction (%)
Borax Cooling Tower	Westend Facility	0.0057
#1 Sulfate Cooling Tower	Westend Facility	0.0092
#2 Sulfate Cooling Tower	Westend Facility	0.0035
#3 Sulfate Cooling Tower	Westend Facility	0.0457
#4 Sulfate Cooling Tower	Westend Facility	0.0030
Lime Cooling Tower	Westend Facility	0.0011
#11 Cooling Tower	Trona Facility	0.0011
#14 Cooling Tower	Trona Facility	0.0024
Argus Cooling Tower	Argus Facility	0.0113

Most performance specifications written for drift eliminators today set 0.005% or less as the maximum drift fraction acceptable. Drift fractions as low as 0.0002 percent of water flow rate have been documented.

2.0 INTRODUCTION

In the operation of an evaporative cooling tower, circulating water is mechanically broken up, via the fill and water distribution system, to enhance air/water interface and resultant heat transfer. In this process, airflow through the cooling equipment carries smaller droplets with it, presenting the droplets to drift eliminators, which inertially separate a portion of the droplet population from the air stream. That portion which is not collected or is reentrained in the air is referred to as drift (or carry over), and is exhausted via the cooling fan into the environment. The droplets initially have the same mineral content as the cooling water, but evaporation can result in the droplets becoming more concentrated than the cooling water.

2.1 Test Objective

Kerr McGee Chemical Corporation (KMCC) contracted with Environmental Systems Corporation (ESC) to conduct isokinetic sampling of drift emissions from nine induced draft cooling towers. The towers were located within plant boundaries at three sites adjacent to Searles Lake (a dry lake bed), near Trona, California. The objective of the sampling program was to measure the mineral mass emissions due to cooling water droplets escaping in the exhaust air from each cooling tower. In addition, the collected minerals from each tower were to be analyzed chemically and the results compared with chemical analyses of the recirculating cooling water from the appropriate cooling tower.

2.2 Tower Descriptions

The induced draft cooling towers sampled during the project were of both counterflow and crossflow configurations. The number of cells per tower varied between 1 and 4 and all cells contained drift eliminators. Table 2.1 provides a listing of the towers tested and other pertinent information.

Table 2.1

Summary of Test Locations

Tower Designation	Tower Location	Tower Description
Borax Cooling Tower	Westend Facility	3 cell counterflow
No. 1 Sulfate Cooling Tower	Westend Facility	2 cell counterflow
No. 2 Sulfate Cooling Tower	Westend Facility	2 cell counterflow
No. 3 Sulfate Cooling Tower	Westend Facility	2 cell counterflow
No. 4 Sulfate Cooling Tower	Westend Facility	2 cell crossflow
Lime Cooling Tower	Westend Facility	1 cell counterflow
No. 11 Cooling Tower	Trona Facility	3 cell crossflow
No. 14 Cooling Tower	Trona Facility	4 cell crossflow
Argus Cooling Tower	Argus Facility	4 cell crossflow

3.0 TEST PREPARATION AND EXECUTION

3.1 Pre-Test Inspection

During the week prior to the start of the sampling program, representatives of the Marley Cooling Tower Company and Kerr-McGee inspected each tower and selected the cells to be sampled. The goal during this inspection was to select cells in which the drift eliminators were in good condition and in which the drift losses appeared to be lowest for that tower. Therefore, the data resulting from this sampling program represents a conservative baseline for evaluating future upgrades.

The only unusual condition observed during the sampling program was in the #4 Sulfate Cooling Tower at the Westend Facility. The south cell of this two-cell crossflow tower was selected for sampling. At the time of sampling, the north cell was out of service for fan rotor repairs. However, hot water was still being distributed over both cells. This operating mode was characterized by normal water loadings over each cell, but abnormally low air velocities through the drift eliminators of the tower. There is no partition wall in the exhaust air plenum between the cells. With the north cell fan out of service, a large portion of the air discharged from the south cell was short circuited ambient air that entered the tower through the fan shroud of the north cell. As a result, the air velocity through the fill and the drift eliminators must have been significantly below normal.

Generally, drift eliminators work better at higher air velocities, because greater droplet momentum causes smaller droplets to cross streamlines and impinge on the drift eliminator surfaces. However, every drift eliminator design has a maximum velocity that cannot be exceeded without experiencing reentrainment of collected drift. In the case of the #4 Sulfate Cooling Tower, lower than normal capture efficiency for small droplets could be expected.

Conversely, the lower air velocities through the fill would tend to produce fewer small droplets. With the lower air velocities exiting the drift eliminators, larger droplets that escaped the eliminators may have fallen out in the exhaust air plenum. These uncertainties make it impossible to determine exactly what drift rates are normal for this tower. However considering all factors, we believe that the drift rates measured in the south cell of the #4 Sulfate Cooling Tower still represent a conservative estimate of normal emissions.

3.2 Pre-Test Instrumentation Calibrations

Two main types of instruments were used to set isokinetic sampling conditions during the test program. A Gill propeller anemometer was used to measure updraft air velocity at 20 equal area points in the exit plane of each fan exhaust stack.

The propeller anemometer is well suited to velocity measurements in the turbulent environment of the fan stack. Velocity vectors at this location have a wide range of magnitude and direction. The Gill propeller anemometer exhibits a near-cosine response to non-normal vectors up to angles of about 25° (i.e. the indicated velocity is the velocity vector perpendicular to the fan exit plane). As a result, readings are typically within 5% of the true value up to angles of 18° and within 10% up to a 25° angle.

The propeller anemometer (ESC #1) used in this test program was calibrated at the National Oceanic and Atmospheric Administration wind tunnel in Oak Ridge, Tennessee by comparison with a National Bureau of Standards calibrated anemometer. The resulting anemometer response curve is shown in Appendix A.

The second set of instruments was associated with the vacuum air sampling system. Flow rate of air through the sampling train was measured using a bank of Dwyer Rotameters, each of which had a manual flow regulating valve immediately downstream. Prior to shipment of the equipment to Trona, the rotameters were calibrated over a wide range of air flows. A standard flow meter was connected to the sampling train in series upstream of the system rotameters. Readings of the standard flow meter were recorded over the range of 100 to 810 SCFH. These corresponded to readings from 195 to 1625 SCFH on the system rotameters. The standard meter readings were corrected for barometric pressure and used to back-calculate updraft air velocity at the inlet throat of the sampling tube. A plot of updraft air velocity versus system flow meter readings was prepared for use in the field. Flow calibration data and the plot are included in Appendix A. Figure 3.2 shows a schematic diagram of the sampling train.

3.3 Test Procedures

For each fan stack sampled, the location of the sampling point had to be determined. The inside diameter of the stack was measured at the outlet plane using a steel tape. The distances from the inside perimeter of the stack to each sample point were calculated, and the traverse boom was marked with tape at these locations. Figure 3.1 depicts the boom and shuttle system used to move the anemometer and sampling tube between sampling points. The data sheets for each calculation are included in Appendix B.

At each sampling point, the updraft air velocity was measured with the propeller anemometer and the flow rate through the sampling train was then set to achieve isokinetic conditions (i.e.: velocity of air entering the sampling tube was set to match the mean exhaust air velocity at that point). In order to eliminate observer bias, anemometer voltage output values were hand entered and averaged via calculator. The proper system flow rate was then determined using the Anemometer Curve and the vacuum system Calibration Curve. Using this method, isokinetic conditions were typically established within 30 seconds of

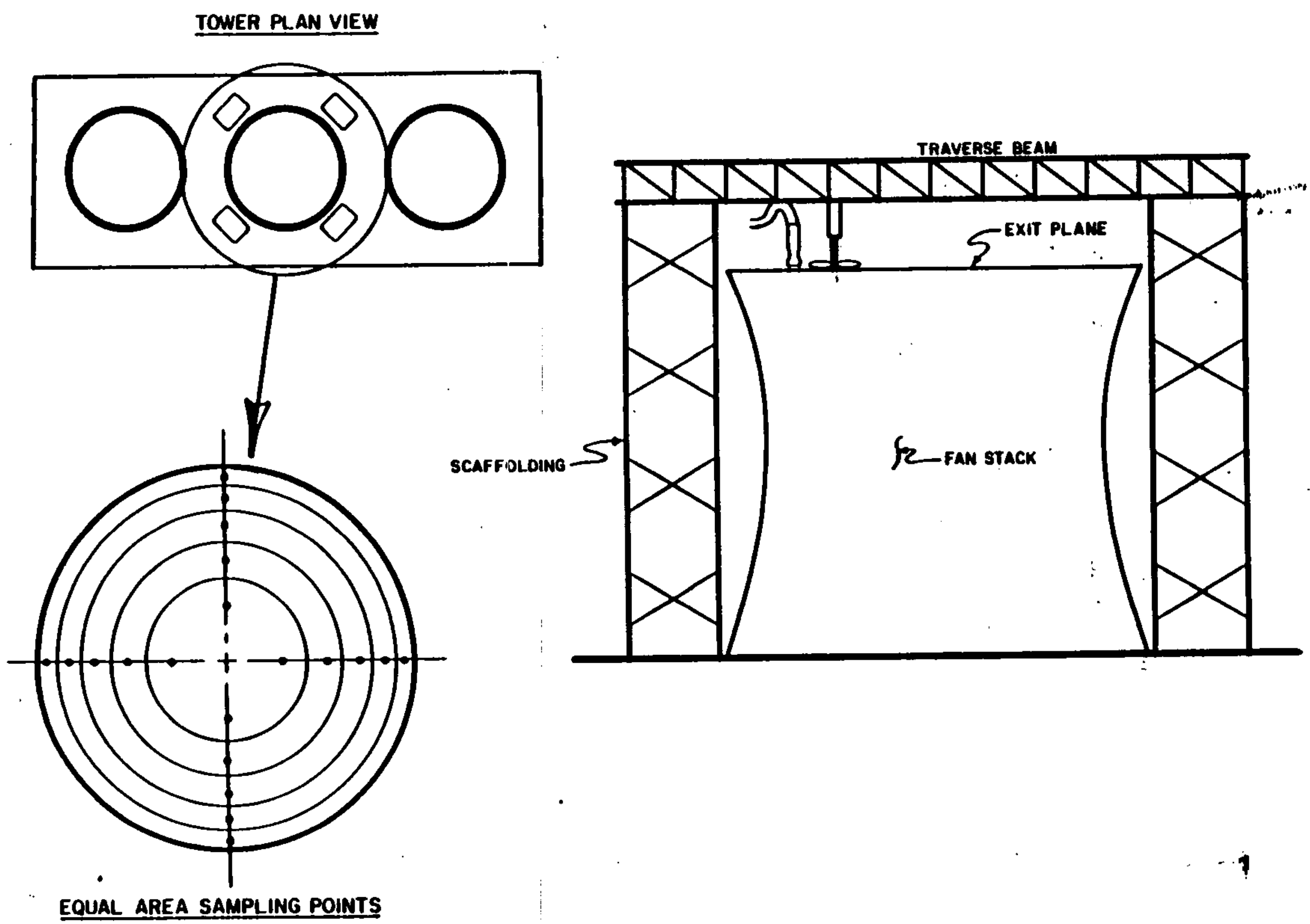


Figure 3.1 ISOKINETIC DRIFT SAMPLING

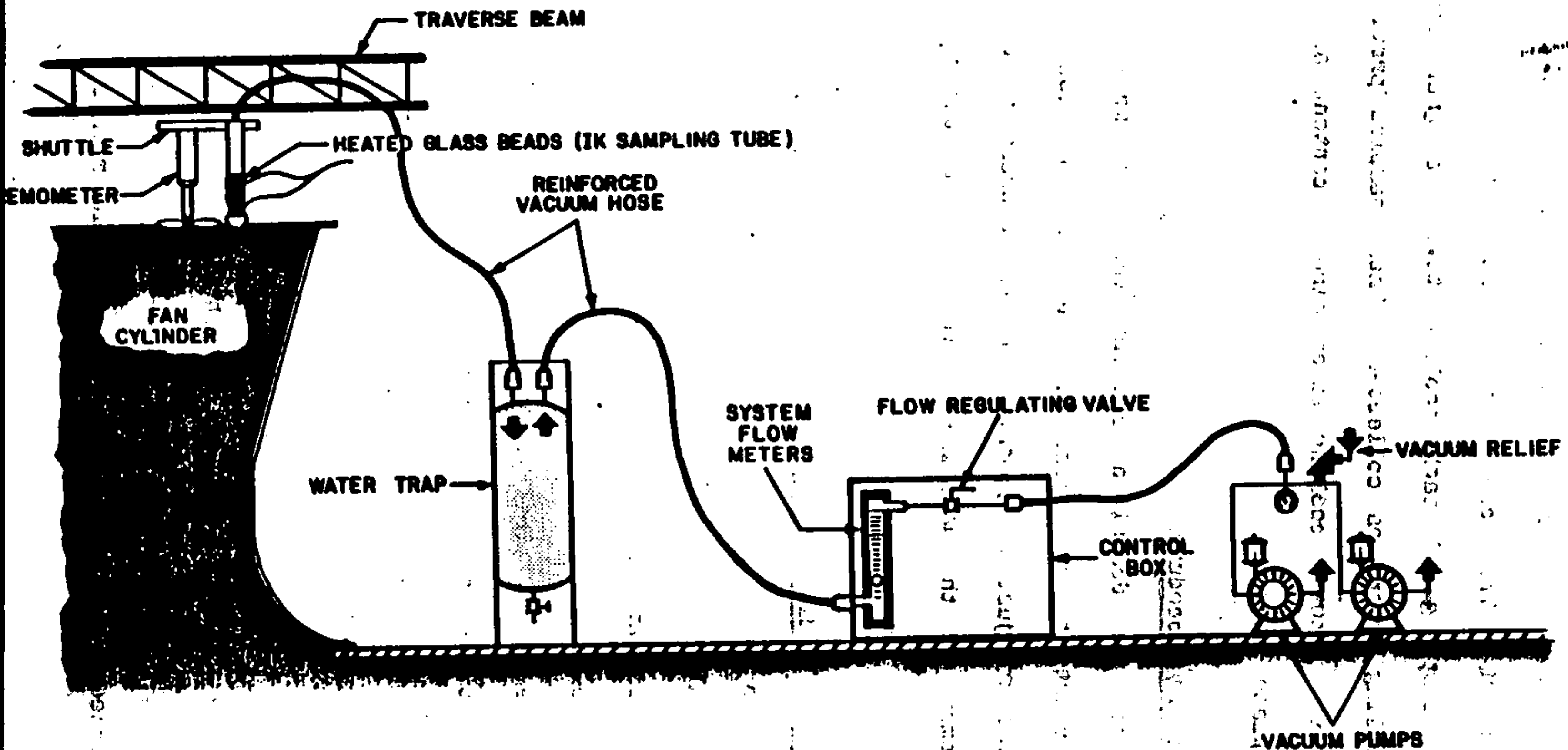

TRAVERSE BEAM
SHUTTLE
EMOMETER
HEATED GLASS BEADS (IK SAMPLING TUBE)
REINFORCED VACUUM HOSE
FAN CYLINDER
WATER TRAP
SYSTEM FLOW METERS
FLOW REGULATING VALVE
CONTROL BOX
VACUUM RELIEF
VACUUM PUMPS

Figure 3.2

moving the shuttle to a new sampling point. In order to provide a permanent record of each test, the average air velocities and rotameter settings were recorded on data sheets. These can be found in Appendix B.

During the sampling of each cooling tower, a grab sample of the recirculating cooling water was collected. These samples provide a chemical basis of comparison between cooling water mineral content and dry residues retained on the glass beads.

3.4 IK Tube Handling Procedures

By the methods just described, sampling tubes were moved from one equal area sampling point to the next and subjected to isokinetic sampling conditions. However, just as important to the success of the mineral mass emission measurement is the handling of the tubes in the field and in the laboratory.

3.4.1 Pre-Test Handling Procedures

Prior to mobilization in the field, each of the sampling tubes was washed with warm 10 volume % hydrochloric acid and rinsed with distilled water to remove existing deposits. This procedure was performed twice. The final wash and rinse solutions were collected and analyzed. The background values for ionic parameters of interest are reported in Appendix C and summaried in Tables 4.1 a through i. Each tube was then allowed to air dry and was individually wrapped in plastic for shipment to the site.

3.4.2 On-Site Handling Procedures

The sampling procedure is described as follows. The ground glass fitting of the sampling tube was coated with stop cock grease and attached by a clamp to the receptacle mounted on the shuttle.

Figure 3.3 shows the design features of a typical isokinetic sampling tube. After installing the sampling tube, positive and negative electrical leads from a 110 VAC rheostat were connected to the heat tape surrounding the tube. A current of 1.0 to 2.0 amperes was applied resulting in the heating of the glass beads to a temperature above the boiling point of water. After heating was begun, the vacuum pumps were started and an initial visual average anemometer reading was taken. The appropriate flow rate through the rotameters was then set using the regulating valve(s). This operation was completed within ten seconds and consistently established flows within ±15% of isokinetic conditions. During the next 30 seconds, the arithmetic mean velocity, by the calculator method, was performed to "fine tune" the flow setting. After the sampling duration for that point was satisfied, the shuttle was moved to the next point and the procedure was repeated. When the last point of the first traverse was completed, the power supplies to the heating tape and the vacuum pumps were interrupted. Then the sampling tube was disconnected from the receptacle and wrapped in plastic until the traverse boom could be repositioned for the second traverse. The second traverse was performed in the same manner as the first. At the end of that traverse the tube was disconnected in the same manner, wrapped in clean plastic and stored for transportation to the analytical laboratory.

One IK sampling tube was exposed in each fan stack. In addition, a procedural blank was performed. In all respects, this IK tube was handled in the same manner as all of the others, except that no exhaust air was drawn through it.

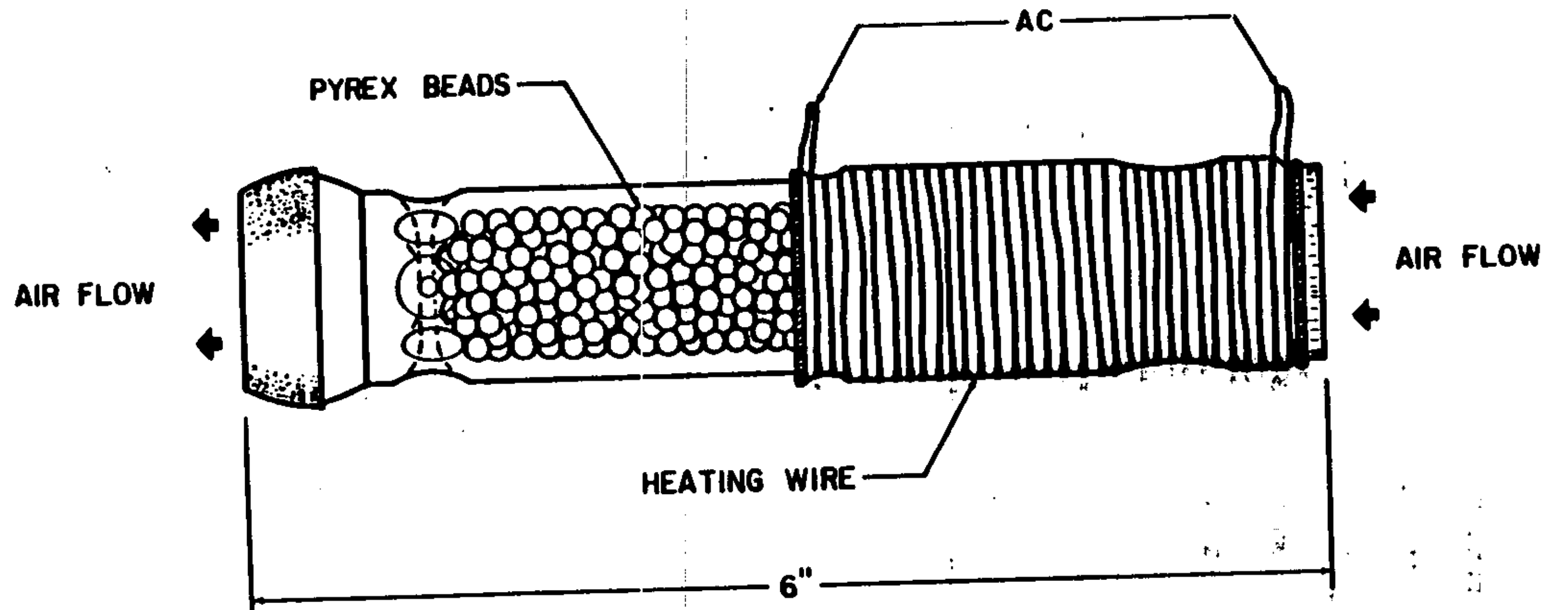


Figure 3.3

ISOKINETIC SAMPLING TUBE

3.4.3 Post-Test Handling Procedures

The sampling tubes were hand carried to the Brown and Caldwell Analytical Laboratory in Pasadena, California. This lab is nationally recognized and is certified by the State of Califonia Department of Health Services for analysis of drinking water and hazardous waste testing. The samples were logged in and discussions were held between B.R. Crocker (ESC) and L.L. Schaleger (B&C). A copy of the standard washing procedure was provided to Mr. Schaleger, and the procedure was discussed in detail (see Washing Procedure, Appendix C). In addition to the redissolved residues from the IK sampling tubes, Brown and Caldwell was directed to chemically analyze the samples of recirculating cooling water collected during the tests. The analytical methods used by Brown and Caldwell for water sample analysis were consistent with those employed for the analysis of redissolved residues.

