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NESHAP — Cooling Towers Chromium

Emission Test Report Exxon Company, U.S.A. Baytown, Texas

EMISSION TEST REPORT

EXXON COMPANY, INC.
BAYTOWN REFINERY
BAYTOWN, TEXAS

ESED 85/02

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Prepared By
Entropy Environmentalists, Inc.
Post Office Box 12291
Research Triangle Park, North Carolina 27709

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EPA Task Manager
Dan Bivins

U.S. Environmental Protection Agency
Emission Measurement Branch
Emission Standards and Engineering Division
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1.0 INTRODUCTION

During the week of September 1, 1986, Entropy Environmentalists, Inc. (Entropy), under contract to the U. S. Environmental Protection Agency, Emission Measurement Branch, conducted an emission measurement program at the Exxon Refinery in Baytown, Texas operated by the Exxon Company, U. S. A. The purpose of the measurement program was to provide data on chromium emissions from cooling towers in support of a possible chromium standard under the National Emission Standards for Hazardous Air Pollutants (NESHAPS).

Comprehensive testing was conducted at two cooling towers located at the Baytown Refinery. Cooling tower No. 68 consists of two sections with two counterflow cells in one section and a crossflow cell in the other section. Both sections of No. 68 are equipped with typical-efficiency drift eliminators. Cooling tower No. 84 consists of four counterflow cells, each equipped with a high-efficiency drift eliminator. These two cooling towers at the Baytown facility were selected for source testing for the following reasons:

- The refinery operates both high-efficiency and typical-efficiency drift eliminators on cooling towers with chromate-based cooling water treatment programs. The test data should provide a basis for comparing the performance of these two drift eliminator types.
- Cooling tower No. 68 has both crossflow and counterflow sections and provides a comparison of emission characteristics from these two types of tower design.
- The facility operates the two cooling towers in a manner considered representative of other industrial cooling towers.
- Operating parameters were easily maintained and monitored during the tests to ensure proper conditions existed.

- The facility agreed to allow the addition of sodium bromide (NaBr) to the cooling tower water for further evaluation of bromide as a surrogate compound for cooling tower drift emissions testing.

The cooling tower emissions were characterized using a Method 13-type impinger train following the draft cooling tower test method (Appendix C) to collect the drift from the cooling tower exhaust. The impinger contents were analyzed by Research Triangle Institute (RTI) for total chromium content by solubilizing the chromium with nitric acid and using graphite furnace atomic absorption (GFAA). The velocity of the airflow through each fan cell was determined using a propeller anemometer following the draft method (Appendix C). The gas temperature and percent moisture were also determined. The corresponding cooling water samples collected during each sampling run were analyzed by RTI for hexavalent chromium using the diphenylcarbazide wet chemical method and by North Carolina State University (NCSU) for total chromium in the filtered residue using Neutron Activation Analysis (NAA). Sampling was also conducted using an "aligned nozzle train" and a "disc train" (see Chapter 4) to determine the percentage of chromium emissions associated with drift particles smaller than a certain particle size (approximately 15 um).

An independent determination of the drift rate and drift size distribution was conducted by personnel from Environmental Systems Corporation (ESC) using their Sensitive Paper (SP) system and microscopic analysis. ESC personnel also conducted the waterflow measurements on the two cooling towers. For this, ESC used calibrated pitot tubes and a methodology similar to EPA Methods 1 and 2 for air velocity measurements.

A sampling protocol using absorbent papers and ion exchange papers in a sensitive paper holder was evaluated as part of an effort to develop a potential screening technique for cooling tower emission testing and to determine the percentage of chromium emissions associated with particles greater than a certain particle size (approximately 30 um). These AP's were analyzed for total chromium content by NCSU using NAA.

Mr. David Randall of Midwest Research Institute (MRI) monitored the operating conditions of the cooling tower and determined when conditions were suitable for sampling. Mr. Dan Bivins (EPA Task Manager) of the Emission Measurement Branch (EMB) was present to observe the testing program. Mr. E. W. Biggers of Exxon Company served as the contact for the Baytown Refinery facility.

This report is organized into several sections that address the various aspects of the testing program. Immediately following this introduction is the "Process Operation" section describing the process involving the cooling tower tested, the cooling tower systems, and the control equipment in each tower. Following the "Process Operation" section is the "Summary of Results" section presenting tables summarizing the test conditions, the calculated emission and drift rates, the drift size distribution, and the analytical results. The next section, "Sampling Locations and Test Methods" describes and illustrates the various sampling locations for the emissions testing program and then explains the sampling strategies used. The final section, "Quality Assurance," describes the procedures used to ensure the integrity of the sampling and analysis program. The Appendices present the Test Results and Example Calculations (Appendix A); Field and Analytical Data (Appendix B); Sampling and Analytical Procedures (Appendix C); Calibration and Quality Assurance (Appendix D); MRI Process Data (Appendix E); and Test Participants and Observers (Appendix F).

2.0 PROCESS OPERATION

2.1 PROCESS DESCRIPTION AND OPERATION

The two towers tested, Nos. 68 and 84, provide cooling for a number of refining processes. Tower No. 68 serves the catalytic light end units which recover ethylene and other light end products. The cooling requirements of the vacuum distillation unit for lube oil provide the main heat load on tower No. 84. Both towers handle a constant heat load 24 hours per day. Figures 2.1 and 2.2 are sketches of tower Nos. 68 and 84, respectively.

2.1.1 Tower 68

Tower Description - This tower consists of four counterflow cells and one Marley crossflow cell. Each cell has one single-speed fan and redwood herringbone drift eliminators. The counterflow section has redwood splash fill and is served by two risers that distribute the water over the fill through a manifold and pressure spray nozzles. The crossflow section has plastic splash fill and is served by one riser that supplies a water distribution deck equipped with gravity flow nozzles. Water flow rates were not known before the test, but pump curves indicate that peak efficiency would be achieved at a flow rate of about 19,500 gallons per minute (gal/min). Two pumps circulate water from the northern end of the common basin to the process heat exchangers, and a third pump is on standby. Blowdown is withdrawn from the system before the water is returned to the tower. Makeup water from the San Jacinto River is supplied through a 4-inch pipeline to the basin. The fans are 18 feet in diameter in the counterflow cells and 24 feet in diameter in the crossflow cell, but the airflows were not known before the test.

SYSTEM DATA

PARAMETER	VALUE
TOWER AGE (ORIGINAL SECTION) YEARS	31
NO. OF FAN CELLS	5
AIRFLOW, dry scfm	
CELLS 1-4, AVERAGE PER CELL	$3.0\text{x}10^{-5}$
CELL 5	$8.9\text{x}10^{-5}$
DIAMETER OF FAN STACKS, ft	
CELLS 1-4	18
CELL 5	24

PARAMETER	VALUE
NO. OF RISERS	3
RECIRCULATING WATER FLOW RATE, gal/min	
RISERS 1 AND 2, EACH	7,300
RISER 3 FOR CELL 5	8,800

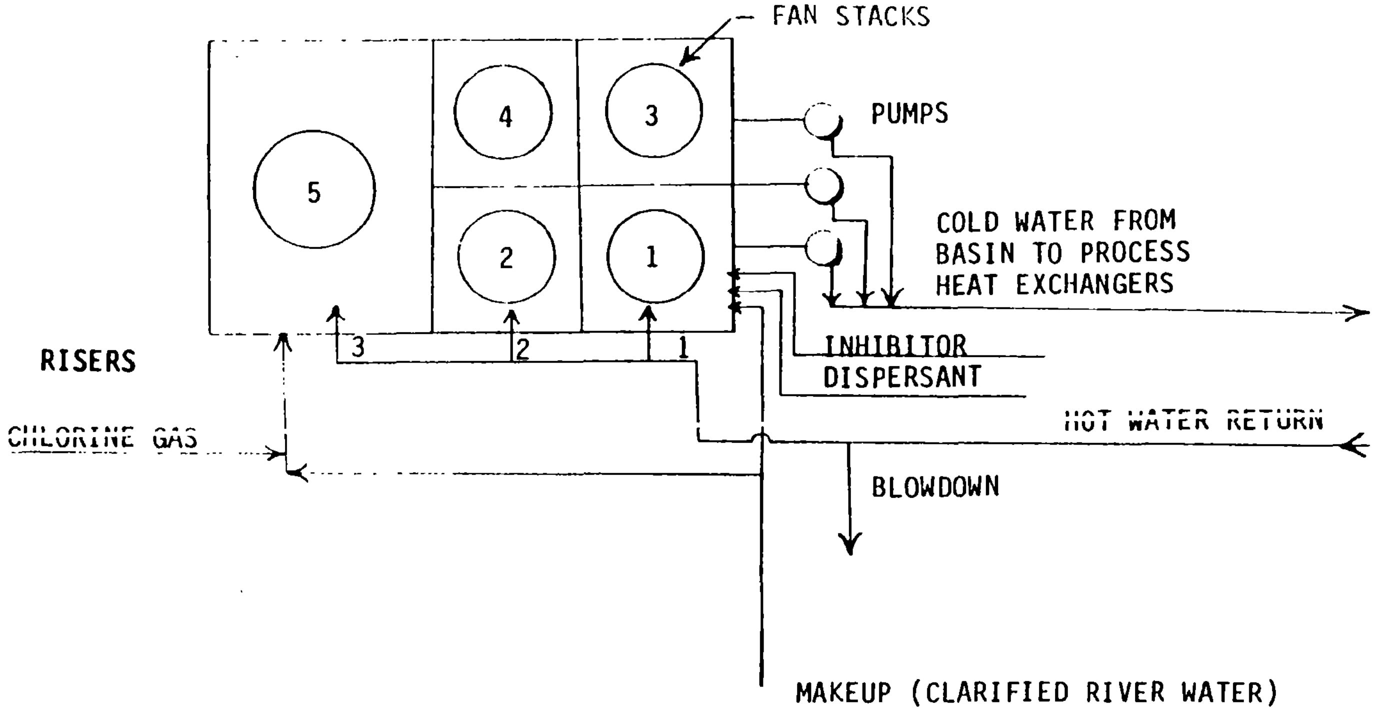
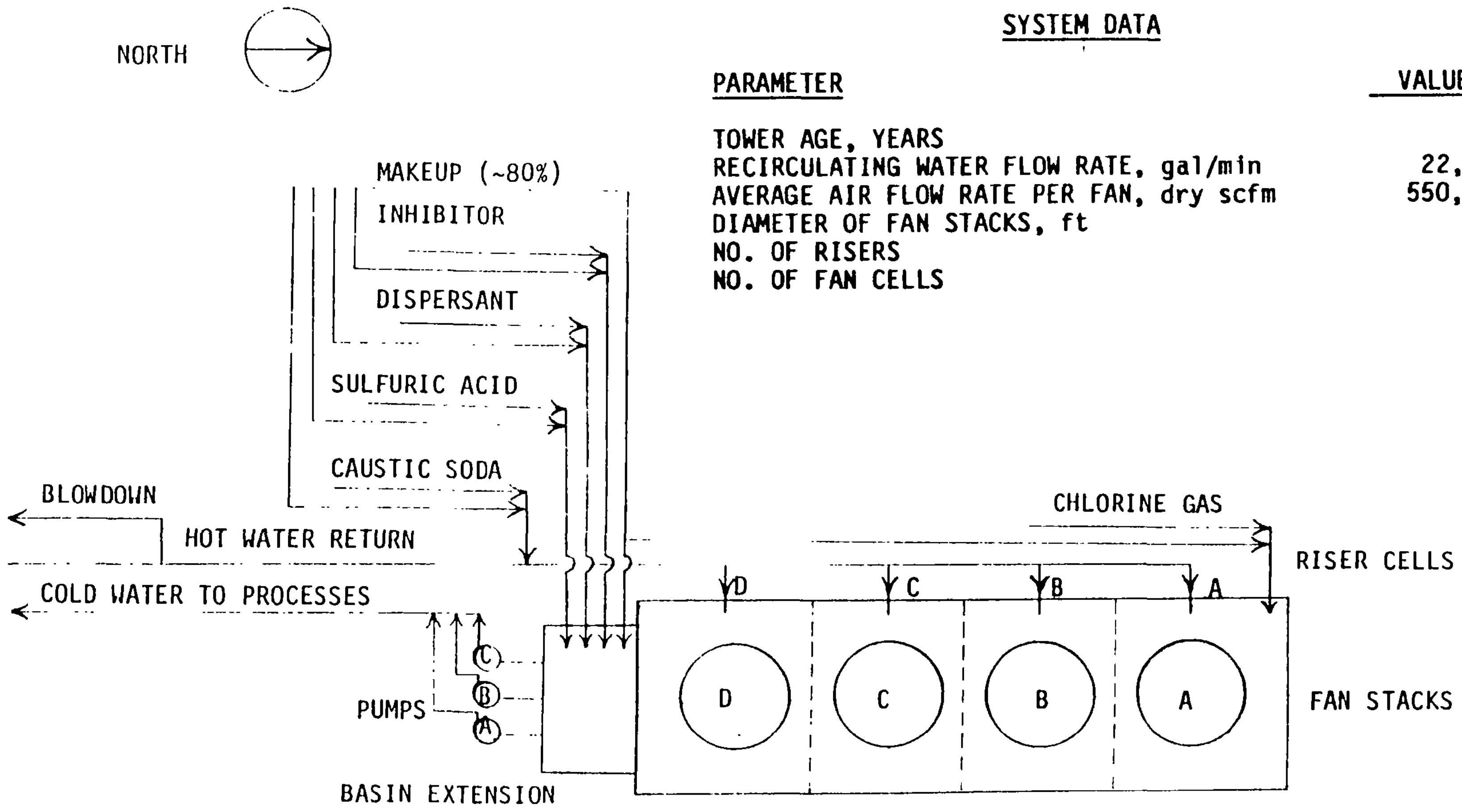


Figure 2.1. Tower 68 at Exxon-Baytown refinery.



SYSTEM DATA

PARAMETER	VALUE
TOWER AGE, YEARS	<1
RECIRCULATING WATER FLOW RATE, gal/min	22,700
AVERAGE AIR FLOW RATE PER FAN, dry scfm	550,000
DIAMETER OF FAN STACKS, ft	22
NO. OF RISERS	4
NO. OF FAN CELLS	4

Figure 2.2. Tower 84 at Exxon-Baytown refinery.

Chemical treatment and monitoring system - The corrosion inhibitor is Betz 10K, which is a chromate/zinc formulation. The target concentration of chromate in the recirculating water is 10 to 15 parts per million (ppm). The solution is added automatically at a rate that is set manually. Dispersant is added automatically at a rate that is set manually. Dispersant is added in the same manner. A free chlorine residual of 0.2 to 0.5 is the target for control of microbiological growth. Chlorine gas is injected into a side stream of the makeup water and added to the southern end of the basin. Both the chromate and free chlorine residual are measured once per shift by the operating personnel and about twice a week by the Betz representative.

The pH of the water is monitored continuously, but it is not used as an automatic controller. When pH exceeds the critical control range of 6.0 to 9.0, it must be corrected by manually adding acid or caustic soda. The ratio of calcium hardness in the recirculating water to that in the makeup water defines the number of cycles of concentration. This value is only used as a general indicator of system operation. Blowdown is dictated by the conductivity, which should not exceed 1,500 micromhos (umhos). Part of the blowdown is discharged through a rotameter, but the capacity of the rotameter is insufficient to provide measurement of the full blowdown flow. Thus, a bypass is used for part of the blowdown discharge. Maximum discharge through both lines (as during the test) generally keeps the conductivity in the control range of 900 to 1,200 umhos. If it is necessary to reduce the blowdown (perhaps because of reduced load, and, therefore, reduced water recirculation), flow through the rotameter or bypass can be reduced. However, if it is necessary to increase the blowdown (because of increased conductivity of the makeup water, for example), a valve in the process area or at the pumps must be opened to increase the discharge.

Operating Conditions During the Testing - The operating parameters that were monitored throughout the test period to ensure that appropriate conditions existed included fan motor amperage, pump outlet pressure, hot water line pressure, water flow in each riser, temperature in each riser, basin water temperature, pH, conductivity, wind speed and direction, and dry bulb temperature. The makeup flow rate was also monitored September 2, and the blowdown was estimated that afternoon. Table 2.1 is a summary of the cooling tower operating parameters and meteorological data recorded during the test period.

On Sunday, August 31, ESC personnel measured the recirculating water flow rates. The flow in the crossflow cell was about 20 percent greater than the flow in each of the counterflow cells. The pump head pressure and the manufacturer's pump curve indicated that the flow should be about 21,500 gal/min, which is 92 percent of the measured flow (23,400 gal/min). Design flow rates for the tower were not available, but the pumps were being operated normally within 90 to 100 percent of the design flow and near peak efficiency. The amperage required by the fans was constant, although different among the four fans, and the fans were also operating normally. Therefore, no changes were made to the air or water flow rates for the test.

The drift eliminator on one side of the crossflow cell was determined to be in good condition on the visual inspection through the doorway at one end of the tower. The drift eliminators in the counterflow cells could not be inspected, but the quantity of drift out of each stack appeared similar although it may have been slightly less from cell No. 1. The quantity of steam (presumably a combination of drift and condensed water vapor) rising from cell No. 1 also appeared to be slightly less than that from the other cells. Some of the nozzles in the distribution deck on cell No. 5 were plugged, and a few of the redwood slats in the lower sections of the counterflow cells were broken; however, the overall condition of the tower was reasonably good.

TABLE 2.1. SUMMARY OF OPERATING PARAMETERS AND METEOROLOGICAL DATA DURING TESTING OF TOWER 68

Parameter	Pretest	Test series No. 1	Test series No. 2
Date	08/31/86	09/01/86	09/02/86
Recirculating water flow, gal/min[a]			
Riser 1	7,307		
Riser 2	7,260		
Riser 3	8,827		
Fan amperage, amps			
Cell 1		85	84-85
Cell 2		90	89-90
Cell 3		78	77-78
Cell 4		90	90
Cell 5		120	120
Pump outlet pressure, psig			
Pump 3		80	80
Pump 3B		80	80
Hot water line pressure, psig		28	28
Water temperature, °F			
Basin 1/3		82-85.5	83-85
Basin 2/4		85	83-84.5
Basin 5		83-85.5	83-85
Hot water line, °F		99.5-102	100-102
Riser 1		100-102	--
Riser 2		-103	--
Riser 3		100-102	101-102
Makeup water flow, gal/min			~325
Blowdown, gal/min			~70
Water chemistry on-line monitor			
pH		7.87-7.96	7.90-8.04
Conductivity, μmhos		1,029-1,056	1,026-1,038
Operator analysis			
pH		7.7	7.9-8.1
Conductivity, μmhos		1,000-1,057	1,022-1,035
Free chlorine, ppm		0.2	0-0.1
Chromate, ppm		12	13-14

(continued)

TABLE 2.1. (continued)

Parameter	Pretest	Test series No. 1	Test series No. 2
Vendor analysis[b]			
pH			7.9
Conductivity, μmhos			1,020
m-alkalinity, ppm			80
Chromate, ppm			14
Free chlorine, ppm			0
Calcium, ppm			226
Cycles			5.9
Chromate inhibitor feed rate, gal/d			4.0
Meteorological data at tower			
Wind speed, mph		4-25	1-20
Wind direction, 00-360		180-360	Unknown
Ambient temperture, °F		-89	87-91
Meteorological data at Exxon station			
Wind speed, mph		5-12	7-14
Wind direction, 00-360		90-180	90-180
Ambient temperature, °F		77.8-86.4	84-86

[a] As determined by ESC.
[b] Vendor analysis only performed on date of second test series.

Water meters are not installed on the makeup and total blowdown lines. To estimate these flows, alternative methods were attempted. On September 3, 1986, a meter was connected to the pressure taps on an existing orifice plate in the makeup line. This indicated an average flow of about 280 gal/min over the 6 hours of monitoring (greater in the afternoon than in the morning), but did not include the 15 to 20 gal/min diverted for chlorine injection or the amount leaking through a valve into the system from a nearby tower. That tower (No. 58) is treated with a phosphate inhibitor from Calgon. The Betz representative used the phosphate concentration in the recirculating water of tower No. 68 to calculate a gain of about 25 gal/min. The Calgon representative estimated the loss from tower No. 58 to be about 100 to 150 gal/min. The Betz calculation is probably more accurate, since Calgon only made a rough estimate of the difference in blowdown from tower No. 58 on Friday, September 5, from the blowdown earlier in the year without the benefit of a meter on the blowdown line. (Later work by Exxon confirmed that the Betz estimate was correct.)

To estimate the tower No. 68 blowdown, the combined flow through the rotameter and bypass was diverted to a 55-gallon drum. The time to fill the drum a couple of times was recorded. This produced a flow rate within 20 percent of the estimate calculated by the Betz representative based on cycles of concentration and an estimate of evaporation.

Water temperatures also are not monitored by online equipment. Therefore, fittings were attached to taps on the three risers and the hot water return line itself. Mercury-in-glass thermometers were used to record the temperature. The basin temperature was determined about 5 feet from the basin wall below cell Nos. 1, 2, and 5. A mercury-in-glass thermometer was placed in a perforated can that was attached to a length of conduit. With this method, it was not possible to determine the actual temperature drop in each cell, but the average basin temperature in all three locations was the same.

Two sources of meteorological data were available: one station set up at the tower and one maintained by Exxon refinery personnel less than a mile from the tower. Both stations indicated that the wind direction was from the southeast, and very few directional changes deviated more than 45 degrees from the southeast. Both average and peak wind speeds, however, were considerably higher at the tower station. Other than instrument calibration differences, the reason for this is not clear. There may have been a slight tunneling effect created at the tower station where the wind had to pass between the cooling tower and a cryogenic process column (and other shorter equipment) 30 to 40 yards downwind of the station. Gusts rarely exceeded 15 mph, and drift was never visible from the side of the crossflow tower. The ambient temperature also varied between the stations. The actual temperature is probably that obtained at the tower site since the several thermometers that were used recorded the same levels.

On Friday, August 29, 1986, the Exxon process personnel responsible for the tower disconnected the chlorine injection line to preclude any possible adverse health effects on test personnel. Chlorine will also react with most hydrocarbons. Thus, a decrease in the free chlorine residual concentration (normally determined once per shift) is the best indicator of a process fluid leak into the water. Alternatively, gas traps on the hot water return line, visual inspection of the surface of the water in the basin and the distribution deck of cell No. 5, and the chromate concentration were used to confirm that the process heat exchangers were not leaking. The chromate concentration, as determined by the operators each shift, was essentially constant and within the desired control range during the testing period. The Betz analysis on Tuesday, September 2, agreed with that of the operators. The pH and conductivity were also within control ranges.

2.1.2 Tower 84

Tower Description - The tower is a 4-cell (riser and fan) Marley counterflow design with one 22-ft diameter constant-speed fan per cell. The average airflow per fan as measured by Entropy was about 550,000 dry standard cubic feet per minute (dscfm). Each cell is equipped with PVC film fill and a high-efficiency Marley XCEL-15 drift eliminator. Water is distributed over the fill through a manifold and spray nozzles. Two pumps circulate the water from the basin extension at the south end of the tower through the process heat exchangers. A recent potassium retention time study determined that the system volume was about 550,000 gallons of water.

Blowdown is designed to be controlled by the conductivity of the recirculating water. At certain set points, a valve is actuated in a line off the main hot water return. Most of the makeup water is supplied through a 6-inch pipe to the basin extension, but part of it is diverted continuously into five smaller lines. The inhibitor, dispersant, chlorine, sulfuric acid, and caustic soda are injected into the smaller lines automatically.

Chemical Treatment and Monitoring System - The corrosion inhibitor, Nalco 7374, is a chromate/zinc formulation in a 7:1 ratio. The target concentration in the recirculating water is 8 to 12 ppm. The solution is injected into one of the small makeup lines for a specific fraction of every 10-minute interval. The on/off time fraction can be changed by entering new values into the computer memory. The dispersant is injected into another makeup line in an identical manner. Acid and caustic are injected based on pH set points within the control range of 6.8 to 7.5. Chlorine gas is injected continuously at a rate controlled by a free chlorine residual monitor that is generally set to keep the concentration in the range of 0.3 to 0.5. For this system, the ratio of the conductivity of the recirculating water to that of the makeup water defines the number of cycles of concentration. The conductivity of the makeup water is about 150 umhos, and the control range for the number of cycles is 6 to 8.

Operating conditions during the testing - The tower is operating at less than design capacity, but in July 1986 full-time operation began. The following operating parameters were monitored throughout the test period to ensure that appropriate conditions existed: (1) fan motor amperage, (2) pump outlet pressures, (3) cold water line pressure, (4) water flow in each riser, (5) temperature in three of the risers, (6) basin temperature, (7) temperature in pump inlet lines, (8) pH, (9) conductivity, (10) wind speed and direction, and (11) dry bulb temperature. The computerized system that monitors inlet and outlet temperatures and the makeup, blowdown, and recirculating water flow rates was not calibrated correctly at the start of the test. With the exception of the blowdown, attempts at calibration were not successful. These problems are not considered to affect the amount of drift, and only the makeup and blowdown could not be monitored directly by the test personnel. Table 2.2 is a summary of the cooling tower operating parameters and meteorological data recorded during the test period.

On Wednesday, September 3, 1986, ESC personnel measured the water flow rates in each riser and found the flow in Risers A and B to be about 15 percent less than the flow in Risers C and D. The total flow was 25 percent greater than the tower design, and 20 percent greater than the pump ratings. From the pump head pressure and the manufacturer's pump curves, it was calculated that the flow should be about 20,600 gal/min. The measured rate was about 10 percent greater than this calculated rate. As scale and fouling increase, and with additional process heat loads, the head pressure will increase slightly and cause a decrease in the flow rate. The conditions as measured (and with

TABLE 2.2. SUMMARY OF OPERATING PARAMETERS AND METEOROLOGICAL DATA DURING TESTING OF TOWER 84

Parameter	Pretest	Test series No. 1	Test series No. 2
Date	09/03/86	09/04/86	09/05/86
Recirculating water flow, gal/min[a]			
Riser A	5,300		
Riser B	5,200		
Riser C	6,100		
Riser D	6,100		
Fan amperage, amps			
Cell A	60	60	60
Cell B	60	60	60
Cell C	60	60	60
Cell D	63	63	63
Pump outlet pressure, psig			
Pump 84A		80	80
Pump 84B		80	80
Cold water line pressure, psig			
Water temperature, °F			
Basin		-85	84-85
Line to pump 84A		82-83	82-83
Line to pump 84B		82-83	82-83
Riser A		99.5-100	98.5-100
Riser C		99.5-100	98.5-100
Riser D		99.5-100	98.5-100
Makeup flow rate, gal/min			
Blowdown, gal/min			
Water chemistry on-line monitoring			
pH		6.8-7.1	6.8-7.0
Conductivity, µmhos		Unknown	Unknown
Free chlorine, ppm		0.35-0.57	0.15-0.30
Operator analysis			
pH		7.25	7.0
Conductivity, µmhos		1,200	1,100
Makeup conductivity, µmhos		160	150
Chromate, ppm		12.5	12.5

(continued)

TABLE 2.2. (continued)

Parameter	Pretest	Test series No. 1	Test series No. 2
Vendor analysis[b]			
pH			6.9
Free chlorine, ppm			0.2
Chromate, ppm			12.5
Conductivity, μmhos			1,100
Cycles			7.3
Chromate feed rate, gal/d			3.0
Meteorological data at tower			
Wind speed, mph		3-22	4-18
Wind direction, 00-360		270-360	270-360
Ambient temperature, °F		-92	84-91
Meteorological data at Exxon station			
Wind speed, mph		5-10	1-5
Wind direction, 00-360		90-110	120-180
Ambient temperature, °F		86-87	-86-

[a]As determined by ESC.
[b]Vendor analysis only performed on date of second test series.

all the fans running) represented normal operation. Therefore, no attempt was made to even the flow in the risers or to reduce the overall flow to the designed rate.

The drift eliminators could be inspected through a porthole in the fan stack below the fan. The drift eliminator in Cell A is assumed to have at least one defect because entrained droplets were observed periodically in the same area of the stack. The other drift eliminators appeared to be in good condition. The water distribution through the fill was even, although it did cascade along some vertical beams at a greater rate than along others.

The quantity of blowdown was not easily determined because the conductivity control was not working and the valves in the line were closed. Also, recirculating water can be withdrawn from the system in the process area for general ground cleaning purposes. The operators, however, indicated that they had not been using any of this water on the test days. Finally, a water balance on the process side of the overhead vacuum condensers indicated an excess of about 50 gal/min. This is just about the amount that the Nalco representatives calculated for the blowdown based on the cycles of concentration and an estimation of the evaporation loss. An analysis of the process fluid for chromate was negative. The makeup could not be monitored because of the inaccurate calibration.

The recirculating water temperature was measured with mercury-in-glass thermometers in fittings attached to taps in three of the risers. The basin temperature was determined with a mercury-in-glass thermometer at the intersection of the main basin and the basin extension. The temperatures indicated by gauges on the lines to the pumps were also recorded; they were always 2 degrees lower than the thermometer reading.

As with tower No. 68, meteorological data were available both at the tower site and from the Exxon meteorological station almost a mile away. The wind direction continued to be steady from the southeast, and the wind speeds were higher on the chart recorder at the tower station. At this site, there were no obstructions around the station except for the tower itself.

The operator log of the chromate concentration in the recirculating water was constant at the upper limit of the control range over a 2-day test period. The concentration agreed with that obtained by the Nalco representative on August 29. The pH, conductivity, and free chlorine residual were also within the control ranges.

Possible Effects on Drift Measurements - Several conditions discussed above could have an effect on the drift measurements; each is considered below.

1. The recirculating water flow through tower No. 84 is higher than design, which may result in a higher rate of drift than would be produced if the tower were operating at the designed rate (and at a higher temperature range). Comparison of drift measurement from Cell B (5,200 gal/min) with measurements from Cells C and D (6,100 gal/min) should confirm this. However, the current operating conditions are not an operating problem, and there is no incentive to modify them.
2. The rate of drift from Cell A in tower No. 84 is likely to be higher than that from Cell B because of the apparent defect in the drift eliminator of Cell A.

3.0 SUMMARY OF RESULTS

Tests were conducted to determine the mass emission rates of hexavalent chromium and total chromium from cooling tower Nos. 68 and 84 at Exxon Company's Baytown Refinery in Baytown, Texas. Four of the cells on tower No. 68 (fan cells No. 1-4) were counterflow cells and were served by two risers. Fan cell No. 5 was a crossflow type and had its own riser. Because of its configuration, tower No. 68 was treated as two separate towers for testing purposes and represented: 1) a counterflow tower with standard-efficiency drift eliminators and 2) a crossflow tower with a standard-efficiency drift eliminator. Tower 84 was a counterflow tower with a high-efficiency drift eliminators. The mass emission rate tests used a Method 13-type impinger train to sample the five fan stacks on three riser cells on tower No. 68 and the four fan stacks on four riser cells on No. 84. The testing schedules that were followed for the Exxon cooling towers are presented in Tables 3.1A and 3.1B. The results of these tests are discussed briefly below and in detail in Section 3.1.

The pollutant mass emission rates for hexavalent chromium, calculated by the ratio of areas (PMR_a) method, for the counterflow cells on tower No. 68 ranged from 275 to 25,000 milligrams per hour (mg/hr), for the crossflow cell on tower No. 68 ranged from 2,500 to 58,500 mg/hr, and for the four riser cells on tower No. 84 ranged from 210 to 9,900 mg/hr. As is evident, the pollutant mass emission rates measured for hexavalent chromium were highly variable from run to run even for runs conducted on the same cell. Measured emission values for the same cell showed, in most cases, a 10- to 50-fold difference. However,

TABLE 3.1 A. TESTING SCHEDULE FOR COOLING TOWER 68 AT EXXON COMPANY, INC, BAYTOWN REFINERY

Date (1986)	Sample Type	Riser Cell E Fan Cells 1 and 4 (Counterflow Cell)		Riser Cell F Fan Cells 2 and 3 (Counterflow Cell)		Riser Cell G Fan Cell 5 (Crossflow Cell)	
		Run No.*	Test Time 24 h clock	Run No.*	Test Time 24 h clock	Run No.*	Test Time 24 h clock
9/1	Chromium	68-1-1	1109-1326				
	Chromium			68-2-1	1417-1628		
	Chromium					68-5-1	1050-1328
	Chromium					68-5-2	1400-1631
	Particle Size	68-DI-1	1145-1345	68-DI-1	1354-1554		
	Particle Size	68-NZ-1	1145-1345	68-NZ-1	1354-1554		
9/2	Chromium			68-3-1	0933-1138		
	Chromium	68-4-1	1229-1446				
	Chromium					68-5-3	1033-1302
	Particle Size			68-DI-2	0950-1351		
	Particle Size			68-NZ-2	0950-1351		
9/3	Particle Size					68-DI-3	0910-1310
	Particle Size					68-NZ-3	0910-1310

TABLE 3.1 B. TESTING SCHEDULE FOR COOLING TOWER 84 AT EXXON COMPANY, INC, BAYTOWN REFINERY

Date (1986)	Sample Type	Riser Cell A		Riser Cell B		Riser Cell C		Riser Cell D	
		Run No.*	Test Time 24 h clock	Run No.*	Test Time 24 h clock	Run No.*	Test Time 24 h clock	Run No.*	Test Time 24 h clock
9/4	Chromium	84-A-1	0950-1200						
	Chromium	84-A-2	1230-1441						
	Chromium					84-C-1	0953-1207		
	Chromium					84-C-2	1224-1442		
	Particle Size							84-DI-4	1010-1410
	Particle Size							84-NZ-4	1010-1410
9/5	Chromium			84-B-1	0850-1100				
	Chromium			84-B-2	1130-1340				
	Chromium							84-D-1	0835-1043
	Chromium							84-D-2	1104-1317
	Particle Size	84-DI-5	820-1220						
	Particle Size	84-NZ-5	820-1220						

Run numbers for chromium runs indicate: Cooling Tower - Riser or Fan Cell - Run.
Run numbers for particle size runs indicate: Cooling Tower - Technique - Run.

when simultaneous runs which were conducted on different cells were compared, the mass emission rate values typically showed only a 1- to 5-fold difference. This indicates that cooling tower chromium emissions may vary widely with time and/or ambient conditions.