4.0 RESULTS

4.1 Chemical Analysis and Computation of Results

Each sample of cooling water or redissolved residue was analyzed for the presence of 35 chemical constituents. For consistency the cooling water samples were given sample numbers that coincided with the number of the IK sampling tube (i.e. IK #6 and W#6 refer to the redissolved residue sample and the cooling water sample respectively for the Borax Cooling Tower). Five blank washing solutions generated before the tests were analyzed to determine IK tube cleanliness. Galbraith Laboratories of Knoxville, TN conducted these analyses. Their analysis reports can be found in Appendix C. The "Chain of Custody Records" and the analysis reports from Brown and Caldwell Analytical Laboratories are also included in Appendix C. Tables 4.1a through i present the chemical analyses pertaining to each of the towers tested. These tables also present the mineral mass emission rates calculated for several key chemical constituents in the redissolved residues. Equation 4.1 was used to calculate the mineral mass emission rates.

eq. 4.1 $$F_{kj} = \frac{\text{mineral element collected}}{\text{sampling time x sampling area}} = \frac{M_{kj} - M_{BK}}{t_s \cdot A_s}$$

where:

F = mineral element flux ($mgm/m^2 \cdot S$) $\frac{Mg}{sec \times m^2}$

M = mass of mineral element (micrograms per sample)

t_s = sampling time (seconds)

A_s = sampling area (square meters)

k represents the mineral element analyzed

j represents the mineral collected during sampling

Bk represents the mineral element present in the blank

Although it is possible to directly calculate the mineral mass emission for each parameter using equation 4.1, many parameters are below detectable concentration limits in the redissolved residue samples. A more accurate method is to use a single tracer, such as sodium (Na) to determine the volumetric drift rate (drift fraction) as a percentage of recirculating waterflow. Then, the emission rate for any constituent can be calculated from the drift fraction and an analysis of the cooling water. Equation 4.2 illustrates the calculation of drift fraction. Equation 4.3 shows how the mass emission rate for a particular constituent can be determined using the drift fraction.

eq. 4.2 $$DF = \frac{\text{liters/minute emitted}}{\text{liters/minute circulated}} = \frac{F_{kj} \cdot A_{fs} \cdot S_t \cdot 1585}{R \cdot C}$$

where:

DF = Drift fraction (% of R)

F_{kj} = Mineral mass emission rate of sodium $\left(\frac{\text{mgm}}{\text{m}^2 \cdot \text{s}}\right)$

A_{fs} = Area of the fan stack (m^2)

S_t = Number of stacks per tower

R = Recirculating water flow rate (GPM)

C = Concentration of sodium in the cooling water (mgm/L)

eq. 4.3 $$M_E = DF \cdot R \cdot C_x \cdot 5.008 \times 10^{-6}$$

where:

M_E = Mineral Mass Emission Rate (lb/hr)

C_x = Concentration of any parameter in the cooling water (mgm/L)

Table 4.2 summarizes the results derived when equation 4.2 is used to calculate drift fraction in terms of sodium and equation 4.3 is used to calculate the mass emission rates for Boron and Sulfate. The procedure

Table 4.1a

IK Tube Number: IK6 (Log #11-079-5)
Cooling Water Sample Number: W6 (Log #11-079-15)
Cooling Tower Name: Borax Cooling Tower (Westend Facility)

Date of Sampling: October 31, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mgms}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	35		15	
Antimony	<0.4	<200		<200	
Arsenic	0.60	<1.5	0.5	<1.5	
Barium	0.07	5		80	
Beryllium	<0.006	<3		<3	
Boron	59	33		4.5	0.0125
Cadmium	0.02	<10		<10	
Calcium	29	380	35.8	155	0.151
Chromium Total	5.3	<15	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.04	<15		<15	
Copper	<0.03	<20		950	
Iron	0.04	240		140	0.0439
Lead	<0.03	<1.5 △1		2 △1	
Lithium	.71	<10		10	
Magnesium	3.1	30		20	0.0044
Manganese	0.007	1.5		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	76	<500		<500	
Selenium	1	<500		<500	
Silicon	56	200		100	
Silver	<0.01	<5		<5	
Sodium	9900	5500 △1	22	200 △1	2.403 △1
Strontium	2.6	3		1.5	
Thallium	<0.4	<250		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	14		22	
Vanadium	<0.22	<15		<15	
Zinc	<0.08	<40		<40	
Anions					
Chloride	13,000				
Fluoride	3.6	5		<5	
Sulfate	2,700	2,450 △1	<995	<500 △1	0.855 △1
Solids					
Total Dissolved Solids	25,000	20,000 △1		20,000 △1	

* Average of five (5) samples of second pre-test rinse. (IK Tube Nos.)

△1 Indication of changed data

Table 4.1b

IK Tube Number: IK11 (Log #11-079-9)
Cooling Water Sample Number: W11 (Log #11-079-19)
Cooling Tower Name: #1 Sulfate Cooling Tower (Westend Facility)

Date of Sampling: October 31, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mgms}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	50		15	
Antimony	<0.4	<200		<200	
Arsenic	0.74	<1.5	0.5	<1.5	
Barium	0.07	5		80	
Beryllium	<0.006	<3		<3	
Boron	80	95		4.5	0.0397
Cadmium	0.02	<10		<10	
Calcium	16	1900	35.8	155	0.818
Chromium Total	8.5	<15	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	0.16	35		950	
Iron	<0.03	2,050		140	0.838
Lead	<0.03	<1.5 △		2 △	
Lithium	0.93	15		10	
Magnesium	2.5	55		20	0.0154
Manganese	<0.003	9		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	120	<500		<500	
Selenium	<1	<500		<500	
Silicon	64	100		100	
Silver	<0.01	<5		<5	
Sodium	13,000	18,000 △	22	200 △	7.885 △
Strontium	3.2	6		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	44.5		22	
Vanadium	0.27	<15		<15	
Zinc	<0.08	900		<40	0.377
Anions					
Chloride	19,000				
Fluoride	4.8	10		<5	
Sulfate	3,400	4,650 △	<995	< 500 △	1.820 △
Solids					
Total Dissolved Solids	34,000	60,000 △		20,000 △	

* Average of five (5) samples of second pre-test rinse. (IK Tube Nos.)

△ Indication of changed data

Table 4.1c

IK Tube Number: IK2 (Log #11-079-2)
Cooling Water Sample Number: W2 (Log #11-079-12)
Cooling Tower Name: #2 Sulfate Cooling Tower (Westend Facility)

Date of Sampling: November 1, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux ngms / $m^2 \cdot s$
Metals					
Aluminum	<0.03	45		15	
Antimony	<0.4	<200		<200	
Arsenic	1.0	<1.5	0.5	<1.5	
Barium	0.13	10		80	
Beryllium	<0.006	<3		<3	
Boron	90	49		4.5	0.0195
Cadmium	0.03	<10		<10	
Calcium	51	240	35.8	155	0.090
Chromium Total	12	<15	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	<0.04	<20		950	
Iron	<0.03	900		140	0.333
Lead	<0.03	1.5 ⚠		2 ⚠	
Lithium	.98	335		10	
Magnesium	4.3	20		20	
Manganese	4.0	4.5		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	140	<500		<500	
Selenium	<1	<500		<500	
Silicon	50	100		100	
Silver	<0.01	<5		<5	
Sodium	16,000	8,500 ⚠	22	200 ⚠	3.718 ⚠
Strontium	4.4	3		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006006	11		22	
Vanadium	0.34	<15		<15	
Zinc	<0.08	45		<40	0.0022
Anions					
Chloride	27,000				
Fluoride	5.2	105		<5	
Sulfate	4,400	3,750 ⚠	<995	<500 ⚠	1.425 ⚠
Solids					
Total Dissolved Solids	42,000	90,000 ⚠		20,000 ⚠	

* Average of five (5) samples of second pretest rinse. (IK Tube Nos.)

⚠ Indication of changed data

Table 4.1d

IK Tube Number: IK1 (Log #11-079-1)
Cooling Water Sample Number: W1 (Log #11-079-11)
Cooling Tower Name: #3 Sulfate Cooling Tower (Westend Facility)

Date of Sampling: November 1, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mg}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	40		15	
Antimony	<0.4	<200		<200	
Arsenic	0.95	3.0	0.5	<1.5	
Barium	0.13	5		80	
Beryllium	<0.006	<3		<3	
Boron	91	800		4.5	0.345
Cadmium	0.03	<10		<10	
Calcium	56	480	35.8	155	0.195
Chromium Total	14	105	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	<0.04	35		950	
Iron	<0.03	300		140	0.0702
Lead	<0.03	9 △		2 △	
Lithium	0.97	425		10	
Magnesium	6.3	60		20	0.0175
Manganese	0.014	0.35		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	130	500		<500	
Selenium	———	<500		<500	
Silicon	51	250		100	
Silver	<0.01	<5		<5	
Sodium	16,000	110,000 △	22	200 △	48.24 △
Strontium	4.4	11.5		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	28		22	
Vanadium	0.35	<15		<15	
Zinc	<0.08	<40		<40	
Anions					
Chloride	25,000				
Fluoride	5.4	45		5	
Sulfate	4,700	43,000 △	<955	<500 △	18.64 △
Solids					
Total Dissolved Solids	42,000	325,000 △		20,000 △	

* Average of five (5) samples of second pretest rinse. (IK Tube Nos.)

△ Indicates change of data

Table 4.1e

IK Tube Number: IK5 (Log #11-079-4)
Cooling Water Sample Number: W5 (Log #11-079-14)
Cooling Tower Name: Lime Cooling Tower (Westend Facility)

Date of Sampling: November 2, 1986
Duration: 10 minutes per point
Number of Points Sampled: 18

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)		Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)		Mass Mineral Flux mgms / $m^2 \cdot s$	
Metals								
Aluminum	<0.03	25			15			
Antimony	<0.4	<200			<200			
Arsenic	0.58	1.5		0.5	<1.5			
Barium	0.04	5			80			
Beryllium	<0.006	<3			<3			
Boron	33	<2.5			4.5			
Cadmium	<0.02	<10			<10			
Calcium	39	600		35.8	155		0.117	
Chromium Total	<0.03	<0.3		<2.5	<15			
Chromium (Hex)	<0.02	<10			<10			
Cobalt	<0.03	<0.3			<15			
Copper	<0.04	<0.4			950			
Iron	<0.03	6.9			140			
Lead	<0.03	2	⚠		2	⚠		
Lithium	0.49	25			10			
Magnesium	1.5	200			20		0.0373	
Manganese	<0.003	<2			2			
Mercury	<0.002	ND		<0.5	ND			
Molybdenum	<0.2	<100			<100			
Nickel	<0.06	<30			<30			
Potassium	56	<500			<500			
Selenium	<1	<500			<500			
Silicon	33	200			100			
Silver	<0.01	<5			<5			
Sodium	4,400	3,300	⚠	22	200	⚠	1.438	⚠
Strontium	1.1	1.5			1.5			
Thallium	<0.4	<200			<200			
Tin	<0.6	<300			<300			
Titanium	<0.006	22.5			22			
Vanadium	2.8	<15			<15			
Zinc	<0.08	<40			<40			
Anions								
Chloride	6,100							
Fluoride	2.0	5.0			<5			
Sulfate	1,500	700	⚠	<995	<500	⚠	0.041	⚠
Solids								
Total Dissolved Solids	13,000	375,000	⚠		20,000	⚠		

* Average of five (5) samples of second pretest rinse. (IK Tube Nos.)

⚠ Indicates change of data

Table 4.1f

IK Tube Numbers: 1K9 (Log #11-079-8)
Cooling Water Sample Number: W9 (Log #11-079-18)
Cooling Tower Name: #4 Sulfate Cooling Tower (Westend Facility)

Date of Sampling: November 2, 1986
Duration: 5 minutes per point
Number of Points Sampled: 15

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux mgm/($m^2 \cdot s$)	lbs/hr
Metals						
Aluminum	<0.03	15		15		
Antimony	<0.4	<200		<200		
Arsenic	0.65	<1.5	0.5	<1.5		
Barium	0.09	5		80		
Beryllium	<0.006	<3		<3		
Boron	73	<2.5		<4.5		
Cadmium	<0.02	<10		<10		
Calcium	76	180	35.8	155	0.0674	
Chromium Total	32	<15	<2.5	<15		
Chromium (Hex)	41	<10		<10		
Cobalt	<0.03	15		<15		
Copper	<0.04	25		950		
Iron	<0.03	115		140		
Lead	<0.03	<1.5 △		2 △		
Lithium	0.8	<10		10		
Magnesium	2.5	<30		20	0.0047	
Manganese	<0.003	1.5		2		
Mercury	<0.002	ND	<0.5	ND		
Molybdenum	<0.2	<100		<100		
Nickel	<0.06	<30		<30		
Potassium	100	<500		<500		
Selenium	<1	<500		<500		
Silicon	60	100		100		
Silver	<0.01	<5		<5		
Sodium	12,000	2,600 △	22	200 △	1.206 △	
Strontium	3.0	1.5		1.5		
Thallium	<0.4	<200		<200		
Tin	0.6	<300		<300		
Titanium	<0.006	11.5		22		
Vanadium	0.26	<15		<15		
Zinc	<0.08	<40		<40		
Anions						
Chloride	15,000					
Fluoride	4.1	<5		<5		
Sulfate	3,300	<500 △	<995	<500 △	0.0 △	
Solids						
Total Dissolved Solids	32,000	15,000 △		20,000 △		

* Average of five (5) samples of second pretest rinse. (IK Tube Nos.)

△ Indicates change of data

Table 4.1g

IK Tube Number: IK8 (Log #11-079-7)
Cooling Water Sample Number: W8 (Log #11-079-17)
Cooling Tower Name: #11 Cooling Tower (Trona Facility)

Date of Sampling: November 3, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mgms}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	30		15	
Antimony	<0.4	<200		<200	
Arsenic	18	5	0.5	<1.5	
Barium	0.04	5		80	
Beryllium	<0.006	3		<3	
Boron	1200	460		4.5	0.200
Cadmium	0.45	<10		<10	
Calcium	7.6	145	35.8	155	0.048
Chromium Total	<0.03	<15	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	<0.04	<20		950	
Iron	0.27	335		140	0.0855
Lead	<0.03	2		2	
Lithium	3.2	10		10	
Magnesium	5.2	45		20	0.0110
Manganese	0.0016	3		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	2100	3000		<500	
Selenium	<1	<500		<500	
Silicon	8.6	150		100	
Silver	<0.01	<5		<5	
Sodium	11,000	4500	22	200	1.964
Strontium	2.2	3		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	26		22	
Vanadium	<0.03	<15		<15	
Zinc	<0.08	<40		<40	
Anions					
Chloride	21,000				
Fluoride	4.6	<5		<5	
Sulfate	10,000	5000	<995	<500	1.974
Solids					
Total Dissolved Solids	60,000	44,000		20,000	

* Average of five (5) samples of second pretest Rinse. (IK Tube Nos.)

Indicates change of data

Table 4.1h

IK Tube Number: IK7 (Log #11-079-6)
Cooling Water Sample Number: W7 (Log #11-079-16)
Cooling Tower Name: #14 Cooling Tower (Trona Facility)

Date of Sampling: November 3, 1986
Duration: 5 minutes per point
Number of Points Sampled: 18

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mgms}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	75		15	
Antimony	<0.4	<200		<200	
Arsenic	11	4	0.5	<1.5	
Barium	0.02	20		80	
Beryllium	<0.006	<3		<3	
Boron	270	140		4.5	0.0528
Cadmium	0.29	<10		<10	
Calcium	3.2	135	35.8	155	0.039
Chromium Total	<0.04	<15	<2.5	<15	
Chromium (Hex)	<0.02	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	<0.04	<20		950	
Iron	0.22	2,250		140	0.823
Lead	<0.03	2 △		2 △	
Lithium	4.0	15		10	
Magnesium	7.7	30		20	0.0039
Manganese	0.016	10.5		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	570	<500		<500	
Selenium	<1	<500		<500	
Silicon	9.1	100		100	
Silver	<0.01	<5		<5	
Sodium	19,000	9,000 △	22	200 △	3.500 △
Strontium	2.4	3		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	17		22	
Vanadium	<0.03	<15		<15	
Zinc	<0.08	<40		<40	
Anions					
Chloride	26,000				
Fluoride	6.5	5		<5	
Sulfate	11,000	5,000 △	<995	<500 △	1.754 △
Solids					
Total Dissolved Solids	57,000	38,000 △		20,000 △	

* Average of five (5) samples of second pretest Rinse. (IK Tube Nos.)

△ indicates change of data

Table 4.11

IK Tube Number: IK4 (Log #11-079-3)
Cooling Water Sample Number: W4 (Log #11-079-13)
Cooling Tower Name: Argus Cooling Tower (Argus Facility)

Date of Sampling: November 4, 1986
Duration: 5 minutes per point
Number of Points Sampled: 16

Chemical Analysis

Chemical Constituent	Recirculating Cooling Water (mg/L)	Redissolved IK Tube Residue (micrograms) (sample)	Pretest Blank* IK Tube Second (micrograms) (sample)	Procedural Blank (micrograms) (sample)	Mass Mineral Flux $\frac{mgm}{m^2 \cdot s}$
Metals					
Aluminum	<0.03	30		15	
Antimony	<0.4	<200		<200	
Arsenic	0.56	1.5	0.5	<1.5	
Barium	0.08	5		80	
Beryllium	<0.006	<3		<3	
Boron	53	210		4.5	0.090
Cadmium	<0.02	<10		<10	
Calcium	14	205	35.8	155	0.074
Chromium Total	11	25	<2.5	<15	
Chromium (Hex)	14	<10		<10	
Cobalt	<0.03	<15		<15	
Copper	<0.04	120		950	
Iron	<0.03	295		140	0.0680
Lead	<0.03	6 ⚠		2 ⚠	
Lithium	1.0	<10		10	
Magnesium	2.2	100		20	0.0351
Manganese	<0.003	2.5		2	
Mercury	<0.002	ND	<0.5	ND	
Molybdenum	<0.2	<100		<100	
Nickel	<0.06	<30		<30	
Potassium	65	<500		<500	
Selenium	<1	<500		<500	
Silicon	60	200		100	
Silver	<0.01	<5		<5	
Sodium	8,200	24,500 ⚠	22	200 ⚠	10.736 ⚠
Strontium	2.7	7.5		1.5	
Thallium	<0.4	<200		<200	
Tin	<0.6	<300		<300	
Titanium	<0.006	17		22	
Vanadium	0.20	<15		<15	
Zinc	<0.08	<40		<40	
Anions					
Chloride	12,000				
Fluoride	3.3	15		<5	
Sulfate	2,100	7,000 ⚠	<995	<500 ⚠	2.851 ⚠
Solids					
Total Dissolved Solids	22,000	90,000 ⚠		20,000 ⚠	

* Average of five (5) samples of second pretest Rinse. (IK Tube Nos.)

⚠ Indicates change of data

described by equation 4.3 can be used in quantifying individual emission rates for all ions of interest.

Table 4.2

Drift Fraction and Emissions

for Boron and Sulfate

Tower	Recirculating Flow Rate (GPM)	Concentration in mg/L		Drift △ Fraction (%)	Mass Emission △ lbs/hr	
		Boron	Sulfate		Boron	Sulfate
Borax Cooling Tower (South Cell)	3000	59	2700	0.0057	0.0053	0.231
#1 Sulfate Cooling Tower (South Cell)	3500	80	3400	0.0092	0.0129	0.548
#2 Sulfate Cooling Tower (North Cell)	3500	90	4400	0.0035	0.0055	0.270
#3 Sulfate Cooling Tower (South Cell)	3500	91	4700	0.0457	0.0789	3.765
#4 Sulfate Cooling Tower (South Cell)	9360	73	3300	0.0030	0.0103	0.464
Lime Cooling Tower	2950	33	1500	0.0011	0.00054	0.024
#11 Cooling Tower (North East Cell)	15000	1200	10000	0.0011	0.0992	0.826
#14 Cooling Tower (South Cell)	24000	270	11000	0.0024	0.0779	3.173
Argus Cooling Tower (#2)	30000	53	2100	0.0113	0.0900	3.565

4.2 Discussion of Results

The drift fraction calculations performed using equation 4.2 and the concentration of sodium in the cooling water samples revealed drift fractions between 0.0011 and 0.0457 percent of recirculating water flow rate.

The 0.0457 percent drift fraction for the #3 Sulfate Cooling Tower represents an unusually high rate of drift loss. This could have been caused by a physical gap between drift eliminator panels; however, no such gaps were visible to the test crew working at the exit plane of the fan stack. Another possible explanation for the high drift loss in this tower may be the very low air velocities measured. The average updraft air velocity in this tower measured 386 feet per minute at the fan stack exit plane. Updraft velocity at the location of the drift eliminators would be even lower, due to the larger cross-sectional area. This velocity may not impart enough momentum to the water droplets for high efficiency drift elimination to be realized. In this tower remedial action scenarios should also consider means of increasing air velocity at the location of the drift eliminators.

APPENDIX A

PRETEST INSTRUMENT CALIBRATIONS

Title: CALIBRATION OF WS/WD SENSORS

No. ESC-PI-PPP-11

Rev. 0

LABORATORY CALIBRATION RECORD

TIME: 3:50
TEMP.:
B.P.: 589.5

Wind Speed Sensor (Generator Type)

Test Sensor

Model GILL PROP 27106 S/N ESC #1

Standard A.T.D.L.

Model GILL 27106 S/N 5775

Blade 5775 A Calib. Date 12-5-85

Test Equipment

Item	Model	S/N	Date of Last Intercomparison
FLUKE D.V.M.	8022B	3500041	4-16-86

FAN R.P.M.	STANDARD		TEST SENSOR		
	Velocity M/S	Actual Vel.	Volts/ Velocity (Units)	Error	RANGE
92	START	0.69	.029		.000
222	2	2.02	.109		.001
379	4	4.01	.223		.001
543	6	6.01	.338		.001
708	8	8.00	.452		.002
873	10	9.99	.565		.002
1042	12	12.02	.680		.002
1208	14	14.00	.793		.003
1374	16	16.01	.907		.003
1455	18	17.41	.986		.004

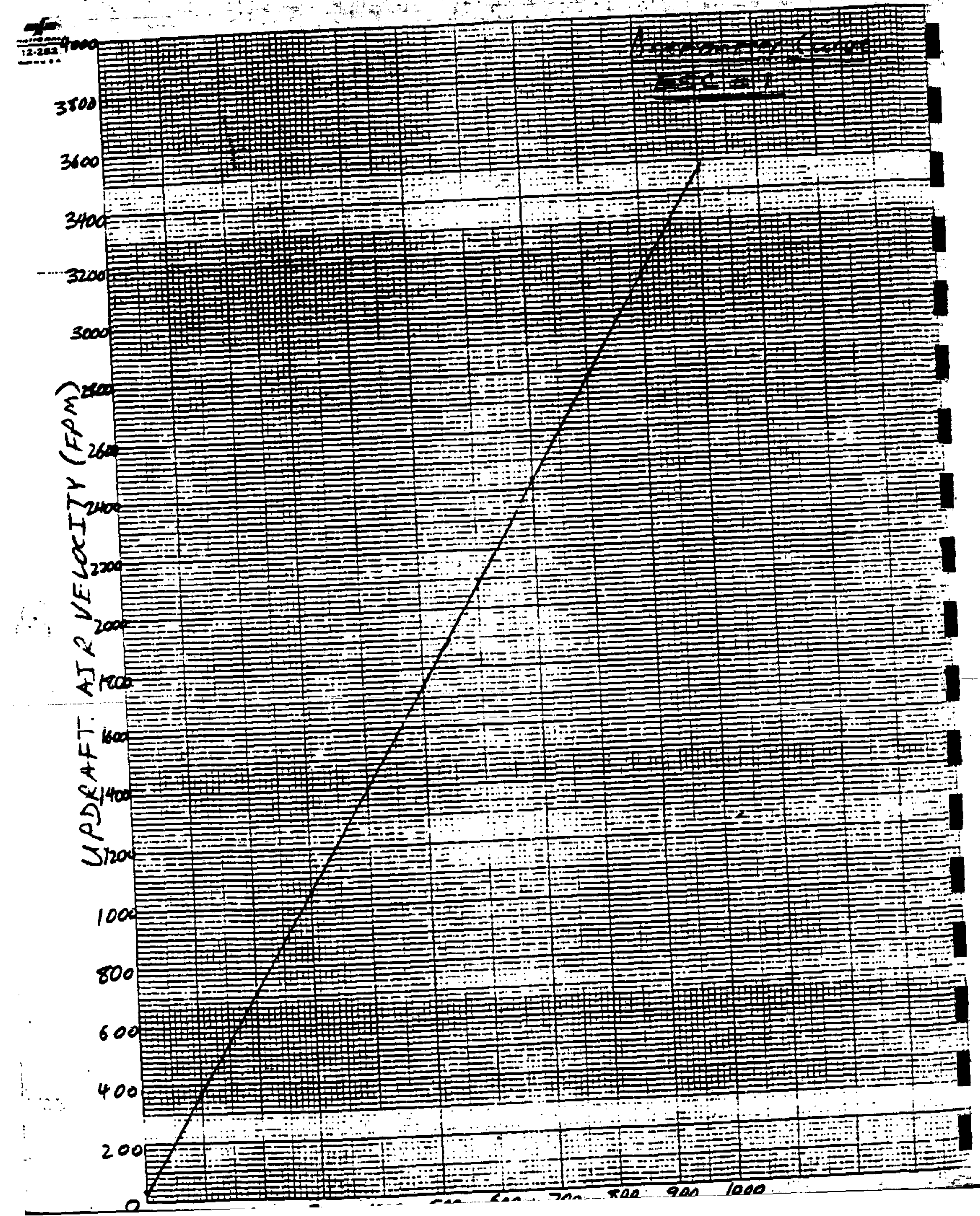
Performed by: Harry W. Smith Date: 10-28-86

Reviewed by: [illegible] Date: 10-28-86

ANEMOMETER CALIB. OF ESC #1 10-28-86

VEL(FPM)=3455.0*VOLTS+ 17.2

VOLTS	V(MPS)	V(FPM)	VPRED(FPM)	ERR(%)	CL(FPM)	CL(%)
0.109	2.02	398	394	0.970	3.860	0.980
0.223	4.01	789	788	0.220	3.199	0.406
0.338	6.01	1183	1185	-0.158	2.625	0.222
0.452	8.00	1575	1579	-0.254	2.219	0.141
0.565	9.99	1967	1969	-0.135	2.075	0.105
0.680	12.02	2366	2367	-0.015	2.243	0.095
0.793	14.00	2756	2757	-0.036	2.661	0.097
0.907	16.01	3152	3151	0.026	3.238	0.103
0.986	17.41	3427	3424	0.101	3.693	0.108



UPDRAFT AIR VELOCITY (FPM)
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
700
800
900
1000

ESC

PROJECT Kerr McGee Chemical Corp.
SUBJECT Vacuum System Flow Calibration

BY BRC DATE 10/29/86 PAGE 1 OF 3

	System Vacuum Reading** (in Hg)	PSI	Calibration (CM) Meter Reading (SCFH)	(CM) Corrected for Bar Press. *	System Meter Reading **
	24.4	-11.98	100	100	195
	23.9	-11.74	150	150	275
	23.4	-11.49	200	200	355
	22.5	-11.05	250	249	445
1 system Rotometer in service ↑	21.6	-10.61	300	298	530
	20.9	-10.27	350	347	615
	20.0	-9.82	400	396	725
	19.6	-9.63	430	425	765
	19.6	-9.63	430	425	780
					Σ of 2 ↓
↓ 2 system Rotometers in service	19.7	-9.68	440	435	775
	18.9	-9.28	495	490	885
	17.4	-8.55	605	598	1095
	16.1	-7.91	700	685	1320
	15.3	-7.51	760	745	1475
	14.9	-7.32	810	795	1625

* From DWYER CONVERSION curves FOR Gases
* Bar. Pressure on Calibration Meter 29.33 in Hg at 69.5 °F
or -.295 PsiG

1.0 PSI = 2.036 in Hg

Average I.k tube Inside Diameter = .968 inches

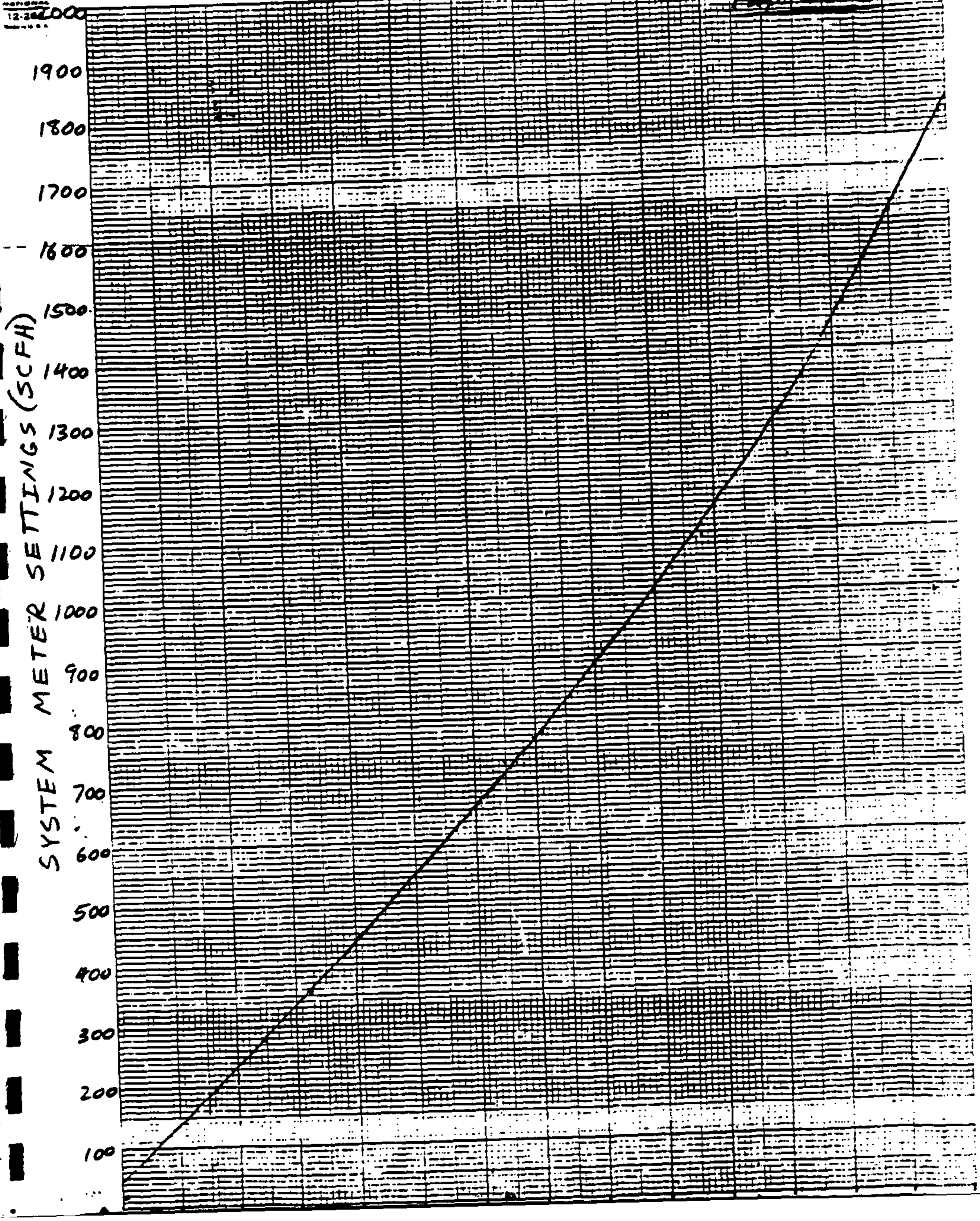
Curve Plot Coordinates

System Meter Readings SCFH	Actual Flow SCFM	Updraft Velocity (FPM)
195	1.667	326.9
275	2.500	490.2
355	3.333	653.5
445	4.150	813.7
530	4.967	973.9
615	5.783	1133.9
725	6.600	1294.1
765	7.083	1388.8
775	7.250	1421.6
885	8.167	1601.4
1095	9.967	1954.3
1320	11.417	2238.6
1475	12.417	2434.7
1625	13.250	2598.0

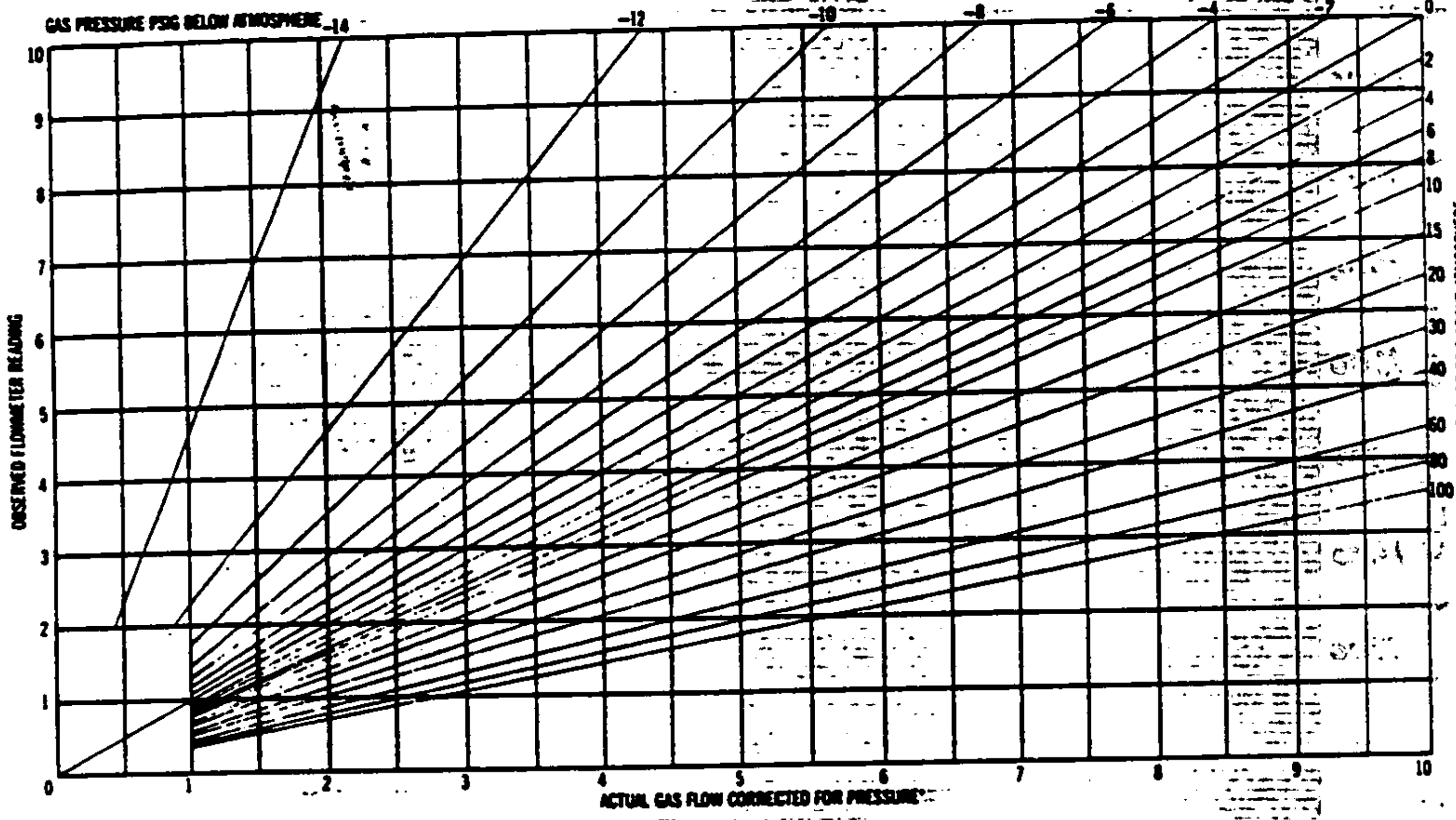
$$A = \frac{\pi D^2}{4} = \frac{(3.1416)(0.0065)}{4} = 0.0051 \text{ ft}^2$$

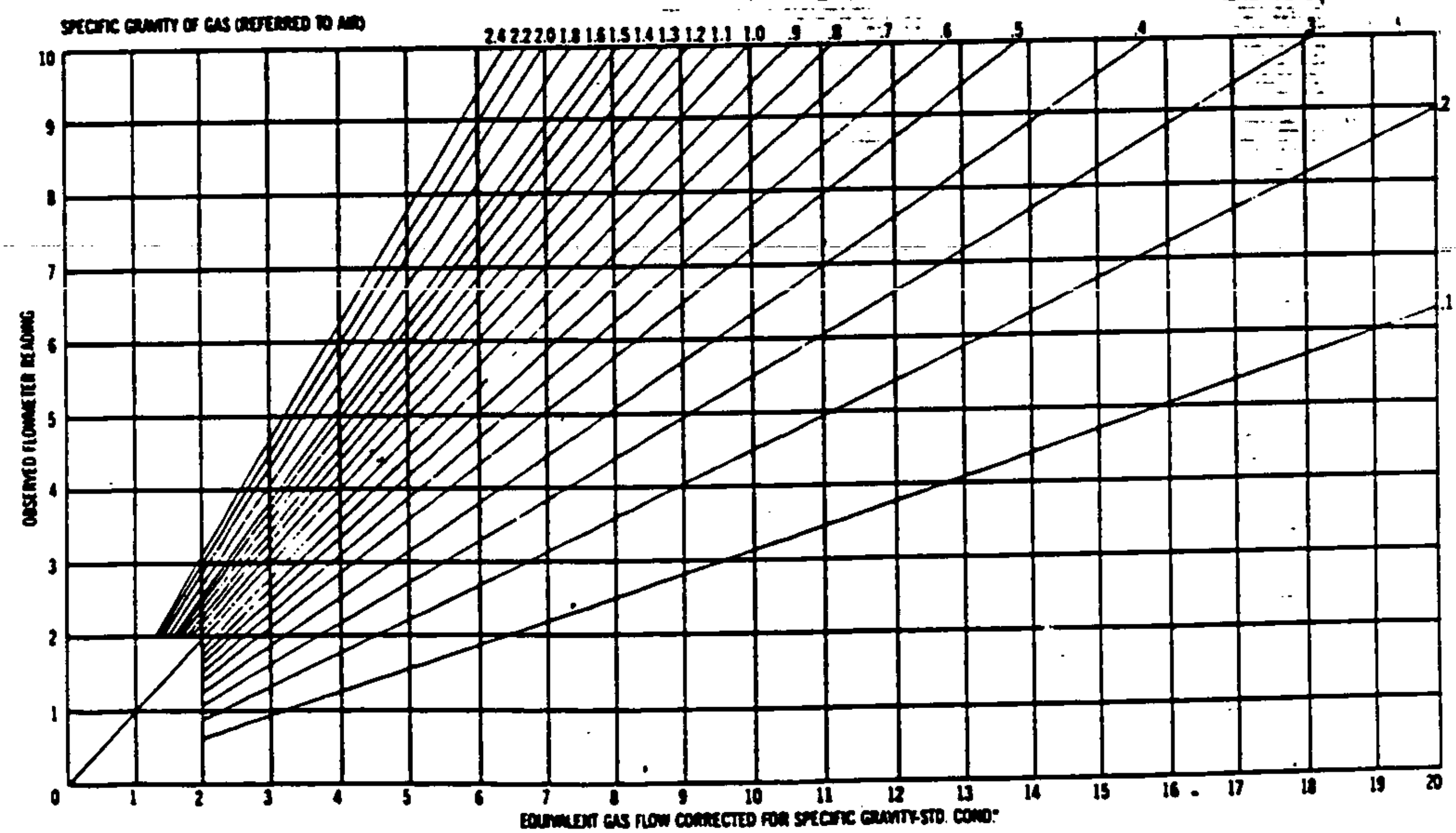
$$Q = VA, \quad V = \frac{Q}{A}, \quad V_{(FPM)} = \frac{Q_{SCFM}}{0.0051}$$

VACUUM SYSTEM FLO
CALIBRATION 10/29/8[illegible]
Page 3 of 3



CONVERSION CURVES FOR GASES





If more convenient, approximate correction factors may be determined using the following formulas.