The drift size distribution (drift being defined here as cooling water entrained in the exit air and emitted to the atmosphere in droplet form), along with the drift rate, was determined by Environmental Systems Corporation (ESC) using their sensitive paper (SP) technique. The results of the SP testing suggest that the drift emissions from the counterflow fan cells on tower No. 68 had an average mass mean diameter of 290 um; from the crossflow cell on tower No. 68, an average mass mean diameter of 360 um, and from the counterflow cells on tower No. 84, an average mass mean diameter of 235 um.

Another particle sizing method was evaluated for determining the percent of hexavalent chromium in particles smaller than a certain size (approximately 15 um under these sampling conditions). The sampling protocol involved using a set of paired trains; one, referred to as the "disc train," was designed to capture only the smaller particles (less than 15 um) and the other, a Method 13-type train with the nozzle aligned directly into the flow of the fan exhaust (referred to as the "aligned nozzle train"), was designed to capture all sizes of drift particles. Data from two screening techniques being evaluated utilizing absorbent paper (AP) and ion exchange paper (XP) were also used for particle sizing purposes. The AP and XP data were used based on collection (under these sampling conditions) of particles greater than approximately 30 um in diameter.

The paired train particle sizing data suggest that most of the hexavalent chromium emissions from the fan cells tested on the two towers are associated with particles less than 15 um. The data from the paper collection techniques for these cells suggest that 1.0 to 15.1 percent of the chromium emissions from the standard-efficiency drift eliminators and 1.0 to 2.9 percent from the high-efficiency drift eliminators are associated with particles greater than 30 um. The particle sizing results and the differences between the two methods are discussed in detail in Section 3.2.

The analytical results for hexavalent chromium and residue (trivalent) chromium in the cooling water samples and the total chromium in the impinger samples are presented in Section 3.3 along with the analytical results for the blanks and the quality assurance samples. The results of the analysis of the absorbent papers and ion exchange papers, which are being evaluated as screening techniques for cooling tower emissions, are also presented in Section 3.3, and the techniques are discussed in Section 3.4.

Drift rate calculations based on the water flow to the riser cells, the concentration of chromium in the cooling water, and the mass emission rates calculated from the impinger train samples and the AP and ion exchange paper samples are presented in Section 3.5. Drift rate calculations from the SP data are also presented and the drift rates calclulated by the various methods are compared.

3.1 HEXAVALENT CHROMIUM AND TOTAL CHROMIUM EMISSIONS

The mass emission rates for hexavalent chromium and total chromium for the nine fan cells on the two towers were determined. Sampling was conducted isokinetically with the isokinetic values for the fifteen sampling runs ranging from 99.7% to 109.5% (see Table 3.2). The sampling runs were typically 2 hours in length, with a single traverse on each fan stack cell comprising a single sample; for fan cell 5 on tower 68, which was treated as a separate tower, two perpendicular traverses were conducted. Stack gas conditions were calculated assuming that the exhaust was saturated.

TABLE 3.2. SUMMARY OF FLUE GAS CONDITIONS

Run No.	Date (1986)	Test Time 24 h clock	Volumetric Flow Rate: Actual[a] acmh x 10^6	Actual[a] acfh x 10^6	Standard[b] dscmh x 10^6	Standard[b] dscfh x 10^6	Stack Temperature °C	Stack Temperature °F	Moisture %	Isokinetic %
Tower 68, Riser Cells E and F										
68-1-1	9/1	1109-1326	0.576	20.35	0.543	19.19	28.9	84.1	3.9	104.0
68-4-1	9/2	1229-1446	0.542	19.15	0.502	17.74	31.7	89.0	4.6	103.6
68-2-1	9/1	1417-1623	0.508	17.93	0.474	16.73	30.8	87.5	4.3	99.7
68-3-1	9/2	0933-1138	0.558	19.72	0.513	18.10	33.2	91.8	5.0	104.9
Average			0.55	19.3	0.51	17.9	31.2	88.1	4.5	
Tower 68, Riser Cell G										
68-5-1	9/1	1050-1328	1.569	55.39	1.470	51.92	30.0	86.0	4.1	102.9
68-5-2	9/1	1400-1631	1.673	59.07	1.552	54.81	31.7	89.1	4.6	102.0
68-5-3	9/2	1033-1302	1.636	57.76	1.524	53.81	30.7	87.3	4.3	102.8
Average			1.63	57.4	1.52	53.5	30.8	87.5	4.3	
Tower 84, Riser Cell A										
84-A-1	9/4	0950-1200	1.038	36.67	0.959	33.86	33.1	91.5	4.9	109.5
84-A-2	9/4	1230-1441	1.054	37.23	0.985	34.80	31.0	87.9	4.4	111.5
Average			1.05	37.0	0.97	34.3	32.1	89.7	4.6	
Tower 84, Riser Cell B										
84-B-1	9/5	0850-1100	1.084	38.29	1.001	35.34	32.6	90.6	4.8	105.9
84-B-2	9/5	1130-1340	1.123	39.66	1.036	36.60	32.6	90.8	4.8	107.7
Average			1.10	39.0	1.02	36.0	32.6	90.7	4.8	
Tower 84, Riser Cell C										
84-C-1	9/4	0953-1207	0.995	35.15	0.915	32.32	34.1	93.4	5.2	106.1
84-C-2	9/4	1224-1442	0.994	35.10	0.917	32.40	33.5	92.4	5.0	106.8
Average			0.99	35.12	0.92	32.36	33.8	92.9	5.1	
Tower 84, Riser Cell D										
84-D-1	9/5	0835-1043	0.952	33.60	0.881	31.12	32.4	90.3	4.8	102.5
84-D-2	9/5	1104-1317	0.868	30.66	0.798	28.17	33.7	92.7	5.1	104.0
Average			0.91	32.1	0.84	29.6	33.0	91.5	5.0	

The hexavalent chromium emissions in the drift were calculated using the values for the total chromium emissions and the ratio of hexavalent-to-total chromium in the cooling water. The assumption was made that the chromium emissions from the cooling tower fan stack maintained the same ratio of hexavalent-to-total chromium measured in the cooling water.

The concentration of hexavalent and total chromium emissions, in milligrams per dry standard cubic meter (mg/dscm), micrograms of chromium per gallon of cooling water flow through the tower for that fan cell (ug/gal), and milligrams per million Btu's of heat removed (mg/10^6 Btu), and the mass emission rates of hexavalent and total chromium, in milligrams per hour (mg/hr) are presented in Table 3.3 for each sampling run. These results are based on the total chromium analysis conducted by RTI using GFAA with the hexavalent chromium values calculated using the ratio of hexavalent-to-total chromium in the cooling water sample for that run. The hexavalent and total chromium values are representative of the emissions from a single fan stack on the corresponding riser cell. The mass emission rates were calculated using the ratio of the fan stack area to the sampling nozzle area, the catch weight of total chromium or the calculated catch weight of hexavalent chromium, and the sampling time (see Appendix A for example calculations).

3.1.1 Tower 68, Counterflow Fan Cells, Standard-Efficiency Drift Eliminators

Flue Gas Conditions - A summary of the flue gas conditions for the counterflow fan cells tested on tower No. 68 is presented at the top of Table 3.2. The volumetric flow rates were fairly constant for all four fan cells and averaged 550,000 actual cubic meters per hour (19,300,000 actual cubic feet per hour). The stack temperature for these fan cells averaged 31°C (88°F) and the moisture content averaged 4.5%. The isokinetic sampling rates were well within the allowable limits for all four runs.

TABLE 3.3. SUMMARY OF HEXAVALENT AND TOTAL CHROMIUM EMISSIONS BASED ON GRAPHITE FURNACE ATOMIC ABSORPTION (GFAA)

Run No.	Date	Hexavalent Chromium				Total Chromium			
		concentration			mass emissions	concentration			mass emissions
		(mg/dscm) x 10^{-3}	ug/gal	mg/10^6 Btu	mg/hr	(mg/dscm) x 10^{-3}	ug/gal	mg/10^6 Btu	mg/hr
Standard-Efficiency, Counterflow Tower 68, Riser Cell E									
1-1	9/1	44.36	99.63	257.8	25,060	44.49	99.91	258.5	25,130
4-1	9/2	0.528	1.09	2.8	275	0.528	1.09	2.8	275
Standard-Efficiency, Counterflow Tower 68, Riser Cell F									
2-1	9/1	8.713	19.54	48.7	4,115	8.713	19.54	48.7	4,115
3-1	9/2	0.983	2.51	5.8	528	0.991	2.53	5.9	533
Standard-Efficiency, Crossflow Tower 68, Riser Cell G									
5-1	9/1	38.69	136.40	261.5	58,560	38.69	136.40	261.5	58,560
5-2	9/1	4.61	17.00	28.6	7,300	4.61	17.00	28.6	7,300
5-3	9/2	1.63	5.94	10.1	2,550	1.63	5.94	10.1	2,550
High Efficiency, Counterflow Tower 84, Riser Cell A									
A-1	9/4	4.042	14.02	28.0	4,244	4.065	14.10	28.2	4,269
A-2	9/4	0.389	1.41	2.5	427	0.402	1.46	2.6	441
High-Efficiency, Counterflow Tower 84, Riser Cell B									
B-1	9/5	0.650	2.16	4.4	689	0.652	2.17	4.4	691
B-2	9/5	0.205	0.72	1.2	229	0.206	0.72	1.2	230
High-Efficiency, Counterflow Tower 84, Riser Cell C									
C-1	9/4	8.665	23.18	58.3	8,418	8.993	24.06	60.5	8,737
C-2	9/4	0.373	1.01	2.3	365	0.375	1.01	2.3	368
High-Efficiency, Counterflow Tower 84, Riser Cell D									
D-1	9/5	0.232	0.58	1.4	210	0.234	0.58	1.4	211
D-2	9/5	11.927	27.14	68.1	9,898	11.957	27.21	68.3	9,923

Hexavalent Chromium Emissions - A summary of the hexavalent chromium emission values for the test runs conducted on the four counterflow fan cells on tower No. 68 is presented in Table 3.3. The hexavalent chromium concentrations for the four fan cells were quite variable and ranged from 0.0005 to 0.044 milligrams per dry standard cubic meter of exhaust gas, 1.1 to 100 micrograms per gallon of water flow to the fan cells, and 2.8 to 258 milligrams per million Btu's of heat removed from the water. The mass emission rates of hexavalent chromium for the four cells ranged from 275 to 25,100 milligrams per hour.

Total Chromium Emissions - The total chromium emissions for each test run on the counterflow fan cells on tower No. 68 (see Table 3.3) were also variable, but were consistent with the corresponding hexavalent chromium emissions. The total chromium emission concentrations ranged from 0.0005 to 0.044 milligrams per dry standard cubic meter, 1.1 to 100 micrograms per gallon of water flow, and 2.8 to 259 milligrams per million Btu's removed. The mass emission rates for total chromium ranged from 275 to 25,100 milligrams per hour.

3.1.2 Tower 68, Crossflow Fan Cell, Standard-Efficiency Drift Eliminators

Flue Gas Conditions - The flue gas conditions for fan cell #5 (crossflow) on tower No. 68 are presented in Table 3.2. The volumetric flowrates for all three runs conducted on this cell were consistent and averaged 1,630,000 actual cubic meters per hour (57,400,000 actual cubic feet per hour). The stack temperature averaged 31°C (88°F) and the moisture content averaged 4.3%. The isokinetic sampling rates were well within the allowable range for all three runs.

Hexavalent Chromium Emissions - The summary of hexavalent chromium emission values for the crossflow fan cell on tower No. 68 is presented in Table 3.3. As for the counterflow cells, the hexavalent chromium concentrations for the three runs on the crossflow section of tower No. 68 were variable. They ranged from 0.0016 to 0.039 milligrams per dry standard cubic meter, 5.9 to 136 micrograms per gallon of water flow, and 10.1 to 262 milligrams per million Btu's of heat removed. The mass emission rates of hexavalent chromium ranged from 2550 to 58,600 milligrams per hour.

Total Chromium Emissions - The total chromium emissions for the crossflow fan cell are also presented in Table 3.3. The total chromium emission concentrations for the runs on this fan cell ranged from 0.0016 to 0.039 milligrams per dry standard cubic meter, 5.9 to 136 micrograms per gallon of water flow to the fan cell, and 10.1 to 262 milligrams per million Btu's of heat removed. The mass emission rates of total chromium ranged from 2550 to 58,600 milligrams per hour.

3.1.3 Tower 68, Simultaneous Runs - When examined as whole and cell by cell, the hexavalent chromium emissions for tower No. 68 are extremely variable from run-to-run. However, comparison of the emission values for those runs conducted simultaneously (1-1 and 5-1, 2-1 and 5-2, and 3-1 and 5-3) reveals a distinct correlation. For example, there is a 91-fold difference between the two mass emission rates calculated for riser cell E (Runs 1-1 and 4-1) and only a 2.3-fold difference between the mass emission rates for the two runs conducted simultaneously (1-1 and 5-1) on riser cells E and G. Similar comparisons show 8- and 23-fold differences in the mass emission rates for the runs for riser cells F and G, respectively, and only 1.8- and 4.8-fold differences for the two pairs of simultaneous runs (2-1 and 5-2, and 3-1 and 5-3, respectively) conducted on these two riser cells.

3.1.4 Tower 84, Counterflow Fan Cells, High-Efficiency Drift Eliminators

Flue Gas Conditions - The flue gas conditions for the four pairs of runs conducted on the four counterflow fan cells with high-efficiency drift eliminators on tower No. 84 are presented in Table 3.2. The volumetric flowrates for all runs on all four cells were fairly consistent and averaged 1,010,000 actual cubic meters per hour (35,800,000 actual cubic feet per hour). For these four cells, the stack temperature averaged 33°C (91°F) and the moisture content averaged 4.9%. The isokinetic sampling rates for all eight runs were well within the acceptable range.

Hexavalent Chromium Emissions - A summary of the hexavalent chromium emissions for the test runs conducted on tower No. 84 is presented in Table 3.3. The hexavalent chromium emission concentrations for the four cells on the tower were again variable and ranged from 0.0002 to 0.012 milligrams per dry standard cubic meter, 0.7 to 27 micrograms per gallon of water flow, and 1.2 to 68 milligrams per million Btu's of heat removed. The mass emission rates of hexavalent chromium for the four cells ranged from 230 to 9,900 milligrams per hour.

Total Chromium Emissions - The total chromium emissions for the fan cells on tower No. 84 are also presented in Table 3.3 and were consistent with the corresponding hexavalent chromium emissions. The total chromium emission concentrations emitted by the four cells ranged from 0.0002 to 0.012 milligrams per dry standard cubic meter, 0.7 to 27 micrograms per gallon of water flow, and 1.2 to 68 milligrams per million Btu's of heat removed. The mass emission rates of total chromium from the fan cells on this tower ranged from 230 to 9,900 milligrams per hour.

3.1.5 Tower 84, Simultaneous Runs - Like tower 68, when examined as a whole and cell by cell, the hexavalent chromium emissions for tower 84 are extremely variable. Comparison of simultaneous runs (A-1 and C-1, A-2 and C-2, B-1 and D-1, and B-2 and D-2), however, yields much less variability. Comparison of the hexavalent chromium emission values for the pairs of runs conducted on riser cells A and C show a 10- and a 23-fold difference, respectively. However, comparison of the values for the simultaneous runs conducted on the same two fan cells show only 2- and 1.2-fold differences. In a similar manner, comparison of the values for the pairs of runs conducted on cells B and D yield 3- and 47-fold differences, while comparison of values for the simultaneous runs on the same two cells show differences of 3.3- and 43-fold.

3.2 SIZE DISTRIBUTION OF DRIFT AND CHROMIUM

3.2.1 Size Distribution of Drift

The drift size distribution and the drift rates were measured by ESC, using their sensitive paper (SP) technique, for each fan cell tested by Entropy. The total flux, the mean particle diameter for mass and particle count, the mass emission rate, and a drift rate expressed as a percent of water flow to the fan cell are presented in Table 3.4 for each of the nine fan stacks tested. The drift rates calculated using the SP data as a percent of water flow averaged 0.007% for the counterflow cells on tower No. 68, 0.005% for the crossflow cell on tower No. 68, and 0.0007% for the counterflow cells on tower No. 84.

The mass mean diameter of the drift is that particle diameter at which half the drift mass is composed of particles with diameters larger than the mean diameter and half the mass is composed of particles with diameters smaller than

TABLE 3.4. SUMMARY OF SENSITIVE PAPER (SP) DRIFT SIZE DATA

Date	Total Flux		Mean Diameter		Mass Emission Rate*	Water Flow	Drift Rate
	mass $(ug/m^2/sec) \times 10^4$	count $(\#/m^2/sec) \times 10^7$	mass (um)	count (um)	(grams/hr)	(gpm)	
Cooling Tower 68, Riser Cell E, Fan Cell 1							
9/1	52.6	3.65	276	50	0.00344	4193	0.0047%
Cooling Tower 68, Riser Cell F, Fan Cell 2							
9/1	97.0	6.42	360	42	0.00636	3511	0.0103%
Cooling Tower 68, Riser Cell F, Fan Cell 3							
9/1	67.4	5.18	278	46	0.00442	3511	0.0072%
Cooling Tower 68, Riser Cell E, Fan Cell 4							
9/1	45.4	5.29	248	44	0.00297	4193	0.0040%
Cooling Tower 68, Riser Cell G, Fan Cell 5							
9/1	48.8	9.52	360	44	0.00569	7157	0.0045%
Cooling Tower 84, Riser Cell A							
9/3	6.63	1.81	282	34	0.00081	5046	0.0009%
Cooling Tower 84, Riser Cell B							
9/3	4.30	1.73	206	34	0.00052	5320	0.0006%
Cooling Tower 84, Riser Cell C							
9/3	3.92	1.15	218	39	0.00048	6054	0.0005%
Cooling Tower 84, Riser Cell D							
9/3	6.76	1.74	234	39	0.00082	6079	0.0008%

*These values represent drift emission rates and cannot be compared with hexavalent and/or total chromium mass emission rates.

the mean diameter (D_{50}). The mass mean diameter for the drift particles averaged 290 um for the counterflow cells on tower No. 68, 360 um for the crossflow cell on tower No. 68, and 235 um for the counterflow cells on tower No. 84.

3.2.2 Size Distribution of Chromium

Two methods were used for estimating the percent of hexavalent chromium in two particle size ranges. The first method involved the use of paired trains with an "aligned nozzle train" and a "disc train" (described in Section 4.11). The aligned nozzle train, which was used for a reference measurement, was designed to collect all particle sizes isokinetically. The disc train was operated at the same sampling rate as the nozzle train and was designed to collect primarily the smaller particles (less than about 15 um). The purpose of the paired train particle sizing was to determine the percent of the chromium emissions associated with the smaller particles.

The second particle sizing method, the absorbent paper (AP) technique, was also being evaluated as a screening method for cooling tower testing. Southern Research Institute's (SoRI) Aerosal Science Division calculated the cut sizes for both particle sizing methods. Using the fan cell gas velocity and the inside diameter of the disc train probe, SoRI calculated the diameter of particles collected at 50 percent efficiency (D_{50}) by the disc train. The D_{50} for the disc train runs ranged from 12.6 to 12.7 um (see Appendices A and C) with particles less than this size range being collected. The D_{50} for the AP sampling device, which collected primarily larger particles (i.e., 30 um and up), ranged from 27.0 to 32.5 um with particles larger than this size range being collected.

The ratio of the emission rates of hexavalent chromium measured by the paired trains for runs 1, 2, 3, 4, and 5 for fan cells on risers E, F, G, D, and A, respectively, are shown in Table 3.5. In one instance, comparing the disc train value with the impinger train value indicates that the disc train collected over 100% of the hexavalent chromium as compared to the nozzle train. In two more instances, the disc train collected over 50% of the hexavalent chromium as compared to the nozzle train. These instances suggest that a significant portion of the chromium emissions from the fan cells are associated with particles less than 15 um.

The second particle sizing method involved using the AP device attached to the traversing impinger train. The percent of chromium associated with particles greater than the 30 um cut size was calculated using the ratio of the PMR_a values for the AP device and the corresponding impinger (IMP) train run values (see Table 3.5). The ratio of the AP to impinger train values ranged from 1.0% to 15.1% for the fan cells tested. This suggests that only a small portion of the chromium emissions are associated with particles larger than 30 um.

3.3 SUMMARY OF ANALYTICAL RESULTS FOR HEXAVALENT CHROMIUM AND TOTAL CHROMIUM

3.3.1 Cooling Water Samples

Two analytical techniques (see Figure 4.3) were used for the analysis of hexavalent chromium and total chromium in the cooling water samples. To measure hexavalent chromium, a portion of each cooling water sample was analyzed by RTI using the diphenylcarbazide colorimetric procedure. Another 10-ml aliquot of each cooling water sample was filtered through a Teflon filter with a 1.0-um pore size. The filter, which was used to catch the insoluble trivalent (Cr^{+3}) chromium residue, was then analyzed for total chromium by NCSU using NAA. The sum of the hexavalent chromium (Cr^{+6}) and the residue on the filter (Cr^{+3}) then represents the total chromium content of the cooling water. Cooling water blanks were taken from each cooling tower before the addition of the sodium bromide.

TABLE 3.5. SUMMARY OF PARTICLE SIZING DATA USING DISC TRAIN AND ABSORBENT PAPER

Run Number	Hexavalent Chromium PMRc (mg/hr)	Ratio of Disc to Nozzle	Run Number	Hexavalent Chromium PMRa mg/hr	Hexavalent Chromium PMRa Avg.	Ratio of AP to IMP train	Sum of AP/IMP and Disc/Nozzle Ratios
Cooling Tower 68, Riser Cells E and F, Fan Cells 1 and 2, Standard-Efficiency Drift Elimin							
CT-68-DI-1	716	58.1%	1-1(AP)	149.4		1.0%	59%
			2-1(AP)	145.0	147.2		
CT-68-NZ-1	1,233		1-1(IMP)	25,060			
			2-1(IMP)	4,115	14,588		
Cooling Tower 68, Riser Cell F, Fan Cell 3, Standard-Efficiency Drift Eliminator							
CT-68-DI-2	9,354	108.3%	3-1(AP)	79.9		15.1%	123%
CT-68-NZ-2	8,641		3-1(IMP)	528			
Cooling Tower 68, Riser Cell G, Fan Cell 5, Standard-Efficiency Drift Eliminator							
CT-68-DI-3	9,282	92.1%	5-1(AP)	175.1		2.0%	94%
			5-2(AP)	145.6			
			5-3(AP)	1,057	459.2		
CT-68-NZ-3	10,075		5-1(IMP)	58,560			
			5-2(IMP)	7,300			
			5-3(IMP)	2,550	22,803		
Cooling Tower 84, Riser Cell D, High-Efficiency Drift Eliminator							
CT-84-DI-4	467	21.6%	D-1(AP)	46.9		1.0%	23%
			D-2(AP)	53.1	50.0		
CT-84-NZ-4	2,166		D-1(IMP)	210			
			D-2(IMP)	9,898	5,054		
Cooling Tower 84, Riser Cell A, High-Efficiency Drift Eliminator							
CT-84-DI-5	537	35.6%	A-1(AP)	68.8		2.9%	39%
CT-84-NZ-5	1,508		A-1(IMP)	4,244			
			A-2(IMP)	427	2,336		

The hexavalent chromium results for the diphenylcarbazide analysis of the cooling water samples presented in Table 3.6 show a range of 7.33 to 8.71 micrograms per milliliter (ug/ml) of hexavalent chromium. The levels of trivalent chromium determined using NAA (see Table 3.6) ranged from 0.00 to 0.309 ug/ml.

The ratio of hexavalent chromium to total chromium in the cooling water based on the NAA of the cooling water filtrate and filter residue ranged from 0.933 to 1.00 (93.3% to 100.0% hexavalent chromium). The percent hexavalent chromium value determined for each water sample collected was used to calculate the hexavalent chromium emissions from the total chromium emissions measured by the impinger train for that corresponding run.

Cooling water samples collected at the beginning and end of testing on each cooling tower were also analyzed for calcium (Ca), magnesium (Mg), manganese (Mn), and sodium (Na) content, and pH. The results for these analyses are presented in Table 3.7.

TABLE 3.7. MINERAL CONTENT AND pH OF SELECTED COOLING WATER SAMPLES

Sample No.	Ca (ug/ml)	Mg (ug/ml)	Mn (ug/ml)	Na (ug/ml)	pH
Blank 1-W	72.8	12.3	<0.01	83.1	6.7
Blank 2-W	66.8	11.6	<0.01	109	6.7
Blank 3-W	72.9	12.4	0.05	74.9	7.0
PS-3-W	69.0	12.0	<0.01	110	7.3
PS-5-W	74.4	11.7	0.05	94.1	6.9

3.3.2 Impinger Train Samples

The analytical results for the samples from each impinger train run and each paired train particle sizing run are presented in Table 3.8. The impinger train and paired train samples, consisting of the impinger contents and rinses, the probe rinses, and a filter, were analyzed principally by RTI using graphite furnace atomic absorption (GFAA). Each result was blank corrected using the results of a DI water or a DI water/filter blank. The chromium in each sample

TABLE 3.6. SUMMARY OF ANALYTICAL RESULTS FOR COOLING WATER SAMPLES

Run No.	Sample Type	Sample No. Analyzed	Chromium (ug/ml)
	Cooling Tower 68 - Riser Cell E		
1-1	Cooling Water (Cr+6)	1-1-W	7.64
1-1	Cooling Water (Cr+3)	1-1-R	0.023
1-1	Cooling Water (Total Cr)		7.66 *
4-1	Cooling Water (Cr+6)	4-1-W	7.33
4-1	Cooling Water (Cr+3)	4-1-R	0.000
4-1	Cooling Water (Total Cr)		7.33 *
	Cooling Tower 68 - Riser Cell F		
2-1	Cooling Water (Cr+6)	2-1-W	7.58
2-1	Cooling Water (Cr+3)	2-1-R	0.000
2-1	Cooling Water (Total Cr)		7.58 *
3-1	Cooling Water (Cr+6)	3-1-W	7.45
3-1	Cooling Water (Cr+3)	3-1-R	0.065
3-1	Cooling Water (Total Cr)		7.51 *
	Cooling Tower 68 - Riser Cell G		
5-1	Cooling Water (Cr+6)	5-1-W	7.44
5-1	Cooling Water (Cr+3)	5-1-R	0.000
5-1	Cooling Water (Total Cr)		7.44 *
5-2	Cooling Water (Cr+6)	5-2-W	7.82
5-2	Cooling Water (Cr+3)	5-2-R	0.000
5-2	Cooling Water (Total Cr)		7.82 *
5-3	Cooling Water (Cr+6)	5-3-W	7.65
5-3	Cooling Water (Cr+3)	5-3-R	0.000
5-3	Cooling Water (Total Cr)		7.65 *

(continued)

TABLE 3.6 (continued)

Run No.	Sample Type	Sample No. Analyzed	Chromium (ug/ml)
	Cooling Tower 84 - Riser Cell A		
A-1	Cooling Water (Cr+6)	A-1-W	8.19
A-1	Cooling Water (Cr+3)	A-1-R	0.048
A-1	Cooling Water (Total Cr)		8.24 *
A-2	Cooling Water (Cr+6)	A-2-W	8.33
A-2	Cooling Water (Cr+3)	A-2-R	0.270
A-2	Cooling Water (Total Cr)		8.60 *
	Cooling Tower 84 - Riser Cell B		
B-1	Cooling Water (Cr+6)	B-1-W	8.33
B-1	Cooling Water (Cr+3)	B-1-R	0.019
B-1	Cooling Water (Total Cr)		8.35 *
B-2	Cooling Water (Cr+6)	B-2-W	8.68
B-2	Cooling Water (Cr+3)	B-2-R	0.039
B-2	Cooling Water (Total Cr)		8.72 *
	Cooling Tower 84 - Riser Cell C		
C-1	Cooling Water (Cr+6)	C-1-W	8.17
C-1	Cooling Water (Cr+3)	C-1-R	0.309
C-1	Cooling Water (Total Cr)		8.48 *
C-2	Cooling Water (Cr+6)	C-2-W	8.47
C-2	Cooling Water (Cr+3)	C-2-R	0.062
C-2	Cooling Water (Total Cr)		8.53 *
	Cooling Tower 84 - Riser Cell D		
D-1	Cooling Water (Cr+6)	D-1-W	8.05
D-1	Cooling Water (Cr+3)	D-1-R	0.061
D-1	Cooling Water (Total Cr)		8.11 *
D-2	Cooling Water (Cr+6)	D-2-W	8.71
D-2	Cooling Water (Cr+3)	D-2-R	0.022
D-2	Cooling Water (Total Cr)		8.73 *

* This value represents the total chromium content of the cooling water and is the sum of the hexavalent chromium (Cr+6) measured by the diphenylcarbazide wet chemical method and the trivalent chromium (Cr+3) which is the chromium measured by NAA in the filtered residue of the cooling water sample.