A. Pressure: $Q_2 = Q_1 \times \sqrt{\frac{P_2}{P_1}}$

where Q_1 = Observed flowmeter reading
Q_2 = Actual flow corrected for pressure
P_1 = Standard atmospheric pressure, 14.7 PSI
P_2 = Actual pressure, 14.7 PSI + pressure in PSI inside flowmeter. Measured at outlet on all but TMV units. Inlet pressure on TMV models.

where Q_1 = Observed flowmeter reading
Q_2 = Actual flow corrected for specific gravity
1 = Specific gravity of air
S.G. = Specific gravity of gas being used in flowmeter originally calibrated for air.

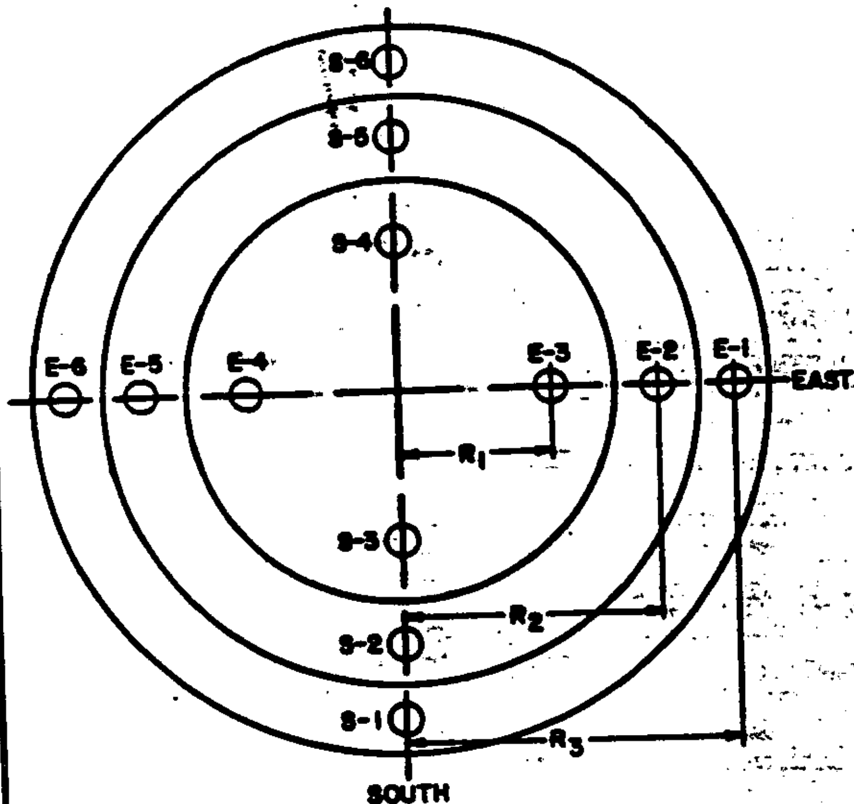
NOTE: The corrections shown in the curves and in the formulas are for variations in specific gravity and internal pressure* only. Further correction may be necessary for variations in viscosity and changes in type of flow from laminar to turbulent or vice versa. This is particularly true in the case of extremely low flows of the lighter gases. Nevertheless these charts and

APPENDIX B

ON-SITE CALCULATIONS AND DATA LOGS

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES

Vestend Boray Cooling Tower



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

ID = 170.25 inches

POINT NO.	Number of Areas 2	3	4	5		6
1	6.2	4.4	3.23	2.2	3.75 in.	2.0
2	25.0	14.7	10.47	8.2	13.96 in.	6.7
3	75.0	29.4	19.38	14.5	24.69 in.	11.8
4	93.8	70.6	32.32	22.7	38.65 in.	17.7
5		85.3	67.68	34.4	58.57 in.	25.0
6		95.6	80.62	65.6	111.68 in.	35.4
7			89.53	77.3	131.60 in.	64.6
8			96.77	85.5	145.56 in.	75.0
9				91.8	156.29 in.	82.3
10				97.8	166.50 in.	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corporation
LOCATION/SITE Westend
TOWER Borax Cooling Tower
DATE 10/31/86
TEST ENGR. BR Crocker / Brian Margetts

Ik tube
#6
5 minutes per point

TEST Traverse A START 10:45 PST STOP L/G

TEST Traverse B START STOP L/G

WATER LOADING
EXIT DRY BULB
EXIT WET BULB
SPECIFIC VOLUME

WATER LOADING
EXIT DRY BULB
EXIT WET BULB
SPECIFIC VOLUME

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. m(VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	Rotameter SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~	MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. m(VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	Rotameter SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	10:45	224.5	800	SCFH 435	1	11:55	66.6	250	165
2		261.5	925	510	2		221	800	435
3		265	925	510	3		355	1230	730
4		297	1050	580	4		377	1325	750
5		—	—	—	5		—	—	—
6		—	—	—	6		—	—	—
7		270	940	530	7		258	910	500
8		413	1440	795	8		353	1230	730
9		355	1230	730	9		258	910	500
10	11:45	296	1050	580	10	12:45	154	555	325

AVERAGE VELOCITY (VOLTS)
AVERAGE VELOCITY (FT./MIN.)
AVERAGE VELOCITY (M./SEC.)
AMBIENT DRY BULB
AMBIENT WET BULB

AVERAGE VELOCITY (VOLTS)
AVERAGE VELOCITY (FT./MIN.)
AVERAGE VELOCITY (M./SEC.)
AMBIENT DRY BULB
AMBIENT WET BULB

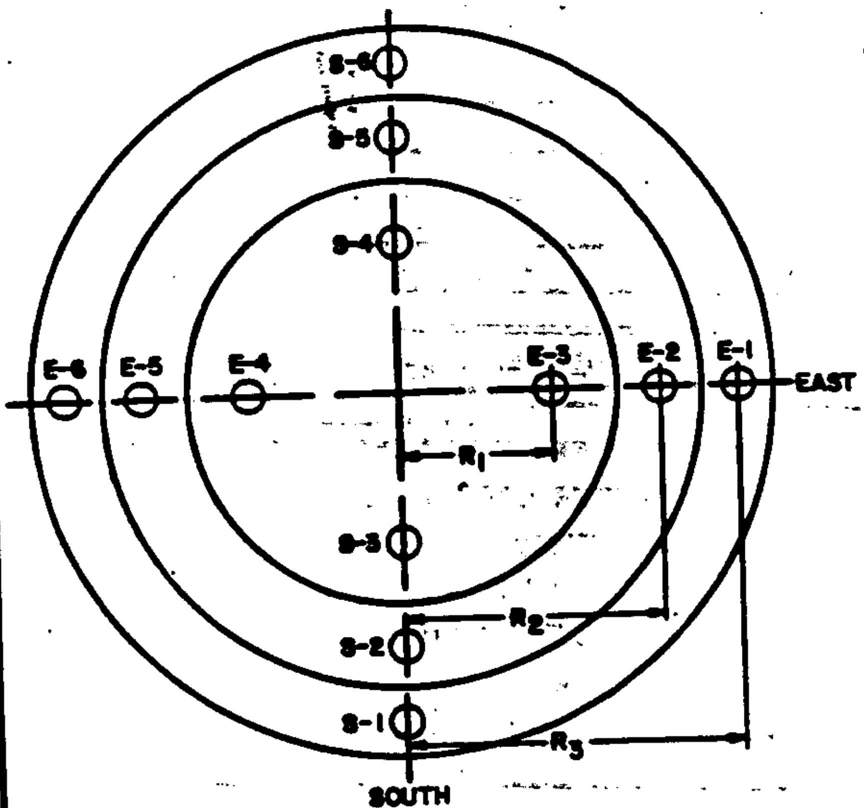
ID of Fan Shroud 170-1/4"

* Distance from near edge to meas. pt.

ESC ENVIRONMENTAL SYSTEMS CORPORATION
200 TECH CENTER DRIVE
KNOXVILLE, TENNESSEE 37912

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES

Westend
#1 Sulfate Cooling Tower



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

ID 181.5 inches

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

POINT NO.	Number of Areas: 2	3	4	5		6
1	6.2	4.4	3.23	2.2	3.99	2.0
2	25.0	14.7	10.47	8.2	14.88	6.7
3	75.0	29.4	19.38	14.5	26.32	11.8
4	93.8	70.6	32.32	22.7	41.20	17.7
5		85.3	67.68	34.4	62.44	25.0
6		95.6	80.62	65.6	119.06	35.4
7			89.53	77.3	140.30	64.6
8			96.77	85.5	155.18	75.0
9				91.8	166.62	82.3
10				97.8	177.51	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corp.
LOCATION/SITE Westend Facility
TOWER #1 Sulfate Cooling Tower (South) I k Tube #11
DATE 10/31/86
TEST ENGR. Ben Crocker / Brian Margetts 5mins/point

Traverse TEST A	START	STOP	L/G

WATER LOADING
EXIT DRY BULB
EXIT WET BULB
SPECIFIC VOLUME

Traverse TEST B	START	STOP	L/G

WATER LOADING
EXIT DRY BULB
EXIT WET BULB
SPECIFIC VOLUME

Test A

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	18:42	305	1065	580
2		394	1380	760
3		474	1655	920
4		212	795	410
5		—	—	—
6		—	—	—
7		205	715	395
8		501	1735	970
9		441	1540	865
10	19:38	284	1000	545

Test B

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	UPDRAFT AIR VEL. (M./SEC.)
1	17:35	227	800	440
2		296	1060	575
3		438	1525	840
4		250	880	480
5		—	—	—
6		—	—	—
7		416	1450	795
8		539	1875	1065
9		304	1065	580
10	18:30	107	390	230

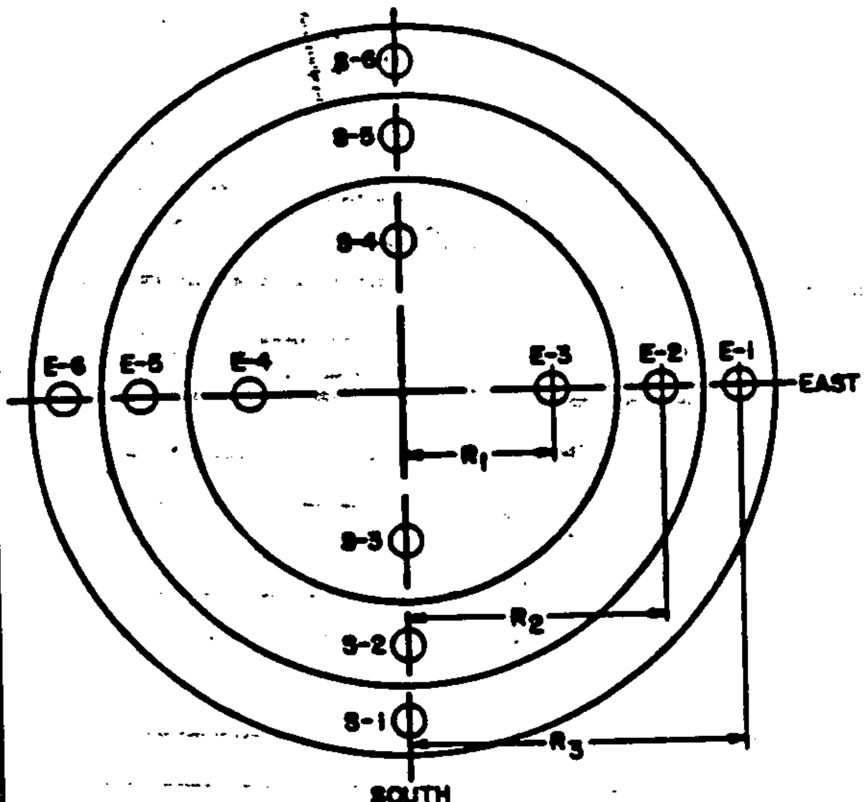
AVERAGE VELOCITY (VOLTS)
AVERAGE VELOCITY (FT./MIN.)
AVERAGE VELOCITY (M./SEC.)
AMBIENT DRY BULB
AMBIENT WET BULB

AVERAGE VELOCITY (VOLTS)
AVERAGE VELOCITY (FT./MIN.)
AVERAGE VELOCITY (M./SEC.)
AMBIENT DRY BULB
AMBIENT WET BULB

ESC ENVIRONMENTAL SYSTEMS CORPORATION
200 TECH CENTER DRIVE
KNOXVILLE, TENNESSEE 37912

FIG. 2. TRAVERSE POSITIONS IN ROUND FLUES

Vestend Facility #2 Sulfate CT



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \cdot \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

ID 181.75 in.

% of flue diameter from circumference to test point

5 min per point

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	4.00	2.0
2	25.0	14.7	10.47	8.2	14.90	6.7
3	75.0	29.4	19.38	14.5	26.35	11.8
4	93.8	70.6	32.32	22.7	41.26	17.7
5		85.3	67.68	34.4	62.52	25.0
6		95.6	80.62	65.6	119.23	35.4
7			89.53	77.3	140.49	64.6
8			96.77	85.5	155.40	75.0
9				91.8	166.85	82.3
10				97.8	177.75	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER: Kerr McGee Chemical Corp.

LOCATION/SITE: Westend Facility — IK Tube #2

TOWER: #2 Sulfate Cooling Tower — 5 min./point

DATE: 11/1/86

TEST ENGR.: Ben Crocker / Brian Margetts

Traverse TEST A	START ____ STOP ____	L/G ____	Traverse TEST B	START ____ STOP ____	L/G ____

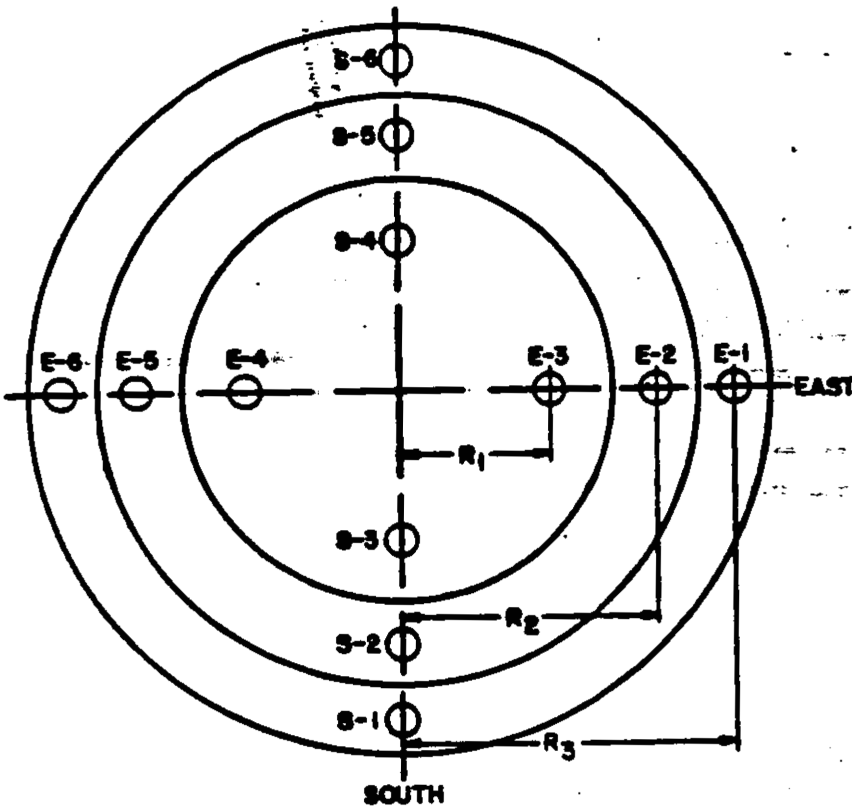
WATER LOADING ____	WATER LOADING ____
EXIT DRY BULB ____	EXIT DRY BULB ____
EXIT WET BULB ____	EXIT WET BULB ____
SPECIFIC VOLUME ____	SPECIFIC VOLUME ____

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~	MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	08:55	76	280	175	10:07	1	—	—	—
2		140	500	280		2	—	—	—
3		420	1440	790		3	375	1310	715
4		365	1270	695		4	490	1710	950
5		54	205	140		5	180	620	355
6		—	—	—		6	—	—	—
7		334	1165	635		7	57	215	145
8		514	1785	1000		8	480	1670	935
9		511	1770	990		9	375	1305	710
10	09:00	300	1050	575		10	230	810	445

AVERAGE VELOCITY (VOLTS) ____	AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____	AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____	AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____	AMBIENT DRY BULB ____
AMBIENT WET BULB ____	AMBIENT WET BULB ____

* STRONG WINDS FROM NE 15-25 MPH

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

westend #3 Sulfate CT

ID. 181.75 in.

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	4.00	2.0
2	25.0	14.7	10.47	8.2	14.90	6.7
3	75.0	29.4	19.38	14.5	26.35	11.8
4	93.8	70.6	32.32	22.7	41.26	17.7
5		85.3	67.68	34.4	62.52	25.0
6		95.6	80.62	65.6	119.23	35.4
7			89.53	77.3	140.49	64.6
8			96.77	85.5	155.40	75.0
9				91.8	166.85	82.3
10				97.8	177.75	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corporation
LOCATION/SITE Westend Facility
TOWER #3 Sulfate Cooling Tower
DATE 11/1/86
TEST ENGR. Ben Crocker/Brian Margetts

Intake #1

TEST Traverse A START ___ STOP ___ L/G ___

WATER LOADING ___
EXIT DRY BULB ___
EXIT WET BULB ___
SPECIFIC VOLUME ___ System SCFH

TEST Traverse B START ___ STOP ___ L/G ___

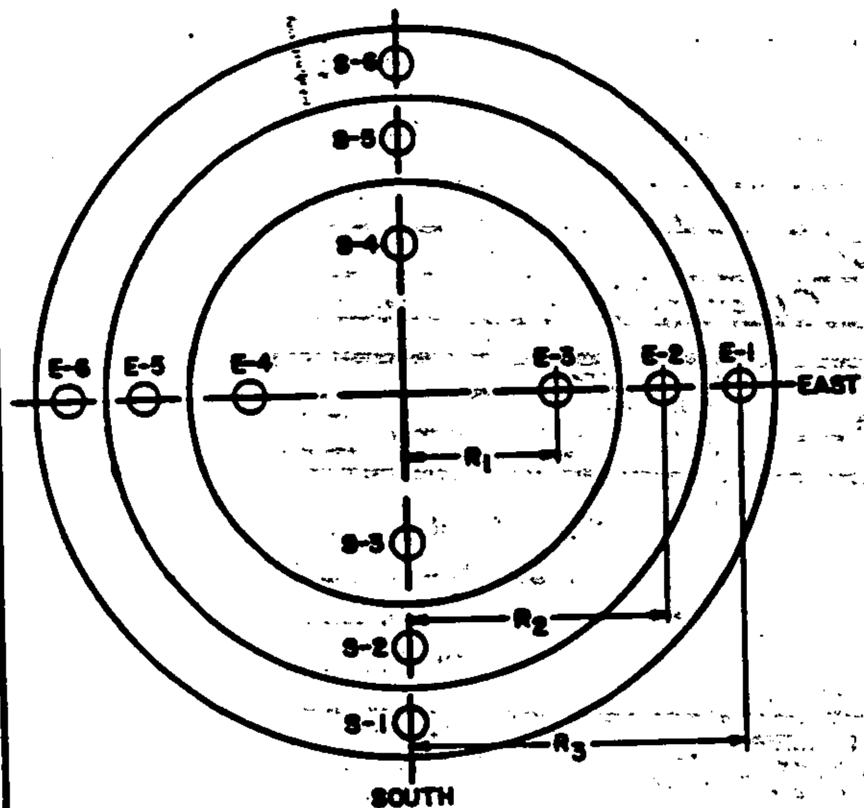
WATER LOADING ___
EXIT DRY BULB ___
EXIT WET BULB ___
SPECIFIC VOLUME ___ SCFH

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~	MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~
1	11:50	125	460	265	1	12:55	125	460	265
2		121	440	255	2		119.5	400	240
3		125	460	265	3		235	820	445
4		115	410	235	4		262	915	505
5		—	—	—	5		—	—	—
6		87	325	195	6		75	275	175
7		170	605	335	7		275	965	525
8		78	300	185	8		154	555	315
9		—	—	—	9		55	215	145
10	12:40	30	120	100	10	13:45	—	—	—

AVERAGE VELOCITY (VOLTS) ___
AVERAGE VELOCITY (FT./MIN.) ___
AVERAGE VELOCITY (M./SEC.) ___
AMBIENT DRY BULB ___
AMBIENT WET BULB ___

AVERAGE VELOCITY (VOLTS) ___
AVERAGE VELOCITY (FT./MIN.) ___
AVERAGE VELOCITY (M./SEC.) ___
AMBIENT DRY BULB ___
AMBIENT WET BULB ___

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES Westerd Facility Lime Cooling Tower



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d\sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

ID= 183.0 in.

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	4.03	2.0
2	25.0	14.7	10.47	8.2	15.01	6.7
3	75.0	29.4	19.38	14.5	26.54	11.8
4	93.8	70.6	32.32	22.7	41.54	17.7
5		85.3	67.68	34.4	62.95	25.0
6		95.6	80.62	65.6	120.05	35.4
7			89.53	77.3	141.46	64.6
8			96.77	85.5	156.47	75.0
9				91.8	167.99	82.3
10				97.8	178.97	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corp. — Ik Tube #5
LOCATION/SITE Western Facility — 10 mins/point
TOWER Lime Cooling Tower
DATE 11/2/86
TEST ENGR. Ben Crocker / Brian Margetts

TEST Traverse A	START	STOP	L/G

TEST Traverse B	START	STOP	L/G

Test A

WATER LOADING ______
EXIT DRY BULB ______
EXIT WET BULB ______
SPECIFIC VOLUME ______

Test B

WATER LOADING ______
EXIT DRY BULB ______
EXIT WET BULB ______
SPECIFIC VOLUME ______

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~ SCFH	MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~ SCFH
1	10:05	320	1120	610	1	11:58	—	—	—
2		432	1500	830	2		215	760	415
3		529	1840	1035	3		365	1275	695
4		528	1840	1035	4		441	1540	855
5		223	790	435	5		167	600	335
6		—	—	—	6		168	600	335
7		304	1065	580	7		488	1700	945
8		448	1565	865	8		340	1200	655
9		.488	1700	945	9		237	825	450
10	11:48	230	815	445	10	13:34	208	730	400

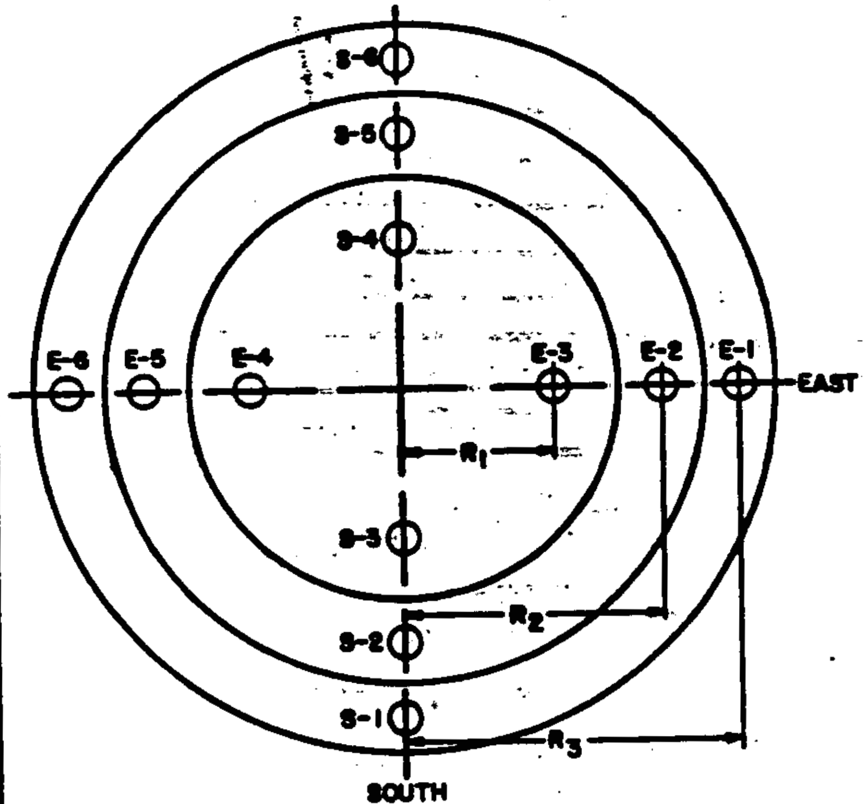
Test A

AVERAGE VELOCITY (VOLTS) ______
AVERAGE VELOCITY (FT./MIN.) ______
AVERAGE VELOCITY (M./SEC.) ______
AMBIENT DRY BULB ______
AMBIENT WET BULB ______

Test B

AVERAGE VELOCITY (VOLTS) ______
AVERAGE VELOCITY (FT./MIN.) ______
AVERAGE VELOCITY (M./SEC.) ______
AMBIENT DRY BULB ______
AMBIENT WET BULB ______

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

westend
#4 Sulfate CT

EQUAL AREA ZONES FOR VELOCITY TRAVERSE. D= 254.0 in.

% of flue diameter from circumference to test point

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	5.59	2.0
2	25.0	14.7	10.47	8.2	20.83	6.7
3	75.0	29.4	19.38	14.5	36.83	11.8
4	93.8	70.6	32.32	22.7	57.66	17.7
5		85.3	67.68	34.4	87.38	25.0
6		95.6	80.62	65.6	166.62	35.4
7			89.53	77.3	196.34	64.6
8			96.77	85.5	217.17	75.0
9				91.8	233.17	82.3
10				97.8	248.41	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corporation
LOCATION/SITE Searles Drylake / westend IR tube#9
TOWER #4 Sulfate Cooling Tower 5 mins/point
DATE 11/2/86
TEST ENGR. Ben Crocker / Brian Margetts

TEST A Traverse START ______ STOP ______ L/G ______

WATER LOADING ______
EXIT DRY BULB ______
EXIT WET BULB ______
SPECIFIC VOLUME ______

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	16:28	120	440	250
2		250	885	485
3		200	710	395
4		—	—	—
5				
6				
7		175	620	350
8		201	710	395
9		223	780	425
10	17:05	150	550	310

AVERAGE VELOCITY (VOLTS) ______
AVERAGE VELOCITY (FT./MIN.) ______
AVERAGE VELOCITY (M./SEC.) ______
AMBIENT DRY BULB ______
AMBIENT WET BULB ______

TEST B Traverse START ______ STOP ______ L/G ______

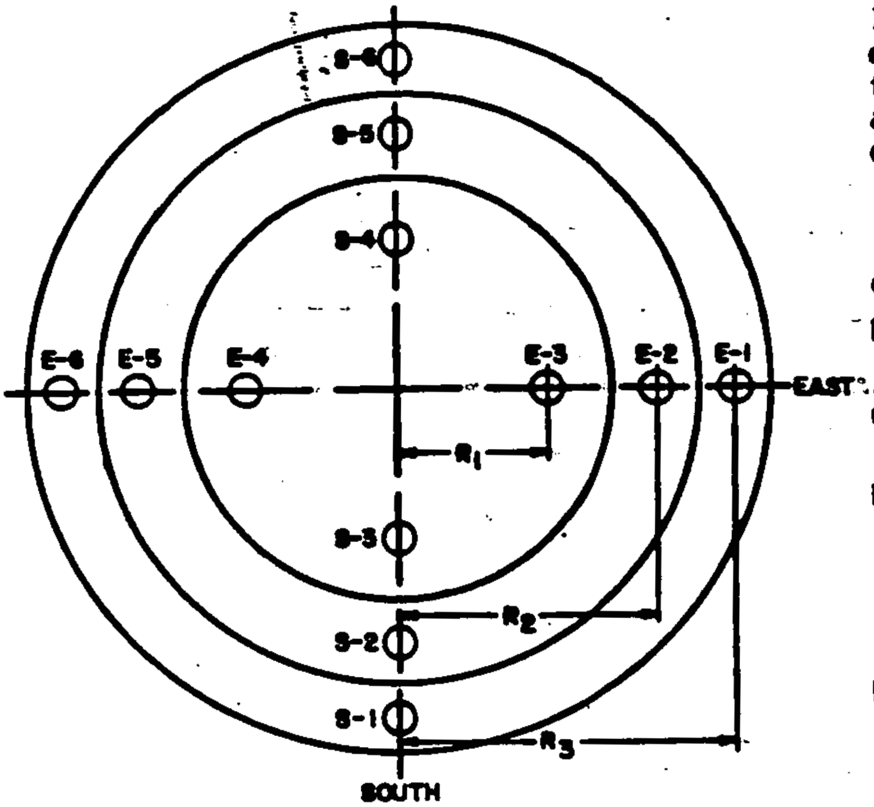
WATER LOADING ______
EXIT DRY BULB ______
EXIT WET BULB ______
SPECIFIC VOLUME ______

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	17:20	114	410	235
2		251	885	485
3		225	780	425
4		251	885	485
5		—	—	—
6		—	—	—
7		187	665	370
8		204	715	395
9		220	775	425
10	18:10	102	370	225

AVERAGE VELOCITY (VOLTS) ______
AVERAGE VELOCITY (FT./MIN.) ______
AVERAGE VELOCITY (M./SEC.) ______
AMBIENT DRY BULB ______
AMBIENT WET BULB ______

ESC ENVIRONMENTAL SYSTEMS CORPORATION
200 TECH CENTER DRIVE
KNOXVILLE, TENNESSEE 37912

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

Trona Facility
#11 Cooling Tower

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

I.D. 200.0 inches

	Number of Areas					
POINT NO.	2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	4.40	2.0
2	25.0	14.7	10.47	8.2	16.40	6.7
3	75.0	29.4	19.38	14.5	29.00	11.8
4	93.8	70.6	32.32	22.7	45.40	17.7
5		85.3	67.68	34.4	68.80	25.0
6		95.6	80.62	65.6	131.20	35.4
7			89.53	77.3	154.60	64.6
8			96.77	85.5	171.00	75.0
9				91.8	183.60	82.3
10				97.8	195.60	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee Chemical Corporation IK Tube #8
LOCATION/SITE Trona Facility 5 mins/pt.
TOWER #11 Cooling Tower
DATE 11/3/86
TEST ENGR. Ben Crocker / Brian Margetts

TEST A (Traverse) START ____ STOP ____ L/G ____

WATER LOADING ____
EXIT DRY BULB ____
EXIT WET BULB ____
SPECIFIC VOLUME ____

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~ SCFH
1	11:22	303	1065	575
2	↓	580	2020	1160
3		660	2280	1345
4		681	2355	1405
5		—	—	—
6		—	—	—
7		540	1880	1065
8		704	2425	1470
9		545	1890	1070
10	12:11	233	825	450

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

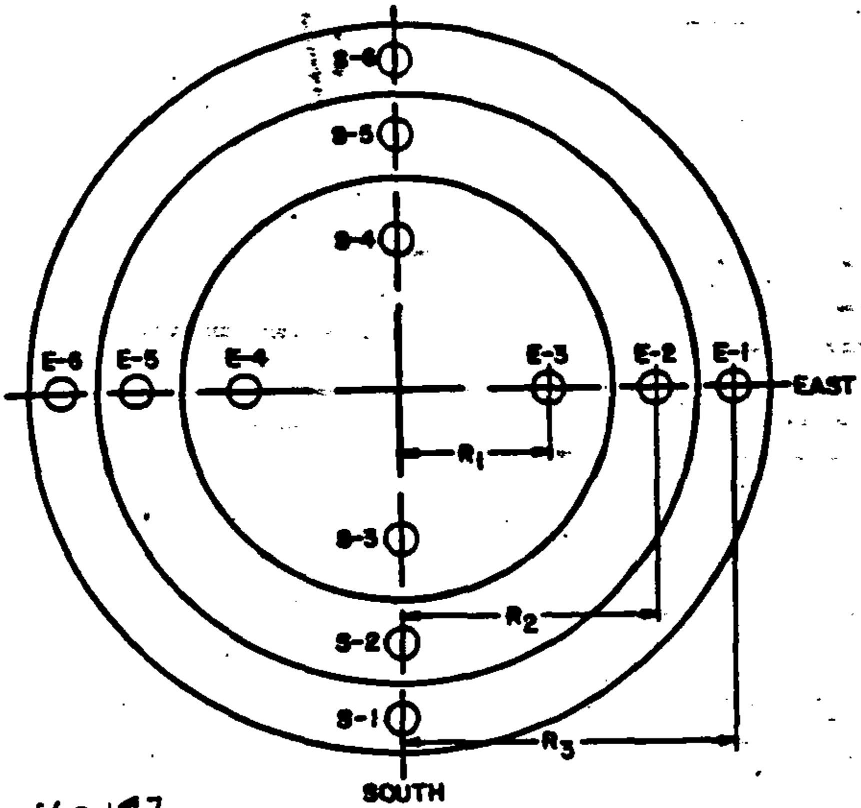
TEST B (Traverse) START ____ STOP ____ L/G ____

WATER LOADING ____
EXIT DRY BULB ____
EXIT WET BULB ____
SPECIFIC VOLUME ____

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	~~UPDRAFT AIR VEL. (M./SEC.)~~ SCFH
1	12:21	375	1320	720
2	↓	526	1815	1020
3		677	2350	1400
4		604	2095	1210
5		—	—	—
6		—	—	—
7		581	2020	1160
8		607	2105	1210
9		574	1970	1120
10	13:10	572	1970	1120

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d\sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

X 2197

ID 309 inches

EQUAL AREA ZONES FOR VELOCITY TRAVERSE #14 Cooling Tower

% of flue diameter from circumference to test point

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	6.80	2.0
2	25.0	14.7	10.47	8.2	25.34	6.7
3	75.0	29.4	19.38	14.5	44.81	11.8
4	93.8	70.6	32.32	22.7	70.14	17.7
5		85.3	67.68	34.4	106.30	25.0
6		95.6	80.62	65.6	202.70	35.4
7			89.53	77.3	238.86	64.6
8			96.77	85.5	265.12	75.0
9				91.8	283.66	82.3
10				97.8	302.20	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER: KERR McGEE #7 IK Tube
LOCATION/SITE: TRONA / TRONA 5 min/pt.
TOWER: #14 CELL #~~13~~
DATE: 11-3-86
TEST ENGR. BEN CROCKER / BRIAN MARGETTS

TEST ____ START ____ STOP ____ L/G ____

WATER LOADING ____
EXIT DRY BULB ____
EXIT WET BULB ____
SPECIFIC VOLUME ____

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	1637	225	800	440
2		340	1200	655
3		557	1930	1100
4		350	1220	670
5*		—	—	—
6		200	720	400
7		605	2100	1210
8		483	1660	920
9		246	855	470
10	1734	230	810	445

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

TEST ____ START ____ STOP ____ L/G ____

WATER LOADING ____
EXIT DRY BULB ____
EXIT WET BULB ____
SPECIFIC VOLUME ____

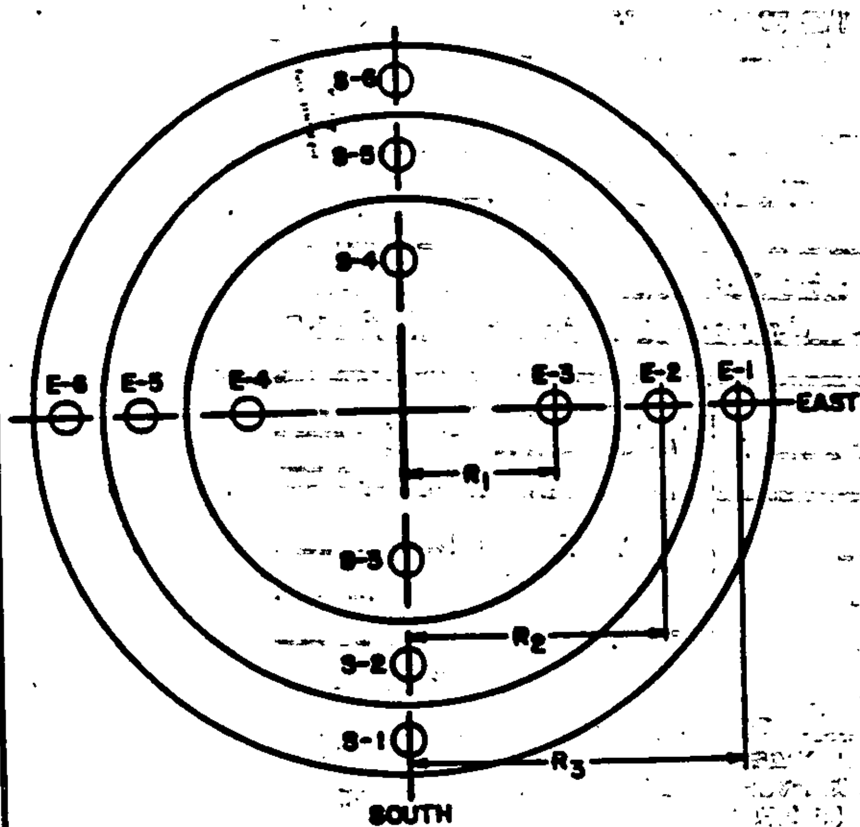
MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	SCFH ~~UPDRAFT AIR VEL. (M./SEC.)~~
1	1800	369	1225	670
2		634	2180	1270
3		680	2360	1410
4		607	2100	1210
5		150	535	300
6		—	—	—
7		449	1560	860
8		625	2175	1200
9		580	2020	1160
10	1657	340	1180	645

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

* NEGATIVE VELOCITY

ESC ENVIRONMENTAL SYSTEMS CORPORATION 200 TECH CENTER DRIVE KNOXVILLE, TENNESSEE 37912

FIG. 2 TRAVERSE POSITIONS IN ROUND FLUES



If the table below does not have enough points, the distance R from the center of the flue to any given test point, n, is calculated by the formula

$$R = d \sqrt{\frac{2n-1}{4N}}$$

d = diameter of flue

N = number of readings across a diameter

n = the n'th point from the center

R = Distance from center of flue to n'th test point, numbered from the center consecutively. In the diagram, n=1 for E-3, E-4, S-3, and S-4

Note: Using compass points to designate stations helps to orient the test locations.