TABLE 3.8. SUMMARY OF ANALYTICAL RESULTS FOR CHROMIUM

Run Number	Sample Number	Sample Type	Sample Size	Total Chromium by NAA (ug)	Total Chromium by GFAA (ug)
		Tower 68, Riser Cell E, Fan Cell 1			
CT-68-1-1	1-1-abc	Impinger Contents & Filter	27.4020 ml		65.465
CT-68-1-1	1-1-AP	Traversing Absorbent Paper	13.2 sq.cm	16.265	
		Tower 68, Riser Cell F, Fan Cell 2			
CT-68-2-1	2-1-a	1st Impinger & Probe Rinse	25.3218 ml		1.598
CT-68-2-1	2-1-b	Second Impinger Content	25.9171 ml		9.353
CT-68-2-1	2-1-c	Third Impinger and Filter	28.1114 ml		0.200
CT-68-2-1	2-1-AP	Traversing Absorbent Paper	13.2 sq.cm	15.741	
		Tower 68, Riser Cell E, Fan Cell 3			
CT-68-3-1	3-1-abc	Impinger Contents & Filter	26.0679 ml		1.388
CT-68-3-1	3-1-AP	Traversing Absorbent Paper	13.2 sq.cm	8.738	
		Tower 68, Riser Cell F, Fan Cell 4			
CT-68-4-1	4-1-abc	Impinger Contents & Filter	26.5272 ml		0.600
CT-68-4-1	4-1-AP	Traversing Absorbent Paper	13.2 sq.cm	11.972	
		Tower 68, Riser Cell G, Fan Cell 5			
CT-68-5-1	5-1-abc	Impinger Contents & Filter	27.5749 ml		66.683
CT-68-5-1	5-1-AP	Traversing Absorbent Paper	13.2 sq.cm	8.379	
CT-68-5-2	5-2-a	1st Impinger & Probe Rinse	23.9277 ml		6.701
CT-68-5-2	5-2-b	Second Impinger Content	24.6471 ml		1.973
CT-68-5-2	5-2-c	Third Impinger and Filter	19.7954 ml		0.182
CT-68-5-2	5-2-AP	Traversing Absorbent Paper	13.2 sq.cm	6.967	
CT-68-5-3	5-3-abc	Impinger Contents & Filter	27.2730 ml		2.902
CT-68-5-3	5-3-X-1	Traversing Ion Exch. Paper	13.2 sq.cm	31.528	
CT-68-5-3	5-3-X-2	Traversing Ion Exch. Paper	13.2 sq.cm	19.037	
		Tower 84, Riser Cell A			
CT-84-A-1	A-1-a	1st Impinger & Probe Rinse	27.7122 ml		5.092
CT-84-A-1	A-1-b	Second Impinger Content	24.5078 ml		1.197
CT-84-A-1	A-1-c	Third Impinger and Filter	29.0468 ml		0.451
CT-84-A-1	A-1-AP	Traversing Absorbent Paper	13.2 sq.cm	4.376	
CT-84-A-2	A-2-abc	Impinger Contents & Filter	26.3708 ml		0.708
		Tower 84, Riser Cell B			
CT-84-B-1	B-1-abc	Impinger Contents & Filter	18.8088 ml		1.581
CT-84-B-1	B-1-AP	Traversing Absorbent Paper	13.2 sq.cm	8.031	
CT-84-B-2	B-2-abc	Impinger Contents & Filter	24.6307 ml		0.529
CT-84-B-2	B-2-XP	Traversing Ion Exch. Paper	13.2 sq.cm	8.424	

(continued)

TABLE 3.8. (continued)

Run Number	Sample Number	Sample Type	Sample Size	Total Chromium By NAA (ug)	Total Chromium By GFAA (ug)
		Tower 84, Riser Cell C			
CT-84-C-1	C-1-a	1st Impinger & Probe Rinse	25.6174 ml		10.663
CT-84-C-1	C-1-b	Second Impinger Content	25.4790 ml		2.172
CT-84-C-1	C-1-c	Third Impinger and Filter	25.9525 ml		0.423
CT-84-C-1	C-1-AP	Traversing Absorbent Paper	13.2 sq.cm	3.339	
CT-84-C-1	C-2-abc	Impinger Contents & Filter	26.5968 ml		0.554
CT-84-C-1	C-2-XP	Traversing Ion Exch. Paper	13.2 sq.cm	3.115	
		Tower 84, Riser Cell D			
CT-84-D-1	D-1-abc	Impinger Contents & Filter	24.1260 ml		0.4588
CT-84-D-1	D-1-AP	Traversing Absorbent Paper	13.2 sq.cm	2.986	
CT-84-D-2	D-2-abc	Impinger Contents & Filter	24.8029 ml		21.540
CT-84-D-2	D-2-XP	Traversing Ion Exch. Paper	13.2 sq.cm	3.364	
		Particle Sizing, Riser Cells A, D, E, F, and G			
CT-68-DI-1	DI-1-p	Disc Train Probe Rinse	24.8876 ml		4.086
CT-68-DI-1	DI-1	Disc Train Imp. & Filter	28.5310 ml		1.525
CT-68-DI-2	DI-2-p	Disc Train Probe Rinse	26.1345 ml		2.630
CT-68-DI-2	DI-2	Disc Train Imp. & Filter	28.7162 ml		71.316
CT-68-DI-3	DI-3-p	Disc Train Probe Rinse	24.9680 ml		3.796
CT-68-DI-3	DI-3	Disc Train Imp. & Filter	25.4153 ml		28.399
CT-84-DI-4	DI-4-p	Disc Train Probe Rinse	24.4289 ml		0.849
CT-84-DI-4	DI-4	Disc Train Imp. & Filter	24.5252 ml		1.339
CT-84-DI-5	DI-5-p	Disc Train Probe Rinse	24.1451 ml		1.785
CT-84-DI-5	DI-5	Disc Train Imp. & Filter	24.1605 ml		0.670
CT-68-NZ-1	NZ-1	Nozzle Train Imp. & Filter	24.8408 ml		9.866
CT-68-NZ-2	NZ-2	Nozzle Train Imp. & Filter	22.1188 ml		69.744
CT-68-NZ-3	NZ-3	Nozzle Train Imp. & Filter	27.6306 ml		34.914
CT-84-NZ-4	NZ-4	Nozzle Train Imp. & Filter	27.7520 ml		9.970
CT-84-NZ-5	NZ-5	Nozzle Train Imp. & Filter	21.7376 ml		6.385
		Blanks and Quality Assurance Samples			
	*	Sample Train Blank			0.1
	*	1st.Imp. and Probe Rinse Blank			0.1
	*	2nd. Impinger Blank			0.04
	*	3rd Imp. and Filter Blank			0.02
	Blank-AP	Adsorbent Paper Blank	13.2 sq.cm	0.075	
	Blank-XP	Ion Exch. Paper Blank	13.2 sq.cm	0.304	
	QA-1	QA Sample 1, 7.5 ug Cr+6 on AP	13.2 sq.cm	2.841	
	QA-2	QA Sample 2, 7.5 ug Cr+6 on XP	13.2 sq.cm	4.983	
	QA-3	QA Sample 3, 7.5 ug/ml Cr+6	--		7.4 ug/ml
	QA-4	QA Sample 4, 7.5 ug Cr+6	2.0 ml	6.23	
	QA-5	QA Sample 5, 150 ng/ml Cr+6	--		153 ng/ml
	QA-6	QA Sample 6, 150 ng Cr+6	25.0 ml	<0.05	

* Blank values calculated from GFAA results for samples: P-42, P-43, Blank-f, Blank, Blank 1, and Blank 2.

was first solubilized using nitric acid so that the GFAA analysis, which measures only soluble chromium, would yield results for total chromium. A small correction factor was added to the sample results to account for a prior NAA analysis of a small aliquot of each sample (see example calculations in Appendix A).

Prior to analysis, each sample was concentrated down in a glass beaker and then transferred to another container. Each beaker used was then treated with aqua regia to solubilize any residual chromium remaining after sample transfer. This aqua regia solution (beaker residue) was also analyzed by GFAA. Thus, the analytical results presented for total chromium in each impinger sample is the sum of the total chromium for the sample measured by GFAA (with the NAA correction factor) and the residual chromium recovered from the sample concentration beakers measured by GFAA (see example calculations in Appendix A).

The sampling train collection efficiencies (for runs 68-2-1, 68-5-2, 84-A-1, and 84-C-1) are presented in Table 3.9. The collection efficiency for all runs showed greater than 93% of the chromium being collected in the first and second impingers.

TABLE 3.9. SAMPLING TRAIN (IMPINGER) COLLECTION EFFICIENCY

Date (1986)	Run No.	1st Imp. Catch, ug	Cumulative % of Catch	2nd Imp. Catch, ug	Cumulative % of Catch	3rd Imp. Catch, ug	Cumulative % of Catch
9/1	CT-68-2-1	1.598	14.33%	9.353	98.21%	0.200	100.00%
9/1	CT-68-5-2	6.701	75.67%	1.973	97.94%	0.182	100.00%
9/4	CT-84-A-1	5.092	75.55%	1.197	93.31%	0.451	100.00%
9/4	CT-84-C-1	10.663	80.43%	2.172	96.81%	0.423	100.00%

3.3.3 Absorbent Papers and Ion Exchange Papers

The analytical results for the absorbent paper and ion exchange paper measurements are also presented in Table 3.8. For these samples, the entire

47 mm papers were submitted directly to NCSU for NAA. The results in Table 3.8 are also blank corrected using the analytical results for blank papers (Blank-AP and Blank-XP).

3.3.4 Blanks and Quality Assurance Samples

The results of the analyses for the blanks and the quality assurance samples are also presented in Table 3.8. There were two blanks for the impinger train samples. The first type of blank was measured and used to correct the values for impinger train samples containing a Teflon filter. This blank consisted of a blank Teflon filter identical to the ones used in the sampling trains and 500 ml of DI water concentrated to approximately 25 milliliters. The second type of blank was measured and used to correct the values for the impinger train efficiency samples consisting of liquid only. The second blank consisted of 500 ml of DI water concentrated to approximately 25 milliliters.

Blanks for the cooling water analysis consisted of a DI water blank filtered through a 1.0-um pore size Teflon filter with the filtrate being collected for analysis. The filter and a 1.0-ml aliquot of the DI water filtrate were submitted separately for analysis. Ion exchange and absorbent paper blanks were also measured by NAA to correct for the screening method sampling (see Section 3.4). The results of the analyses of the quality assurance samples (audit samples described above) are presented in Table 3.8 and discussed in Section 5.0.

3.4 ABSORBENT PAPER AND ION EXCHANGE PAPER SAMPLING

Sampling protocols using absorbent (filter) paper (AP) and ion exchange paper (XP) were evaluated in an effort to develop a screening method for cooling tower emission testing. The absorbent papers and ion exchange papers were loaded in a device similar to the sensitive paper holder, and were exposed to the fan stack exhaust by being attached to the traversing impinger train. The traversing papers allowed the use of the impinger train results as a reference to determine the sample collection efficiency of both types of paper. Other AP's and XP's were loaded in a sensitive paper holder and exposed to the stack exhaust at a single point. The catch of total chromium on the papers was determined by placing them directly into 2-ml vials and submitting the vials for NAA.

PMR_a's for total chromium for the paper tests were calculated using the exposed area of the paper (diameter of 41 mm). Some of these results are presented in Table 3.10 for comparison with the PMR_a's calculated for the impinger train samples. (The hexavalent-to-total chromium ratios determined for the cooling water samples can be used to calculate a hexavalent chromium PMR_a for the AP's and XP's.) The PMR_a values for the AP's and XP's were lower than the corresponding PMR_a's for the impinger trains. This low bias may be explained by the 30 um cut size calculated for the paper sampling techniques, with only particles greater than 30 um being collected, and the association of the majority of the chromium emissions with particles less than 15 um (see Section 3.2.2).

A separate report will be prepared summarizing the results of the screening tests conducted at all the cooling towers tested. The evaluation of the use of sodium bromide as a surrogate for cooling tower emission tests will also be summarized in the screening test summary report.

3.5 DRIFT RATE DETERMINATION

Drift rates for each sampling run were calculated as a percent of water flow to the individual fan cells being tested (see Appendix A). The water flow measurements made by ESC are presented in Table 3.4. The water flow values used to calculate the drift rates were determined by dividing the total water

TABLE 3.10. COMPARISON OF MEASUREMENT METHODS FOR TOTAL CHROMIUM EMISSIONS

Run Number	Pollutant Mass Rate by Ratio of Areas (mg/hr): Total Chromium by Impinger Train (GFAA)	Pollutant Mass Rate by Ratio of Areas (mg/hr): Total Chromium by Absorbent and Ion Exchange Papers (NAA)
Cooling Tower 68, Counterflow Section, Riser Cell E and F, Fan Cells 1, 2, 3 and 4		
CT-68-1-1	25,060	149.8
CT-68-2-1	4,115	145.0
CT-68-3-1	528	80.5
CT-68-4-1	275	110.3
Average	7,495	121.4
Cooling Tower 68, Crossflow Section, Riser Cell G, Fan Cell 5		
CT-68-5-1	58,560	175.1
CT-68-5-2	7,300	145.6
CT-68-5-3	2,550	1057 *
Average	22,803	160.3
Cooling Tower 84, Riser Cell A		
CT-84-A-1	4,244	69.2
CT-84-A-2	427	
Average	2,336	69.2
Cooling Tower 84, Riser Cell B		
CT-84-B-1	689	127.0
CT-84-B-2	229	133.2 **
Average	459	130.1
Cooling Tower 84, Riser Cell C		
CT-84-C-1	8,418	52.8
CT-84-C-2	365	49.2 **
Average	4,392	51.0
Cooling Tower 84, Riser Cell D		
CT-84-D-1	210	47.2
CT-84-D-2	9,898	53.2 **
Average	5,054	50.2

* Ion exchange paper; results not included in cell average.
** Ion exchange paper; results included in cell average.

flow to the riser by the number of individual fan cells (one or two), because the PMR_a values used to calculate the drift rates were for individual fan cells. The drift rates from the impinger train results and the AP and XP results were calculated using the PMR_a for total chromium and the total chromium in the cooling water at the time of the sampling run. It was assumed that the concentration of chromium in the drift was the same as the concentration of chromium in the cooling water. The drift rates for the impinger train samples and the AP samples were calculated using the following formula:

$$\text{\% Drift Rate} = \frac{\text{Cr} \quad \text{PMRa (mg/hr)} \times 1 \text{ hour/60 minutes}}{\text{Cr in water (mg/l)} \times \text{water flow (gpm)} \times 3.785 \text{ L/gal}} \times 100\%$$

The calculated drift rates for each run are presented in Table 3.11.

Drift rate as a percent of water flow was also calculated using the mass emission rate of drift (not chromium) determined by the ESC SP method. The ESC method is used here for comparison purposes only, as it is not being considered for use as an EPA reference method. The drift was assumed to have a specific gravity of 1 gram per milliliter (g/ml). The drift rate was calculated from the ESC data using the following formula:

$$\text{\% Drift Rate} = \frac{\text{mass emission rate (g/sec)} \times 60 \text{ sec/min}}{1 \text{ g/ml} \times \text{water flow (gpm)} \times 3785.3 \text{ ml/gal}} \times 100\%$$

The calculated drift rates from the SP results are also presented in Table 3.11 as the average fan cell drift rates for each riser cell tested.

The average drift rates calculated using the impinger train mass emission rates for riser cells E and F, G, A, B, C, and D were 0.1063%, 0.1874%, 0.0248%, 0.0045%, 0.0390%, and 0.421%, respectively. They averaged 0.1469% and 0.0276% for the riser cells on cooling towers 68 and 84, respectively.

TABLE 3.11. COMPARISON OF MEASUREMENT METHODS FOR DRIFT RATES

Run Number	Drift Rate As A Percent Of Water Flow		
	Impinger Train (GFAA)	Absorbent and Ion Exchange Paper (NAA)	Sensitive Paper
Cooling Tower 68, Counterflow Section, Riser Cell E and F			
CT-68-1-1	0.3444%	0.0021%	0.0047%
CT-68-2-1	0.0681%	0.0024%	0.0103%
CT-68-3-1	0.0089%	0.0013%	0.0072%
CT-68-4-1	0.0039%	0.0016%	0.0040%
Average	0.1063%	0.0019%	0.0066%
Cooling Tower 68, Crossflow Section, Riser Cell G, Fan Cell 5			
CT-68-5-1	0.4842%	0.0014%	
CT-68-5-2	0.0574%	0.0011%	
CT-68-5-3	0.0205%	0.0085% *	
Average	0.1874%	0.0013%	0.0045%
Cooling Tower 84, Riser Cell A			
CT-84-A-1	0.0452%	0.0007%	
CT-84-A-2	0.0045%		
Average	0.0248%	0.0007%	0.0009%
Cooling Tower 84, Riser Cell B			
CT-84-B-1	0.0068%	0.0013%	
CT-84-B-2	0.0022%	0.0013%	
Average	0.0045%	0.0013%	0.0006%
Cooling Tower 84, Riser Cell C			
CT-84-C-1	0.0749%	0.0005%	
CT-84-C-2	0.0031%	0.0004%	
Average	0.0390%	0.0005%	0.0005%
Cooling Tower 84, Riser Cell D			
CT-84-D-1	0.0019%	0.0004%	
CT-84-D-2	0.0823%	0.0004%	
Average	0.0421%	0.0004%	0.0008%

*Results not included in cell average.

The drift rates calculated using the AP and XP data and the SP results show a low bias compared to the impinger results and good agreement between the two methods themselves. The differences between the AP (and XP) and SP results and the impinger results may be explained based on the observations made by SoRI. Both the SP and other paper techniques may significantly underestimate the small droplet flux downstream of high-efficiency drift eliminators. The possibility also exists that the assumption made for calculating drift on chromium emissions is incorrect and the concentration of chromium in the drift throughout the particle size range is not the same as the concentration of chromium in the cooling water.

4.0 SAMPLING LOCATIONS AND TEST METHODS

This section describes the sampling locations and test methods used to characterize emissions from the two cooling towers tested at the Exxon Refinery in Baytown, Texas. The schematics of cooling tower Nos. 68 and 84 and relative sampling locations are shown in Figures 4.1 and 4.2, respectively. The fan stacks shown in Figures 4.1 and 4.2 have been systematically assigned numbers or letters for identification purposes only. Emissions from the fan cell stacks of both cooling tower Nos. 68 and 84 were sampled to measure chromium emission and drift rates, drift size distribution, and exhaust gas velocity. In addition, the water flow rate to each riser cell in both cooling towers was measured and water samples were taken for analysis for hexavalent and total chromium. Meteorological conditions were monitored and data collected using a portable weather station set up adjacent to each cooling tower. The sampling plan for both cooling towers is presented in Table 4.1. The subsections that follow further describe each sampling location and the applicable test methods.

4.1 COOLING TOWER NO. 68 OUTLETS, COUNTERFLOW RISER CELLS E AND F, STANDARD EFFICIENCY DRIFT ELIMINATORS (SAMPLING LOCATION A)

Emissions testing for chromium and drift emissions, and drift size distribution determinations by several methods were conducted over the four fan cell stacks (Nos. 1 through 4, see Figure 4.1) on the counterflow section of cooling tower No. 68. As shown in Figure 4.1, each counterflow riser cell for this section of cooling tower No. 68 has two fan cells; fan cells 1 and 4

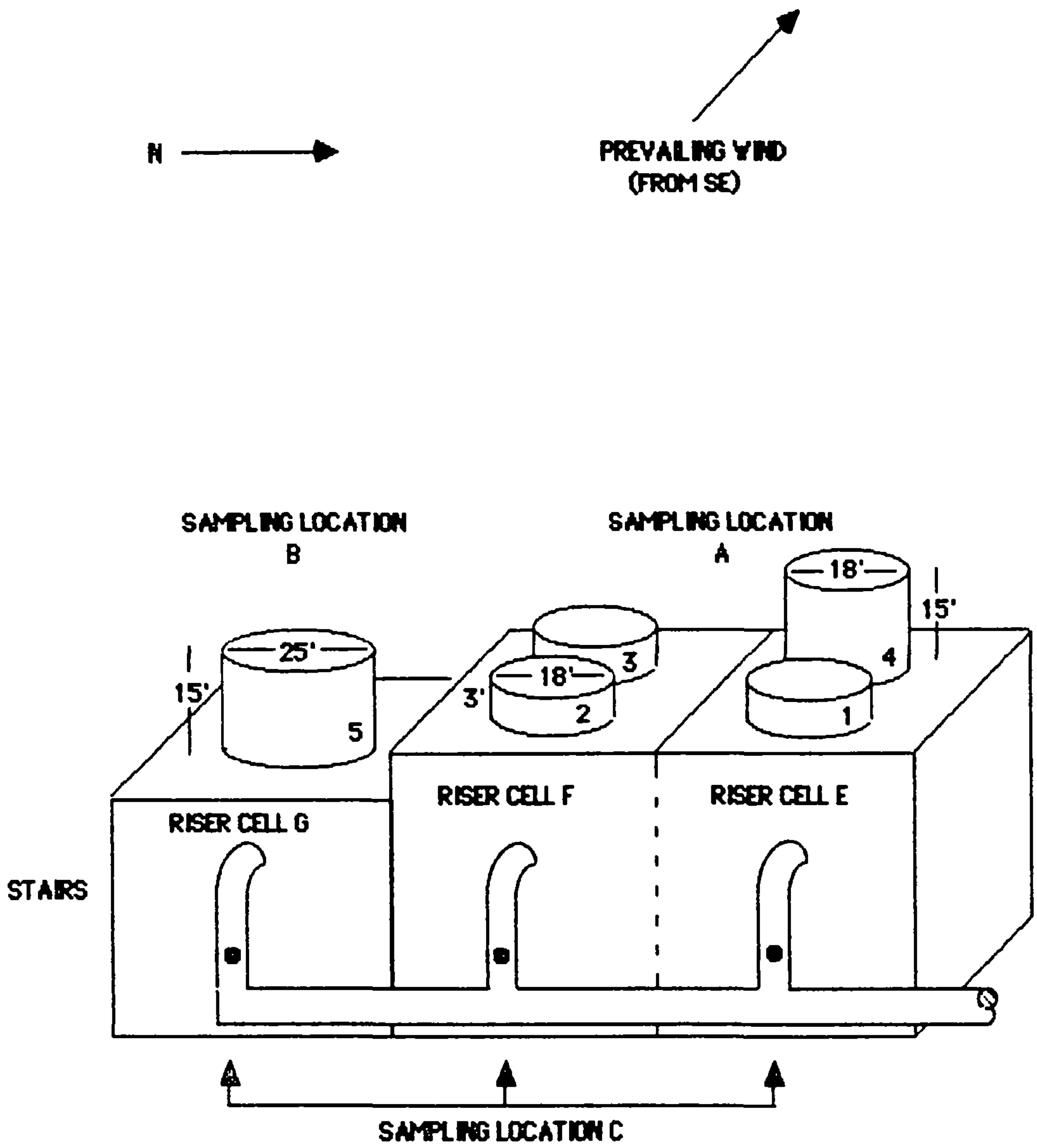


FIGURE 4-1. EXXON REFINERY BAYTOWN, TEXAS: SKETCH OF THE SAMPLING LOCATIONS ON COOLING TOWER NO. 68, SHOWING FAN CELL NUMBERING.

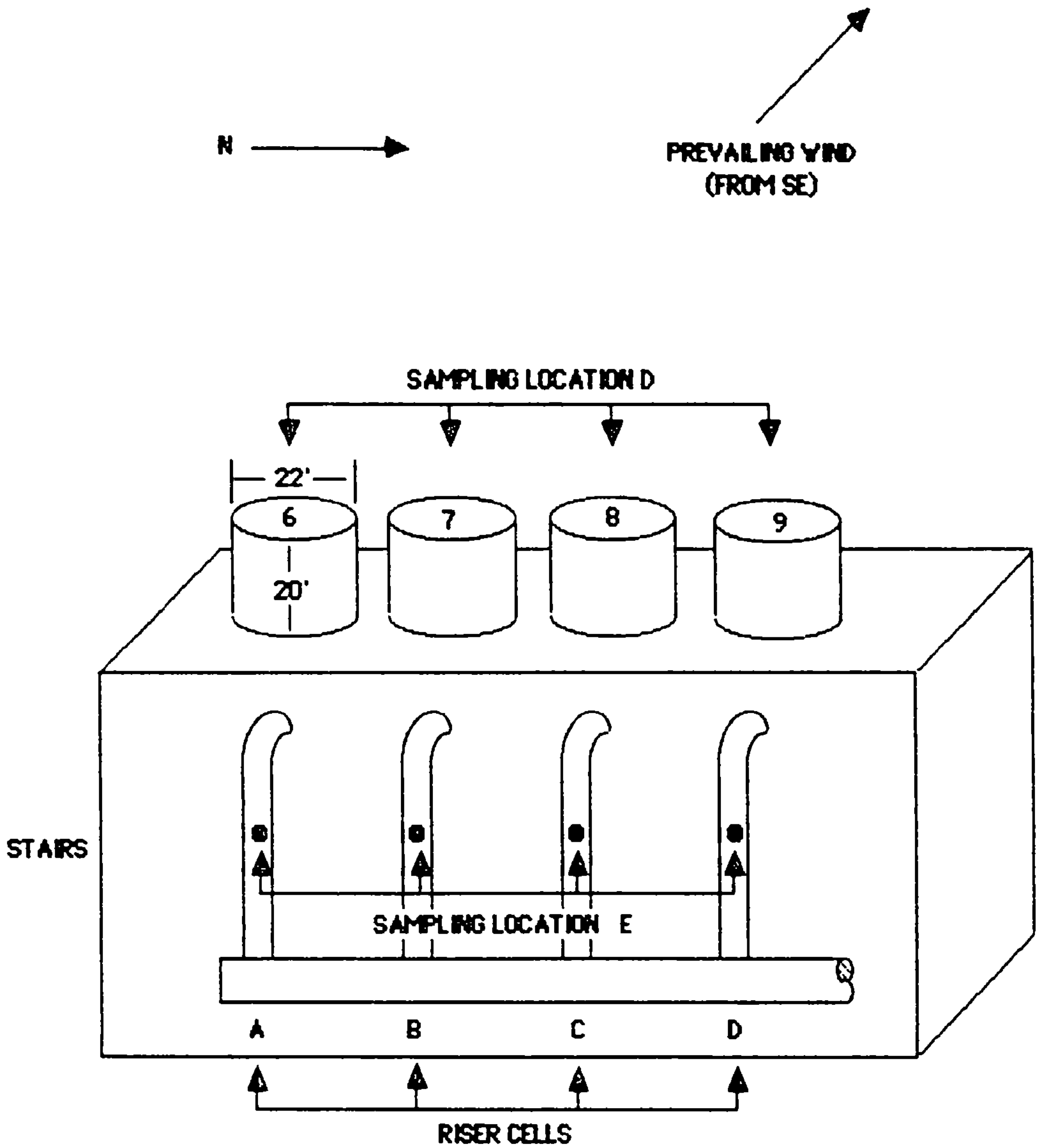


FIGURE 4-2. EXXON REFINERY BAYTOWN, TEXAS: SKETCH OF THE SAMPLING LOCATIONS ON COOLING TOWER NO. 84, SHOWING FAN CELL NUMBERING.

TABLE 4.1. SAMPLING PLAN FOR COOLING TOWERS NO. 68 AND 84
EXXON COMPANY, BAYTOWN REFINERY

Sample Type	Sampling Location	Number of Runs	Methods
Total Chromium & Drift Emissions	A, B, D	3 (A) 2 (B) 6 (D)	EPA Method 13-type impinger train with GFAA analysis
Total Chromium Chromium & Drift Emissions	A, B, D	1 (A) 1 (B) 2 (D)	EPA Method 13-type impinger train with GFAA analysis; filters and impingers recovered separately for collection efficiency check
Drift Size Distribution and Drift Rate Determination	A, B, D	1 or more at each location	Aligned nozzle and disc trains with GFAA and NAA analysis; absorbent paper with NAA analysis; sensitive paper with microscopic analysis
Recirculating Water Flowrate	C, E	Single point check before each run; must be within 10% of initial determination by complete traverse	Calibrated pitot tube traverse
Cooling Water Samples	C, E	3 grab samples per run combined into one composite sample	Cr^{+6} and NAA (Cr^{+3}) analysis
Meteorological Data	Local	Hourly	Dry, wet bulb temperatures, humidity, wind speed, and wind direction

are associated with riser cell E and fan cells 2 and 3 are associated with riser cell F.

Each fan cell stack was approximately 18 feet in diameter at the plane of the fan blade. Sampling probes connected to sampling train boxes containing impingers and filter were introduced into the fan cell exhaust and were suspended from a monorail to facilitate traversing the stack. Three fan cell stacks (numbered 1, 2, and 3) were 3 feet in height and were 219 inches in diameter at the plane of the nozzle and train. The fan cell No. 4 was 15 feet in height and 244 inches in diameter at the plane of the nozzle and train. The propeller anemometer used to measure the axial component of the exhaust flow was located 3 to 5 inches above the sampling point.

A Method 13-type impinger train was used for chromium and drift emissions sample collection. The fan cell stacks were traversed along one axis at 12 points following the draft method (Appendix C). Each of the 12 points was sampled for 10 minutes for a total of 120 minutes of sampling per run. One run was conducted at each fan cell stack. The sampling run conducted at fan cell stack No. 2 had the impinger contents and filter recovered separately for a collection efficiency check.

Paired train test runs using the "disc" and "aligned nozzle" particle sizing trains (see Section 4.11) were also conducted. The first run was conducted for 120 minutes at a single point over riser cell E in addition to 120 minutes of sampling at a single point over riser cell F. The second paired test train was conducted for 240 minutes at a single point over riser cell F only.

Sensitive paper (SP) (see Section 4.12) size distribution testing was conducted once at each sampling location. Sensitive papers of 47 mm diameter were exposed at each test point. Exposure times were selected in order to produce samples with a sufficient number of stains to allow confidence in the resultant droplet size distribution, and also to prevent overlapping stains. Local updraft air velocity values were taken at each sampling point using a Gill propeller anemometer and a Fluke digital multimeter.

Absorbent paper (AP) and ion exchange paper (XP) (see Section 4.13) samples were collected during each run at various sampling points.

4.2 COOLING TOWER NO. 68 OUTLETS, CROSSFLOW RISER CELL G, STANDARD EFFICIENCY DRIFT ELIMINATOR (SAMPLING LOCATION B)

Emissions testing for chromium and drift emissions and drift size distribution determinations by several methods were conducted directly over the fan cell stack (No. 5, see Figure 4.1) on the crossflow section of cooling tower No. 68.

The fan cell stack was approximately 24 feet in diameter at the plane of the fan blade with a height of 18 feet. Sampling probes connected to sampling train boxes containing impingers and filter were introduced into the fan exhaust and were suspended from a monorail to facilitate traversing the stack. The cell stack was 330 inches in diameter at the plane of the nozzle and train. The propeller anemometer used to measure the axial component of the exhaust flow was located 3 to 5 inches above the sampling point.

A Method 13-type impinger train was used for chromium and drift emissions sample collection. The fan cell stack was traversed along two perpendicular axes with a single traverse and twelve sampling points on each axis following the draft method (Appendix C). Each of the 12 points on each traverse axis was sampled for five minutes for a total of 120 minutes of sampling per run. Three sampling runs were conducted with the impinger contents and filter from one run recovered separately for a collection efficiency check.

One paired train run was conducted using the "disc" and "aligned nozzle" particle sizing trains (see Section 4.11) at a single point in the fan cell stack for a total of 240 minutes.

Sensitive paper (SP) (see Section 4.12) size distribution testing was conducted once at this sampling location. Sensitive papers of 47 mm diameter were exposed at each test point. Exposure times were selected to produce samples with a sufficient number of stains to allow confidence in the resultant droplet size distribution while avoiding overlapping stains. Local updraft air velocity values were taken at each sampling point using a Gill propeller anemometer and a Fluke digital multimeter.

Absorbent paper (AP) and ion exchange paper (XP) (see Section 4.13) samples were collected during each run at various sampling points.

4.3 COOLING TOWER NO. 68 RECIRCULATING WATER PIPES (SAMPLING LOCATION C)

Circulating water flow rate was determined by traversing the hot water riser pipe of each riser cell tested using a calibrated pitot tube. A complete traverse was made initally on each recirculation pipe and then a subsequent single point check was made prior to each run. The single point check was considered sufficient if the measured value was within 10% of the value determined by the initial complete traverse. If the measured value was over $\pm$10% of the initial value, a complete traverse was performed again. The pitot tube traverse procedure and calibration data can be found in Appendices C and D, respectively.

During each emissions test run, a recirculating cooling water sample was taken from the hot water riser pipe of each riser cell tested. These samples were taken by hand and stored in 500 ml glass jars. Each sample was analyzed by RTI for hexavalent chromium (wet chemical method) and total soluble chromium by ICAP. Aliquots of each water sample were filtered through 1.0 um Teflon filters. Both the filter residue and the filtrate were analyzed by NCSU for total chromium by neutron activation analysis (NAA).

4.4 COOLING TOWER NO. 84 OUTLETS, COUNTERFLOW RISER CELLS A, B, C, AND D, HIGH EFFICIENCY DRIFT ELIMINATORS (SAMPLING LOCATION D)

Emissions testing for determination of chromium and drift emissions and drift size distribution using several methods was conducted at each of four fan cells on the counterflow cooling tower No. 84. A schematic of the sampling locations for cooling tower No. 84 is shown in Figure 4.2. As shown in Figure 4.2, there is only one fan cell associated with each riser cell.

The fan cell stacks were identical in construction, approximately 24 feet in diameter at the plane of the fan blade, and 18 feet in height. Sampling probes connected to sampling train boxes containing impingers and filter were introduced into the fan cell exhausts and were suspended from a monorail to facilitate traversing the stack. The cell stacks were 287 inches in diameter at the plane of the nozzle and train. The propeller anemometer used to measure the axial component of the exhaust gas flow was located 3 to 5 inches above the sampling point.

A Method 13-type impinger train was used for chromium and drift emissions sample collection. Each fan cell stack was traversed along one axis at 12 points following the draft method (Appendix C). Each of the twelve points was sampled for 10 minutes for a total sampling time of 120 minutes per run. Two runs were conducted per fan cell stack with two of these runs (one on riser cell A and one on riser cell C, see Figure 4.2) having the impinger contents and filter recovered separately for an efficiency check.

Paired train test runs using the "disc" and "aligned nozzle" particle sizing trains (see Section 4.11) were also conducted. One such run was conducted at a single point over the fan cell stack of riser cell A and the other was conducted at a single point over riser cell D. Both paired train runs were 240 minutes in length.

Sensitive paper (SP) (see Section 4.12) size distribution testing was conducted once at each sampling location. Sensitive papers of 47 mm diameter were exposed at each test point. Exposure times were selected to produce samples with a sufficient number of stains to allow confidence in the resultant droplet size distribution, and to prevent overlapping stains. Local updraft air velocity values were taken at each sampling point using a Gill propeller anemometer and a Fluke digital multimeter.

Absorbent paper (AP) and ion exchange paper (XP) (see Section 4.13) samples were collected during each run at various sampling points.

4.5 COOLING TOWER NO. 84 RECIRCULATING WATER PIPES (SAMPLING LOCATION E)

Circulating water flow rate was determined by traversing the hot water riser pipe of each riser cell tested using a calibrated pitot tube. A complete traverse was made initially on each recirculation pipe and then a subsequent single point check was made prior to each run. The single point check was considered sufficient if the measured value was within 10% of the value determined by the initial complete traverse. If the measured value was over $\pm$10% of the inital value, a complete traverse was performed again. The pitot tube traverse procedure and calibration data can be found in Appendices C and D, respectively.