Argus Facility ID 284 inches

EQUAL AREA ZONES FOR VELOCITY TRAVERSE

% of flue diameter from circumference to test point

Argus CT

POINT NO.	Number of Areas 2	3	4	5	inches	6
1	6.2	4.4	3.23	2.2	6.25	2.0
2	25.0	14.7	10.47	8.2	23.29	6.7
3	75.0	29.4	19.38	14.5	41.18	11.8
4	93.8	70.6	32.32	22.7	64.47	17.7
5		85.3	67.68	34.4	97.70	25.0
6		95.6	80.62	65.6	186.30	35.4
7			89.53	77.3	219.53	64.6
8			96.77	85.5	242.82	75.0
9				91.8	260.71	82.3
10				97.8	277.75	88.2
11						93.3
12						98.0

DRIFT MEASUREMENT DATA SHEET

CUSTOMER Kerr McGee

LOCATION/SITE Argus Facility / Trona, CA. IK #9

TOWER Argus Center Cell 5 min/point

DATE 11-4-86

TEST ENGR. Ben Crocker / Brian Margetts

TEST ____ START ____ STOP ____ L/G ____	TEST ____ START ____ STOP ____ L/G ____
WATER LOADING ____ EXIT DRY BULB ____ EXIT WET BULB ____ SPECIFIC VOLUME ____	WATER LOADING ____ EXIT DRY BULB ____ EXIT WET BULB ____ SPECIFIC VOLUME ____

MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	UPDRAFT AIR VEL. (M./SEC.)	MEAS. POS.	SAMPLE TIME	UPDRAFT AIR VEL. (VOLTS)	UPDRAFT AIR VEL. (FT./MIN.)	UPDRAFT AIR VEL. (M./SEC.)
1	1101	268	925	510	1	1210	500	1740	970
2		510	1760	980	2		565	1925	1110
3		620	2150	1250	3		630	2180	1270
4		600	2090	1205	4		599	2070	1205
5*		—	—	—	5*		—	—	—
6*		—	—	—	6*		—	—	—
7		530	1880	1065	7		602	2090	1205
8		655	2265	1340	8		640	2220	1300
9		580	2020	1130	9		605	2100	1210
10	1155	410	1430	780	10	1258	505	1760	990

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

AVERAGE VELOCITY (VOLTS) ____
AVERAGE VELOCITY (FT./MIN.) ____
AVERAGE VELOCITY (M./SEC.) ____
AMBIENT DRY BULB ____
AMBIENT WET BULB ____

* Negative airflow

ESC ENVIRONMENTAL SYSTEMS CORPORATION 200 TECH CENTER DRIVE KNOXVILLE, TENNESSEE 37912

APPENDIX C

LABORATORY ANALYSES

H. WASHING PROCEDURE

1. The tubes will be brought to the analytical laboratory with thin plastic sheet covers on both ends held in place by rubber bands. The plastic covers are removed and the tubes are inspected for visible irregularities (such as cracks or collection of insects or foreign debris). A cleaned polyethylene stopper is inserted in the inlet end of the tube and the external portion of the tube near the inlet end is washed off with distilled water using a squirt bottle. The tubes are then allowed to dry.

2. Next, the stopper is removed and approximately 15 ml of 10% HCl by volume aqueous wash solution (which is hot to the touch) is poured from the back side of the tube such that the wash solution falls out of the inlet end of the tube into a clean beaker. During the pouring the tube is rotated by hand to allow the solution to come into contact with all of the internal surfaces. This wash procedure is repeated twice more, each time with the same 15 ml of wash solution.

3. The properly collected volume of approximately 15 ml is then transferred to a volumetric flask. The IK tube is then rinsed with ~ 15 ml of distilled water using the same procedure and beakers as for the acid wash. This 15 ml is added to the 15 ml of acid solution already in the volumetric flask. The rinse process is repeated with still another 15 ml of distilled water.

4. The approximately 45 ml is then brought to the standard 50 ml volume. The 50 ml volumes now containing the minerals are analyzed by standard analysis techniques.

(p 1 of 2)

BC Log Number 86-11-079

CHAIN OF CUSTODY RECORD

Client name: Environmental Systems Corp.

Job number:

Project name: Drift analysis

Project manager: Ben Crocker

Sampler(s):

Analyses required: F | Cr(VI) | TDS | SO4 | 31 metals-see list | Hazardous sample | Special handling required

Sample number	Date sampled	Time sampled	Type Composite or Grab	Sample description	Number of containers	F	Cr(VI)	TDS	SO4	31 metals-see list			Hazardous sample / Special handling required	Remarks
IK-6	10-31		IK	Glass beads-particulates	1									One-week Rush
IK-5	11-2				1									
IK-8	11-3				1									
IK-4	11-4				1									
IK-7	11-3				1									
IK-9	11-2				1									
IK-1	11-1				1									
IK-2	11-1				1									
IK-11	10-31				1									
IK-10	10-31				1									Procedural blank

	Signature	Company	Date	Time
Relinquished by	Benjamin K. Crocker		11-5-86	
Received by	Cathy B. Shaliger		11-5-86	
Relinquished by				
Received by				
Relinquished by				
Received by				

BROWN AND CALDWELL Analytical Laboratories
1255 Powell Street, Emeryville, CA 94608 (415) 428-2300

Note: Samples are discarded 30 days after results are reported [redacted]ss c[redacted]rrang[redacted]s are[redacted]. Hazardous samples will be returned to client or disposed [redacted] (n 2 of 2) [redacted] Log [redacted] P86-11-079

CHAIN OF CUSTODY RECORD

...nt name: Environmental Systems Corp.	Job number:
...ject name: Drift analysis	
...ject manager: Ben Crocker	Sampler(s):

...mple ...mber	Date sampled	Time sampled	Type Composite or Grab	Sample description	Number of containers	F	Cr(VI)	Cl	TDS	SO4	31 metals-see list	Hazardous sample	Special handling required	Remarks
...-6	10-31			Aqueous	1									One-week Rush
...-5	11-2				1									
...-8	11-3				1									
...-4	11-4				1									
...-7	11-3				1									
...-9	11-2.				1									
...-1	11-1				1									
...-2	11-1				1									
...-11	10-31				1									
[redacted]														

	Signature	Company	Date	Time
...elinquished by	X Benjamin A. Crocker			
...eceived by	Jerry L. Schaleger			
...elinquished by				
...eceived by				
...elinquished by				
...eceived by				

...ROWN AND CALDWELL Analytical Laboratories

1265 Powell Street, Emeryville, CA 94608 (415) 428-2300

373 South Fair Oaks Avenue, Pasadena, CA 91105 (213) 681-4655

Note: Samples are discarded 30 days after results are reported unless other arrangements are made.
Hazardous samples will be returned to client or disposed

BROWN AND CALDWELL ANALYTICAL LABORATORIES

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

Page 1

LOG NO	SAMPLE DESCRIPTION, SOLID SAMPLES	DATE SAMPLED
11-079-1	IK tube #1	01 NOV 86
11-079-2	IK tube #2	01 NOV 86
11-079-3	IK tube #4	04 NOV 86
11-079-4	IK tube #5	02 NOV 86
11-079-5	IK tube #6	31 OCT 86

PARAMETER	11-079-1	11-079-2	11-079-3	11-079-4	11-079-5
Semi Quant ICP Scan					
Silver, mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Aluminum, mg/L	0.8	0.9	0.6	0.5	0.7
Arsenic, mg/L	<10	<10	<10	<10	<10
Barium, mg/L	0.1	0.2	0.1	0.1	0.1
Beryllium, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06
Calcium, mg/L	10	<8	<8	12	10
Cadmium, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Cobalt, mg/L	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium, mg/L	2.1	<0.3	0.5	<0.3	<0.3
Copper, mg/L	0.7	<0.4	2.4	<0.4	<0.4
Iron, mg/L	6.0	18	5.9	6.9	4.8
Potassium, mg/L	10	<10	<10	<10	<10
Magnesium, mg/L	1.1	0.4	1.9	0.4	0.5
Manganese, mg/L	0.007	0.09	0.05	0.04	0.03
Molybdenum, mg/L	<2	<2	<2	<2	<2
Sodium, mg/L	430	40	110	10	30
Nickel, mg/L	<0.6	<0.6	<0.6	<0.6	<0.6
Lead, mg/L	<4	<4	<4	<4	<4
Antimony, mg/L	<4	<4	<4	<4	<4
Selenium, mg/L	<10	<10	<10	<10	<10
Silicon, mg/L	7	3	4	3	3
Tin, mg/L	<6	<6	<6	<6	<6

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOLID SAMPLES	DATE SAMPLED
11-079-1	IK tube #1	01 NOV 86
11-079-2	IK tube #2	01 NOV 86
11-079-3	IK tube #4	04 NOV 86
11-079-4	IK tube #5	02 NOV 86
11-079-5	IK tube #6	31 OCT 86

PARAMETER	11-079-1	11-079-2	11-079-3	11-079-4	11-079-5
Strontium, mg/L	0.23	0.06	0.15	0.03	0.06
Titanium, mg/L	0.56	0.19	0.32	0.39	0.28
Thallium, mg/L	<4	<4	<4	<4	<4
Vanadium, mg/L	<0.3	<0.3	<0.3	<0.3	<0.3
Zinc, mg/L	<0.8	0.9	<0.8	<0.8	<0.8
HCl Wash, Date	11/20/86	11/20/86	11/20/86	11/20/86	11/20/86
Boron, mg/L	16	0.98	4.2	<0.05	0.66
Hexavalent Chromium, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Filterable Residue (TDS), mg/~~kg~~ L	6500	1800	1800	7500	400
Fluoride, mg/L	0.9	2.1	0.3	0.1	0.1
Sulfate, mg/~~kg~~ L	860	75	140	14	49
Arsenic, mg/L	0.06	<0.03	<0.03	<0.03	<0.03
Calcium, mg/L	9.6	4.8	4.1	12	7.6
Lead, mg/~~kg~~ L	0.18	0.03	0.12	0.04	<0.03
Lithium, mg/L	8.5	6.7	<0.2	0.5	<0.2
Magnesium, mg/L	1.2	<0.6	2.0	2.0	0.6
Mercury, mg/~~kg~~ L	NA	NA	NA	NA	NA
Silicon, mg/L	5	2	4	4	4
Sodium, mg/~~kg~~ L	2200	170	490	66	110
Titanium, mg/L	0.64	0.22	0.34	0.45	0.32
Nitric Acid Digestion, Date	11/20/86	11/20/86	11/20/86	11/20/86	11/20/86

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOLID SAMPLES	DATE SAMPLED
11-079-6	IK tube #7	03 NOV 86
11-079-7	IK tube #8	03 NOV 86
11-079-8	IK tube #9	02 NOV 86
11-079-9	IK tube #11	31 OCT 86
11-079-10	IK tube #10 (Procedural Blank)	31 OCT 86

PARAMETER	11-079-6	11-079-7	11-079-8	11-079-9	11-079-10
Semi Quant ICP Scan					
Silver, mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Aluminum, mg/L	1.5	0.6	<0.3	1.0	0.3
Arsenic, mg/L	<10	<10	<10	<10	<10
Barium, mg/L	0.4	0.1	0.1	0.1	1.6
Beryllium, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06
Calcium, mg/L	<8	<8	<8	44	<8
Cadmium, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Cobalt, mg/L	<0.3	<0.3	0.3	<0.3	<0.3
Chromium, mg/L	<0.3	<0.3	<0.3	<0.3	<0.3
Copper, mg/L	<0.4	<0.4	0.5	0.7	19
Iron, mg/L	45	6.7	2.3	41	2.8
Potassium, mg/L	<10	60	<10	<10	<10
Magnesium, mg/L	0.5	0.6	<0.3	1.0	0.4
Manganese, mg/L	0.21	0.06	0.03	0.18	0.04
Molybdenum, mg/L	<2	<2	<2	<2	<2
Sodium, mg/L	50	30	20	80	<10
Nickel, mg/L	<0.6	<0.6	<0.6	<0.6	<0.6
Lead, mg/L	<4	<4	<4	<4	<4
Antimony, mg/L	<4	<4	<4	<4	<4
Selenium, mg/L	<10	<10	<10	<10	<10
Silicon, mg/L	2	2	1	2	2
Tin, mg/L	<6	<6	<6	<6	<6

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, SOLID SAMPLES	DATE SAMPLED.
11-079-6	IK tube #7	03 NOV 86
11-079-7	IK tube #8	03 NOV 86
11-079-8	IK tube #9	02 NOV 86
11-079-9	IK tube #11	31 OCT 86
11-079-10	IK tube #10 (Procedural Blank)	31 OCT 86

PARAMETER	11-079-6	11-079-7	11-079-8	11-079-9	11-079-10
Strontium, mg/L	0.06	0.06	0.03	0.12	0.03
Titanium, mg/L	0.32	0.47	0.20	0.89	0.38
Thallium, mg/L	<4	<4	<4	<4	<4
Vanadium, mg/L	<0.3	<0.3	<0.3	<0.3	<0.3
Zinc, mg/L	<0.8	<0.8	<0.8	18	0.8
HCl Wash, Date	11/20/86	11/20/86	11/20/86	11/20/86	11/20/86
Boron, mg/L	2.8	9.2	<0.05	1.9	0.09
Hexavalent Chromium, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Filterable Residue (TDS), mg/~~kg~~ L	760	880	300	1200	400
Fluoride, mg/L	0.1	<0.1	<0.1	0.2	<0.1
Sulfate, mg/~~kg~~ L	100	100	<10	93	<10
Arsenic, mg/L	0.08	0.10	<0.03	<0.03	<0.03
Calcium, mg/L	2.7	2.9	3.6	38	3.1
Lead, mg/~~kg~~ L	0.04	0.04	<0.03	<0.03	0.04
Lithium, mg/L	0.3	0.2	<0.2	0.3	0.2
Magnesium, mg/L	0.6	0.9	<0.6	1.1	<0.6
Mercury, mg/~~kg~~ L	NA	NA	NA	NA	NA
Silicon, mg/L	2	3	2	2	2
Sodium, mg/~~kg~~ L	180	90	52	360	4.0
Titanium, mg/L	0.34	0.52	0.23	0.92	0.44
Nitric Acid Digestion, Date	11/20/86	11/20/86	11/20/86	11/20/86	11/20/86

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
11-079-11	W-1	01 NOV 86
11-079-12	W-2	01 NOV 86
11-079-13	W-4	04 NOV 86
11-079-14	W-5	02 NOV 86
11-079-15	W-6	31 OCT 86

PARAMETER	11-079-11	11-079-12	11-079-13	11-079-14	11-079-15
Semi Quant ICP Scan					
Silver, mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Aluminum, mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic, mg/L	<1	<1	<1	<1	<1
Barium, mg/L	0.13	0.13	0.08	0.04	0.07
Beryllium, mg/L	<0.006	<0.006	<0.006	<0.006	<0.006
Calcium, mg/L	57	51	15	36	25
Cadmium, mg/L	0.03	0.03	<0.02	<0.02	0.02
Cobalt, mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Chromium, mg/L	14	12	11	<0.03	5.3
Copper, mg/L	<0.04	<0.04	<0.04	<0.04	<0.04
Iron, mg/L	<0.03	<0.03	<0.03	<0.03	0.04
Potassium, mg/L	130	140	65	56	76
Magnesium, mg/L	5.5	4.0	2.0	1.4	2.7
Manganese, mg/L	0.014	0.007	<0.003	<0.003	0.007
Molybdenum, mg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Sodium, mg/L	420	420	460	470	460
Nickel, mg/L	<0.06	<0.06	<0.06	<0.06	<0.06
Lead, mg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Antimony, mg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Selenium, mg/L	<1	<1	<1	<1	1
Silicon, mg/L	51	51	64	36	54
Tin, mg/L	<0.6	<0.6	<0.6	<0.6	<0.6

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
11-079-11	W-1	01 NOV 86
11-079-12	W-2	01 NOV 86
11-079-13	W-4	04 NOV 86
11-079-14	W-5	02 NOV 86
11-079-15	W-6	31 OCT 86

PARAMETER	11-079-11	11-079-12	11-079-13	11-079-14	11-079-15
Strontium, mg/L	4.4	4.4	2.7	1.1	2.6
Titanium, mg/L	<0.006	<0.006	<0.06	<0.006	<0.006
Thallium, mg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Vanadium, mg/L	0.35	0.34	0.20	2.8	0.22
Zinc, mg/L	<0.08	<0.08	<0.08	<0.08	<0.08
Boron, mg/L	91	90	53	33	59
Hexavalent Chromium, mg/L	<0.02	<0.02	14	<0.02	<0.02
Filterable Residue (TDS), mg/L	42,000	42,000	22,000	13,000	25,000
Chloride, mg/L	25,000	27,000	12,000	6100	13,000
Fluoride, mg/L	5.4	5.2	3.3	2.0	3.6
Sulfate, mg/L	4700	4400	2100	1500	2700
Arsenic, mg/L	0.95	1.0	0.56	0.58	0.60
Calcium, mg/L	56	51	14	39	29
Lead, mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Lithium, mg/L	0.97	0.98	1.0	0.49	0.71
Magnesium, mg/L	6.3	4.3	2.2	1.5	3.1
Mercury, mg/L	<0.002	<0.002	<0.002	<0.002	<0.002
Silicon, mg/L	51	50	60	33	56
Sodium, mg/L	16,000	16,000	8200	4400	9900
Titanium, mg/L	<0.006	<0.006	<0.006	<0.006	<0.006
Dissolved Digestion, Date	11/17/86	11/17/86	11/17/86	11/17/86	11/17/86
Sulfate* (mg/L)	4200	4000	2200	1400	2600

*See B+C Analyses Reported 10 Dec. 86

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
11-079-16	W-7	03 NOV 86
11-079-17	W-8	03 NOV 86
11-079-18	W-9	03 NOV 86
11-079-19	W-11	31 OCT 86

PARAMETER	11-079-16	11-079-17	11-079-18	11-079-19
Semi Quant ICP Scan				
Silver, mg/L	<0.01	<0.01	<0.01	<0.01
Aluminum, mg/L	<0.03	<0.03	<0.03	<0.03
Arsenic, mg/L	11	16	<1	1
Barium, mg/L	0.02	0.04	0.09	0.07
Beryllium, mg/L	<0.006	<0.006	<0.006	<0.006
Calcium, mg/L	6.7	9.7	69	29
Cadmium, mg/L	0.29	0.45	0.02	0.02
Cobalt, mg/L	<0.03	<0.03	<0.03	<0.03
Chromium, mg/L	<0.03	<0.03	32	8.5
Copper, mg/L	<0.04	<0.04	<0.04	0.16
Iron, mg/L	0.22	0.27	<0.03	<0.03
Potassium, mg/L	570	2100	100	120
Magnesium, mg/L	8.7	4.6	2.3	2.2
Manganese, mg/L	0.016	0.0016	<0.003	<0.003
Molybdenum, mg/L	<0.2	<0.2	<0.2	<0.2
Sodium, mg/L	400	420	440	430
Nickel, mg/L	<0.06	<0.06	<0.06	<0.06
Lead, mg/L	<0.4	<0.4	<0.4	<0.4
Antimony, mg/L	<0.4	<0.4	<0.4	<0.4
Selenium, mg/L	<1	<1	<1	<1
Silicon, mg/L	8.4	8.4	63	65
Tin, mg/L	<0.6	<0.6	<0.6	<0.6
Strontium, mg/L	2.4	2.2	3.0	3.2

LOG NO: P86-11-079

Received: 05 NOV 86
Reported: 21 NOV 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
11-079-16	W-7	03 NOV 86
11-079-17	W-8	03 NOV 86
11-079-18	W-9	03 NOV 86
11-079-19	W-11	31 OCT 86

PARAMETER	11-079-16	11-079-17	11-079-18	11-079-19
Titanium, mg/L	<0.006	<0.006	<0.006	<0.006
Thallium, mg/L	<0.4	<0.4	<0.4	<0.4
Vanadium, mg/L	<0.03	<0.03	0.26	0.27
Zinc, mg/L	<0.08	<0.08	<0.08	<0.08
Boron, mg/L	270	1200	73	80
Hexavalent Chromium, mg/L	<0.02	<0.02	41	<0.02
Filterable Residue (TDS), mg/L	57,000	60,000	32,000	34,000
Chloride, mg/L	26,000	21,000	15,000	19,000
Fluoride, mg/L	6.5	4.6	4.1	4.8
Sulfate, mg/L	11,000	10,000	3300	3400
Arsenic, mg/L	11	18	0.65	0.74
Calcium, mg/L	3.2	7.6	76	16
Lead, mg/L	<0.03	<0.03	<0.03	<0.03
Lithium, mg/L	4.0	3.2	0.8	0.93
Magnesium, mg/L	7.7	5.2	2.5	2.5
Mercury, mg/L	<0.002	<0.002	<0.002	<0.002
Silicon, mg/L	9.1	8.6	60	64
Sodium, mg/L	19,000	11,000	12,000	13,000
Titanium, mg/L	<0.006	<0.006	<0.006	<0.006
Dissolved Digestion, Date	11/17/86	11/17/86	11/17/86	11/17/86

NA = Not available. Mercury results for these samples will follow under separate cover.

Sulfate* mg/L	11,000	11,000	3,000	3,300

Robert Peak for

Edward Wilson, Laboratory Director

BROWN AND CALDWELL
ANALYTICAL LABORATORIES

LOG NO: P86-12-089

Received: 05 DEC 86
Reported: 10 DEC 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

Page 1

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
12-089-1	#1	03 NOV 86
12-089-2	#2	03 NOV 86
12-089-3	#4	03 NOV 86
12-089-4	#5	03 NOV 86
12-089-5	#6	03 NOV 86

PARAMETER	12-089-1	12-089-2	12-089-3	12-089-4	12-089-5
Sulfate, mg/L	4200	4000	2200	1400	2600

LOG NO: P86-12-089

Received: 05 DEC 86
Reported: 10 DEC 86

Ben Crocker
Environmental Systems Corporation
200 Tech Center Drive
Knoxville, TN 37912

Purchase Order: 16965

REPORT OF ANALYTICAL RESULTS

LOG NO	SAMPLE DESCRIPTION, WATER SAMPLES	DATE SAMPLED
12-089-6	#7	03 NOV 86
12-089-7	#8	03 NOV 86
12-089-8	#9	03 NOV 86
12-089-9	#11	03 NOV 86

PARAMETER	12-089-6	12-089-7	12-089-8	12-089-9
Sulfate, mg/L	11,000	11,000	3000	3300

Edward Wilson, Laboratory Director

GALBRAITH LABORATORIES, INC.
P. O. BOX 4187, 2323 SYCAMORE DR., KNOXVILLE, TENNESSEE 37921 / 615 546-1335

CERTIFICATE OF ANALYSIS

Mr. Ben Crocker
Page 2
November 25, 1986

Your water sample No. 2 Our No. WD-3154 gave the following results:

pH (Standard Units	Sulfate (as S) <5 *	Iron
Color (Units)	Sulfide (as S)	Lead
Odor at Room Temperature (Units)	Sulfite (as SO_3)	Lithium
Specific Conductance Micromhos	Bromide	Magnesium
Turbidity (Jackson Units)	Chloride	Manganese
Acidity (total) as $CaCO_3$	Cyanide	Mercury <0.01
Alkalinity as $CaCO_3$	Fluoride	Molybdenum
Hardness Total $CaCO_3$	Oil & Grease	Nickel
Total Solids	Phenols	Potassium
Total Dissolved Solids	Surfactants	Selenium
Total Suspended Solids	Silicon	Silver
Total Volatile Solids	Boron	Sodium <0.15
Settleable Solids	Fecal Streptococci Bacteria	Strontium
Total Organic Carbon (TOC)	Coliform Bacteria	Tin
Dissolved Oxygen (DO)	Aluminum	Titanium
BOD (5-day)	Antimony	Vanadium
BOD (Ultimate)	Arsenic <0.01	Zinc
Chemical Oxygen Demand (COD)	Barium	
Ammonia (as N)	Beryllium	
Kjeldahl Nitrogen	Cadmium	
Organic Nitrogen	Calcium 0.14	
Nitrate (as N)	Chromium, Hexavalent	
Nitrite (as N)	Chromium, Total <0.05	
Phosphorus-Ortho (as P)	Cobalt	
Phosphorus-Total (as P)	Copper	

All results are reported as mg/liter unless otherwise noted.

GALBRAITH LABORATORIES, INC.
P. O. BOX 4187, 2323 SYCAMORE DR., KNOXVILLE, TENNESSEE 37921 / 615 546-1335

CERTIFICATE OF ANALYSIS

Mr. Ben Crocker
Page 5
November 25, 1986

Your water sample No. 4 Our No. WD-3157 gave the following results:

pH (Standard Units)		Sulfate (as S)	12	Iron	
Color (Units)		Sulfide (as S)		Lead	
Odor at Room Temperature (Units)		Sulfite (as SO_3)		Lithium	
Specific Conductance Micromhos		Bromide		Magnesium	
Turbidity (Jackson Units)		Chloride		Manganese	
Acidity (total) as $CaCO_3$		Cyanide		Mercury	<0.01
Alkalinity as $CaCO_3$		Fluoride		Molybdenum	
Hardness Total $CaCO_3$		Oil & Grease		Nickel	
Total Solids		Phenols		Potassium	
Total Dissolved Solids		Surfactants		Selenium	
Total Suspended Solids		Silicon		Silver	
Total Volatile Solids		Boron		Sodium	0.86
Settleable Solids		Fecal Streptococci Bacteria		Strontium	
Total Organic Carbon (TOC)		Coliform Bacteria		Tin	
Dissolved Oxygen (DO)		Aluminum		Titanium	
BOD (5-day)		Antimony		Vanadium	
BOD (Ultimate)		Arsenic	<0.01	Zinc	
Chemical Oxygen Demand (COD)		Barium			
Ammonia (as N)		Beryllium			
Kjeldahl Nitrogen		Cadmium			
Organic Nitrogen		Calcium	2.06		
Nitrate (as N)		Chromium, Hexavalent			
Nitrite (as N)		Chromium, Total	<0.05		
Phosphorus-Ortho (as P)		Cobalt			
Phosphorus-Total (as P)		Copper			

All results are reported as mg/liter unless otherwise noted.

Gail R Hutchens

Gail R. Hutchens, Exec. Vice-President

GALBRAITH LABORATORIES, INC.
P. O. BOX 4187, 2323 SYCAMORE DR., KNOXVILLE, TENNESSEE 37921 / 615 546-1335

CERTIFICATE OF ANALYSIS

Mr. Ben Crocker
Page 3
November 25, 1986

Your water sample No. 5 Our No. WD-3155 gave the following results:

pH (Standard Units		Sulfate (as S)	<5 *	Iron	
Color (Units)		Sulfide (as S)		Lead	
Odor at Room Temperature (Units)		Sulfite (as SO_3)		Lithium	
Specific Conductance Micromhos		Bromide		Magnesium	
Turbidity (Jackson Units)		Chloride		Manganese	
Acidity (total) as $CaCO_3$		Cyanide		Mercury	<0.01
Alkalinity as $CaCO_3$		Fluoride		Molybdenum	
Hardness Total $CaCO_3$		Oil & Grease		Nickel	
Total Solids		Phenols		Potassium	
Total Dissolved Solids		Surfactants		Selenium	
Total Suspended Solids		Silicon		Silver	
Total Volatile Solids		Boron		Sodium	0.47
Settleable Solids		Fecal Streptococci Bacteria		Strontium	
Total Organic Carbon (TOC)		Coliform Bacteria		Tin	
Dissolved Oxygen (DO)		Aluminum		Titanium	
BOD (5-day)		Antimony		Vanadium	
BOD (Ultimate)		Arsenic	<0.01	Zinc	
Chemical Oxygen Demand (COD)		Barium			
Ammonia (as N)		Beryllium			
Kjeldahl Nitrogen		Cadmium			
Organic Nitrogen		Calcium	0.78		
Nitrate (as N)		Chromium, Hexavalent			
Nitrite (as N)		Chromium, Total	<0.05		
Phosphorus-Ortho (as P)		Cobalt			
Phosphorus-Total (as P)		Copper			

All results are reported as mg/liter unless otherwise noted.

GALBRAITH LABORATORIES, INC.
P. O. BOX 4187, 2323 SYCAMORE DR., KNOXVILLE, TENNESSEE 37921 / 615 546-1335

CERTIFICATE OF ANALYSIS

November 25, 1986

Mr. Ben Crocker
Environmental Systems Corp.
200 Tech Center Drive
Knoxville, Tennessee 37912

Received: November 19th

Your water sample No. 6 Our No. WD-3153 gave the following results:

		Sulfate (as S)	<5 *	Iron	
pH (Standard Units)		Sulfide (as S)		Lead	
Color (Units)		Sulfite (as SO_3)		Lithium	
Odor at Room Temperature (Units)		Bromide		Magnesium	
Specific Conductance Micromhos		Chloride		Manganese	
Turbidity (Jackson Units)		Cyanide		Mercury	<0.01
Acidity (total) as $CaCO_3$		Fluoride		Molybdenum	
Alkalinity as $CaCO_3$		Oil & Grease		Nickel	
Hardness Total $CaCO_3$		Phenols		Potassium	
Total Solids		Surfactants		Selenium	
Total Dissolved Solids		Silicon		Silver	
Total Suspended Solids		Boron		Sodium	0.34
Total Volatile Solids		Fecal Streptococci Bacteria		Strontium	
Settleable Solids		Coliform Bacteria		Tin	
Total Organic Carbon (TOC)		Aluminum		Titanium	
Dissolved Oxygen (DO)		Antimony		Vanadium	
BOD (5-day)		Arsenic	<0.01	Zinc	
BOD (Ultimate)		Barium			
Chemical Oxygen Demand (COD)		Beryllium			
Ammonia (as N)		Cadmium			
Kjeldahl Nitrogen		Calcium	0.33		
Organic Nitrogen		Chromium, Hexavalent			
Nitrate (as N)		Chromium, Total	<0.05		
Nitrite (as N)		Cobalt			
Phosphorus-Ortho (as P)		Copper			
Phosphorus-Total (as P)					

All results are reported as mg/liter unless otherwise noted.

* Sulfate as Sulfur can not get lower due to Chlorine interferences.

GALBRAITH LABORATORIES, INC.
P. O. BOX 4187, 2323 SYCAMORE DR., KNOXVILLE, TENNESSEE 37921 / 615 546-1335

CERTIFICATE OF ANALYSIS

Mr. Ben Crocker
Page 4
November 25, 1986

Your water sample No. 7 Our No. WD-3156 gave the following results:

pH (Standard Units	Sulfate (as S) <5 *	Iron
Color (Units)	Sulfide (as S)	Lead
Odor at Room Temperature (Units)	Sulfite (as SO_3)	Lithium
Specific Conductance Micromhos	Bromide	Magnesium
Turbidity (Jackson Units)	Chloride	Manganese
Acidity (total) as $CaCO_3$	Cyanide	Mercury <0.01
Alkalinity as $CaCO_3$	Fluoride	Molybdenum
Hardness Total $CaCO_3$	Oil & Grease	Nickel
Total Solids	Phenols	Potassium
Total Dissolved Solids	Surfactants	Selenium
Total Suspended Solids	Silicon	Silver
Total Volatile Solids	Boron	Sodium 0.38
Settleable Solids	Fecal Streptococci Bacteria	Strontium
Total Organic Carbon (TOC)	Coliform Bacteria	Tin
Dissolved Oxygen (DO)	Aluminum	Titanium
BOD (5-day)	Antimony	Vanadium
BOD (Ultimate)	Arsenic <0.01	Zinc
Chemical Oxygen Demand (COD)	Barium	
Ammonia (as N)	Beryllium	
Kjeldahl Nitrogen	Cadmium	
Organic Nitrogen	Calcium 0.27	
Nitrate (as N)	Chromium, Hexavalent	
Nitrite (as N)	Chromium, Total <0.05	
Phosphorus-Ortho (as P)	Cobalt	
Phosphorus-Total (as P)	Copper	

All results are reported as mg/liter unless otherwise noted.

APPENDIX D

CALCULATION FILE

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Calculation of micrograms of Contaminant per sample (Tables 4.1a–i)

BY BRC DATE 12/11/86 PAGE 1 OF 1

(REVISED)

Formulas for Ik tube Samples

mg/L to μg/sample

$$X_{mg/L} \cdot \frac{1000 \text{ micrograms}}{\text{milligram}} \cdot \frac{50 \text{ milliliters}}{\text{Sample}} \cdot \frac{1 \text{ Liter}}{1000 \text{ ml}}$$

$$\boxed{\therefore \quad X_{mg/L} \times 50 = \frac{X \text{ micrograms}}{\text{Sample}}}$$

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Average Analysis of Pretest Blanks (IK tubes 2, 4, 5, 6, 7

BY BRC DATE 11/25/86 PAGE 1 OF 1

Pretest Blanks
50ml samples of 2nd acid wash Soln.

Sample

Parameter (micrograms/sample)	Tube # 2	Tube # 4	Tube # 5	Tube # 6	Tube # 7	Proc. Blank
Sodium	<7.5	43	23.5	17	19	200
Arsenic	<0.5	<0.5	<0.5	<0.5	<0.5	<1.5
Calcium	7.0	103	39	16.5	13.5	155
Mercury	<0.5	<0.5	<0.5	<0.5	<0.5	ND
Chromium	<25	<2.5	<2.5	<2.5	<2.5	<15
Sulfate	<750	1976	<750	<750	<750	<500

Average of 5 Pretest Blanks

	Avg.
Sodium	22
Arsenic	<0.5
Calcium	35.8
Mercury	<0.5
Chromium	<2.5
Sulfate	<995

ESC

PROJECT: Kerr McGee Chemical Corporation
SUBJECT: Calculation of Mass Mineral Flux
BY: ERC DATE: 11/25/86 PAGE 1 OF 10

Average Sampling Area (A_s)

Average Diameter of Sampling Tubes = 0.968 inches

$$A_s = \frac{\pi (0.968 \text{ in})^2}{4} = 0.736 \text{ in}^2$$

$$0.736 \text{ in}^2 \times \frac{1 \text{ ft}^2}{144 \text{ in}^2} \times \frac{1 \text{ m}^2}{10.76 \text{ ft}^2} = \boxed{4.750 \times 10^{-4} \text{ m}^2}$$

Calculation of:

$$\text{Mass Mineral Flux} \left(\frac{\text{gms}}{\text{m}^2 \cdot \text{s}}\right) = \frac{M_{IK} - M_{SK}}{A_s \cdot t_s}$$

t_s = time of sampling

Conversion to lbs/hr.

$$Y \frac{\text{gms}}{\text{m}^2 \cdot \text{s}} \cdot \frac{1 \text{ lbs}}{453.6 \text{ gms}} \cdot \frac{3600 \text{ sec}}{1 \text{ hr}} \cdot \frac{1 \text{ m}^2}{10.76 \text{ ft}^2} \cdot \frac{Y \text{ ft}^2}{\text{for stack}} = X \frac{\text{lbs}}{\text{hr} \cdot \text{stack}}$$

$$\boxed{X \frac{\text{gms}}{\text{m}^2 \cdot \text{s}} \cdot 0.7376 \cdot \frac{Y \text{ ft}^2}{\text{for stack}} = X \frac{\text{lbs}}{\text{hr} \cdot \text{stack}}}$$

ESC

PROJECT Kerr McGee Chemical Corp.

SUBJECT Calculation of Mass (?) Flux

BY BRC DATE 11/25/95 PAGE 2 OF 10

IK Tube #6 (Borax Cooling Tower)

use Procedural Blank (except for Na, Ca, SO4 use Average Pretest Blank)

Fan Stack Area = 158.1 ft² = 14.69 m²

Sampling time 16 pts × 5 min/pt = 80 minutes

Sample tube Area = $4.750 \times 10^{-4}\ m^2$

$$\frac{X_{IK} - X_{BK}}{4.750 \times 10^{-4} m^2 \cdot 4800\ sec} \cdot \frac{1\ mgm}{1000\ \mu gms} = \frac{X_{IK} - X_{BK}}{2280} = \frac{mgms}{m^2 \cdot sec}$$

Sodium $\frac{5500 - 22}{2280} = \boxed{\frac{2.403\ mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times \frac{158.1\ ft^2}{stack} \times 3\ stacks = \boxed{0.841\ \frac{lbs}{hr}}$ Na

Calcium $\frac{380 - 35.8}{2280} = \boxed{\frac{0.151\ mgm}{m^2 \cdot s}} \times \frac{.7376 \times 158.1 \times 3}{1000} = \boxed{0.053\ \frac{lbs}{hr}}$ Ca

Sulfate $\frac{2450 - 500}{2280} = \boxed{\frac{0.855\ mgm}{m^2 \cdot s}} \times \frac{.7376 \times 158.1 \times 3}{1000} = \boxed{0.299\ \frac{lbs}{hr}}$ SO_4

Magnesium $\frac{30 - 20}{2280} = \boxed{\frac{.0044\ mgm}{m^2 \cdot s}} \times \frac{.7376 \times 158.1 \times 3}{1000} = \boxed{0.0015\ \frac{lbs}{hr}}$ Mg

Potassium — — —

Iron $\frac{240 - 140}{2280} = \boxed{\frac{.0439\ mgm}{m^2 \cdot s}} \times \frac{.7376 \times 158.1 \times 3}{1000} = \boxed{0.015\ \frac{lbs}{hr}}$ Fe

Boron $\frac{33 - 4.5}{2280} = \boxed{\frac{.0125\ mgm}{m^2 \cdot s}} \times \frac{.7376 \times 158.1 \times 3}{1000} = \boxed{0.004\ \frac{lbs}{hr}}$ B

ESC

PROJECT Kerr McGee Chemical Corporation
SUBJECT Calculation of Mass Mineral Flux
BY BRC DATE 11/25/86 PAGE 3 OF 10

Ik Tube #11 (#1 Sulfate Cooling Tower)

use Procedural Blank (except for Na, Ca, SO_4 use Average Pretest Blank)

Fan Stack Area = 179.7 ft^2 = 16.70 m^2

Sampling time = 16 pts X 5 min/pt = 80 min or 4800 sec

Sample tube area = 4.75×10^{-4} m^2

$$\frac{X_{Ik} - X_{Bk}}{4.750\times10^{-4} \cdot 4800\,sec} \cdot \frac{1\,mgm}{1000\,\mu gms} = \frac{X_{Ik} - X_{Bk}}{2280} = \frac{mgm}{m^2 \cdot sec}$$

Sodium

⚠ $\frac{18000 - 22}{2280} = \boxed{7.885 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 ft^2 \times 2 stacks = \boxed{2.090 \frac{lbs}{hr}}$ Na

Calcium

$\frac{1900 - 35.8}{2280} = \boxed{0.818 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.217 \frac{lbs}{hr}}$ Ca

Sulfate

⚠ $\frac{4650 - 500}{2280} = \boxed{1.820 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.481 \frac{lbs}{hr}}$ SO_4

Magnesium

$\frac{55 - 20}{2280} = \boxed{0.0154 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.0041 \frac{lbs}{hr}}$ Mg

Zinc

$\frac{900 - 40}{2280} = \boxed{0.377 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.100 \frac{lbs}{hr}}$ Zn

Iron

$\frac{2050 - 140}{2280} = \boxed{0.838 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.222 \frac{lbs}{hr}}$ Fe

Boron

$\frac{95 - 4.5}{2280} = \boxed{0.0397 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 179.7 \times 2 = \boxed{0.0105 \frac{lbs}{hr}}$ B