During each emissions test run, a recirculating cooling water sample was taken from the hot water riser pipe of each riser cell tested. These samples were taken by hand and stored in 500 ml glass jars. Each sample was analyzed by RTI for hexavalent chromium (wet chemical method) and total soluble chromium by ICAP. Aliquots of each water sample were filtered through 1.0 um Teflon filters. Both the filter residue and the filtrate were analyzed by NCSU for total chromium by neutron activiation analysis (NAA).

4.6 AMBIENT METEOROLOGICAL STATION

A portable meteorological station was assembled and operated continuously on the ground approximately 100 feet from each cooling tower tested to monitor ambient conditions at the time of sampling. Wind speed and direction were measured using a cup anemometer and directional anemometer. Ambient wet bulb/dry bulb temperatures were obtained using a psychrometer. Meteorological data collected are summarized in Chapter 2.

4.7 VELOCITY AND GAS TEMPERATURE

A propeller anemometer was used to determine the total flow velocity in the axial direction at each sampling point as described in the draft test method (see Appendix C). The temperature at each sampling point was measured using a thermocouple and digital readout.

4.8 MOLECULAR WEIGHT

Flue gas composition was essentially that of the ambient air drawn into the cooling tower via the fan. Therefore, the dry molecular weight and composition of air was used.

4.9 CHROMIUM COLLECTED BY IMPINGER TRAINS

Method 5-type sampling procedures, as described in the Federal Register,* were used with the Method 13-type trains to measure chromium and drift emissions at each emissions sampling location (see the draft test method in Appendix C). Sampling trains consisted of a heated, glass-lined probe and a series of Greenburg-Smith impingers (two containing 100 ml of deionized-distilled water, one empty, and one with silica gel) with a 3-inch nominal

*40 CFR 60, Appendix A, Reference Methods 2, 3, and 5, July 1, 1980.

Teflon filter located between the third and fourth impinger. A deionized-distilled water rinse of the nozzle, probe, appropriate filter holder portions, and impingers of the sampling train was made at the end of each test. This rinse, the impinger contents, and the filter were combined and stored in a 500 ml glass jar, except for the four sampling runs on which collection efficiency checks were made. For these four runs, the rinse, impinger contents, and filter were stored and analyzed separately.

The samples were typically concentrated to approximately 25 ml in a 500 ml glass beaker and then were transferred to another container. The 500 ml beakers used to concentrate the samples were treated with aqua regia to solubilize residual chromium and these solutions were treated as separate samples. The total chromium content of the impinger samples (after solubilization of the chromium with nitric acid) and the total chromium content of the solution containing the residual chromium from the beakers was determined by RTI using graphite furnace atomic absorption (GFAA). The total chromium catch for each impinger run is the sum of the total chromium content in the corresponding impinger sample and the total chromium content solubilized from the appropriate beaker using aqua regia.

4.10 CHROMIUM IN COOLING WATER

Cooling water samples collected were analyzed by RTI for hexavalent chromium using the diphenylcarbazide wet chemical method. Also, a 10-ml aliquot of the cooling water was filtered through a Teflon filter with a 1.0-um pore size, and the residue (trivalent chromium) and the filter were analyzed for total chromium by NAA. A flow chart for the analysis of cooling water samples is presented in Figure 4.3.

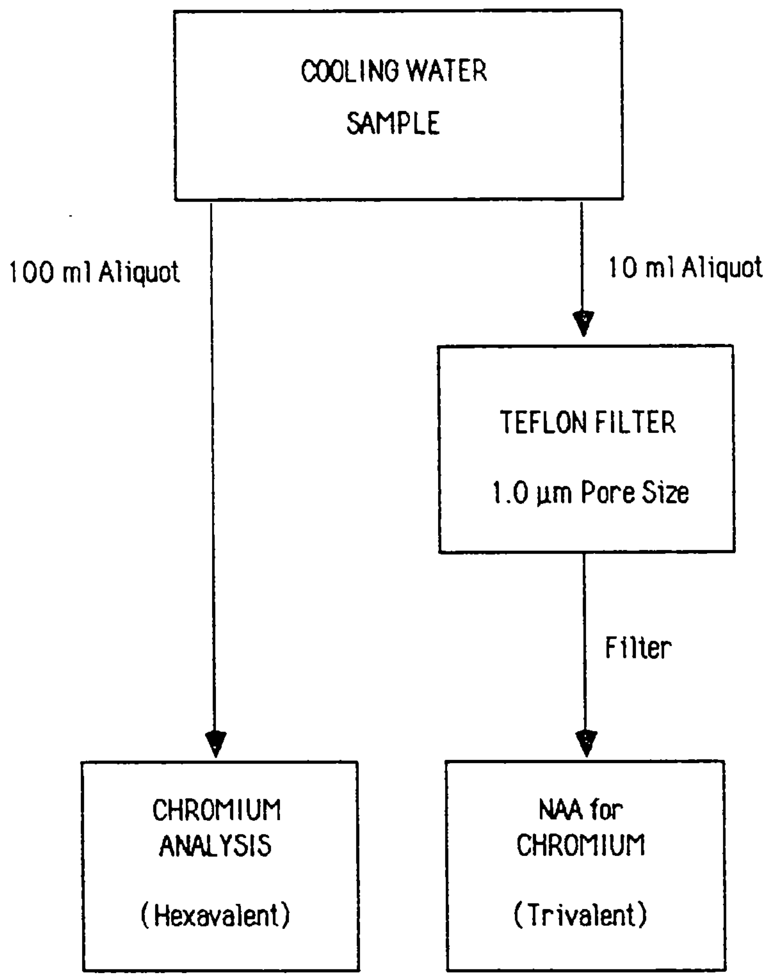


FIGURE 4.3. FLOW CHART FOR ANALYSIS OF COOLING WATER SAMPLES.

4.11 DRIFT SIZING USING ALIGNED NOZZLE AND DISC TRAINS

Paired aligned nozzle and disc trains were used to estimate the percent chromium in drift particles smaller than a certain size. The disc train consisted of the impinger train set-up described in Section 4.9 with the exception that no nozzle was attached to the probe and a plexiglass disc was attached in the plane of the flow around the opening of the probe. This configuration was designed to collect the majority of drift particles less than a certain diameter.

The aligned nozzle train was run at the same time as the disc train at the same single sampling point to serve as a reference measurement for collection of all sizes of drift particles. It was identical to the impinger train used. The nozzle was aligned directly with the flow at the point sampled; the exact flow direction and delta P at that point was determined using a three-dimensional pitot tube.

The catches from each train were analyzed as previously described for the chromium emissions and drift testing.

4.12 SENSITIVE PAPER TESTING

Sensitive paper (SP) testing was used to measure drift rate and size distribution. The SP testing relies on droplet collection by inertial impaction on water-sensitive paper held perpendicular to the flow. This paper is chemically treated so the impinging droplet generates a well-defined blue stain on the pale yellow background of the paper. The size and shape of the stain and the droplet size were correlated by calibrating the SP system with a mono-disperse water droplet generator over a range of droplet sizes and impaction velocities.

Processing of exposed SP's consisted of measuring the stain diameters using a microscope and a semi-automated GRAF PEN digitizer linked to a microcomputer which groups stain counts by size range. A computer program employing calibration curves for specific droplet sizes and impaction velocities was used to correlate stains with their original droplet sizes. In addition, a correction factor was applied which incorporated the collection efficiency of each droplet size range.

4.13 ABSORBENT PAPER AND ION EXCHANGE PAPER TESTING

Absorbent paper (Whatman™ 541 filter paper) held in a sensitive paper sampling device was attached to each traversing impinger train to collect drift emissions. This was part of an effort to evaluate screening techniques for cooling tower testing. The sensitive paper device and absorbent paper were positioned on the probe of the impinger train and were exposed so as to collect drift emissions during the 120 minutes of impinger train sampling. Absorbent paper samples were analyzed for total chromium by NAA.

Ion exchange paper (Schleicher and Schuell™ DEAE (Diethylaminoethyl) cellulose membrane filter paper) was also used in the SP device to collect drift emissions as part of the effort to evaluate screening techniques for cooling towers. The positively charged papers were exposed at traverse points as well as at single stationary points in order to collect ions entrained in the drift emissions. The ion exchange paper samples were analyzed for total chromium by NAA.

5.0 QUALITY ASSURANCE

Because the end product of testing is to produce representative emission results, quality assurance is one of the main facets of stack sampling. Quality assurance guidelines provide the detailed procedures and actions necessary for defining and producing acceptable data. Two such documents were used in this test program to ensure the collection of acceptable data and to provide a definition of unacceptable data. These documents are the EPA Quality Assurance Handbook Volume III, EPA-600/4-77-027 and Entropy's "Quality Assurance Program Plan," which has been approved by the U. S. EPA, EMB.

Relative to this test program, the following steps were taken to ensure that the testing and analytical procedures produce quality data.

- Calibration of field sampling equipment. (Appendix D describes calibration guidelines in more detail.)
- Checks of train configuration and calculations.
- On-site quality assurance checks of sampling train components.
- Use of designated analytical equipment and sampling reagents.

Pre- and post-test calibrations were performed for each of the meter boxes used for sampling. Calibrations were also performed for the temperature sensing equipment, nozzles, water flow pitot tubes, anemometer sensor, and the entire propeller anemometer apparatus. Appendix D includes the calibration data sheets for each dry gas meter used for testing and data sheets for the calibrations of the other sampling equipment mentioned.

An on-site audit was performed on the meter boxes used for sampling and the data are summarized in Table 5.1. Entropy used the procedures described in the December 14, 1983 Federal Register (48F255670).

TABLE 5.1. METER BOX CALIBRATION AUDIT

Meter Box No.	Pre-Audit Y Value	Allowable Error $0.97Y < Y < 1.03Y$	Calculated Yc	Within Allowable Limits
N-6	1.0123	0.9819 - 1.0427	1.0124	✓
N-10	0.9847	0.9552 - 1.0142	1.0028	✓
N-12	1.010	0.9797 - 1.0403	0.9866	✓
N-14	1.005	0.9749 - 1.0352	1.0173	✓

Audit solutions were used to check the analytical procedures of the laboratories conducting the chromium analyses. Table 5.2 presents the results of these analytical audits.

The sampling equipment, reagents, and analytical procedures for this test series were in compliance with all necessary guidelines set forth for accurate test results as described in Volume III of the Quality Assurance Handbook.

TABLE 5.2. AUDIT REPORT CHROMIUM ANALYSIS

Plant: Exxon - Baytown, TX Task No.: 3505

Date Samples Received: ________ Date Analyzed: 10/86

Samples Analyzed By: RTI, NCSU

Reviewed By: P. Grohse, J. Weaver Date of Review: 10/86

Sample Number	ug/mL Cr^{+6} or Cr	Source of Sample	Analytical Technique	Audit Value	Relative Error, %
QA-1	7.5 μg Cr^{+6}	QAD/EEI	NAA	2.841	-62.1
QA-2	7.5 μg Cr	QAD/EEI	NAA	4.983	-33.6
QA-3	7.5 μg/ml Cr^{+6}	QAD/EEI	GFAA	7.36	-1.87
QA-4	7.5 μg Cr^{+6}	QAD/EEI	NAA	6.230	-16.9
QA-5	0.15 μg/ml Cr^{+6}	QAD/EEI	GFAA	0.153	+2.0
QA-6	0.15 μg Cr	QAD/EEI	NAA	<0.05	≥67.0

APPENDIX A.

TEST RESULTS AND EXAMPLE CALCULATIONS

FIELD DATA

PLANT	EXXON	DATE	9-1-86
SAMPLING LOCATION	CT 68 FAN CELL #1	RUN NUMBER	CT-68-1-1
OPERATOR	TMS	NOZZLE #	206
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.250
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1417	TOT VOL. H2O COLL.(ml)	44.8
RUN STOP TIME	1623	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	65.273 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	65.465 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,688.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	748.104	0.110	0.450	0.450	90	4.0	330	55	80	
A-2	5	750.130	0.110	0.450	0.450	90	4.0	330	58	80	
A-3	10	752.280	0.240	0.950	0.950	90	6.0	480	57	80	
A-4	15	754.980	0.300	1.190	1.190	91	7.0	540	57	81	
A-5	20	757.980	0.290	1.130	1.130	92	7.0	525	56	81	
A-6	25	761.250	0.280	1.100	1.100	93	6.0	520	56	83	
A-7	30	764.730	0.220	0.870	0.870	94	6.0	460	58	83	
A-8	35	767.320	0.200	0.790	0.790	94	5.0	440	57	82	
A-9	40	769.940	0.140	0.560	0.560	93	5.0	370	58	82	
A-10	45	772.350	0.110	0.450	0.450	93	4.0	330	59	82	
A-11	50	774.140	0.040	0.150	0.150	93	2.0	195	59	84	
A-12	55	775.480	0.050	0.180	0.180	93	3.0	210	61	83	
B-1	60	776.730	0.040	0.170	0.170	93	3.0	205	60	83	0.000
B-2	5	777.930	0.040	0.150	0.150	92	2.0	193	60	84	0.000
B-3	10	779.040	0.030	0.100	0.100	92	2.0	159	59	84	
B-4	15	780.070	0.070	0.280	0.280	93	3.0	263	61	87	
B-5	20	781.680	0.220	0.860	0.860	93	6.0	465	58	89	
B-6	25	784.310	0.140	0.760	0.760	94	6.0	435	58	89	
B-7	30	786.480	0.140	0.540	0.540	94	5.0	366	61	88	
B-8	35	788.880	0.190	0.730	0.730	93	6.0	424	63	86	
B-9	40	791.320	0.290	1.120	1.120	93	7.0	529	62	89	
B-10	45	794.370	0.290	1.160	1.160	94	7.0	535	62	86	
B-11	50	797.710	0.100	0.400	0.400	94	4.0	314	64	86	
B-12	55	799.600	0.140	0.550	0.550	94	5.0	369	63	86	
	120/OFF	801.743									
FINAL DIFF/AVGS.		53.639	0.1429		0.629	92.7				84.1	

FIELD DATA

PLANT	EXXON	DATE	9-2-86
SAMPLING LOCATION	CT 68 FAN CELL #4	RUN NUMBER	CT-68-4-1
OPERATOR	TMS	NOZZLE #	204
BAR.PRESS.,in Hg	30.2000	NOZZLE DIAMETER,inches	0.255
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0020	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1229	TOT VOL. H2O COLL.(ml)	40.8
RUN STOP TIME	1446	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	0.600 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	0.600 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	46,759.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	900.204	0.160	0.630	0.630	93	4.0	398	53	88	
A-2	5	902.530	0.130	0.490	0.490	94	3.0	352	54	91	
A-3	10	904.870	0.120	0.450	0.450	94	3.0	332	56	91	
A-4	15	906.760	0.140	0.540	0.540	95	3.0	367	57	91	
A-5	20	908.980	0.190	0.750	0.750	96	4.0	435	57	91	
A-6	25	911.420	0.130	0.500	0.500	96	3.0	354	58	91	
A-7	30	913.700	0.040	0.160	0.160	96	1.0	199	59	90	
A-8	35	915.110	0.040	0.160	0.160	96	1.0	203	61	91	
A-9	40	916.300	0.020	0.080	0.080	96	1.0	139	60	89	
A-10	45	917.090	0.030	0.110	0.110	96	1.0	162	60	89	
A-11	50	917.980	0.020	0.080	0.080	96	1.0	143	61	90	
A-12	55	918.910	0.020	0.100	0.100	97	1.0	155	62	89	
B-1	60	919.780	0.040	0.190	0.190	97	2.0	209	61	89	0.000
B-2	5	921.040	0.050	0.200	0.200	97	2.0	215	60	88	0.000
B-3	10	922.390	0.040	0.180	0.180	97	2.0	204	62	88	
B-4	15	923.720	0.040	0.170	0.170	97	2.0	197	63	89	
B-5	20	925.150	0.060	0.240	0.240	98	2.0	237	64	90	
B-6	25	926.510	0.080	0.350	0.350	98	3.0	283	65	89	
B-7	30	928.220	0.130	0.530	0.530	97	3.0	349	64	87	
B-8	35	930.480	0.130	0.550	0.550	96	3.0	355	65	86	
B-9	40	932.720	0.170	0.710	0.710	96	4.0	403	65	87	
B-10	45	935.300	0.160	0.660	0.660	96	4.0	389	66	87	
B-11	50	937.620	0.130	0.570	0.570	97	4.0	362	66	88	
B-12	55	939.990	0.100	0.440	0.440	98	3.0	318	68	88	
	120/OFF	942.014									
FINAL DIFF/AVGS.		41.810	0.0811		0.368	96.2				89.0	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/1,2/86	EXXON REFINERY - BAYTOWN, TX	CT-68-1-1	CT-68-4-1
	Run Start Time	1417	1229
	Run Finish Time	1623	1446
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.250	0.255
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.200
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.629	0.368
Vm	Volume of Metered Gas Sample, Dry ACF	53.639	41.81
tm	Dry Gas Meter Temperature, Degrees F	92.7	96.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	51.968	40.161
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	44.8	40.8
Vw(std)	Volume of Water Vapor, SCF	2.107	1.922
%H2O	Moisture Content, % by Volume	3.90	4.57
Mfd	Dry Mole Fraction	0.961	0.954
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.42	28.34
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.200
ts	Flue Gas Temperature, Degrees F	84	89
Delta p	Average Velocity Head, in. H2O	0.1429	0.0811
vs	Flue Gas Velocity, Ft/Sec	21.60	16.38
A	Stack/Duct Area, Sq. Inches	37688.0	46759.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	319,789.5	295,672.6
Qaw	Volumetric Air Flow Rate, Wet ACFM	339,149.4	319,185.2
%I	Isokinetic Sampling Rate, %	104.0	103.6

EMISSIONS RESULTS

9/1,2/86	EXXON REFINERY - BAYTOWN, TX	CT-68-1-1	CT-68-4-1
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	84.1	89.0
	Degrees Centigrade	28.9	31.7
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.5762	0.5423
	Actual Cubic Feet/hr	20.3490	19.1511
	Dry Std. Cubic Meters/hr	0.5433	0.5024
	Dry Std. Cubic Feet/hr	19.1874	17.7404
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	65.273 ug	0.600 ug
mg/dscm	Concentration, mg/dscm	44.356 x 10E-3	0.528 x 10E-3
gr/dscf	Concentration, grains per dscf	19.3802 x 10E-6	0.2305 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	55.192 x 10E-3	0.605 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	25.057 x 10E-3	0.275 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	65.465 ug	0.600 ug
mg/dscm	Concentration, mg/dscm	44.486 x 10E-3	0.528 x 10E-3
gr/dscf	Concentration, grains per dscf	19.437 x 10E-6	0.231 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	55.355 x 10E-3	0.605 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	25.131 x 10E-3	0.275 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9-1-86
SAMPLING LOCATION	CT 68 FAN CELL #2	RUN NUMBER	CT-68-2-1
OPERATOR	TMS	NOZZLE #	204
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.255
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1417	TOT VOL. H2O COLL.(ml)	43.6
RUN STOP TIME	1623	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	11.151 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	11.151 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,688.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	801.832	0.020	0.080	0.080	94	2.0 *	141	58	81	
A-2	5	802.640	0.020	0.100	0.100	94	2.0 *	153	56	80	
A-3	10	803.520	0.030	0.100	0.100	94	2.0 *	158	55	81	
A-4	15	804.450	0.060	0.240	0.240	94	2.0 *	241	57	81	
A-5	20	805.730	0.140	0.550	0.550	94	4.0 *	369	57	84	
A-6	25	807.930	0.130	0.490	0.490	95	4.0 *	348	60	84	
A-7	30	810.110	0.170	0.660	0.660	96	5.0 *	403	62	85	
A-8	35	812.410	0.170	0.680	0.680	97	5.0 *	406	60	84	
A-9	40	814.970	0.120	0.480	0.480	97	4.0 *	346	59	90	
A-10	45	817.020	0.110	0.410	0.410	98	4.0 *	322	59	91	
A-11	50	819.930	0.050	0.200	0.200	98	3.0 *	221	60	91	
A-12	55	820.410	0.060	0.230	0.230	97	2.0 *	240	62	91	
B-1	60	821.860	0.020	0.080	0.080	97	1.0 *	145	62	92	0.000
B-2	5	822.730	0.030	0.100	0.100	96	1.0 *	158	63	93	0.000
B-3	10	823.570	0.190	0.750	0.750	96	5.0 *	438	61	96	
B-4	15	826.110	0.260	1.000	1.000	96	6.0 *	503	62	94	
B-5	20	828.920	0.170	0.680	0.680	96	5.0 *	413	63	91	
B-6	25	831.510	0.230	0.900	0.900	96	6.0 *	475	62	91	
B-7	30	834.510	0.200	0.800	0.800	95	5.0 *	446	64	87	
B-8	35	836.850	0.230	0.910	0.910	95	6.0 *	476	64	89	
B-9	40	839.720	0.220	0.880	0.880	96	6.0 *	464	63	85	
B-10	45	842.630	0.170	0.690	0.690	96	5.0 *	412	63	86	
B-11	50	844.970	0.110	0.420	0.420	96	4.0 *	321	64	86	
B-12	55	846.990	0.070	0.280	0.280	96	3.0 *	263	65	86	
	120/OFF	848.758									
FINAL DIFF/AVGS.		46.926	0.1101		0.488	95.8				87.5	

FIELD DATA

PLANT	EXXON	DATE	9-2-86
SAMPLING LOCATION	CT 68 FAN CELL #3	RUN NUMBER	CT-68-3-1
OPERATOR	TMS	NOZZLE #	206
BAR.PRESS.,in Hg	30.2000	NOZZLE DIAMETER,inches	0.250
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	933	TOT VOL. H2O COLL.(ml)	55.0
RUN STOP TIME	1138	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	1.376 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	1.388 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,688.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Pt)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	849.072	0.060	0.230	0.230	85	4.0	245	52	93	
A-2	5	850.430	0.040	0.170	0.170	86	4.0	207	54	93	
A-3	10	851.710	0.170	0.650	0.650	86	7.0	410	55	94	
A-4	15	853.950	0.150	0.580	0.580	87	7.0	387	55	94	
A-5	20	856.390	0.150	0.570	0.570	88	7.0	383	57	94	
A-6	25	858.520	0.170	0.640	0.640	89	7.0	407	59	94	
A-7	30	860.890	0.190	0.730	0.730	89	8.0	434	58	93	
A-8	35	863.520	0.180	0.690	0.690	89	8.0	421	58	93	
A-9	40	865.830	0.160	0.600	0.600	90	8.0	391	58	92	
A-10	45	868.410	0.180	0.700	0.700	90	8.0	423	59	91	
A-11	50	870.730	0.040	0.150	0.150	91	3.0	197	57	94	
A-12	55	872.190	0.030	0.120	0.120	91	2.0	173	57	93	
B-1	60	873.090	0.040	0.140	0.140	91	2.0	192	58	94	0.000
B-2	5	874.180	0.040	0.150	0.150	92	2.0	195	59	89	0.000
B-3	10	875.320	0.040	0.160	0.160	92	2.0	199	59	88	
B-4	15	876.480	0.240	0.940	0.940	93	9.0	481	60	83	
B-5	20	879.170	0.240	0.940	0.940	93	9.0	479	61	83	
B-6	25	882.280	0.200	0.790	0.790	94	9.0	440	63	83	
B-7	30	884.820	0.210	0.800	0.800	94	9.0	453	61	94	
B-8	35	887.360	0.230	0.870	0.870	94	9.0	472	61	94	
B-9	40	890.250	0.220	0.840	0.840	94	9.0	465	60	96	
B-10	45	892.890	0.220	0.870	0.870	94	9.0	471	62	95	
B-11	50	895.730	0.190	0.730	0.730	94	8.0	432	63	94	
B-12	55	898.290	0.070	0.260	0.260	94	4.0	257	65	92	
	120/OFF	900.031									
FINAL DIFF/AVGS.		50.959	0.1316		0.555	90.8				91.8	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/1,2/86	EXXON REFINERY - BAYTOWN, TX	CT-68-2-1	CT-68-3-1
	Run Start Time	1417	933
	Run Finish Time	1623	1138
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.255	0.250
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.200
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.488	0.555
Vm	Volume of Metered Gas Sample, Dry ACF	46 926	50 959
tm	Dry Gas Meter Temperature, Degrees F	95.8	90.8
Vm(std)	Volume of Metered Gas Sample, Dry SCF	45.197	49.449
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	43.6	55.0
Vw(std)	Volume of Water Vapor, SCF	2.050	2.591
%H2O	Moisture Content, % by Volume	4.34	4.98
Mfd	Dry Mole Fraction	0.957	0.950
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.37	28.30
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.200
ts	Flue Gas Temperature, Degrees F	87	92
Delta p	Average Velocity Head, in. H2O	0.1101	0.1316
vs	Flue Gas Velocity, Ft/Sec	19.03	20.93
A	Stack/Duct Area, Sq. Inches	37688.0	37688.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	278,776.8	301,625.7
Qaw	Volumetric Air Flow Rate, Wet ACFM	298,864.2	328,656.0
%I	Isokinetic Sampling Rate, %	99.7	104.9

EMISSIONS RESULTS

9/1,2/86	EXXON REFINERY - BAYTOWN, TX	CT-68-2-1	CT-68-3-1
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	87.5	91.8
	Degrees Centigrade	30.8	33.2
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.5078	0.5584
	Actual Cubic Feet/hr	17.9318	19.7194
	Dry Std. Cubic Meters/hr	0.4736	0.5125
	Dry Std. Cubic Feet/hr	16.7266	18.0975
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	11.1514 ug	1.3759 ug
mg/dscm	Concentration, mg/dscm	8.713 x 10E-3	0 983 x 10E-3
gr/dscf	Concentration, grains per dscf	3.8070 x 10E-6	0.4293 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	9.063 x 10E-3	1.163 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	4.115 x 10E-3	0.528 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	11.151 ug	1.388 ug
mg/dscm	Concentration, mg/dscm	8.713 x 10E-3	0.991 x 10E-3
gr/dscf	Concentration, grains per dscf	3.807 x 10E-6	0.433 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	9.063 x 10E-3	1.174 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	4.115 x 10E-3	0.533 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9-1-86
SAMPLING LOCATION	CT 68 FAN CELL #5	RUN NUMBER	CT-68-5-1
OPERATOR	DB	NOZZLE #	704
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.249
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.68
LEAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1050	TOT VOL. H2O COLL.(ml)	55.8 ug
RUN STOP TIME	1328	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	66.683 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	66.683 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	85,530.0		

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	168.400	0.050	0.170	0.170	84	2.0	210	56	86	
A-2	5	169.670	0.190	0.690	0.690	84	5.0	425	58	85	
A-3	10	171.900	0.310	1.170	1.170	85	6.0	550	58	83	
A-4	15	174.940	0.370	1.400	1.400	88	6.0	600	61	82	
A-5	20	178.380	0.380	1.440	1.440	91	6.0	600	64	77	
A-6	25	181.830	0.050	0.190	0.190	94	2.0	220	63	81	
A-7	30	183.230	0.320	1.200	1.200	94	6.0	550	66	80	
A-8	35	186.500	0.450	1.720	1.720	96	7.0	660	65	83	
A-9	40	190.250	0.470	1.800	1.800	98	8.0	675	64	83	
A-10	45	194.200	0.440	1.680	1.680	101	7.0	650	65	83	
A-11	50	198.040	0.270	1.040	1.040	103	6.0	510	67	82	
A-12	55	201.310	0.000	0.010	0.010	104	1.0	52	67	84	
B-1	60	201.630	0.120	0.470	0.470	100	3.0	350	69	94	0.000
B-2	5	203.665	0.330	1.240	1.240	100	6.0	570	68	94	0.000
B-3	10	206.940	0.430	1.610	1.610	100	7.0	650	69	95	
B-4	15	210.670	0.380	1.440	1.440	102	6.0	610	69	92	
B-5	20	214.350	0.130	0.510	0.510	104	4.0	360	68	89	
B-6	25	216.570	0.010	0.040	0.040	104	1.0	95	68	84	
B-7	30	217.105	0.010	0.060	0.060	99	1.0	120	70	90	
B-8	35	217.880	0.160	0.620	0.620	98	4.0	400	70	90	
B-9	40	220.200	0.310	1.170	1.170	99	6.0	550	69	89	
B-10	45	223.450	0.410	1.560	1.560	101	7.0	630	70	87	
B-11	50	227.110	0.320	1.260	1.260	103	6.0	560	70	86	
B-12	55	230.480	0.030	0.130	0.130	104	1.0	180	71	84	
	120/OFF	231.560									
FINAL DIFF/AVGS.		63.160	0.2047		0.943	97.3				86.0	

FIELD DATA

PLANT	EXXON	DATE	9-1-86
SAMPLING LOCATION	CT 68 FAN CELL #5	RUN NUMBER	CT-68-5-2
OPERATOR	DB	NOZZLE #	705
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.257
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.68
LEAK RATE.CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1400	TOT VOL. H2O COLL.(ml)	68.9
RUN STOP TIME	1631	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	8.856 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	8.856 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	85,530.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	231.731	0.200	0.840	0.840	96	4.0	440	56	93	
A-2	5	234.520	0.220	0.910	0.910	96	4.0	460	55	93	
A-3	10	237.400	0.330	1.420	1.420	97	6.0	570	56	91	
A-4	15	240.888	0.420	1.790	1.790	99	7.0	640	57	91	
A-5	20	244.750	0.310	1.350	1.350	101	5.0	550	57	87	
A-6	25	248.200	0.040	0.180	0.180	102	1.0	200	58	85	
A-7	30	249.472	0.160	0.690	0.690	98	4.0	400	60	96	
A-8	35	252.100	0.310	1.310	1.310	99	6.0	550	58	94	
A-9	40	255.320	0.410	1.720	1.720	100	7.0	635	59	96	
A-10	45	259.150	0.420	1.790	1.790	102	7.0	640	60	93	
A-11	50	263.100	0.120	0.520	0.520	104	3.0	340	60	87	
A-12	55	265.280	0.010	0.050	0.050	104	1.0	110	61	86	
B-1	60	265.728	0.050	0.230	0.230	98	1.0	230	63	92	0.000
B-2	5	267.175	0.200	0.840	0.840	97	4.0	440	60	91	0.000
B-3	10	269.800	0.300	1.270	1.270	98	5.0	540	59	92	
B-4	15	273.050	0.430	1.860	1.860	99	8.0	650	61	89	
B-5	20	276.930	0.270	1.150	1.150	101	5.0	510	62	88	
B-6	25	280.180	0.100	0.430	0.430	103	2.0	310	62	86	
B-7	30	282.295	0.320	1.400	1.400	100	6.0	560	66	85	
B-8	35	285.870	0.470	2.050	2.050	101	8.0	675	64	84	
B-9	40	290.070	0.510	2.220	2.220	103	8.0	700	65	83	
B-10	45	294.450	0.480	2.110	2.110	104	8.0	685	67	86	
B-11	50	298.730	0.080	0.350	0.350	105	2.0	250	69	85	
B-12	55	300.510	0.090	0.410	0.410	104	2.0	300	69	85	
	120/OFF	302.448									
FINAL DIFF/AVGS.		70.717	0.2311		1.120	100.5				89.1	