ESC

PROJECT Kerr McGee Chemical Corp.
SUBJECT Calculation of Mass Mineral Flux
BY BRC DATE 11/25/86 PAGE 4 OF 10

IK Tube #2 (#2 Sulfate Cooling Tower)
Use Procedural Blank (except for Na, Ca, SO_4 use Average Pretest Blank)
Fan Stack Area = 90.2 ft^2 or 16.75 m^2
Sampling Time = 16 pts × 5 min/pt = 80 min or 4800 sec
Sample tube area = $4.75 \times 10^{-4}\ m^2$

$$\frac{X_{IK} - X_{BK}}{4.75 \times 10^{-4} \cdot 4800 \cdot 1000} = \frac{X_{IK} - X_{BK}}{2280} = \frac{mgms}{m^2 \cdot sec}$$

Sodium
$$\frac{8500 - 22}{2280} = \boxed{3.718 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 90.2 ... = \boxed{0.988 \frac{lbs}{hr}}$$

Calcium
$$\frac{240 - 35.8}{2280} = \boxed{0.090 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{0.024 \frac{lbs}{hr}}$$ Ca

Sulfate
$$\frac{3750 - 500}{2280} = \boxed{1.425 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{0.379 \frac{lbs}{hr}}$$

Magnesium
$$\frac{20 - 20}{2280} = \boxed{\times \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{\times \frac{lbs}{hr}}$$

Zinc
$$\frac{45 - 40}{2280} = \boxed{0.0022 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{0.0006 \frac{lbs}{hr}}$$ Zn

Iron
$$\frac{900 - 140}{2280} = \boxed{0.333 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{0.079 \frac{lbs}{hr}}$$ Fe

Boron
$$\frac{49 - 4.5}{2280} = \boxed{0.0195 \frac{mgm}{m^2 \cdot S}} \times \frac{.7376}{1000} \times 170.2 \times 2 = \boxed{0.0052}$$ B

ESC

PROJECT Kerr McGee Chemical Corp.
SUBJECT Calculation of Mass Material Flux
BY BKC DATE 11/25/86 PAGE 5 OF 10

IK Tube # 1 (#3 Sulfate Cooling Tower)
use Procedural Blank (except for Na, Ca, SO₄ use Average Pretest Blank)

Fan Stack Area = 180.2 ft² = 16.75 m²
Sampling Time = 16 pts × 5 min/pt = 80 min or 4800 sec
Sampling tube area = 4.75×10^{-4} m²

$$\frac{X_{IK} - X_{BK}}{4.750\times10^{-4} \cdot 4800 \cdot 1000} = \frac{X_{IK} - X_{BK}}{2280} = \frac{mgms}{m^2 \cdot sec}$$

Sodium

$$\frac{110{,}000 - 22}{2280} = \boxed{48.24 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2\,ft^2 \times 2\text{ cells} = \boxed{12.82 \frac{lbs}{hr}}$$

Calcium

$$\frac{480 - 35.8}{2280} = \boxed{0.195 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{0.052 \frac{lbs}{hr}}\ Ca$$

Sulfate

$$\frac{43{,}000 - 500}{2280} = \boxed{18.64 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{4.96 \frac{lbs}{hr}}\ SO_4$$

Magnesium

$$\frac{60 - 20}{2280} = \boxed{0.0175 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{0.0047 \frac{lbs}{hr}}$$

Zinc

$$\frac{<40 - 40}{2280} = \boxed{\times \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{\times \frac{lbs}{hr}}\ Zn$$

Iron

$$\frac{300 - 140}{2280} = \boxed{0.0702 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{0.0187 \frac{lbs}{hr}}\ Fe$$

Boron

$$\frac{800 - 4.5}{2280} = \boxed{0.345 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 180.2 \times 2 = \boxed{0.0927 \frac{lbs}{hr}}\ B$$

ESC

PROJECT: Kerr McGee Chemical Corporation
SUBJECT: Calculation of Mass Mineral Flux
BY: BRC DATE: 11/25/86 PAGE 6 OF 10

IK tube #5 (Lime Cooling Tower)

Use Procedural Blank (except for Na, Ca, SO_4 use Average Pretest Blank)

Fan Stack Area = 182.7 ft^2 = 16.98 m^2

Sampling Time = 18 pts × 10 mins/pt = 180 min or 10800 sec.

Sample Tube Area (A_s) = 4.75×10^{-4} m^2

$$\frac{X_{IK} - X_{BK}}{4.75\times10^{-4}\cdot 10800 \cdot 1000} = \frac{X_{IK} - X_{BK}}{4828} = \frac{mgm}{m^2 \cdot s}$$

Sodium

$$\frac{3300 - 22}{4828} = \boxed{1.438 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7\, ft^2 \times 1 \, ft^{-1} = \boxed{0.194 \frac{lbs}{hr}}$$ Na

Calcium

$$\frac{600 - 35.8}{4828} = \boxed{0.117 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{0.0157 \frac{lbs}{hr}}$$ Ca

Sulfate

$$\frac{700 - 500}{4828} = \boxed{0.041 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{0.0056 \frac{lbs}{hr}}$$ SO_4

Magnesium

$$\frac{200 - 20}{4828} = \boxed{0.0373 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{0.0050 \frac{lbs}{hr}}$$ Mg

Zinc

$$\frac{<40 - 40}{4828} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{X}$$ Zn

Iron

$$\frac{6.9 - 140}{4828} = \boxed{\diagup \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{X}$$ Fe

Boron

$$\frac{<2.5 - 4.5}{4828} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 182.7 = \boxed{X}$$ B

ESC

PROJECT Kerr McGee Chemical Corporation
SUBJECT Calculation of Mass Mineral Flux
BY BRC DATE 11/25/86 PAGE 7 OF 10

IK Tube #9 (#4 Sulfate Cooling Tower)
use Procedural Blank (except for Na, Ca, SO_4): use Average Pretest Blank

Fan Stack Area 351.9 ft^2 or 32.70 m^2
Sampling Time = 15 pts x 5 min/pt. = 75 min or 4500 sec.
Sample Tube Area $(A_s) = 4.75 \times 10^{-4}\ m^2$

$$\frac{X_{IK} - X_{BK}}{4.75\times10^{-4} \cdot 4500 \cdot 1000} = \frac{X_{IK} - X_{BK}}{2138} = \frac{mgm}{m^2 \cdot s}$$

Sodium

$$\frac{2600 - 22}{2138} = \boxed{1.206 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 ft^2 \times 2\ cells = \boxed{0.626 \frac{lbs}{hr}}\ Na$$

Calcium

$$\frac{180 - 35.8}{2138} = \boxed{0.0674 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{0.035 \frac{lbs}{hr}}\ Ca$$

Sulfate

$$\frac{500 - 500}{2138} = \boxed{0.0 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{0.0 \frac{lbs}{hr}}\ SO_4$$

Magnesium

$$\frac{<30 - 20}{2138} = \boxed{0.0047 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{0.0024 \frac{lbs}{hr}}\ Mg$$

Zinc

$$\frac{<40 - 40}{2138} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{X}\ Zn$$

Iron

$$\frac{115 - 140}{2138} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{X}\ Fe$$

Boron

$$\frac{<2.5 - 4.5}{2138} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 351.9 \times 2 = \boxed{X}\ B$$

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Calculation of Mass Mineral Flux

BY BRC DATE 11/25/86 PAGE 8 OF 10

JK Tube #8 (#11 Cooling Tower - Trona)

Use Procedural Blank (except for Na, Ca, SO_4 use Average Pretest Blank)

Fan Stack Area = 218.2 ft^2 or 20.28 m^2

Sampling Time = 16 pts × 5 min/pt = 80 min or 4800 sec

Sample Tube Area (A_s) = $4.75 \times 10^{-4} m^2$

$$\frac{X_{IK} - X_{BK}}{4.75\times10^{-4} \times 4800 \times 1000} = \frac{X_{IK} - X_{BK}}{2280} = \frac{mgms}{m^2 \cdot s}$$

Sodium

$$\frac{4500 - 22}{2280} = \boxed{1.964 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 ft^2 \times 3_{cells} = \boxed{0.948 \frac{lbs}{hr}} \text{ Na}$$

Calcium

$$\frac{145 - 35.8}{2280} = \boxed{0.048 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{0.023 \frac{lbs}{hr}} \text{ Ca}$$

Sulfate

$$\frac{5000 - 500}{2280} = \boxed{1.974 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{0.953 \frac{lbs}{hr}} \text{ SO}_4$$

Magnesium

$$\frac{45 - 20}{2280} = \boxed{0.0110 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{0.0053 \frac{lbs}{hr}} \text{ Mg}$$

Zinc

$$\frac{\text{<40} - 40}{2280} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{X} \text{ Zn}$$

Iron

$$\frac{335 - 140}{2280} = \boxed{0.0855 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{0.043 \frac{lbs}{hr}} \text{ Fe}$$

Boron

$$\frac{460 - 4.5}{2280} = \boxed{0.200 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 218.2 \times 3 = \boxed{0.0966 \frac{lbs}{hr}}$$

ESC

PROJECT: Kerr McGee Chemical Corporation
SUBJECT: Calculation of Mass Mineral Flux
BY BRC DATE 11/25/86 PAGE 9 OF 10

IK Tube #7 (#14 Cooling Tower - Trona)
Use Procedural Blank (except for Na, Ca, SO_4 use Average Protest Blanks)
Fan Stack Area = 520.8 ft^2 or 48.40 m^2
Sampling Time = 18 pts × 5 min/pt = 90 min or 5400 sec
Sample Tube Area (A_s) = $4.75 \times 10^{-4}\ m^2$

$$\frac{X_{IK} - X_{BK}}{4.75\times10^{-4}\times5400\times1000} = \frac{X_{IK} - X_{BK}}{2565} = \frac{mgm}{m^2 \cdot s}$$

Sodium

$$\frac{9000 - 22}{2565} = \boxed{3.500\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8\ ft^2 \times 4 = \boxed{5.378\ \frac{lbs}{hr}}$$

Calcium

$$\frac{135 - 35.8}{2565} = \boxed{0.039\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{0.059\ \frac{lbs}{hr}}$$

Sulfate

$$\frac{5000 - 500}{2.565} = \boxed{1.754\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{2.696\ \frac{lbs}{hr}}$$

Magnesium

$$\frac{30 - 20}{2565} = \boxed{0.0039\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{0.0060\ \frac{lbs}{hr}}$$

Zinc

$$\frac{<40 - 40}{2565} = \boxed{X\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{X\ \frac{lbs}{hr}}$$ Zn

Iron

$$\frac{2250 - 140}{2565} = \boxed{0.823\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{1.264\ \frac{lbs}{hr}}$$ Fe

Boron

$$\frac{140 - 4.5}{2565} = \boxed{0.0528\ \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 520.8 \times 4 = \boxed{0.0812\ \frac{lbs}{hr}}$$ B

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Calculation of Mass Mineral Flux

BY BRC DATE 11/25/86 PAGE 10 OF 10

K Tube #4 (Argus Cooling Tower)

Use Procedural Blank (except for Na, Ca, SO_4 use Average Pretest Blank)

Fan Stack Area = 439.9 ft^2 or 40.88 m^2

Sampling Time = 16 pts × 5 min/pt = 80 min or 4800 sec.

Sample Tube Area (A_S) = 4.75×10^{-4} m^2

$$\frac{X_{IK} - X_{BK}}{4.75 \times 10^{-4} \times 4800 \times 1000} = \frac{X_{IK} - X_{BK}}{2280} = \frac{mgm}{m^2 \cdot s}$$

Sodium

$$\frac{24500 - 22}{2280} = \boxed{10.736 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{13.934 \frac{lbs}{hr}}$$ Na

Calcium

$$\frac{205 - 35.8}{2280} = \boxed{0.074 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{0.096 \frac{lbs}{hr}}$$ Ca

Sulfate

$$\frac{7000 - 500}{2280} = \boxed{2.851 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{3.700 \frac{lbs}{hr}}$$

Magnesium

$$\frac{100 - 20}{2280} = \boxed{0.0351 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{0.0455 \frac{lbs}{hr}}$$

Zinc

$$\frac{40 - 40}{2280} = \boxed{X \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{X \frac{lbs}{hr}}$$ Zn

Iron

$$\frac{295 - 140}{2280} = \boxed{0.0680 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{0.0882 \frac{lbs}{hr}}$$ Fe

Boron

$$\frac{210 - 4.5}{2280} = \boxed{0.090 \frac{mgm}{m^2 \cdot s}} \times \frac{.7376}{1000} \times 439.9 \times 4 = \boxed{0.1170 \frac{lbs}{hr}}$$ B

ESC

PROJECT Kerr McGee Chemical Corporation
SUBJECT Determination of Drift Fraction Based on Sodium
BY BRC DATE 1/26/86 PAGE 1 OF 2

Drift Fraction as Percent of Recirculating Water Flow Rate

$$\% \text{ Drift} = \frac{\text{Liters/minute emitted}}{\text{Liters/minute circulated}} \times 100$$

$$\% \text{ Drift} = \frac{\dfrac{W \cancel{\text{milligrams Na}}}{\cancel{m^2} \cdot \cancel{s}} \cdot \dfrac{60 \cancel{\text{sec}}}{\text{min.}} \cdot \dfrac{m^2}{\text{stack}} \cdot \dfrac{Y \cancel{\text{stacks}}}{\text{tower}} \cdot \dfrac{1}{Z \dfrac{\cancel{\text{mg Na}}}{\text{Liter}}}}{F \dfrac{\text{Gallons}}{\text{min.}} \text{ water flow} \times \dfrac{3.785 \text{ Liters}}{\text{Gallon}}}$$

$$\% \text{ Drift} = \frac{\dfrac{W \cdot X \cdot Y \cdot 60}{Z}}{F \times 3.785} \times 100$$

$$\% \text{ Drift} = \frac{W \cdot X \cdot Y}{F \cdot Z} \times 1585.2$$

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Determination of Drift Fraction Based on Sodium

BY BRC DATE 11/26/86 PAGE 2 OF 2

		F	W	X	Y	Z	
I K Tube	Tower	GPM	$\frac{mg\ Na}{m^2 \cdot s}$	$\frac{m^2}{Stack}$	$\frac{Stacks}{Tower}$	$\frac{mg\ Na}{Liter}$	% [illegible]
6	Borax	3000	2.403	14.69	3	9900	0.0057
11	#1 Sulfate	3500	7.885	16.70	2	13000	0.0092
2	#2 Sulfate	3500	3.718	16.75	2	16000	0.0035
1	#3 Sulfate	3500	48.24	16.75	2	16000	0.0457
5	Lime	2950	1.438	16.98	1	4400	0.0030
9	#4 Sulfate	9360	1.206	32.70	2	12000	0.0011
8	#11 Tower	15000	1.964	20.28	3	11000	0.0011
7	#14 Tower	24000	3.500	48.40	4	19000	0.0024
4	Argus	30000	10.736	40.88	4	8200	0.0113

ESC

PROJECT Kerr McGee Chemical Corporation
SUBJECT Calculation of Mass Emissions (lb/hr) from Drift Fraction
BY BRC DATE 12/11/86 PAGE 1 OF 1

DRIFT Fraction = $\frac{\text{Gallons per minute Drift Loss}}{\text{Gallons per minute Water Circulated}} \times 100$

For chemical constituent X: Example W-6 Borax Tower

Given: Drift Fraction = 0.0054 %

Circulating Water Flow = 3000 GPM

X: Concentration of Boron in Cooling Water Sample

$[B] = 59$

Find: Boron emission Rate in (lbs/hr)

$$\text{GPM drift} = \frac{0.000054 \text{ GPM Drift}}{\text{GPM Circulated}} \times 3000 \text{ GPM circulated} = 0.162 \text{ GPM Drift}$$

$$X \frac{\text{lbs}_B}{\text{hr.}} = \frac{.1628}{\cancel{\text{min}}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{3.785 \text{ L}}{\text{Gallon}} \times \frac{59 \text{ mg}}{\text{L}} \times \frac{1 \text{ gm}}{1000 \text{ mg}} \times \frac{1 \text{ Kg}}{1000 \text{ gm}} \times \frac{2.205 \text{ lbs}}{\text{Kg}}$$

Boron emission rate (Borax Tower) $= 0.0048 \frac{\text{lbs } B}{\text{hr.}}$

General equation 4.3

$$M_E = DF \cdot R \cdot C_X \cdot 5.008 \times 10^{-6}$$

$$M_E = 0.0054 \times 3000 \times 59 \cdot 5.008 \times 10^{-6} = 4.779 \times 10^{-3}$$

$$0.0048 \cong .0048$$

ESC

PROJECT Kerr McGee Chemical Corporation

SUBJECT Comparison of Emission Calculation Bases (Ik versus Using Fraction)

BY BRC DATE 12/11/96 PAGE 1 OF 1

EMISSION RATES (lbs/hr.)

	Ik Based SO_4 Emissions.	Drift Fraction Based SO_4 Emissions	Ik Based Boron Emissions	Drift Fraction Boron Emis.
Borax Tower	0.299	0.231	0.0040	0.0053
#1 SO_4 Tower	0.481	0.548	0.0105	0.0129
#2 SO_4 Tower	0.379	0.270	0.0052	0.0055
#3 SO_4 Tower	.4.960	3.765	0.0927	0.0789
#4 SO_4 Tower	0.0	0.464	0.0	0.0103
Lime Cooling Tower	0.005	0.024	0.0	0.00054
#11 Cooling Tower	0.953	0.826	0.0966	0.0092
#14 Cooling Tower	2.696	3.173	0.0812	0.0779
Argus Cooling Tower	3.700	3.565	0.1170	0.0900

Average Velocity: [illegible] Tunnel

$\overline{V}$ = [illegible] feet per minute
A = 157.1 ft²
Q = [illegible] × 157.1 × 60 min/hr = [illegible]

1 cell = [illegible]
30 s = [illegible]

Average Velocity: #1 Su[illegible] Tunnel

$\overline{V}$ = 944 feet per minute
A = 177.7 ft²
Q = 944 × [illegible] × 60 = 10,[illegible]

1 cell = 169,[illegible]
2 cells = [illegible]

Average Velocity: #2 Su[illegible]

$\overline{V}$ = 855.25 [illegible]
A = 1[illegible]
Q = 855.25 × 180.2 × 60 = 9,[illegible]

1 cell = 154,[illegible]6
2 cells = 307,[illegible]

Average Velocity: #3 Su[illegible] Tunnel

$73.24

$\overline{V}$ = 326.25 feet per minute
A = 180.2 ft²
Q = 326.25 × 180.2 × 60 = 4,[illegible]6,[illegible]

1 cell = [illegible]
2 cells = 1[illegible]20[illegible]

Average Velocity: Lime Cooling [illegible]

$\bar{V}$ = 1073.25 feet per min
A = [illegible] ft
Q = 1073.25 · [illegible] × 60 min/hr = 11,764,[illegible]
[illegible] = [illegible],07[illegible]

Average Velocity: #4 [illegible]

$\bar{V}$ = 509 feet per min
A = 351.9 ft²
Q = 509 × 351.9 × 60 min/hr = 1,07[illegible]
[illegible] = 179,[illegible]17
[illegible] = 357[illegible]

Average Velocity: #11 Cooling Tower

$\bar{V}$ = 15[illegible]9 [illegible]
A = 219.2 [illegible]
Q = [illegible] [illegible] 21[illegible].2 [illegible] = 1[illegible]
[illegible] = [illegible]
3[illegible] = [illegible]

Average Velocity: [illegible]

$\bar{V}$ = 1331.5 [illegible]
A = 520.8 [illegible]
Q = 1331.5 × 520.8 × [illegible] = [illegible],60[illegible]
[illegible] = 6[illegible]
[illegible] = [illegible]

[illegible]: [illegible]

$\bar{V}$ = 1532 feet per min.
A = 439.9 ft²
Q = 1532 × 439.9 × [illegible] = [illegible]
[illegible] = 673,927 [illegible]
[illegible] = 2,[illegible] [illegible]