FIELD DATA

PLANT	EXXON	DATE	9-1-86
SAMPLING LOCATION	CT 68 FAN CELL #5	RUN NUMBER	CT-68-5-3
OPERATOR	DB	NOZZLE #	704
BAR.PRESS.,in Hg	30.2000	NOZZLE DIAMETER,inches	0.249
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.68
LEAK RATE,CFM	0.0050	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1033	TOT VOL. H2O COLL.(ml)	60.4
RUN STOP TIME	1302	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	2.902 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	2.902 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	85,530.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	302.700	0.080	0.300	0.300	86	2.0	280	56	87	
A-2	5	304.360	0.180	0.670	0.670	86	2.0	420	56	88	
A-3	10	306.500	0.430	1.620	1.620	88	5.0	650	58	86	
A-4	15	310.300	0.460	1.740	1.740	90	5.0	670	59	84	
A-5	20	314.050	0.280	7.060	1.060	94	3.0	520	60	84	
A-6	25	317.140	0.090	0.350	0.350	97	2.0	300	60	84	
A-7	30	318.972	0.320	1.200	1.200	96	6.0	560	62	83	
A-8	35	322.200	0.470	1.800	1.800	100	8.0	675	60	84	
A-9	40	326.110	0.500	1.940	1.940	102	9.0	700	59	85	
A-10	45	330.130	0.440	1.680	1.680	104	8.0	650	60	84	
A-11	50	333.950	0.070	0.290	0.290	106	3.0	170	61	89	
A-12	55	335.670	0.030	0.100	0.100	106	1.0	160	62	84	
B-1	60	336.730	0.200	0.770	0.770	102	4.0	450	65	96	0.000
B-2	5	339.430	0.330	1.260	1.260	102	6.0	575	63	95	0.000
B-3	10	342.770	0.430	1.640	1.640	103	8.0	650	64	91	
B-4	15	346.685	0.390	1.490	1.490	106	7.0	620	64	93	
B-5	20	350.320	0.160	0.640	0.640	107	4.0	400	66	86	
B-6	25	352.785	0.020	0.100	0.100	106	1.0	155	66	83	
B-7	30	353.700	0.030	0.130	0.130	100	1.0	180	69	90	
B-8	35	354.820	0.160	0.620	0.620	99	2.0	400	67	91	
B-9	40	357.280	0.300	1.140	1.140	98	2.0	545	70	90	
B-10	45	360.390	0.370	1.410	1.410	99	6.0	600	70	87	
B-11	50	363.780	0.260	0.980	0.980	100	4.0	500	70	87	
B-12	55	366.735	0.080	0.300	0.300	100	2.0	275	70	84	
	120/OFF	368.340									
FINAL DIFF/AVGS.		65.640	0.2215		0.968	99.0				87.3	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/1,2/86	EXXON REFINERY - BAYTOWN, TX	CT-68-5-1	CT-68-5-2	CT-68-5-3
	Run Start Time	1050	1400	1033
	Run Finish Time	1328	1631	1302
Theta	Net Run Time, Minutes	120	120	120
	Net Sampling Points	24	24	24
Dia	Nozzle Diameter, Inches	0.249	0.257	0.249
Cp	Pitot Tube Coefficient	0.840	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.004	1.004	1.004
Pbar	Barometric Pressure, Inches Hg	30.250	30.250	30.200
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.943	1.120	0.968
Vm	Volume of Metered Gas Sample, Dry ACF	63.16	70 717	65.64
tm	Dry Gas Meter Temperature, Degrees F	97.3	100.5	99.0
Vm(std)	Volume of Metered Gas Sample, Dry SCF	60.865	67.796	62.961
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	55.8	68.9	60.4
Vw(std)	Volume of Water Vapor, SCF	2.627	3.244	2.845
%H2O	Moisture Content, % by Volume	4.14	4.57	4.32
Mfd	Dry Mole Fraction	0.959	0.954	0.957
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.39	28.34	28.37
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.250	30.200
ts	Flue Gas Temperature, Degrees F	86	89	87
Delta p	Average Velocity Head, in. H2O	0.2047	0.2311	0.2215
vs	Flue Gas Velocity, Ft/Sec	25.91	27.63	27.01
A	Stack/Duct Area, Sq. Inches	85530.0	85530.0	85530.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	865,367.7	913,506.8	896,827.8
Qaw	Volumetric Air Flow Rate, Wet ACFM	923,231.4	984,581.1	962,591.2
%I	Isokinetic Sampling Rate, %	102.9	102.0	102.8

EMISSIONS RESULTS

		CT-68-5-1	CT-68-5-2	CT-68-5-3
9/1.2/86	EXXON REFINERY - BAYTOWN, TX			
	FLUE GAS TEMPERATURE			
	Degrees Fahrenheit	86.0	89.1	87 3
	Degrees Centigrade	30.0	31.7	30.7
	AIR FLOW RATES x million			
	Actual Cubic Meters/hr	1.5686	1.6728	1.6355
	Actual Cubic Feet/hr	55.3939	59.0749	57.7555
	Dry Std. Cubic Meters/hr	1.4703	1.5521	1.5237
	Dry Std. Cubic Feet/hr	51.9221	54.8104	53.8097
	CONCENTRATIONS AND EMISSION RATES - PMRa			
	HEXAVALENT CHROMIUM (GFAA)			
ug	Catch	66.683 ug	8.8559 ug	2.9017 ug
mg/dscm	Concentration, mg/dscm	38.691 x 10E-3	4.613 x 10E-3	1.628 x 10E-3
gr/dscf	Concentration, grains per dscf	16.9051 x 10E-6	2.0155 x 10E-6	0.7111 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	128.991 x 10E-3	16.081 x 10E-3	5.613 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	58.562 x 10E-3	7.301 x 10E-3	2.548 x 10E-3
	TOTAL CHROMIUM (GFAA)			
ug	Catch	66.683 ug	8.856 ug	2.902 ug
mg/dscm	Concentration, mg/dscm	38.691 x 10E-3	4.613 x 10E-3	1.628 x 10E-3
gr/dscf	Concentration, grains per dscf	16.905 x 10E-6	2.016 x 10E-6	0.711 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	128.991 x 10E-3	16.081 x 10E-3	5.613 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	58.562 x 10E-3	7.301 x 10E-3	2.548 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9-4-86
SAMPLING LOCATION	CT 84 FAN CELL A	RUN NUMBER	CT-84-A-1
OPERATOR	DB	NOZZLE #	204
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	0.255
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	950	TOT VOL. H2O COLL.(ml)	64.3
RUN STOP TIME	1200	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	6.701 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	6.740 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
1	0/0	942.924	0.210	0.870	0.870	90	5.0	450	56	89	
	5	945.870	0.210	0.870	0.870	91	6.0	450	56	91	
2	10	948.890	0.330	1.370	1.370	92	8.0	565	56	91	
	15	952.100	0.330	1.370	1.370	95	8.0	565	57	91	
3	20	955.620	0.340	1.420	1.420	98	8.0	575	58	92	
	25	959.210	0.340	1.420	1.420	99	8.0	575	59	90	
4	30	962.950	0.280	1.180	1.180	101	7.0	525	60	89	
	35	966.225	0.280	1.180	1.180	102	7.0	525	60	89	
5	40	969.680	0.040	0.180	0.180	104	1.0	205	60	89	
	45	971.020	0.040	0.180	0.180	105	1.0	205	60	91	
6	50	972.430	0.020	0.100	0.100	105	1.0	155	60	91	
	55	973.500	0.020	0.100	0.100	107	1.0	155	63	90	
12	60	974.676	0.120	0.510	0.510	105	3.0	340	66	91	0.000
	5	976.970	0.120	0.510	0.510	105	3.0	340	64	92	0.000
11	10	979.210	0.230	0.990	0.990	105	6.0	475	63	93	
	15	982.440	0.230	0.990	0.990	106	6.0	475	63	93	
10	20	985.480	0.260	1.100	1.100	109	6.0	500	64	92	
	25	988.850	0.260	1.100	1.100	111	6.0	500	64	93	
9	30	992.160	0.270	1.140	1.140	112	7.0	510	66	93	
	35	995.420	0.270	1.140	1.140	114	7.0	510	68	95	
8	40	998.870	0.060	0.270	0.270	115	2.0	250	69	94	
	45	1000.530	0.060	0.270	0.270	115	2.0	250	70	94	
7	50	1002.310	0.020	0.100	0.100	115	1.0	150	70	92	
	55	1003.390	0.020	0.100	0.100	115	1.0	150	70	92	
	120/OFF	1004.452									
FINAL DIFF/AVGS.		61.528	0.1553		0.769	104.8				91.5	

FIELD DATA

PLANT	EXXON	DATE	9-4-86
SAMPLING LOCATION	CT 84 FAN CELL A	RUN NUMBER	CT-84-A-2
OPERATOR	DB	NOZZLE #	705
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	0.257
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1230	TOT VOL. H2O COLL.(ml)	60.6
RUN STOP TIME	1441	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	0.685 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	0.708 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
12	0/0	4.697	0.140	0.630	0.630	115	4.0	370	58	90	
	5	7.370	0.140	0.630	0.630	115	4.0	370	57	90	
11	10	9.850	0.270	1.200	1.200	113	5.0	510	57	91	
	15	13.200	0.270	1.200	1.200	112	5.0	510	58	91	
10	20	16.740	0.260	1.100	1.100	110	5.0	505	56	92	
	25	20.000	0.280	1.250	1.250	112	5.0	520	56	90	
9	30	23.480	0.260	1.160	1.160	112	5.0	500	59	89	
	35	26.880	0.260	1.160	1.160	114	5.0	500	60	89	
8	40	30.420	0.100	0.450	0.450	114	2.0	310	62	87	
	45	32.770	0.080	0.340	0.340	114	2.0	270	62	87	
7	50	34.630	0.030	0.150	0.150	114	2.0	180	63	84	
	55	36.100	0.030	0.150	0.150	113	2.0	180	65	85	
1	60	37.400	0.230	1.040	1.040	111	5.0	475	69	89	0.000
	5	40.750	0.230	1.040	1.040	110	5.0	475	66	89	0.000
2	10	44.000	0.310	1.410	1.410	110	6.0	550	67	87	
	15	47.620	0.310	1.410	1.410	111	6.0	550	69	88	
3	20	51.380	0.340	1.510	1.510	112	6.0	570	70	87	
	25	55.800	0.340	1.510	1.510	112	6.0	570	71	87	
4	30	59.120	0.170	0.750	0.750	113	4.0	400	70	86	
	35	62.100	0.160	0.740	0.740	112	4.0	400	70	88	
5	40	64.800	0.040	0.160	0.160	112	2.0	185	69	85	
	45	66.510	0.040	0.190	0.190	111	2.0	200	69	86	
6	50	68.000	0.040	0.190	0.190	111	2.0	200	71	86	
	55	69.565	0.040	0.190	0.190	110	2.0	200	71	86	
	120/OFF	70.942									
FINAL DIFF/AVGS.		66.245	0.1614		0.815	112.2				87.9	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/4/86	EXXON REFINERY - BAYTOWN, TX	CT-84-A-1	CT-84-A-2
	Run Start Time	950	1230
	Run Finish Time	1200	1441
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.255	0.257
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.350	30.350
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.769	0.815
Vm	Volume of Metered Gas Sample, Dry ACF	61.528	66.245
tm	Dry Gas Meter Temperature, Degrees F	104.8	112.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	58.544	62.227
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	64.3	60.6
Vw(std)	Volume of Water Vapor, SCF	3.027	2.852
%H2O	Moisture Content, % by Volume	4.92	4.38
Mfd	Dry Mole Fraction	0.951	0.956
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.31	28.37
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.350	30.350
ts	Flue Gas Temperature, Degrees F	92	88
Delta p	Average Velocity Head, in. H2O	0.1553	0.1614
vs	Flue Gas Velocity, Ft/Sec	22.67	23.02
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	564,258.1	579,963.8
Qaw	Volumetric Air Flow Rate, Wet ACFM	611,105.2	620,454.5
%I	Isokinetic Sampling Rate, %	109.5	111.5

EMISSIONS RESULTS

9/4/86	EXXON REFINERY - BAYTOWN, TX	CT-84-A-1	CT-84-A-2
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	91.5	87.9
	Degrees Centigrade	33.1	31.0
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	1.0383	1.0542
	Actual Cubic Feet/hr	36.6663	37.2273
	Dry Std. Cubic Meters/hr	0.9587	0.9854
	Dry Std. Cubic Feet/hr	33.8555	34.7978
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	6.7005 ug	0.6854 ug
mg/dscm	Concentration, mg/dscm	4.042 x 10E-3	0.389 x 10E-3
gr/dscf	Concentration, grains per dscf	1.7660 x 10E-6	0.1700 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	9.348 x 10E-3	0 941 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	4.244 x 10E-3	0.427 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	6.740 ug	0.708 ug
mg/dscm	Concentration, mg/dscm	4.065 x 10E-3	0.402 x 10E-3
gr/dscf	Concentration, grains per dscf	1.776 x 10E-6	0.175 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	9.402 x 10E-3	0.972 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	4.269 x 10E-3	0.441 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9-5-86
SAMPLING LOCATION	CT 84 FAN CELL B	RUN NUMBER	CT-84-B-1
OPERATOR	DB	NOZZLE #	207
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.307
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-14
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.72
LEAK RATE,CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	850	TOT VOL. H2O COLL.(ml)	91.6
RUN STOP TIME	1100	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	1.578 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	1.581 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
12	0/0	80.476	0.240	2.070	2.070	88	11.0	480	55	89	
	5	84.500	0.240	2.070	2.070	89	11.0	480	56	89	
11	10	88.710	0.260	2.270	2.270	91	12.0	500	58	88	
	15	93.120	0.260	2.270	2.270	91	12.0	500	59	89	
10	20	97.570	0.260	2.270	2.270	96	12.0	500	61	90	
	25	102.020	0.300	2.670	2.670	99	13.0	540	60	90	
9	30	106.850	0.270	2.380	2.380	102	13.0	510	60	91	
	35	111.480	0.270	2.390	2.390	104	13.0	510	60	91	
8	40	116.300	0.120	1.120	1.120	105	8.0	350	60	92	
	45	119.750	0.090	0.830	0.830	105	6.0	300	60	92	
7	50	122.490	0.070	0.670	0.670	106	6.0	270	61	91	
	55	125.210	0.070	0.670	0.670	106	6.0	270	62	91	
1	60	127.710	0.160	1.480	1.480	106	9.0	400	67	90	0.000
	5	131.500	0.160	1.480	1.480	106	9.0	400	63	91	0.000
2	10	135.320	0.250	2.310	2.310	108	12.0	500	62	92	
	15	139.850	0.260	2.320	2.320	110	12.0	500	62	91	
3	20	144.520	0.290	2.630	2.630	114	13.0	530	64	91	
	25	149.420	0.290	2.630	2.630	115	13.0	530	66	91	
4	30	154.450	0.210	1.900	1.900	118	11.0	450	67	92	
	35	158.720	0.210	1.900	1.900	118	11.0	450	68	92	
5	40	163.000	0.050	0.420	0.420	118	5.0	210	70	91	
	45	165.060	0.050	0.420	0.420	118	5.0	210	71	91	
6	50	167.310	0.030	0.290	0.290	118	4.0	175	70	90	
	55	169.030	0.030	0.290	0.290	116	4.0	175	70	90	
	120/OFF	170.830									
FINAL DIFF/AVGS.		90.354	0.1691		1.656	106.1				90.6	

FIELD DATA

PLANT	EXXON	DATE	9-5-86
;AMPLING LOCATION	CT 84 FAN CELL B	RUN NUMBER	CT-84-B-2
)PERATOR	DB	NOZZLE #	209
ЗAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.308
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-14
.EAK TEST VACUUM,in.Hg	15.0000	METER BOX ˆH@	1.72
.EAK RATE,CFM	0.0000	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1130	TOT VOL. H2O COLL.(ml)	97.5
?UN STOP TIME	1340	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	0.527 ug
?ITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	0.529 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Pt)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	ˆH Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
1	0/0	172.800	0.160	1.420	1.420	109	5.0	390	54	90	
	5	176.580	0.170	1.570	1.570	109	6.0	410	56	90	
2	10	180.520	0.280	2.510	2.510	110	7.0	520	56	91	
	15	185.350	0.290	2.620	2.620	112	7.0	530	58	91	
3	20	190.380	0.290	2.630	2.630	114	7.0	530	58	91	
	25	195.400	0.290	2.630	2.630	116	7.0	530	58	92	
4	30	200.440	0.220	1.980	1.980	115	6.0	460	58	92	
	35	204.830	0.220	2.020	2.020	115	6.0	465	60	92	
5	40	209.750	0.160	1.490	1.490	114	5.0	400	60	93	
	45	213.140	0.140	1.250	1.250	114	5.0	365	62	91	
6	50	216.750	0.030	0.270	0.270	113	2.0	170	62	91	
	55	218.370	0.030	0.290	0.290	112	2.0	175	64	91	
12	60	220.185	0.180	1.650	1.650	110	6.0	470	68	90	0.000
	5	224.250	0.160	1.490	1.490	110	6.0	400	65	90	0.000
11	10	228.150	0.310	2.810	2.810	110	8.0	550	65	91	
	15	233.270	0.270	2.420	2.420	110	7.0	510	66	91	
10	20	238.640	0.310	2.820	2.820	112	8.0	550	69	91	
	25	243.375	0.330	2.980	2.980	113	8.0	565	70	91	
9	30	248.700	0.280	2.540	2.540	113	8.0	520	71	90	
	35	253.600	0.280	2.540	2.540	113	8.0	520	72	90	
8	40	258.570	0.120	1.090	1.090	114	5.0	340	71	90	
	45	261.870	0.120	1.090	1.090	114	5.0	340	73	90	
7	50	265.200	0.050	0.420	0.420	114	2.0	210	75	89	
	55	267.450	0.040	0.370	0.370	110	2.0	200	75	90	
	120/OFF	269.515									
FINAL DIFF/AVGS.		96.715	0.1814		1.788	112.3				90.8	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/5/86	EXXON REFINERY - BAYTOWN, TX	CT-84-B-1	CT-84-B-2
	Run Start Time	850	1130
	Run Finish Time	1100	1340
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.307	0.308
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.250
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	1.656	1.788
Vm	Volume of Metered Gas Sample, Dry ACF	90.354	96.715
tm	Dry Gas Meter Temperature, Degrees F	106.1	112.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	85.678	90.744
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	91.6	97.5
Vw(std)	Volume of Water Vapor, SCF	4.313	4.587
%H2O	Moisture Content, % by Volume	4.79	4.81
Mfd	Dry Mole Fraction	0.952	0.952
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.32	28.32
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.250
ts	Flue Gas Temperature, Degrees F	91	91
Delta p	Average Velocity Head, in. H2O	0.1691	0.1814
vs	Flue Gas Velocity, Ft/Sec	23.67	24.53
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	589,015.6	609,927.1
Qaw	Volumetric Air Flow Rate, Wet ACFM	638,138.3	661,075.0
%I	Isokinetic Sampling Rate, %	105.9	107.7

EMISSIONS RESULTS

		CT-84-B-1	CT-84-B-2
9/5/86	EXXON REFINERY - BAYTOWN, TX		
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	90.6	90.8
	Degrees Centigrade	32.6	32.6
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	1.0842	1.1232
	Actual Cubic Feet/hr	38.2883	39.6645
	Dry Std. Cubic Meters/hr	1.0007	1.0363
	Dry Std. Cubic Feet/hr	35.3409	36.5956
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	1.5778 ug	0.5268 ug
mg/dscm	Concentration, mg/dscm	0.650 x 10E-3	0.205 x 10E-3
gr/dscf	Concentration, grains per dscf	0.2841 x 10E-6	0.0896 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	1.519 x 10E-3	0.504 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	0.689 x 10E-3	0.229 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	1.581 ug	0.529 ug
mg/dscm	Concentration, mg/dscm	0.652 x 10E-3	0.206 x 10E-3
gr/dscf	Concentration, grains per dscf	0.285 x 10E-6	0.090 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	1.522 x 10E-3	0.506 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	0.691 x 10E-3	0.230 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9-4-86
SAMPLING LOCATION	CT 84 FAN CELL C	RUN NUMBER	CT-84-C-1
OPERATOR	TMS	NOZZLE #	206
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	0.250
STATIC PRESS.in H2O	1.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ˆH@	1.68
LEAK RATE,CFM	0.0010	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	953	TOT VOL. H2O COLL.(ml)	60.8
RUN STOP TIME	1207	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	12.775 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	13.259 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	ˆH Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
1	0/0	368.639	0.230	0.850	0.850	90	6.0	469	55	91	
	5	371.400	0.230	0.870	0.870	93	6.0	473	53	90	
2	10	373.920	0.330	1.250	1.250	94	8.0	568	55	92	
	15	399.610	0.330	1.250	1.250	94	8.0	566	56	91	
3	20	380.570	0.340	1.310	1.310	94	8.0	580	58	91	
	25	384.340	0.330	1.270	1.270	95	8.0	571	57	91	
4	30	387.720	0.150	0.570	0.570	96	5.0	382	58	91	
	35	390.410	0.160	0.610	0.610	98	5.0	401	58	99	
5	40	392.480	0.030	0.120	0.120	98	2.0	176	59	99	
	45	393.690	0.030	0.090	0.090	98	2.0	158	61	102	
6	50	394.670	0.030	0.100	0.100	100	2.0	166	60	103	
	55	395.630	0.030	0.100	0.100	100	2.0	163	61	104	
12	60	396.691	0.150	0.590	0.590	97	5.0	389	57	92	396.633
	5	398.910	0.130	0.510	0.510	98	5.0	362	58	91	396.691
11	10	400.980	0.230	0.870	0.870	99	6.0	471	58	92	
	15	403.870	0.240	0.910	0.910	100	7.0	481	59	92	
10	20	406.620	0.250	0.970	0.970	102	7.0	496	61	92	
	25	409.810	0.260	1.000	1.000	101	7.0	503	60	91	
9	30	412.630	0.250	0.960	0.960	102	7.0	493	60	91	
	35	415.590	0.210	0.820	0.820	102	6.0	455	61	90	
8	40	418.520	0.020	0.070	0.070	102	1.0	129	60	91	
	45	419.610	0.040	0.170	0.170	102	2.0	206	59	92	
7	50	420.800	0.020	0.070	0.070	102	1.0	133	60	92	
	55	421.800	0.020	0.080	0.080	102	1.0	143	62	92	
	120/OFF	422.680									
FINAL DIFF/AVGS.		53.983	0.1424		0.642	98.3				93.4	

FIELD DATA

PLANT	EXXON	DATE	9-4-86
SAMPLING LOCATION	CT 84 FAN CELL C	RUN NUMBER	CT-84-C-2
OPERATOR	TMS	NOZZLE #	704
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	0.249
STATIC PRESS.in H2O	1.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.68
LEAK RATE,CFM	0.0100	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1224	TOT VOL. H2O COLL.(ml)	58.8
RUN STOP TIME	1442	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	0.550 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	0.554 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
12	0/0	422.870	0.150	0.590	0.590	98	3.0	389	53	93	
	5	425.590	0.130	0.510	0.510	98	2.0	362	55	92	
11	10	427.510	0.230	0.870	0.870	98	2.0	471	56	92	
	15	430.420	0.240	0.910	0.910	98	3.0	481	58	92	
10	20	432.990	0.250	0.970	0.970	98	3.0	496	59	92	
	25	436.110	0.260	1.000	1.000	99	3.0	503	60	91	
9	30	439.050	0.250	0.960	0.960	98	3.0	493	59	91	
	35	442.290	0.210	0.820	0.820	98	3.0	455	59	91	
8	40	444.730	0.020	0.070	0.070	97	1.0	129	60	91	
	45	445.640	0.040	0.170	0.170	96	1.0	206	61	93	
7	50	447.280	0.020	0.070	0.070	96	1.0	133	60	94	
	55	447.990	0.020	0.080	0.080	96	1.0	143	60	93	
6	60	449.032	0.030	0.100	0.100	94	1.0	163	58	93	448.918
	5	450.110	0.030	0.100	0.100	94	1.0	166	60	93	449.032
5	10	451.100	0.030	0.090	0.090	94	1.0	158	61	93	
	15	452.080	0.030	0.120	0.120	94	1.0	176	62	93	
4	20	453.290	0.160	0.610	0.610	93	4.0	401	61	93	
	25	455.580	0.150	0.570	0.570	93	4.0	382	62	93	
3	30	457.910	0.330	1.270	1.270	92	6.0	571	63	93	
	35	461.410	0.340	1.310	1.310	92	6.0	580	64	93	
2	40	464.720	0.330	1.250	1.250	92	6.0	566	63	93	
	45	468.160	0.330	1.250	1.250	92	6.0	568	65	92	
1	50	471.190	0.230	0.870	0.870	92	5.0	473	65	91	
	55	474.010	0.230	0.850	0.850	92	5.0	469	65	92	
	120/OFF	476.710									
FINAL DIFF/AVGS.		53.726	0.1424		0.642	95.2				92.4	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/4/86	EXXON REFINERY - BAYTOWN, TX	CT-84-C-1	CT-84-C-2
	Run Start Time	953	1224
	Run Finish Time	1207	1442
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.250	0.249
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.004	1.004
Pbar	Barometric Pressure, Inches Hg	30.350	30.350
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	0.642	0.642
Vm	Volume of Metered Gas Sample, Dry ACF	53 983	53.726
tm	Dry Gas Meter Temperature, Degrees F	98.3	95.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	52.065	52.109
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	60.8	58.8
Vw(std)	Volume of Water Vapor, SCF	2.861	2.768
%H2O	Moisture Content, % by Volume	5.21	5.04
Mfd	Dry Mole Fraction	0.948	0.950
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.28	28.29
Pg	Flue Gas Static Pressure, in. Hg	1.00	1.00
Ps	Absolute Flue Gas Press., in Hg	30.424	30.424
ts	Flue Gas Temperature, Degrees F	93	92
Delta p	Average Velocity Head, in. H2O	0.1424	0.1424
vs	Flue Gas Velocity, Ft/Sec	21.73	21.71
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	538,701.2	539,977.3
Qaw	Volumetric Air Flow Rate, Wet ACFM	585,805.2	585,068.5
%I	Isokinetic Sampling Rate, %	106.1	106.8

EMISSIONS RESULTS

9/4/86	EXXON REFINERY - BAYTOWN, TX	CT-84-C-1	CT-84-C-2
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	93.4	92.4
	Degrees Centigrade	34.1	33.5
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.9953	0.9940
	Actual Cubic Feet/hr	35.1483	35.1041
	Dry Std. Cubic Meters/hr	0.9153	0.9174
	Dry Std. Cubic Feet/hr	32.3221	32.3986
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	12.7753 ug	0.5498 ug
mg/dscm	Concentration, mg/dscm	8.665 x 10E-3	0.373 x 10E-3
gr/dscf	Concentration, grains per dscf	3.7861 x 10E-6	0.1628 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	18.542 x 10E-3	0.804 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	8.418 x 10E-3	0.365 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	13.259 ug	0.554 ug
mg/dscm	Concentration, mg/dscm	8.993 x 10E-3	0.375 x 10E-3
gr/dscf	Concentration, grains per dscf	3.929 x 10E-6	0.164 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	19.244 x 10E-3	0.810 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	8.737 x 10E-3	0.368 x 10E-3

FIELD DATA

PLANT	EXXON
SAMPLING LOCATION	CT 84 FAN CELL D
OPERATOR	TME
BAR.PRESS.,in Hg	30.2500
STATIC PRESS.in H2O	1.0000
LEAK TEST VACUUM,in.Hg	15.0000
LEAK RATE,CFM	0.0090
DATE	9-5-86
RUN NUMBER	CT-84-D-1
NOZZLE #	707
NOZZLE DIAMETER,inches	0.299
METER BOX NUMBER	N-10
METER BOX ^H@	1.68
ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	835
RUN STOP TIME	1043
TOTAL NET RUN TIME (Minutes)	120
PITOT TUBE COEFFICIENT	0.840
GAS METER CALIB. FACTOR (Y)	1.004
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84
STACK/DUCT AREA (in2)	64,692.0
TOT VOL. H2O COLL.(ml)	73.4
TOTAL CATCH - HEXAVALENT CHROMIUM (GFAA)	0.455 ug
TOTAL CATCH - TOTAL CHROMIUM (GFAA)	0.459 ug
TOTAL CATCH -	ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
12	0/0	484.748	0.080	0.610	0.610	90	4.0	276	55	85	
	5	487.090	0.090	0.700	0.700	92	4.0	293	56	84	
11	10	489.910	0.220	1.760	1.760	94	7.0	465	58	84	
	15	493.270	0.230	1.800	1.800	94	7.0	472	58	87	
10	20	497.310	0.240	1.870	1.870	94	7.0	483	59	89	
	25	501.190	0.250	1.960	1.960	94	8.0	496	58	90	
9	30	505.230	0.240	1.870	1.870	95	7.0	485	58	91	
	35	509.270	0.250	1.940	1.940	95	8.0	494	57	92	
8	40	513.320	0.090	0.680	0.680	96	4.0	293	58	92	
	45	515.890	0.080	0.600	0.600	96	3.0	274	59	93	
7	50	518.220	0.020	0.140	0.140	96	1.0	132	58	93	
	55	519.360	0.020	0.130	0.130	96	1.0	127	59	93	
6	60	520.370	0.020	0.190	0.190	96	1.0	153	56	92	0.000
	5	521.820	0.020	0.170	0.170	96	1.0	148	57	91	0.000
5	10	523.100	0.040	0.280	0.280	96	2.0	189	58	91	
	15	524.620	0.040	0.340	0.340	97	2.0	206	60	92	
4	20	526.680	0.240	1.910	1.910	95	8.0	489	59	92	
	25	530.520	0.220	1.740	1.740	93	7.0	467	61	91	
3	30	534.150	0.260	2.020	2.020	94	8.0	503	62	92	
	35	538.390	0.280	2.150	2.150	96	9.0	519	64	92	
2	40	542.820	0.230	1.820	1.820	97	7.0	478	63	91	
	45	547.010	0.240	1.880	1.880	96	8.0	486	64	90	
1	50	550.830	0.100	0.800	0.800	96	4.0	316	65	91	
	55	553.560	0.110	0.830	0.830	95	5.0	323	64	90	
	120/OFF	556.269									
FINAL DIFF/AVGS.		71.521	0.1307		1.175	95.0				90.3	

FIELD DATA

PLANT	EXXON	DATE	9-5-86
SAMPLING LOCATION	CT 84 FAN CELL D	RUN NUMBER	CT-84-D-2
OPERATOR	TME	NOZZLE #	707
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.299
STATIC PRESS.in H2O	1.0000	METER BOX NUMBER	N-10
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.68
LEAK RATE,CFM	0.0080	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1104	TOT VOL. H2O COLL.(ml)	72.7
RUN STOP TIME	1317	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	120	HEXAVALENT CHROMIUM (GFAA)	21.485 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.004	TOTAL CHROMIUM (GFAA)	21.540 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Pt)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
1	0/0	556.523	0.150	1.140	1.140	92	5.0	379	52	90	
	5	559.680	0.150	1.180	1.180	94	5.0	385	52	90	
2	10	562.930	0.260	2.000	2.000	96	8.0	502	53	92	
	15	566.970	0.240	1.910	1.910	98	8.0	489	53	92	
3	20	570.920	0.230	1.830	1.830	100	7.0	479	55	92	
	25	574.950	0.240	1.870	1.870	101	8.0	483	58	92	
4	30	578.020	0.130	1.050	1.050	102	5.0	362	57	92	
	35	582.160	0.130	1.010	1.010	100	5.0	354	58	91	
5	40	585.120	0.020	0.130	0.130	101	1.0	126	59	92	
	45	586.310	0.010	0.110	0.110	102	1.0	119	61	92	
6	50	587.350	0.020	0.130	0.130	100	1.0	124	61	92	
	55	588.600	0.010	0.110	0.110	98	1.0	120	63	92	
7	60	589.510	0.010	0.110	0.110	96	1.0	119	63	95	0.000
	5	590.590	0.020	0.130	0.130	96	1.0	130	61	94	0.000
8	10	591.760	0.020	0.180	0.180	96	2.0	149	61	93	
	15	593.070	0.030	0.260	0.260	96	2.0	182	62	94	
9	20	594.640	0.210	1.630	1.630	98	7.0	433	64	93	
	25	598.240	0.240	1.980	1.980	100	8.0	499	65	94	
10	30	602.420	0.220	1.730	1.730	98	7.0	468	65	94	
	35	606.330	0.230	1.770	1.770	99	7.0	472	66	94	
11	40	610.180	0.170	1.350	1.350	100	6.0	412	65	93	
	45	614.010	0.150	1.140	1.140	100	5.0	379	65	94	
12	50	617.210	0.120	0.900	0.900	99	4.0	337	67	94	
	55	619.670	0.120	0.960	0.960	97	5.0	348	67	93	
	120/OFF	622.638									
FINAL DIFF/AVGS.		66.115	0.1082		1.025	98.3				92.7	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/5/86	EXXON REFINERY - BAYTOWN, TX	CT-84-D-1	CT-84-D-2
	Run Start Time	835	1104
	Run Finish Time	1043	1317
Theta	Net Run Time, Minutes	120	120
	Net Sampling Points	24	24
Dia	Nozzle Diameter, Inches	0.299	0.299
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.004	1.004
Pbar	Barometric Pressure, Inches Hg	30.250	30.250
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	1.175	1.025
Vm	Volume of Metered Gas Sample, Dry ACF	71.521	66.115
tm	Dry Gas Meter Temperature, Degrees F	95.0	98.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	69.256	63.616
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	73.4	72.7
Vw(std)	Volume of Water Vapor, SCF	3.453	3.423
%H2O	Moisture Content, % by Volume	4.75	5.11
Mfd	Dry Mole Fraction	0.953	0.949
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.33	28.29
Pg	Flue Gas Static Pressure, in. Hg	1.00	1.00
Ps	Absolute Flue Gas Press., in Hg	30.324	30.324
ts	Flue Gas Temperature, Degrees F	90	93
Delta p	Average Velocity Head, in. H2O	0.1307	0.1082
vs	Flue Gas Velocity, Ft/Sec	20.78	18.96
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	518,718.3	469,512.5
Qaw	Volumetric Air Flow Rate, Wet ACFM	560,062.5	511,001.5
%I	Isokinetic Sampling Rate, %	102.5	104.0

EMISSIONS RESULTS

9/5/86	EXXON REFINERY - BAYTOWN, TX	CT-84-D-1	CT-84-D-2
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	90.3	92.7
	Degrees Centigrade	32.4	33.7
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.9516	0.8682
	Actual Cubic Feet/hr	33.6038	30.6601
	Dry Std. Cubic Meters/hr	0.8813	0.7977
	Dry Std. Cubic Feet/hr	31.1231	28.1707
	CONCENTRATIONS AND EMISSION RATES - PMRa		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	0.4553 ug	21.4854 ug
mg/dscm	Concentration, mg/dscm	0.232 x 10E-3	11.927 x 10E-3
gr/dscf	Concentration, grains per dscf	0.1014 x 10E-6	5.2113 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	0.462 x 10E-3	21.801 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	0.210 x 10E-3	9.898 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	0.459 ug	21.540 ug
mg/dscm	Concentration, mg/dscm	0.234 x 10E-3	11.957 x 10E-3
gr/dscf	Concentration, grains per dscf	0.102 x 10E-6	5.224 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRa)	0.466 x 10E-3	21.856 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRa)	0.211 x 10E-3	9.923 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9/1/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELLS 1 & 2	RUN NUMBER	CT-68-DI-1
OPERATOR	B.RUDD	NOZZLE #	Disc
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	1.614
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-12
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.76
LEAK RATE,CFM	0.0050	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1145	TOT VOL. H2O COLL.(ml)	215.6
RUN STOP TIME	1554	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	5.596 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	5.611 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,688.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	468.874	0.370	3.520	3.520	94	10.0	600	59	81	
"	15	484.590	0.370	3.520	3.520	96	10.0	600	62	82	
"	30	500.380	0.370	3.520	3.520	99	10.0	600	64	84	
"	45	516.860	0.370	3.520	3.520	100	10.0	600	65	85	
"	60/0	533.690	0.370	3.520	3.520	100	10.0	600	62	87	
"	15	547.380	0.370	3.520	3.520	100	10.0	600	64	87	
"	30	564.120	0.370	3.520	3.520	100	10.0	600	62	86	
"	45	578.710	0.370	3.520	3.520	100	10.0	600	65	86	
"	120/0	593.670	0.370	3.520	3.520	100	10.0	600	61	85	
"	15	609.330	0.370	3.520	3.520	99	10.0	600	63	86	
"	30	627.810	0.370	3.520	3.520	100	10.0	600	64	87	
"	45	641.070	0.370	3.520	3.520	100	10.0	600	66	85	
"	180/0	656.170	0.370	3.520	3.520	100	10.0	600	62	84	593.670
"	15	671.870	0.370	3.520	3.520	101	10.0	600	60	86	593.800
"	30	687.430	0.370	3.520	3.520	100	10.0	600	63	86	
"	45	702.920	0.370	3.520	3.520	100	10.0	600	65	87	
	240/OFF	718.714									
FINAL DIFF/AVGS.		249.710	0.3700		3.520	99.3				85.3	

FIELD DATA

PLANT	EXXON	DATE	9/1/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELLS 1 & 2	RUN NUMBER	CT-68-NZ-1
OPERATOR	B.RUDD	NOZZLE #	208
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.312
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-6
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.71
LEAK RATE,CFM	0.0040	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1145	TOT VOL. H2O COLL.(ml)	220.0
RUN STOP TIME	1554	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	9.840 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	9.866 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,668.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	958.858	0.370	3.520	3.520	85	14.0	600	61	81	
"	15	974.920	0.370	3.520	3.520	92	14.0	600	63	82	
"	30	990.860	0.370	3.520	3.520	97	14.0	600	58	84	
"	45	1007.540	0.370	3.520	3.520	98	14.0	600	60	85	
"	60/0	1024.600	0.370	3.520	3.520	99	14.0	600	62	87	
"	15	1038.660	0.370	3.520	3.520	99	14.0	600	64	87	
"	30	1055.890	0.370	3.520	3.520	100	14.0	600	62	86	
"	45	1070.380	0.370	3.520	3.520	101	14.0	600	62	86	
"	120/0	1085.450	0.370	3.520	3.520	98	14.0	600	63	85	
"	15	1101.470	0.370	3.520	3.520	100	14.0	600	65	86	
"	30	1119.580	0.370	3.520	3.520	97	14.0	600	66	87	
"	45	1133.290	0.370	3.520	.3.520	99	14.0	600	66	85	
"	180/0	1149.340	0.370	3.520	3.520	98	14.0	600	60	84	85.450
"	15	1165.270	0.370	3.520	3.520	99	14.0	600	63	86	85.600
"	30	1181.350	0.370	3.520	3.520	97	14.0	600	62	86	
"	45	1196.980	0.370	3.520	3.520	96	14.0	600	61	87	
	240/OFF	1212.875									
FINAL DIFF/AVGS.		253.867	0.3700		3.520	97.2				85.3	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/1/86	EXXON REFINERY - BAYTOWN. TX	CT-68-DI-1	CT-68-NZ-1
	Run Start Time	1145	1145
	Run Finish Time	1554	1554
Theta	Net Run Time, Minutes	240	240
	Net Sampling Points	16	16
Dia	Nozzle Diameter, Inches	1.614	0.312
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.250
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	3.520	3.520
Vm	Volume of Metered Gas Sample, Dry ACF	249.71	253.867
tm	Dry Gas Meter Temperature, Degrees F	99.3	97.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	240.754	245.695
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	215.6	220.0
Vw(std)	Volume of Water Vapor, SCF	10.147	10.356
%H2O	Moisture Content, % by Volume	4.04	4.04
Mfd	Dry Mole Fraction	0.960	0.960
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.40	28.40
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.250
ts	Flue Gas Temperature, Degrees F	85	85
Delta p	Average Velocity Head, in. H2O	0.3700	0.3700
vs	Flue Gas Velocity, Ft/Sec	34.80	34.80
A	Stack/Duct Area, Sq. Inches	37688.0	37668.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	513,361.9	513,089.1
Qaw	Volumetric Air Flow Rate, Wet ACFM	546,450.9	546,161.0
%I	Isokinetic Sampling Rate, %	3.6	98.3

EMISSIONS RESULTS

9/1/86	EXXON REFINERY - BAYTOWN. TX	CT-68-DI-1	CT-68-NZ-1
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	85.3	85.3
	Degrees Centigrade	29.6	29.6
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.9284	0.9279
	Actual Cubic Feet/hr	32.7871	32.7697
	Dry Std. Cubic Meters/hr	0.8722	0.8717
	Dry Std. Cubic Feet/hr	30.8017	30.7853
	CONCENTRATIONS AND EMISSION RATES - PMRc		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	5.5963 ug	9.8397 ug
mg/dscm	Concentration, mg/dscm	0.821 x 10E-3	1.414 x 10E-3
gr/dscf	Concentration, grains per dscf	0.3587 x 10E-6	0.6179 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.578 x 10E-3	2.718 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.716 x 10E-3	1.233 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	5.611 ug	9.866 ug
mg/dscm	Concentration, mg/dscm	0.823 x 10E-3	1.418 x 10E-3
gr/dscf	Concentration, grains per dscf	0.360 x 10E-6	0.620 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.582 x 10E-3	2.725 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.718 x 10E-3	1.236 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9/2/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELL #3	RUN NUMBER	CT-68-DI-2
OPERATOR	B.RUDD	NOZZLE #	Disc
BAR.PRESS.,in Hg	30.2000	NOZZLE DIAMETER,inches	1.614
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-12
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.76
LEAK RATE,CFM	0.0060	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	950	TOT VOL. H2O COLL.(ml)	263.7
RUN STOP TIME	1351	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	73.355 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	73.946 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,688.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	719.600	0.350	3.210	3.210	86	10.0	585	63	93	
"	15	735.890	0.350	3.210	3.210	90	10.0	585	60	93	
"	30	749.060	0.350	3.210	3.210	94	10.0	585	60	93	
"	45	763.720	0.350	3.210	3.210	94	10.0	585	58	92	
"	60/0	778.580	0.350	3.210	3.210	98	10.0	585	64	91	
"	15	794.220	0.350	3.210	3.210	99	10.0	585	66	93	
"	30	809.690	0.350	3.210	3.210	98	10.0	585	65	93	
"	45	824.420	0.350	3.210	3.210	99	10.0	585	61	93	
"	120/0	839.280	0.350	3.210	3.210	99	10.0	585	62	92	
"	15	856.140	0.350	3.210	3.210	99	10.0	585	60	93	
"	30	874.310	0.350	3.210	3.210	100	10.0	585	57	92	
"	45	887.590	0.350	3.210	3.210	101	10.0	585	60	93	
"	180/0	900.780	0.350	3.210	3.210	102	10.0	585	62	93	0.000
"	15	914.580	0.350	3.210	3.210	102	10.0	585	63	93	0.000
"	30	930.090	0.350	3.210	3.210	104	10.0	585	64	92	
"	45	945.100	0.350	3.210	3.210	103	10.0	585	62	92	
	240/OFF	959.240									
FINAL DIFF/AVGS.		239.640	0.3500		3.210	98.0				92.6	

FIELD DATA

PLANT	EXXON	DATE	9/2/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELL #3	RUN NUMBER	CT-68-NZ-2
OPERATOR	B.RUDD	NOZZLE #	208
BAR.PRESS.,in Hg	30.2000	NOZZLE DIAMETER,inches	0.312
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-6
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.71
LEAK RATE,CFM	0.0020	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	950	TOT VOL. H2O COLL.(ml)	269.6
RUN STOP TIME	1351	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	69.186 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	69.744 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	37,668.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	216.300	0.350	3.210	3.210	87	13.0	585	66	93	
"	15	233.020	0.350	3.210	3.210	91	13.0	585	60	93	
"	30	246.590	0.350	3.210	3.210	94	13.0	585	58	93	
"	45	261.810	0.350	3.210	3.210	94	13.0	585	61	93	
"	60/0	276.990	0.350	3.210	3.210	97	13.0	585	64	91	
"	15	293.010	0.350	3.210	3.210	98	13.0	585	64	93	
"	30	308.520	0.350	3.210	3.210	97	13.0	585	65	93	
"	45	323.560	0.350	3.210	3.210	97	13.0	585	66	93	
"	120/0	338.420	0.350	3.210	3.210	97	13.0	585	62	92	
"	15	355.630	0.350	3.210	3.210	98	13.0	585	60	93	
"	30	372.860	0.350	3.210	3.210	99	13.0	585	61	92	
"	45	386.910	0.350	3.210	3.210	100	13.0	585	62	93	
"	180/0	400.660	0.350	3.210	3.210	101	13.0	585	63	93	0.000
"	15	414.390	0.350	3.210	3.210	101	13.0	585	64	93	0.000
"	30	430.280	0.350	3.210	3.210	103	13.0	585	65	92	
"	45	446.020	0.350	3.210	3.210	103	13.0	585	62	92	
	240/OFF	460.522									
FINAL DIFF/AVGS.		244.222	0.3500		3.210	97.3				92.6	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/2/86	EXXON REFINERY - BAYTOWN. TX	CT-68-DI-2	CT-68-NZ-2
	Run Start Time	950	950
	Run Finish Time	1351	1351
Theta	Net Run Time, Minutes	240	240
	Net Sampling Points	16	16
Dia	Nozzle Diameter, Inches	1.614	0.312
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.200	30.200
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	3.210	3.210
Vm	Volume of Metered Gas Sample, Dry ACF	239.64	244.222
tm	Dry Gas Meter Temperature, Degrees F	98.0	97.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	231.036	235.744
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	263.7	269.6
Vw(std)	Volume of Water Vapor, SCF	12.413	12.691
%H2O	Moisture Content, % by Volume	5.10	5.11
Mfd	Dry Mole Fraction	0.949	0.949
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.29	28.29
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.200	30.200
ts	Flue Gas Temperature, Degrees F	93	93
Delta p	Average Velocity Head, in. H2O	0.3500	0.3500
vs	Flue Gas Velocity, Ft/Sec	34.17	34.17
A	Stack/Duct Area, Sq. Inches	37688.0	37668.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	491,113.4	490,783.5
Qaw	Volumetric Air Flow Rate, Wet ACFM	536,552.2	536,307.9
%I	Isokinetic Sampling Rate, %	3.6	98.6

EMISSIONS RESULTS

9/2/86	EXXON REFINERY - BAYTOWN. TX	CT-68-DI-2	CT-68-NZ-2
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	92.6	92.6
	Degrees Centigrade	33.6	33.7
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	0.9116	0.9112
	Actual Cubic Feet/hr	32.1931	32.1785
	Dry Std. Cubic Meters/hr	0.8344	0.8338
	Dry Std. Cubic Feet/hr	29.4668	29.4470
	CONCENTRATIONS AND EMISSION RATES - PMRc		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	73.3547 ug	69.1863 ug
mg/dscm	Concentration, mg/dscm	11.213 x 10E-3	10.364 x 10E-3
gr/dscf	Concentration, grains per dscf	4.8991 x 10E-6	4.5284 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	20.623 x 10E-3	19.050 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	9.354 x 10E-3	8.641 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	73.946 ug	69.744 ug
mg/dscm	Concentration, mg/dscm	11.303 x 10E-3	10.448 x 10E-3
gr/dscf	Concentration, grains per dscf	4.939 x 10E-6	4.565 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	20.789 x 10E-3	19.203 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	9.430 x 10E-3	8.710 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9/3/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELL #5	RUN NUMBER	CT-68-DI-3
OPERATOR	B.BRIDGES	NOZZLE #	Disc
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	1.614
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-12
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.76
LEAK RATE,CFM	0.0130	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	910	TOT VOL. H2O COLL.(ml)	202.3
RUN STOP TIME	1310	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	32.195 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	32.195 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	85,530.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	959.405	0.370	3.540	3.540	88	9.0	600	61	81	
"	15	975.010	0.370	3.540	3.540	99	9.0	600	61	81	
"	30	990.510	0.370	3.540	3.540	100	9.0	600	60	84	
"	45	1006.170	0.370	3.540	3.540	100	9.0	600	61	83	
"	60/0	1021.960	0.370	3.540	3.540	103	9.0	600	62	83	
"	15	1037.520	0.370	3.540	3.540	103	9.0	600	64	85	
"	30	1053.420	0.370	3.540	3.540	103	9.0	600	63	84	
"	45	1069.240	0.370	3.540	3.540	103	9.0	600	61	83	
"	120/0	1085.350	0.370	3.540	3.540	104	9.0	600	61	83	
"	15	1101.165	0.370	3.540	3.540	104	9.0	600	60	84	
"	30	1117.185	0.370	3.540	3.540	104	9.0	600	61	84	
"	45	1133.185	0.370	3.540	3.540	104	9.0	600	62	84	
"	180/0	1149.350	0.370	3.540	3.540	104	9.0	600	62	83	0.000
"	15	1165.220	0.370	3.540	3.540	104	9.0	600	63	82	0.000
"	30	1181.150	0.370	3.540	3.540	104	9.0	600	63	82	
"	45	1197.120	0.370	3.540	3.540	104	9.0	600	63	82	
	240/OFF	1213.129									
FINAL DIFF/AVGS.		253.724	0.3700		3.540	101.9				83.0	

FIELD DATA

PLANT	EXXON	DATE	9/3/86
SAMPLING LOCATION	COOLING TOWER 68 FAN CELL #5	RUN NUMBER	CT-68-NZ-3
OPERATOR	B.BRIDGES	NOZZLE #	208
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.312
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-6
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.71
LEAK RATE,CFM	0.0020	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	910	TOT VOL. H2O COLL.(ml)	202.5
RUN STOP TIME	1310	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	34.914 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	34.914 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	85,530.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	460.657	0.370	3.540	3.540	88	15.0	600	66	81	
"	15	476.220	0.370	3.540	3.540	96	15.0	600	64	82	
"	30	491.940	0.370	3.540	3.540	99	15.0	600	61	83	
"	45	507.745	0.370	3.540	3.540	100	15.0	600	60	83	
"	60/0	523.640	0.370	3.540	3.540	101	15.0	600	60	83	
"	15	539.450	0.370	3.540	3.540	101	15.0	600	62	84	
"	30	555.350	0.370	3.540	3.540	101	15.0	600	63	83	
"	45	570.160	0.370	3.540	3.540	102	15.0	600	62	83	
"	120/0	587.010	0.370	3.540	3.540	102	15.0	600	60	84	
"	15	602.820	0.370	3.540	3.540	101	15.0	600	62	84	
"	30	628.620	0.370	3.540	3.540	102	15.0	600	64	84	
"	45	634.385	0.370	3.540	3.540	102	15.0	600	64	84	
"	180/0	650.100	0.370	3.540	3.540	102	15.0	600	64	83	0.000
"	15	665.895	0.370	3.540	3.540	102	15.0	600	65	83	0.000
"	30	681.650	0.370	3.540	3.540	102	15.0	600	64	83	
"	45	697.460	0.370	3.540	3.540	102	15.0	600	63	82	
	240/OFF	713.340									
FINAL DIFF/AVGS.		252.683	0.3700		3.540	100.2				83.1	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/3/86	EXXON REFINERY - BAYTOWN, TX	CT-68-DI-3	CT-68-NZ-3
	Run Start Time	910	910
	Run Finish Time	1310	1310
Theta	Net Run Time, Minutes	240	240
	Net Sampling Points	16	16
Dia	Nozzle Diameter, Inches	1.614	0.312
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.250
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	3.540	3.540
Vm	Volume of Metered Gas Sample, Dry ACF	253.724	252.683
tm	Dry Gas Meter Temperature, Degrees F	101.9	100.2
Vm(std)	Volume of Metered Gas Sample, Dry SCF	243.493	243.251
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	202.3	202.5
Vw(std)	Volume of Water Vapor, SCF	9.520	9.531
%H2O	Moisture Content, % by Volume	3.76	3.77
Mfd	Dry Mole Fraction	0.962	0.962
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.43	28.43
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.250
ts	Flue Gas Temperature, Degrees F	83	83
Delta p	Average Velocity Head, in. H2O	0.3700	0.3700
vs	Flue Gas Velocity, Ft/Sec	34.71	34.71
A	Stack/Duct Area, Sq. Inches	85530.0	85530.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	1,170,243.5	1,170,101.3
Qaw	Volumetric Air Flow Rate, Wet ACFM	1,236,902.2	1,236,991.1
%I	Isokinetic Sampling Rate, %	3.6	96.9

EMISSIONS RESULTS

9/3/86	EXXON REFINERY - BAYTOWN. TX	CT-68-DI-3	CT-68-NZ-3
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	83.0	83.1
	Degrees Centigrade	28.3	28.4
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	2.1015	2.1017
	Actual Cubic Feet/hr	74.2141	74.2195
	Dry Std. Cubic Meters/hr	1.9883	1.9880
	Dry Std. Cubic Feet/hr	70.2146	70.2061
	CONCENTRATIONS AND EMISSION RATES - PMRc		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	32.1948 ug	34.9139 ug
mg/dscm	Concentration, mg/dscm	4.669 x 10E-3	5.069 x 10E-3
gr/dscf	Concentration, grains per dscf	2.0402 x 10E-6	2.2147 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	20.464 x 10E-3	22.212 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	9.282 x 10E-3	10.075 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	32.195 ug	34.914 ug
mg/dscm	Concentration, mg/dscm	4.669 x 10E-3	5.069 x 10E-3
gr/dscf	Concentration, grains per dscf	2.040 x 10E-6	2.215 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	20.464 x 10E-3	22.212 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	9.282 x 10E-3	10.075 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9/4/86
SAMPLING LOCATION	COOLING TOWER 84 FAN CELL D	RUN NUMBER	CT-84-DI-4
OPERATOR	B.RUDD	NOZZLE #	Disc
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	1.614
STATIC PRESS.in H2O	0.1000	METER BOX NUMBER	N-6
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ˆH@	1.71
LEAK RATE,CFM	0.0170	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1010	TOT VOL. H2O COLL.(ml)	257.9
RUN STOP TIME	1410	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	2.171 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	2.188 ug
EST DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	ˆH Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	713.502	0.360	3.360	3.360	90	8.0	590	64	88	
"	15	728.800	0.360	3.360	3.360	92	8.0	590	65	88	
"	30	744.420	0.360	3.360	3.360	94	8.0	590	65	88	
"	45	759.650	0.360	3.360	3.360	96	8.0	590	67	88	
"	60/0	775.080	0.360	3.360	3.360	98	8.0	590	67	88	
"	15	792.490	0.360	3.360	3.360	99	8.0	590	61	89	
"	30	806.310	0.360	3.360	3.360	101	8.0	590	59	89	
"	45	824.170	0.360	3.360	3.360	102	8.0	590	63	92	
"	120/0	837.660	0.360	3.360	3.360	102	8.0	590	66	93	
"	15	852.910	0.360	3.360	3.360	103	8.0	590	62	93	
"	30	868.730	0.360	3.360	3.360	103	8.0	590	65	93	
"	45	884.820	0.360	3.360	3.360	103	8.0	590	64	93	
"	180/0	900.110	0.360	3.360	3.360	103	8.0	590	64	93	0.000
"	15	915.280	0.360	3.360	3.360	103	8.0	590	64	93	0.000
"	30	930.270	0.360	3.360	3.360	103	8.0	590	64	93	
"	45	946.270	0.360	3.360	3.360	103	8.0	590	65	93	
	240/OFF	961.934									
FINAL DIFF/AVGS.		248.432	0.3600		3.360	99.7				90.9	

FIELD DATA

PLANT	EXXON	DATE	9/4/86
SAMPLING LOCATION	COOLING TOWER 84 FAN CELL D	RUN NUMBER	CT-84-NZ-4
OPERATOR	B.RUDD	NOZZLE #	208
BAR.PRESS.,in Hg	30.3500	NOZZLE DIAMETER,inches	0.312
STATIC PRESS.in H2O	0.1000	METER BOX NUMBER	N-12
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.76
LEAK RATE,CFM	0.0170	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	1010	TOT VOL. H2O COLL.(ml)	253.5
RUN STOP TIME	1410	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	9.896 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	9.970 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	213.302	0.360	3.360	3.360	90	12.0	590	62	88	
"	15	227.040	0.360	3.360	3.360	92	12.0	590	64	88	
"	30	242.210	0.360	3.360	3.360	94	12.0	590	64	88	
"	45	257.320	0.360	3.360	3.360	95	12.0	590	66	88	
"	60/0	272.280	0.360	3.360	3.360	97	12.0	590	66	88	
"	15	290.160	0.360	3.360	3.360	102	13.0	590	63	89	
"	30	303.960	0.360	3.360	3.360	106	13.0	590	62	89	
"	45	321.620	0.360	3.360	3.360	106	13.0	590	65	92	
"	120/0	334.820	0.360	3.360	3.360	107	13.0	590	66	93	
"	15	350.430	0.360	3.360	3.360	108	13.0	590	62	93	
"	30	365.870	0.360	3.360	3.360	108	13.0	590	64	93	
"	45	381.860	0.360	3.360	3.360	108	13.0	590	66	93	
"	180/0	697.090	0.360	3.360	3.360	108	13.0	590	66	93	0.000
"	15	412.240	0.360	3.360	3.360	108	13.0	590	66	93	0.000
"	30	427.170	0.360	3.360	3.360	108	13.0	590	66	93	
"	45	442.510	0.360	3.360	3.360	108	13.0	590	66	93	
	240/OFF	458.782									
FINAL DIFF/AVGS.		245.480	0.3600		3.360	102.8				90.9	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/4/86	EXXON REFINERY - BAYTOWN. TX	CT-84-DI-4	CT-84-NZ-4
	Run Start Time	1010	1010
	Run Finish Time	1410	1410
Theta	Net Run Time, Minutes	240	240
	Net Sampling Points	16	16
Dia	Nozzle Diameter, Inches	1.614	0.312
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.350	30.350
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	3.360	3.360
Vm	Volume of Metered Gas Sample, Dry ACF	248.432	245.48
tm	Dry Gas Meter Temperature, Degrees F	99.7	102.8
Vm(std)	Volume of Metered Gas Sample, Dry SCF	240.053	235.884
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	257.9	253.5
Vw(std)	Volume of Water Vapor, SCF	12.141	11.930
%H2O	Moisture Content, % by Volume	4.81	4.81
Mfd	Dry Mole Fraction	0.952	0.952
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.32	28.32
Pg	Flue Gas Static Pressure, in. Hg	0.10	0.10
Ps	Absolute Flue Gas Press., in Hg	30.357	30.357
ts	Flue Gas Temperature, Degrees F	91	91
Delta p	Average Velocity Head, in. H2O	0.3600	0.3600
vs	Flue Gas Velocity, Ft/Sec	34.49	34.49
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	860,602.5	860,602.5
Qaw	Volumetric Air Flow Rate, Wet ACFM	929,709.8	929,709.9
%I	Isokinetic Sampling Rate, %	3.7	96.6

EMISSIONS RESULTS

9/4/86	EXXON REFINERY - BAYTOWN. TX	CT-84-DI-4	CT-84-NZ-4
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	90.9	90.9
	Degrees Centigrade	32.7	32.7
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	1.5796	1.5796
	Actual Cubic Feet/hr	55.7826	55.7826
	Dry Std. Cubic Meters/hr	1.4622	1.4622
	Dry Std. Cubic Feet/hr	51.6362	51.6362
	CONCENTRATIONS AND EMISSION RATES - PMRc		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	2.1713 ug	9.8957 ug
mg/dscm	Concentration, mg/dscm	0.319 x 10E-3	1.482 x 10E-3
gr/dscf	Concentration, grains per dscf	0.1396 x 10E-6	0.6473 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.030 x 10E-3	4.775 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.467 x 10E-3	2.166 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	2.188 ug	9.970 ug
mg/dscm	Concentration, mg/dscm	0.322 x 10E-3	1.493 x 10E-3
gr/dscf	Concentration, grains per dscf	0.141 x 10E-6	0.652 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.037 x 10E-3	4.811 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.470 x 10E-3	2.182 x 10E-3

FIELD DATA

PLANT	EXXON	DATE	9/5/86
SAMPLING LOCATION	COOLING TOWER 84 FAN CELL A	RUN NUMBER	CT-84-DI-5
OPERATOR	B.RUDD	NOZZLE #	Disc
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	1.614
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-12
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ˆH@	1.76
LEAK RATE,CFM	0.0170	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	820	TOT VOL. H2O COLL.(ml)	226.7
RUN STOP TIME	1220	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	2.439 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	2.454 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	ˆPitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	ˆH Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	469.307	0.360	3.450	3.450	98	10.0	595	63	86	
"	15	484.420	0.360	3.450	3.450	99	10.0	595	65	86	
"	30	499.490	0.360	3.450	3.450	101	10.0	595	60	87	
"	45	514.710	0.360	3.450	3.450	102	10.0	595	58	87	
"	60/0	530.000	0.360	3.450	3.450	102	10.0	595	60	88	
"	15	545.720	0.360	3.450	3.450	102	10.0	595	63	88	
"	30	560.660	0.360	3.450	3.450	101	10.0	595	65	87	
"	45	576.010	0.360	3.450	3.450	101	10.0	595	66	87	
"	120/0	591.220	0.360	3.450	3.450	98	10.0	595	63	88	
"	15	606.640	0.360	3.450	3.450	98	10.0	595	61	87	
"	30	621.990	0.360	3.450	3.450	98	10.0	595	65	87	
"	45	639.810	0.360	3.450	3.450	98	10.0	595	63	88	
"	180/0	652.860	0.360	3.450	3.450	99	10.0	595	66	88	0.000
"	15	668.330	0.360	3.450	3.450	101	10.0	595	67	88	0.000
"	30	683.700	0.360	3.450	3.450	101	10.0	595	62	88	
"	45	698.990	0.360	3.450	3.450	100	10.0	595	59	88	
	240/OFF	714.331									
FINAL DIFF/AVGS.		245.024	0.3600		3.450	99.9				87.4	

FIELD DATA

PLANT	EXXON	DATE	9/5/86
SAMPLING LOCATION	COOLING TOWER 84 FAN CELL A	RUN NUMBER	CT-84-NZ-5
OPERATOR	B.RUDD	NOZZLE #	208
BAR.PRESS.,in Hg	30.2500	NOZZLE DIAMETER,inches	0.312
STATIC PRESS.in H2O	0.0000	METER BOX NUMBER	N-6
LEAK TEST VACUUM,in.Hg	15.0000	METER BOX ^H@	1.71
LEAK RATE,CFM	0.0090	ASSUMED MOISTURE, %	2.0

ANALYTICAL RESULTS DATA

RUN START TIME	820	TOT VOL. H2O COLL.(ml)	209.9
RUN STOP TIME	1220	TOTAL CATCH -	
TOTAL NET RUN TIME (Minutes)	240	HEXAVALENT CHROMIUM (GFAA)	6.346 ug
PITOT TUBE COEFFICIENT	0.840	TOTAL CATCH -	
GAS METER CALIB. FACTOR (Y)	1.002	TOTAL CHROMIUM (GFAA)	6.385 ug
EST. DRY MOL. WT.(Lb/Lb-Mole)	28.84	TOTAL CATCH -	
STACK/DUCT AREA (in2)	64,692.0		ug

Sample Point No.	Sample Time (min)	Dry Gas Meter Reading (Cu.Ft)	Pitot Vel Head (in.H2O)	Orifice (in.H2O) Ideal	^H Actual	Gas Meter Temp. (deg.F)	Pump Vac. (in.Hg)	Pitot Anemometer (so)MV	Imp.Exit Temp. (deg.F)	Stack Temp (deg.F)	Leak Check
A-1	0/0	970.905	0.360	3.450	3.450	94	14.0	595	61	86	
"	15	986.150	0.360	3.450	3.450	96	14.0	595	66	86	
"	30	1002.150	0.360	3.450	3.450	98	15.0	595	60	87	
"	45	1017.290	0.360	3.450	3.450	99	15.0	595	58	87	
"	60/0	1032.530	0.360	3.450	3.450	100	15.0	595	63	88	
"	15	1047.070	0.360	3.450	3.450	101	15.0	595	66	88	
"	30	1061.520	0.360	3.450	3.450	100	15.0	595	65	87	
"	45	1075.600	0.360	3.450	3.450	96	15.0	595	66	87	
"	120/0	1089.760	0.360	3.450	3.450	96	15.0	595	62	88	
"	15	1103.200	0.360	3.450	3.450	95	15.0	595	60	87	
"	30	1116.530	0.360	3.450	3.450	95	15.0	595	61	87	
"	45	1131.720	0.360	3.450	3.450	95	15.0	595	63	88	
"	180/0	1143.170	0.360	3.450	3.450	97	15.0	595	65	88	0.000
"	15	1156.620	0.360	3.450	3.450	98	15.0	595	61	88	0.000
"	30	1170.070	0.360	3.450	3.450	98	15.0	595	57	88	
"	45	1183.360	0.360	3.450	3.450	98	15.0	595	59	88	
	240/OFF	1196.665									
FINAL DIFF/AVGS.		225.760	0.3600		3.450	97.3				87.4	

ISOKINETIC SAMPLING TRAIN FIELD DATA AND RESULTS TABULATION

9/5/86	EXXON REFINERY - BAYTOWN, TX	CT-84-DI-5	CT-84-NZ-5
	Run Start Time	820	820
	Run Finish Time	1220	1220
Theta	Net Run Time, Minutes	240	240
	Net Sampling Points	16	16
Dia	Nozzle Diameter, Inches	1.614	0.312
Cp	Pitot Tube Coefficient	0.840	0.840
Y	Dry Gas Meter Calibration Factor	1.002	1.002
Pbar	Barometric Pressure, Inches Hg	30.250	30.250
Delta H	Avg. Pressure Differential of Orifice Meter, Inches H2O	3.450	3.450
Vm	Volume of Metered Gas Sample, Dry ACF	245.024	225.76
tm	Dry Gas Meter Temperature, Degrees F	99.9	97.3
Vm(std)	Volume of Metered Gas Sample, Dry SCF	235.932	218.432
Vlc	Total Volume of Liquid Collected in Impingers and Silica Gel, ml	226.7	209.9
Vw(std)	Volume of Water Vapor, SCF	10.671	9.880
%H2O	Moisture Content, % by Volume	4.33	4.33
Mfd	Dry Mole Fraction	0.957	0.957
Md	Estimated Dry Molecular Wt, Lb/Lb-Mole	28.84	28.84
Ms	Wet Molecular Weight, Lb/Lb-Mole	28.37	28.37
Pg	Flue Gas Static Pressure, in. Hg	0.00	0.00
Ps	Absolute Flue Gas Press., in Hg	30.250	30.250
ts	Flue Gas Temperature, Degrees F	87	87
Delta p	Average Velocity Head, in. H2O	0.3600	0.3600
vs	Flue Gas Velocity, Ft/Sec	34.41	34.41
A	Stack/Duct Area, Sq. Inches	64692.0	64692.0
Qsd	Volumetric Air Flow Rate, Dry SCFM	865,425.7	865,424.8
Qaw	Volumetric Air Flow Rate, Wet ACFM	927,530.3	927,530.5
%I	Isokinetic Sampling Rate, %	3.6	89.0

EMISSIONS RESULTS

9/5/86	EXXON REFINERY - BAYTOWN. TX	CT-84-DI-5	CT-84-NZ-5
	FLUE GAS TEMPERATURE		
	Degrees Fahrenheit	87.4	87.4
	Degrees Centigrade	30.8	30.8
	AIR FLOW RATES x million		
	Actual Cubic Meters/hr	1.5759	1.5759
	Actual Cubic Feet/hr	55.6518	55.6518
	Dry Std. Cubic Meters/hr	1.4704	1.4704
	Dry Std. Cubic Feet/hr	51.9255	51.9255
	CONCENTRATIONS AND EMISSION RATES - PMRc		
	HEXAVALENT CHROMIUM (GFAA)		
ug	Catch	2.4392 ug	6.3458 ug
mg/dscm	Concentration, mg/dscm	0.365 x 10E-3	1.026 x 10E-3
gr/dscf	Concentration, grains per dscf	0.1595 x 10E-6	0.4483 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.183 x 10E-3	3.325 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.537 x 10E-3	1.508 x 10E-3
	TOTAL CHROMIUM (GFAA)		
ug	Catch	2.454 ug	6.385 ug
mg/dscm	Concentration, mg/dscm	0.367 x 10E-3	1.032 x 10E-3
gr/dscf	Concentration, grains per dscf	0.160 x 10E-6	0.451 x 10E-6
lb/hr	Emission Rate, lb/hr (PMRc)	1.191 x 10E-3	3.345 x 10E-3
kg/hr	Emission Rate, kg/hr (PMRc)	0.540 x 10E-3	1.517 x 10E-3

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT68-RISER A-9/01/86

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.=13.523
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.996
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 14.13(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 156.7(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.36	0.23	3.95	814.98	4.46	866.00
2	1.15	0.68	6.97	1079.46	7.94	1152.13
3	2.07	1.00	7.72	1133.71	10.00	1290.31
4	3.19	1.39	8.87	1212.16	10.77	1335.69
5	4.83	1.97	9.48	1248.52	10.80	1332.61
				AVG=1097.77(FPM)		AVG=1195.35(FPM)
6	9.30	3.53	9.18	1216.18	11.28	1348.13
7	10.93	4.10	8.40	1159.03	10.19	1276.57
8	12.06	4.50	7.78	1112.55	7.87	1118.97
9	12.97	4.81	3.05	695.14	4.60	853.69
10	13.76	5.09	0.20	177.68	0.30	217.62
				AVG= 872.12(FPM)		AVG= 962.99(FPM)

AVG. VELOCITY=1032.06(FPM)

AVG. SQR OF MAN DEFLEC.= 2.55(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 8400.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 8386.(GPM)

AVG. BLOCKAGE= 2.75(SQ IN)

:TOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT68-RISER B-9/01/86

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.=13.523
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.996
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 16.13(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 204.2(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV T	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.41	0.26	1.06	422.26	0.41	262.61
2	1.32	0.74	2.69	671.09	2.68	669.84
3	2.36	1.10	3.56	770.64	3.40	753.12
4	3.65	1.55	4.32	847.03	4.08	823.17
5	5.51	2.20	4.52	863.63	4.37	849.18
				AVG= 714.93(FPM)		AVG= 671.58(FPM)
6	10.61	3.99	4.38	842.64	4.33	837.82
7	12.48	4.64	4.54	855.09	4.16	818.52
8	13.76	5.09	3.17	712.92	3.65	764.99
9	14.81	5.46	1.15	428.60	2.87	677.09
10	15.71	5.77	0.20	178.46	0.25	199.52
				AVG= 603.54(FPM)		AVG= 659.59(FPM)

AVG. VELOCITY= 662.41(FPM)

AVG. SQR OF MAN DEFLEC.= 1.64(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 7026.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 7022.(GPM)

AVG. BLOCKAGE= 3.10(SQ IN)

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT68-RISER C-9/01/86

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.=13.526
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.996
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 16.83(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 222.3(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.43	0.27	1.40	485.35	1.52	505.73
2	1.37	0.75	2.40	634.09	2.22	609.85
3	2.46	1.14	3.12	721.73	2.94	700.60
4	3.80	1.61	3.32	742.92	3.07	714.40
5	5.75	2.29	3.45	754.98	3.48	758.26
			AVG=	667.81(FPM)	AVG=	657.77(FPM)
6	11.07	4.15	3.25	726.57	3.29	731.03
7	13.02	4.83	3.20	718.71	2.97	692.40
8	14.36	5.30	2.70	658.75	2.71	659.97
9	15.45	5.68	2.26	601.63	2.05	573.00
10	16.39	6.01	0.26	203.75	0.28	211.44
			AVG=	581.88(FPM)	AVG=	573.57(FPM)

AVG. VELOCITY= 620.26(FPM)

AVG. SQR OF MAN DEFLEC.= 1.53(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 7163.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 7157.(GPM)

AVG. BLOCKAGE= 3.22(SQ IN)

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT84-RISER A(9/3/86)

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.= 2.936
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.995
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 17.19(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 232.0(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.44	0.28	5.18	367.43	3.73	311.79
2	1.40	0.77	5.82	388.65	6.18	400.49
3	2.52	1.16	7.23	432.44	7.20	431.54
4	3.89	1.64	7.53	440.40	7.51	439.82
5	5.88	2.33	7.93	450.58	7.88	449.16
				AVG= 415.90(FPM)		AVG= 406.56(FPM)
6	11.31	4.23	7.91	446.29	8.43	460.73
7	13.30	4.93	7.93	445.49	8.37	457.68
8	14.67	5.41	7.33	427.40	8.44	458.62
9	15.78	5.80	6.33	396.50	8.29	453.75
10	16.75	6.14	4.28	325.54	6.10	388.64
				AVG= 408.24(FPM)		AVG= 443.88(FPM)

AVG. VELOCITY= 418.65(FPM)

AVG. SQR OF MAN DEFLEC.= 2.63(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 5045.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 5046.(GPM)

AVG. BLOCKAGE= 3.28(SQ IN)

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT84-RISER B(9/3/86)

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.= 2.931
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.994
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 16.94(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 225.3(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.43	0.27	8.26	463.54	4.22	331.32
2	1.38	0.76	10.80	528.89	7.38	437.20
3	2.48	1.14	12.80	574.79	8.62	471.69
4	3.83	1.62	12.80	573.58	8.97	480.16
5	5.79	2.30	11.71	546.93	9.33	488.20
				AVG= 537.54(FPM)		AVG= 441.71(FPM)
6	11.15	4.18	7.33	429.08	8.72	468.00
7	13.11	4.86	6.28	395.93	9.84	495.60
8	14.46	5.34	5.88	382.29	9.61	488.73
9	15.55	5.72	5.02	352.62	9.43	483.29
10	16.50	6.05	2.78	262.01	7.98	443.91
				AVG= 364.38(FPM)		AVG= 475.90(FPM)

AVG. VELOCITY= 454.89(FPM)

AVG. SQR OF MAN DEFLEC.= 2.86(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 5323.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 5320.(GPM)

AVG. BLOCKAGE= 3.24(SQ IN)

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT84-RISER C(9/3/86)

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.= 2.933
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.994
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 17.25(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 233.7(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.44	0.28	9.85	506.48	4.95	359.05
2	1.41	0.77	14.22	607.27	9.42	494.26
3	2.53	1.16	16.46	652.25	11.09	535.38
4	3.90	1.64	17.47	670.58	11.93	554.14
5	5.90	2.34	15.37	627.08	11.98	553.63
			AVG=	612.73(FPM)	AVG=	499.29(FPM)
6	11.35	4.25	8.97	475.11	10.22	507.13
7	13.35	4.95	7.38	429.63	10.13	503.35
8	14.72	5.43	7.07	419.63	9.21	478.94
9	15.84	5.82	6.17	391.34	9.00	472.64
10	16.81	6.16	3.85	308.67	7.75	437.94
			AVG=	404.87(FPM)	AVG=	480.00(FPM)

AVG. VELOCITY= 499.22(FPM)

AVG. SQR OF MAN DEFLEC.= 3.13(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 6060.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 6054.(GPM)

AVG. BLOCKAGE= 3.29(SQ IN)

PITOT TRAVERSE FOR EPA/ENTROPY(EXXON):CT84-RISER D(9/3/86)

SPECIFIC GRAVITY OF FLUID AT AMB. TEMP.= 2.933
SPECIFIC GRAVITY OF WATER AT AMB. TEMP.= 0.994
SPECIFIC GRAVITY OF WATER AT WATER TEMP.= 0.995
AVERAGE DIAMETER OF PIPE AT TRAVERSE PLANE= 17.19(IN)
AVERAGE AREA OF PIPE AT TRAVERSE PLANE= 232.0(SQ IN)
PITOT TUBE SERIAL NUMBER=WF6A
PITOT TUBE COEFFICIENT=0.833

			TRAV DIAMETER 1		TRAV DIAMETER 2	
TRAV PT	POS (IN)	BLOCK (IN)	DEF (IN FL)	VC (FPM)	DEF (IN FL)	VC (FPM)
1	0.44	0.28	7.94	454.73	6.12	399.23
2	1.40	0.77	11.08	536.04	8.25	462.54
3	2.52	1.16	14.09	603.45	9.89	505.58
4	3.89	1.64	15.11	623.62	10.82	527.71
5	5.88	2.33	15.75	634.76	12.12	556.83
				AVG= 570.52(FPM)		AVG= 490.38(FPM)
6	11.31	4.23	11.57	539.55	11.73	543.26
7	13.30	4.93	9.54	488.43	10.95	523.29
8	14.67	5.41	9.20	478.64	9.96	498.02
9	15.78	5.80	7.67	436.28	8.88	469.43
10	16.75	6.14	6.24	392.92	7.13	420.01
				AVG= 467.17(FPM)		AVG= 490.80(FPM)

AVG. VELOCITY= 504.72(FPM)

AVG. SQR OF MAN DEFLEC.= 3.17(SQR(IN OF FL))

FLOW RATE(LOCAL BLOCKAGE)= 6082.(GPM)

FLOW RATE(AVG. BLOCKAGE)= 6079.(GPM)

AVG. BLOCKAGE= 3.28(SQ IN)

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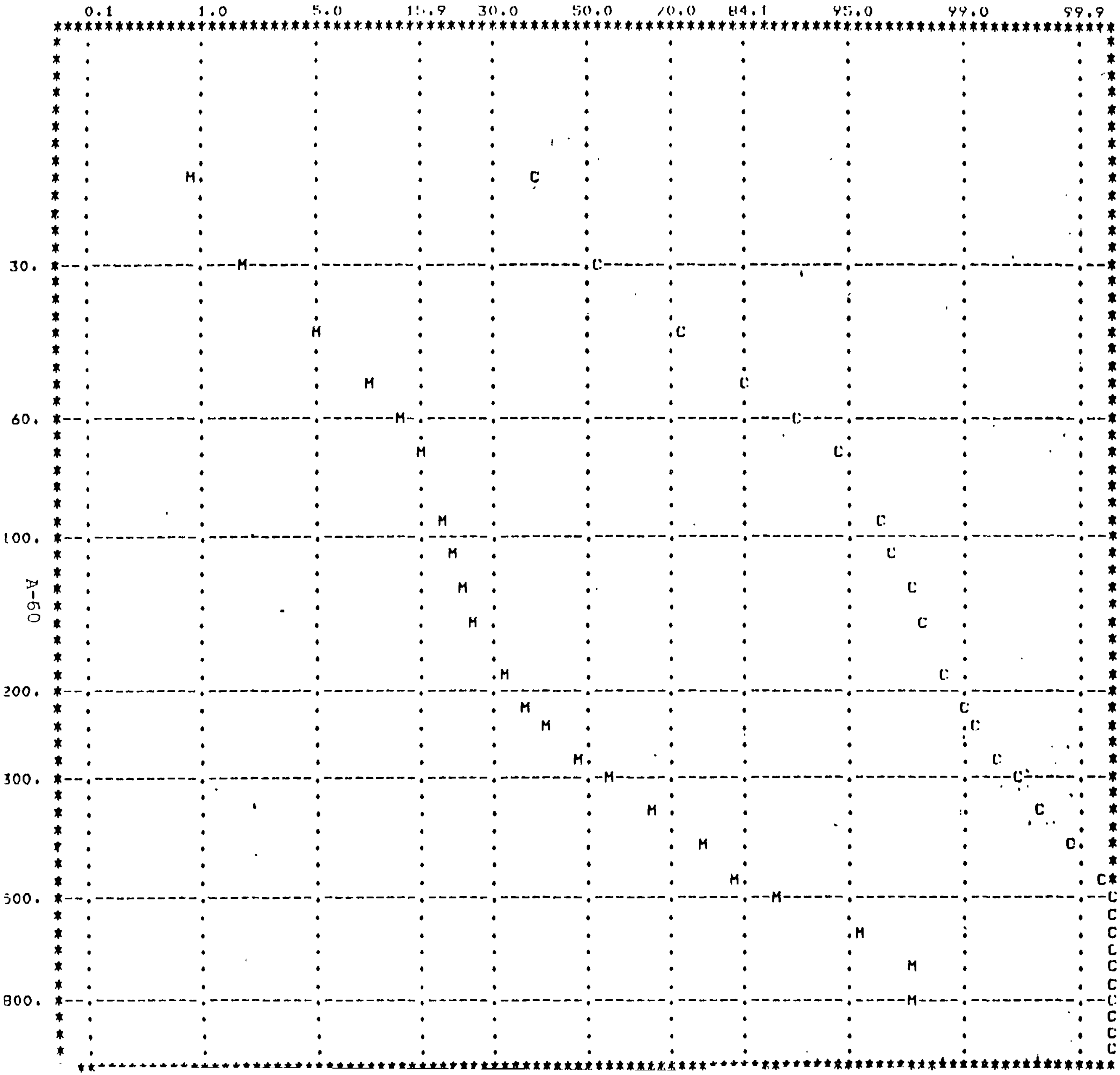
AREA SAMPLED= 43.80 M2
BAY-84-A

D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
*****	*****	*****	**********	**********	**********	**********
10.	20.	1.301	2.81E+02	1.59E+05	0.423	38.391
20.	30.	1.477	5.32E+02	6.51E+04	1.227	54.130
30.	40.	1.602	1.84E+03	8.18E+04	3.998	73.912
40.	50.	1.699	2.37E+03	4.96E+04	7.567	85.901
50.	60.	1.778	2.33E+03	2.67E+04	11.077	92.359
60.	70.	1.845	1.71E+03	1.19E+04	13.651	95.227
70.	90.	1.954	2.49E+03	9.28E+03	17.406	97.472
90.	110.	2.041	1.31E+03	2.50E+03	19.379	98.076
110.	130.	2.114	1.57E+03	1.74E+03	21.751	98.496
130.	150.	2.176	1.74E+03	1.21E+03	24.377	98.789
150.	180.	2.255	3.52E+03	1.50E+03	29.694	99.152
180.	210.	2.322	3.82E+03	9.84E+02	35.462	99.390
210.	240.	2.380	4.00E+03	6.71E+02	41.499	99.552
240.	270.	2.431	4.36E+03	5.03E+02	48.083	99.674
270.	300.	2.477	5.20E+03	4.29E+02	55.931	99.777
300.	350.	2.544	7.93E+03	4.41E+02	67.892	99.884
350.	400.	2.602	6.74E+03	2.44E+02	78.059	99.943
400.	450.	2.653	4.43E+03	1.10E+02	84.746	99.970
450.	500.	2.699	3.73E+03	6.65E+01	90.375	99.986
500.	600.	2.778	4.14E+03	4.75E+01	96.624	99.997
600.	700.	2.845	1.21E+03	8.43E+00	98.453	99.999
700.	800.	2.903	0.00E-01	0.00E-01	98.453	99.999
800.	900.	2.954	1.02E+03	3.19E+00	100.000	100.000

TOTAL MASS FLUX= 6.63E+04 UG/M2/SEC
TOTAL COUNT FLUX= 1.81E+07 #/M2/SEC
MASS MEAN DIAMETER= 282. UM
COUNT MEAN DIAMETER= 34. UM

MASS EMISSION RATE= 2.90E+00 GRAMS/SEC



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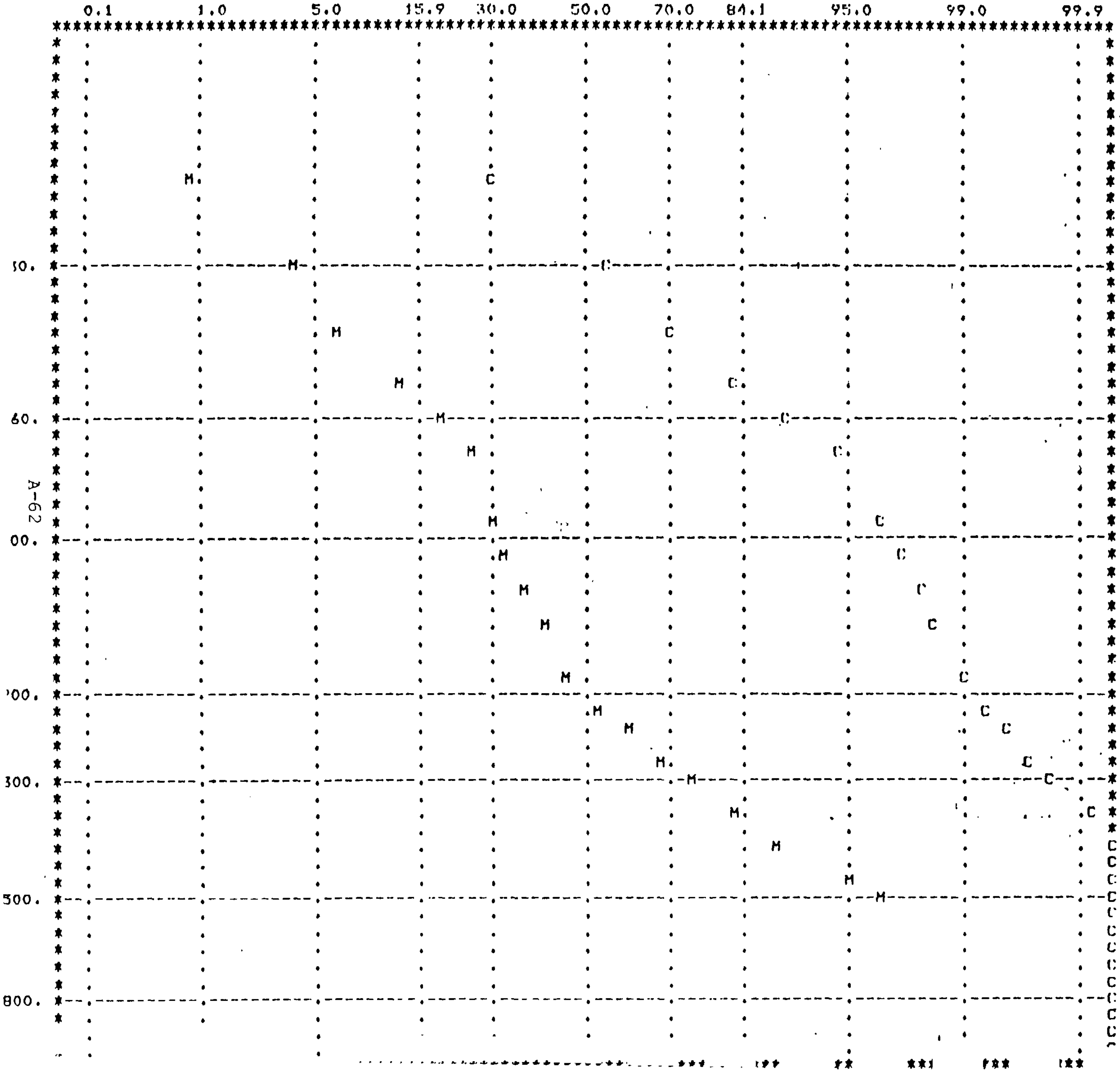
AREA SAMPLED= 43.80 M2
BAY-84-B

D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
*****	*****	*****	**********	**********	**********	**********
10.	20.	1.301	1.90E+02	1.08E+05	0.442	27.232
20.	30.	1.477	9.85E+02	1.20E+05	2.732	57.704
30.	40.	1.602	1.21E+03	5.38E+04	5.539	71.310
40.	50.	1.699	2.37E+03	4.96E+04	11.040	83.860
50.	60.	1.778	2.57E+03	2.95E+04	17.016	91.327
60.	70.	1.845	2.27E+03	1.58E+04	22.303	95.330
70.	90.	1.954	2.47E+03	9.20E+03	28.039	97.658
90.	110.	2.041	1.27E+03	2.43E+03	30.995	98.273
110.	130.	2.114	1.68E+03	1.85E+03	34.895	98.742
130.	150.	2.176	1.86E+03	1.29E+03	39.219	99.070
150.	180.	2.255	2.89E+03	1.23E+03	45.938	99.381
180.	210.	2.322	3.39E+03	8.73E+02	53.817	99.602
210.	240.	2.380	3.53E+03	5.97E+02	62.021	99.751
240.	270.	2.431	3.30E+03	3.80E+02	69.699	99.848
270.	300.	2.477	2.57E+03	2.12E+02	75.678	99.901
300.	350.	2.544	3.95E+03	2.20E+02	84.861	99.957
350.	400.	2.602	2.34E+03	8.46E+01	90.291	99.978
400.	450.	2.653	2.41E+03	5.99E+01	95.886	99.994
450.	500.	2.699	7.89E+02	1.41E+01	97.721	99.997
500.	600.	2.778	9.80E+02	1.12E+01	100.000	100.000

TOTAL MASS FLUX= 4.30E+04 UG/M2/SEC
TOTAL COUNT FLUX= 1.73E+07 #/M2/SEC
MASS MEAN DIAMETER= 206. UM
COUNT MEAN DIAMETER= 34. UM

MASS EMISSION RATE= 1.88E+00 GRAMS/SEC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SUMMARY DROP SIZE DISTRIBUTION

AREA SAMPLED= 43.80 M2

BAY-84-C

I	D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
	*****	*****	*****	**********	**********	**********	**********
1	10.	20.	1.301	1.11E+02	6.28E+04	0.283	23.847
2	20.	30.	1.477	2.29E+02	2.80E+04	0.867	34.460
3	30.	40.	1.602	1.90E+03	8.47E+04	5.717	66.600
4	40.	50.	1.699	2.03E+03	4.26E+04	10.904	82.773
5	50.	60.	1.778	1.78E+03	2.05E+04	15.453	90.541
6	60.	70.	1.845	1.38E+03	9.58E+03	18.967	94.177
7	70.	90.	1.954	1.73E+03	6.44E+03	23.371	96.621
8	90.	110.	2.041	1.32E+03	2.51E+03	26.725	97.574
9	110.	130.	2.114	1.70E+03	1.88E+03	31.054	98.286
10	130.	150.	2.176	1.63E+03	1.14E+03	35.219	98.717
11	150.	180.	2.255	2.82E+03	1.20E+03	42.401	99.171
12	180.	210.	2.322	2.83E+03	7.29E+02	49.620	99.448
13	210.	240.	2.380	2.97E+03	4.98E+02	57.194	99.637
14	240.	270.	2.431	3.00E+03	3.45E+02	64.835	99.768
15	270.	300.	2.477	2.07E+03	1.71E+02	70.107	99.832
16	300.	350.	2.544	3.44E+03	1.91E+02	78.874	99.905
17	350.	400.	2.602	4.66E+03	1.69E+02	90.756	99.969
18	400.	450.	2.653	2.46E+03	6.12E+01	97.031	99.992
19	450.	500.	2.699	1.16E+03	2.07E+01	100.000	100.000

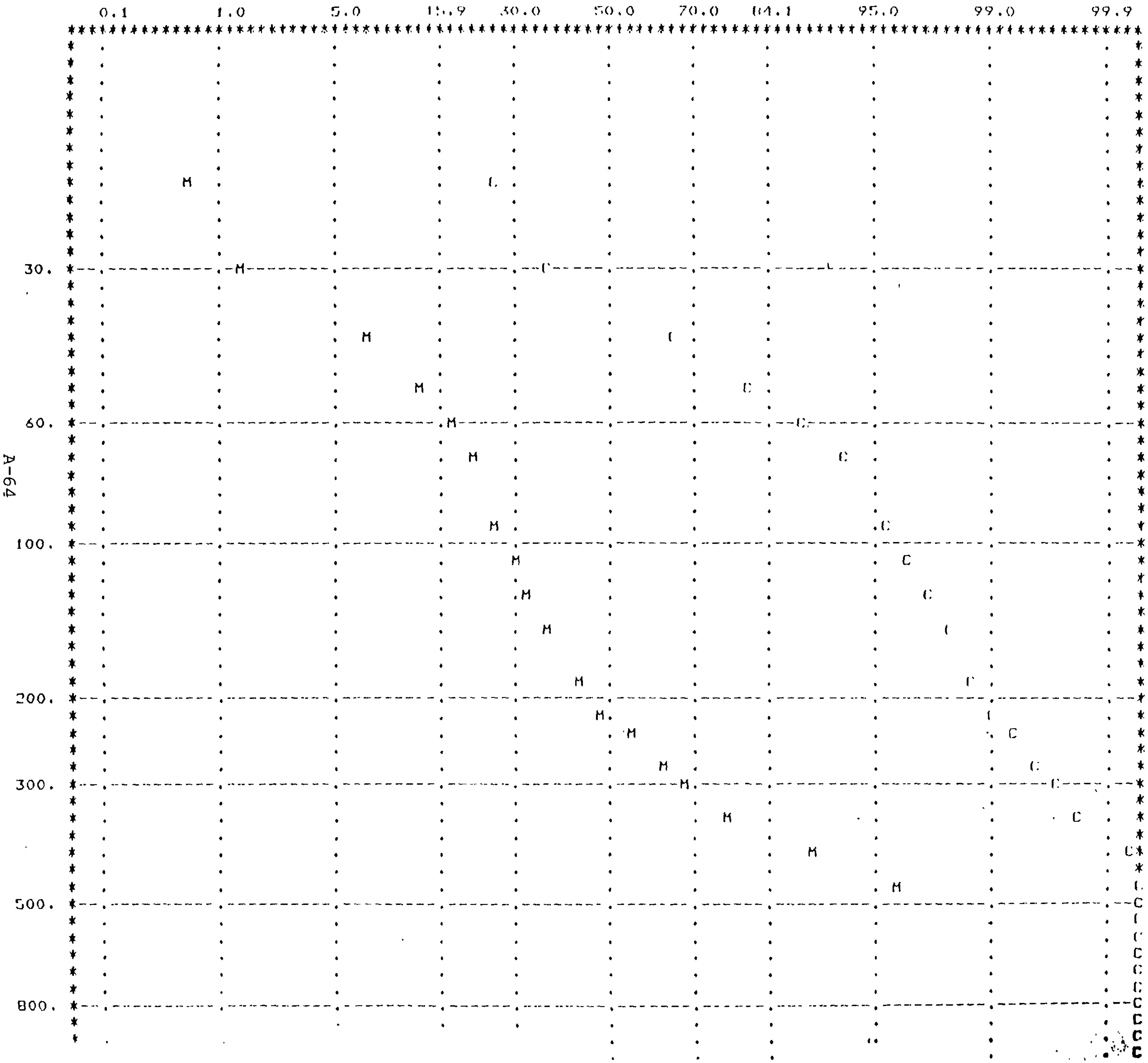
TOTAL MASS FLUX= 3.92E+04 UG/M2/SEC

TOTAL COUNT FLUX= 1.15E+07 #/M2/SEC

MASS MEAN DIAMETER= 218. UM

COUNT MEAN DIAMETER= 39. UM

MASS EMISSION RATE= 1.72E+00 GRAMS/SEC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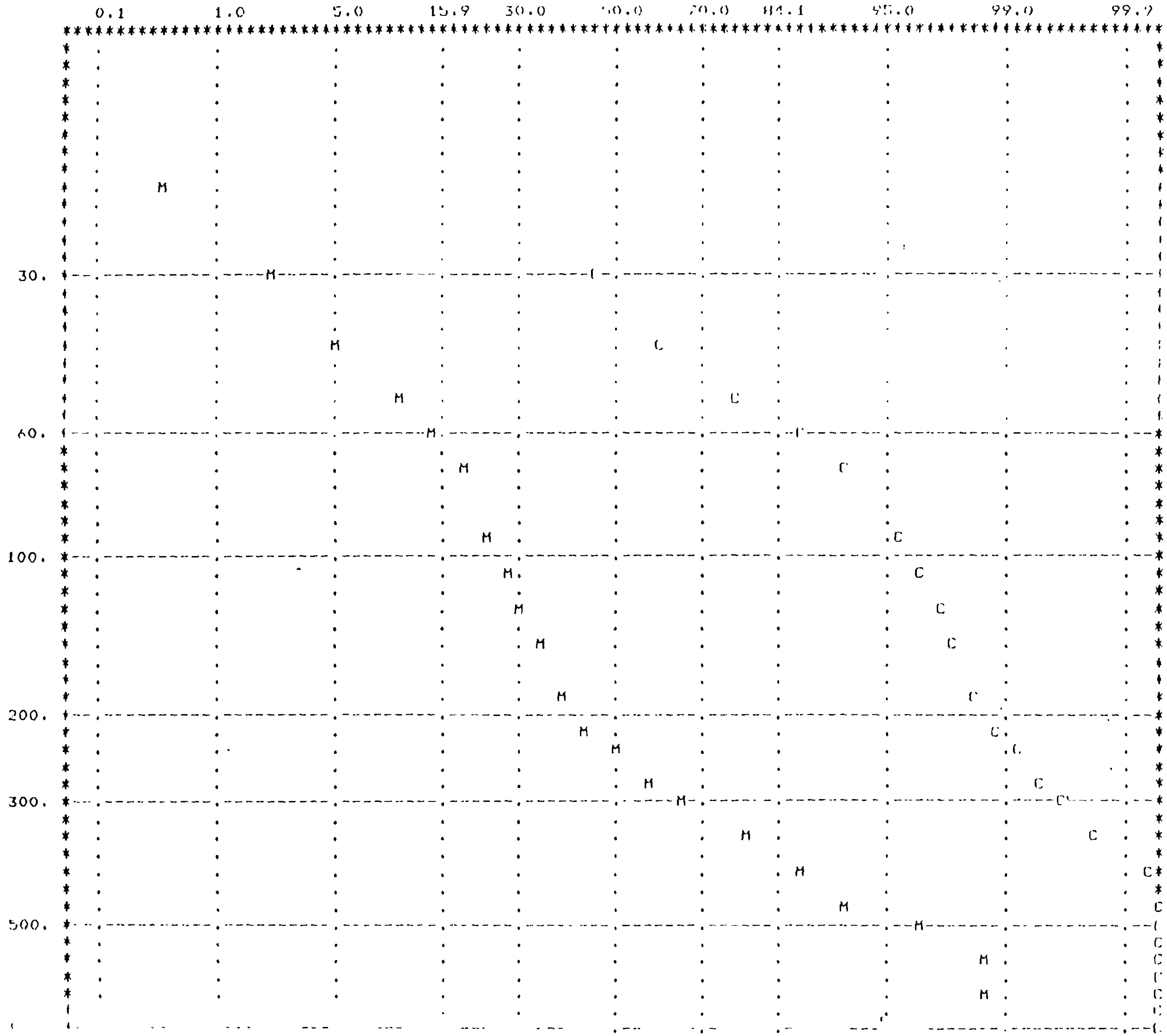
SUMMARY DROP SIZE DISTRIBUTION

AREA SAMPLED= 43.80 M2
BAY-84-II

I	D(LOW) UM *****	D(HI) UM *****	LOG D(HI) *****	MASS FLUX UG/M2/SEC **********	COUNT FLUX #/M2/SEC **********	% MASS SMALLER **********	% COUNT SMALLER **********
1	10.	20.	1.301	1.33E+02	2.52E+04	0.197	18.887
2	20.	30.	1.477	9.01E+02	1.10E+05	1.529	46.540
3	30.	40.	1.602	1.42E+03	6.31E+04	3.624	62.390
4	40.	50.	1.699	3.17E+03	6.64E+04	8.308	79.061
5	50.	60.	1.778	3.34E+03	3.83E+04	13.247	88.689
6	60.	70.	1.845	2.77E+03	1.93E+04	17.344	93.527
7	70.	90.	1.954	3.26E+03	1.22E+04	22.167	96.582
8	90.	110.	2.041	2.20E+03	4.20E+03	25.427	97.638
9	110.	130.	2.114	2.14E+03	2.37E+03	28.594	98.233
10	130.	150.	2.176	2.30E+03	1.60E+03	32.001	98.636
11	150.	180.	2.255	3.47E+03	1.48E+03	37.137	99.007
12	180.	210.	2.322	4.71E+03	1.21E+03	44.106	99.312
13	210.	240.	2.380	5.15E+03	8.63E+02	51.720	99.528
14	240.	270.	2.431	5.07E+03	5.84E+02	59.215	99.675
15	270.	300.	2.477	5.57E+03	4.59E+02	67.448	99.790
16	300.	350.	2.544	8.51E+03	4.74E+02	80.042	.909
17	350.	400.	2.602	6.21E+03	2.25E+02	89.238	9[illegible].965
18	400.	450.	2.653	2.97E+03	7.48E+01	93.618	.981
19	450.	500.	2.699	2.71E+03	4.83E+01	97.632	[illegible]
20	500.	600.	2.778	9.80E+02	1.12E+01	99.08[illegible]	[illegible]
21	600.	700.	2.845	0.00E+01	0.00E+01	99.08[illegible]	[illegible]
22	700.	800.	2.903	6.21E+02	2.81E+00	100.000	100.000

TOTAL MASS FLUX= 6.76E+04 UG/M2/SEC
TOTAL COUNT FLUX= 1.74E+07 #/M2/SEC
MASS MEAN DIAMETER= 234. UM
COUNT MEAN DIAMETER= 39. UM

MASS EMISSION RATE= 2.96E+00 GRAMS/SEC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SUMMARY DROP SIZE DISTRIBUTION

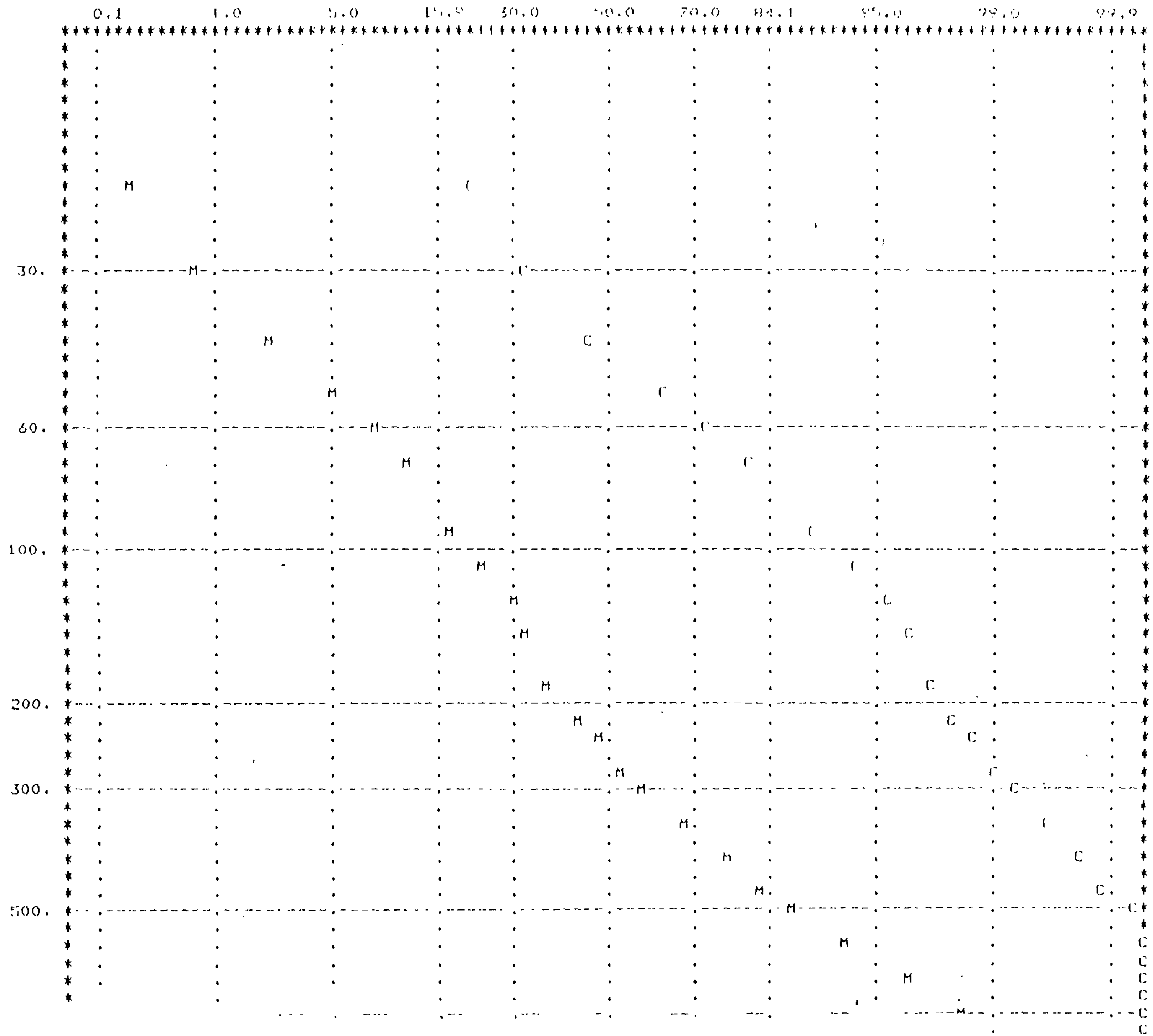
AREA SAMPLED= 23.44 M2

BAY-68-1

I	D(LOW) UM *****	D(HI) UM *****	LOG D(HI) *****	MASS FLUX UG/M2/SEC **********	COUNT FLUX #/M2/SEC **********	% MASS SMALLER **********	% COUNT SMALLER **********
1	10.	20.	1.301	5.10E+02	2.89E+05	0.097	18.67[illegible]
2	20.	30.	1.477	1.39E+03	1.69E+05	0.360	29.673
3	30.	40.	1.602	5.95E+03	2.65E+05	1.491	46.795
4	40.	50.	1.699	1.27E+04	2.64E+05	3.898	63.973
5	50.	60.	1.778	1.48E+04	1.70E+05	6.711	74.968
6	60.	70.	1.845	1.79E+04	1.35E+05	10.115	83.032
7	70.	90.	1.954	3.39E+04	1.27E+05	16.564	91.2[illegible]
8	90.	110.	2.041	2.83E+04	5.40E+04	21.939	94.719
9	110.	130.	2.114	2.88E+04	3.18E+04	27.411	96.779
10	130.	150.	2.176	1.75E+04	1.25E+04	30.822	97.586
11	150.	180.	2.255	2.80E+04	[illegible]	36.152	98.[illegible]
12	180.	210.	2.322	3.09E+04	7.96E+03	42.023	98.874
13	210.	240.	2.380	2.85E+04	4.78E+03	47.440	99.184
14	240.	270.	2.431	3.01E+04	3.47E+03	53.164	99.408
15	270.	300.	2.477	3.62E+04	2.93E+03	60.033	99.601
16	300.	350.	2.544	5.16E+04	2.87E+03	69.846	99.797
17	350.	400.	2.602	4.40E+04	1.59E+03	78.210	99.890
18	400.	450.	2.653	2.97E+04	7.30E+02	83.786	99.93[illegible]
19	450.	500.	2.699	2.64E+04	4.71E+02	88.804	99.968
20	500.	600.	2.778	2.78E+04	3.19E+02	94.083	99.989
21	600.	700.	2.845	1.82E+04	1.27E+02	97.544	99.997
22	700.	800.	2.903	7.45E+03	3.32E+01	98.960	99.999
23	800.	900.	2.954	5.48E+03	1.70E+01	100.000	100.000

TOTAL MASS FLUX= 5.26E+05 UG/M2 SEC
TOTAL COUNT FLUX= 3.65E+07 #/M2/SEC
MASS MEAN DIAMETER= 276. UM
COUNT MEAN DIAMETER= 50. UM

MASS EMISSION RATE= 1.24E+01 GRAMS/SEC



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SUMMARY DROP SIZE DISTRIBUTION

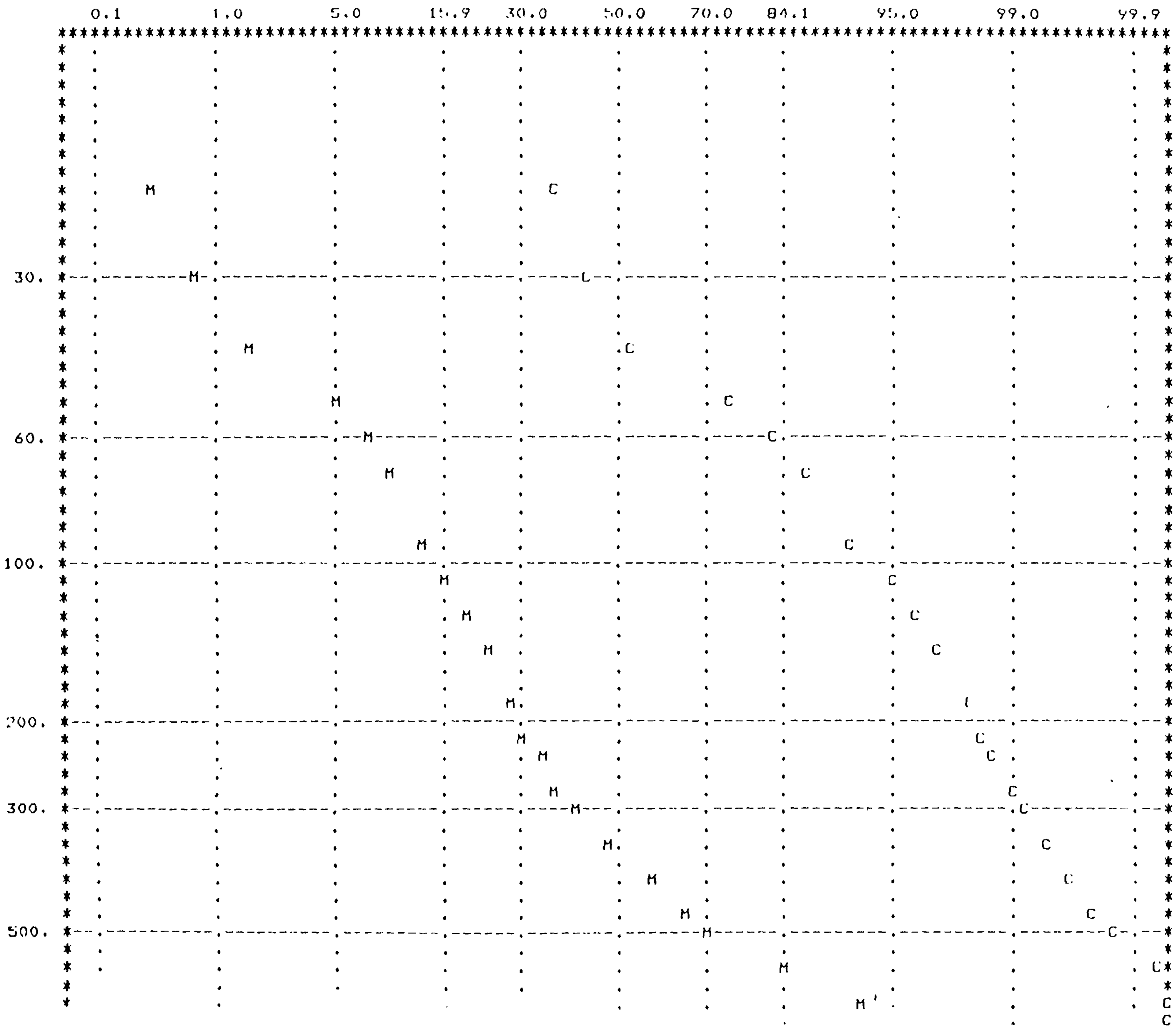
AREA SAMPLED= 23.64 M2

BAY-68-2

I	D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
	*****	*****	*****	**********	**********	**********	**********
1	10.	20.	1.301	1.73E+03	9.77E+05	0.178	35.965
2	20.	30.	1.477	1.69E+03	2.06E+05	0.352	43.551
3	30.	40.	1.602	7.28E+03	3.24E+05	1.102	55.481
4	40.	50.	1.699	2.67E+04	5.60E+05	3.858	76.106
5	50.	60.	1.778	1.98E+04	2.28E+05	5.904	84.487
6	60.	70.	1.845	1.75E+04	1.21E+05	7.703	88.955
7	70.	90.	1.954	3.36E+04	1.25E+05	11.164	93.565
8	90.	110.	2.041	3.62E+04	6.92E+04	14.897	96.110
9	110.	130.	2.114	2.86E+04	3.17E+04	17.850	97.275
10	130.	150.	2.176	2.96E+04	2.06E+04	20.907	98.035
11	150.	180.	2.255	4.07E+04	1.73E+04	25.105	98.672
12	180.	210.	2.322	3.60E+04	9.27E+03	28.817	99.013
13	210.	240.	2.380	3.40E+04	5.70E+03	32.322	99.223
14	240.	270.	2.431	3.80E+04	4.37E+03	36.238	99.384
15	270.	300.	2.477	4.23E+04	3.49E+03	40.600	99.513
16	300.	350.	2.544	8.73E+04	4.86E+03	49.605	99.691
17	350.	400.	2.602	8.64E+04	3.13E+03	58.514	99.807
18	400.	450.	2.653	7.42E+04	1.85E+03	66.169	99.875
19	450.	500.	2.699	6.49E+04	1.16E+03	72.863	99.917
20	500.	600.	2.778	1.27E+05	1.46E+03	85.941	99.971
21	600.	700.	2.845	7.58E+04	5.27E+02	93.756	99.990
22	700.	800.	2.903	5.51E+04	2.50E+02	99.440	99.999
23	800.	900.	2.954	5.43E+03	1.69E+01	100.000	100.000

TOTAL MASS FLUX= 9.70E+05 UG/M2/SEC
TOTAL COUNT FLUX= 6.42E+07 #/M2/SEC
MASS MEAN DIAMETER= 360. UM
COUNT MEAN DIAMETER= 42. UM

MASS EMISSION RATE= 2.29E+01 GRAMS/SEC



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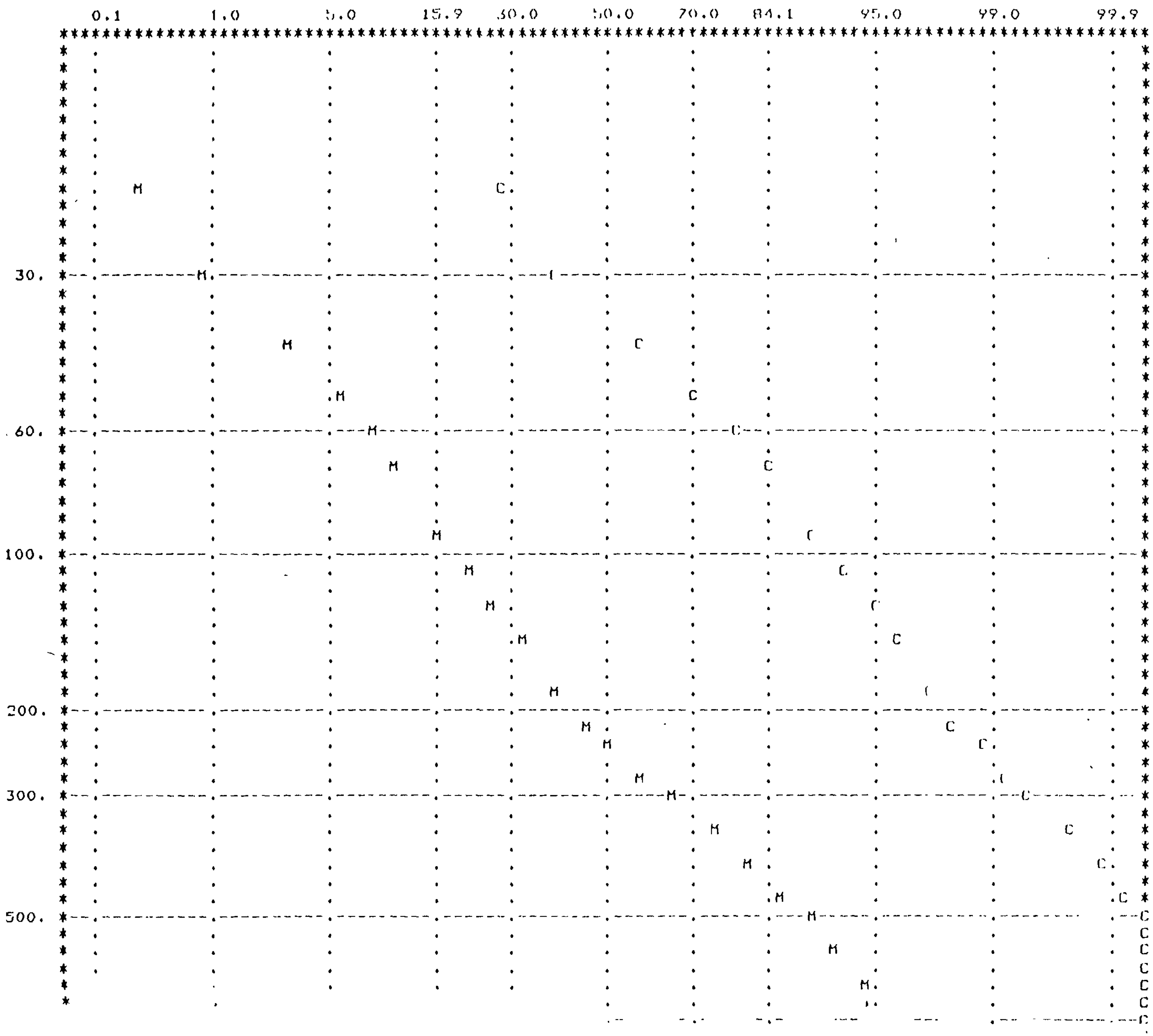
SUMMARY DROP SIZE DISTRIBUTION

AREA SAMPLED= 23.64 M2
RAY-6B-3

I	D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
	*****	*****	*****	**********	**********	**********	**********
1	10.	20.	1.301	9.67E+02	5.47E+05	0.143	24.967
2	20.	30.	1.477	2.13E+03	2.60E+05	0.459	36.841
3	30.	40.	1.602	1.06E+04	4.71E+05	2.027	58.341
4	40.	50.	1.699	1.56E+04	3.26E+05	4.336	73.229
5	50.	60.	1.778	1.38E+04	1.59E+05	6.387	80.474
6	60.	70.	1.845	1.58E+04	1.10E+05	8.728	85.485
7	70.	90.	1.954	3.50E+04	1.31E+05	13.925	91.450
8	90.	110.	2.041	3.39E+04	6.48E+04	18.957	94.408
9	110.	130.	2.114	3.17E+04	3.51E+04	23.664	96.008
10	130.	150.	2.176	3.71E+04	2.58E+04	29.162	97.186
11	150.	180.	2.255	5.19E+04	2.21E+04	36.856	98.193
12	180.	210.	2.322	5.58E+04	1.44E+04	45.128	98.848
13	210.	240.	2.380	5.14E+04	8.62E+03	52.752	99.242
14	240.	270.	2.431	5.44E+04	6.27E+03	60.823	99.528
15	270.	300.	2.477	4.57E+04	3.77E+03	67.599	99.700
16	300.	350.	2.544	6.74E+04	3.75E+03	77.595	99.871
17	350.	400.	2.602	3.83E+04	1.39E+03	83.269	99.934
18	400.	450.	2.653	2.48E+04	6.16E+02	86.944	99.962
19	450.	500.	2.699	2.49E+04	4.45E+02	90.644	99.983
20	500.	600.	2.778	1.89E+04	2.17E+02	93.442	99.993
21	600.	700.	2.845	1.36E+04	9.46E+01	95.459	99.997
22	700.	800.	2.903	1.12E+04	5.07E+01	97.120	99.999
23	800.	900.	2.954	0.00E-01	0.00E-01	97.120	99.999
24	900.	1000.	3.000	0.00E-01	0.00E-01	97.120	99.999
25	1000.	1200.	3.079	0.00E-01	0.00E-01	97.120	99.999
26	1200.	1400.	3.146	1.94E+04	1.69E+01	100.000	100.000

TOTAL MASS FLUX= 6.74E+05 UG/M2/SEC
TOTAL COUNT FLUX= 5.18E+07 #/M2/SEC
MASS MEAN DIAMETER= 278. UM
COUNT MEAN DIAMETER= 46. UM

MASS EMISSION RATE= 1.59E+01 GRAMS/SEC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SUMMARY DROP SIZE DISTRIBUTION

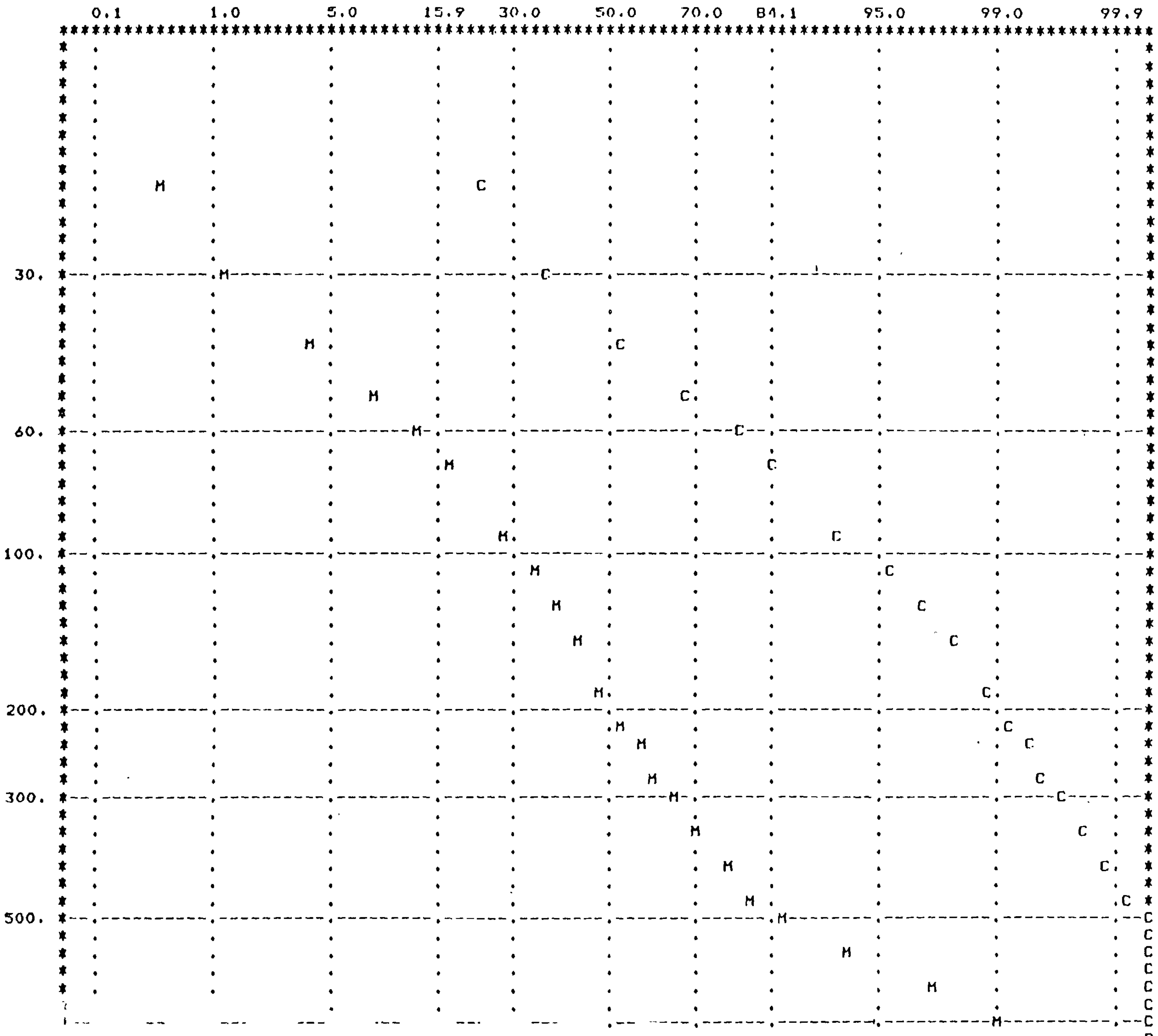
AREA SAMPLED= 23.64 M2

BAY-6B-4

I	D(LOW) UM	D(HI) UM	LOG D(HI)	MASS FLUX UG/M2/SEC	COUNT FLUX #/M2/SEC	% MASS SMALLER	% COUNT SMALLER
	*****	*****	*****	**********	**********	**********	**********
1	10.	20.	1.301	8.56E+02	4.84E+05	0.189	21.658
2	20.	30.	1.477	2.39E+03	2.93E+05	0.716	34.747
3	30.	40.	1.602	1.02E+04	4.55E+05	2.967	55.106
4	40.	50.	1.699	1.65E+04	3.45E+05	6.597	70.551
5	50.	60.	1.778	1.94E+04	2.23E+05	10.881	80.535
6	60.	70.	1.845	1.94E+04	1.35E+05	15.164	86.581
7	70.	90.	1.954	4.23E+04	1.58E+05	24.472	93.630
8	90.	110.	2.041	3.73E+04	7.12E+04	32.684	96.814
9	110.	130.	2.114	2.50E+04	2.76E+04	38.195	98.051
10	130.	150.	2.176	2.08E+04	1.45E+04	42.780	98.699
11	150.	180.	2.255	2.86E+04	1.22E+04	49.087	99.243
12	180.	210.	2.322	2.55E+04	6.56E+03	54.698	99.536
13	210.	240.	2.380	1.82E+04	3.04E+03	58.699	99.673
14	240.	270.	2.431	1.86E+04	2.14E+03	62.801	99.769
15	270.	300.	2.477	1.66E+04	1.37E+03	66.457	99.830
16	300.	350.	2.544	2.57E+04	1.43E+03	72.128	99.894
17	350.	400.	2.602	2.70E+04	9.79E+02	78.082	99.938
18	400.	450.	2.653	1.65E+04	4.11E+02	81.721	99.956
19	450.	500.	2.699	2.69E+04	4.79E+02	87.636	99.977
20	500.	600.	2.778	3.09E+04	3.55E+02	94.439	99.993
21	600.	700.	2.845	1.69E+04	1.18E+02	98.172	99.998
22	700.	800.	2.903	5.59E+03	2.53E+01	99.403	100.000
23	800.	900.	2.954	2.71E+03	8.42E+00	100.000	100.000

TOTAL MASS FLUX= 4.54E+05 UG/M2/SEC
TOTAL COUNT FLUX= 5.29E+07 #/M2/SEC
MASS MEAN DIAMETER= 248. UM
COUNT MEAN DIAMETER= 44. UM

MASS EMISSION RATE= 1.07E+01 GRAMS/SEC


0.1
1.0
5.0
15.9
30.0
50.0
70.0
84.1
95.0
99.0
99.9
30.
60.
100.
200.
300.
500.

SUMMARY DROP SIZE DISTRIBUTION

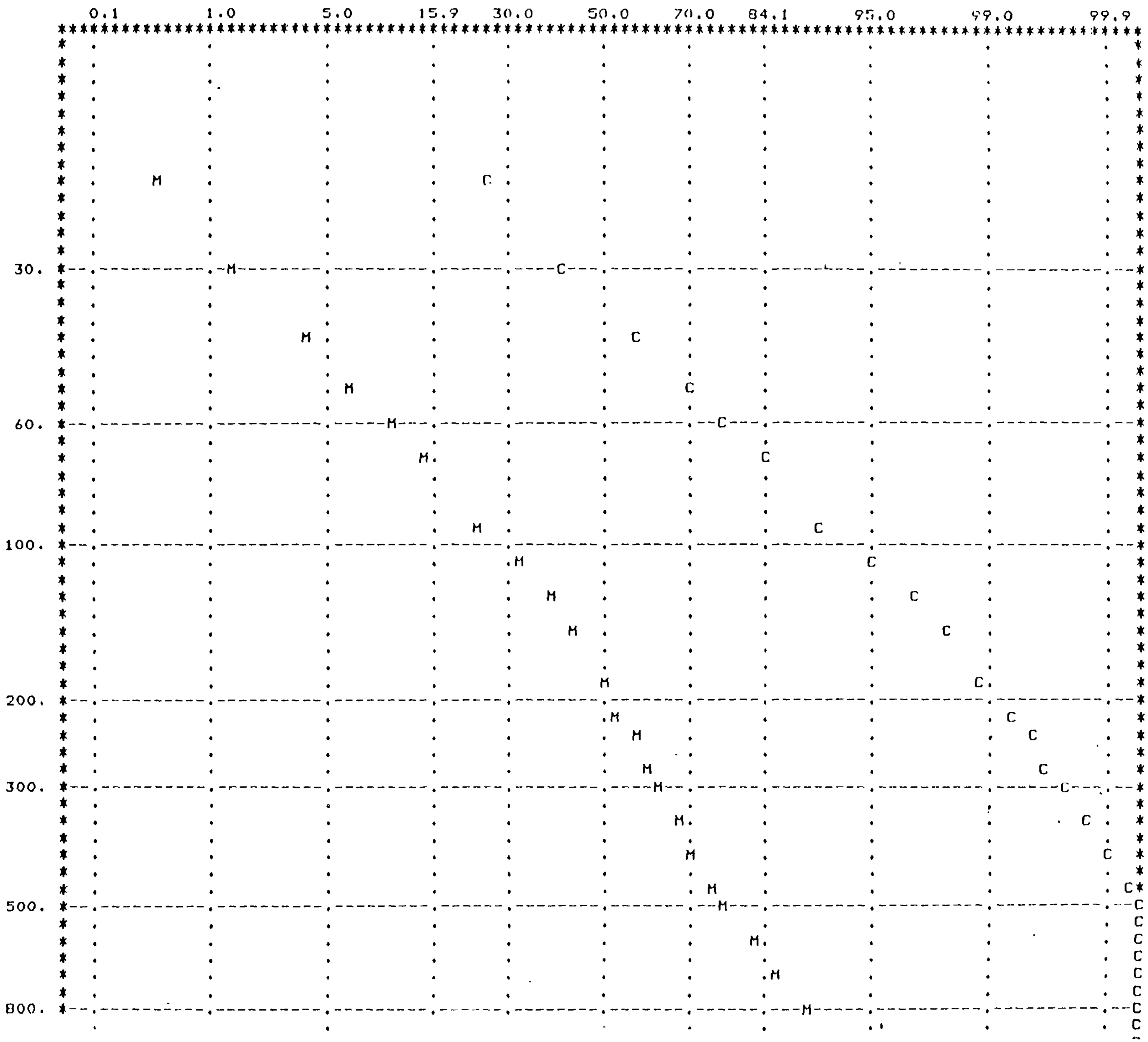
AREA SAMPLED= 42.00 M2

BAY-68-5

I	D(LOW) UM *****	D(HI) UM *****	LOG D(HI) *****	MASS FLUX UG/M2/SEC **********	COUNT FLUX #/M2/SEC **********	% MASS SMALLER **********	% COUNT SMALLER **********
1	10.	20.	1.301	9.57E+02	5.41E+05	0.196	23.887
2	20.	30.	1.477	3.06E+03	3.74E+05	0.823	40.382
3	30.	40.	1.602	9.14E+03	4.07E+05	2.697	58.337
4	40.	50.	1.699	1.38E+04	2.89E+05	5.521	71.074
5	50.	60.	1.778	1.68E+04	1.93E+05	8.974	79.604
6	60.	70.	1.845	1.92E+04	1.33E+05	12.908	85.491
7	70.	90.	1.954	4.15E+04	1.55E+05	21.421	92.323
8	90.	110.	2.041	4.41E+04	8.42E+04	30.459	96.038
9	110.	130.	2.114	3.72E+04	4.11E+04	38.089	97.852
10	130.	150.	2.176	2.98E+04	2.08E+04	44.203	98.768
11	150.	180.	2.255	3.12E+04	1.33E+04	50.603	99.353
12	180.	210.	2.322	2.18E+04	5.60E+03	55.065	99.601
13	210.	240.	2.380	1.78E+04	2.99E+03	58.715	99.732
14	240.	270.	2.431	1.65E+04	1.90E+03	62.090	99.816
15	270.	300.	2.477	1.48E+04	1.22E+03	65.121	99.870
16	300.	350.	2.544	1.96E+04	1.09E+03	69.140	99.918
17	350.	400.	2.602	1.79E+04	6.47E+02	72.805	99.946
18	400.	450.	2.653	2.02E+04	5.03E+02	76.951	99.969
19	450.	500.	2.699	1.23E+04	2.19E+02	79.469	99.978
20	500.	600.	2.778	2.48E+04	2.85E+02	84.557	99.991
21	600.	700.	2.845	1.10E+04	7.68E+01	86.820	99.994
22	700.	800.	2.903	1.86E+04	8.44E+01	90.641	99.998
23	800.	900.	2.954	6.78E+03	2.11E+01	92.031	99.999
24	900.	1000.	3.000	5.68E+03	1.26E+01	93.195	99.999
25	1000.	1200.	3.079	2.94E+03	4.22E+00	93.797	100.000
26	1200.	1400.	3.146	0.00E-01	0.00E-01	93.797	100.000
27	1400.	1600.	3.204	0.00E-01	0.00E-01	93.797	100.000
28	1600.	1800.	3.255	0.00E-01	0.00E-01	93.797	100.000
29	1800.	2000.	3.301	3.03E+04	8.42E+00	100.000	100.000

TOTAL MASS FLUX= 4.88E+05 UG/M2/SEC
TOTAL COUNT FLUX= 9.52E+07 #/M2/SEC
MASS MEAN DIAMETER= 360. UM
COUNT MEAN DIAMETER= 44. UM

MASS EMISSION RATE= 2.05E+01 GRAMS/SEC


0.1 1.0 5.0 15.9 30.0 50.0 70.0 84.1 95.0 99.0 99.9
30.
60.
100.
200.
300.
500.
800.

HEXAVALENT CHROMIUM EMISSIONS IN MILLIGRAMS PER MILLION BTU'S AND MICROGRAMS PER GALLON OF WATERFLOW
COOLING TOWERS 68 AND 84, EXXON COMPANY, INC., BAYTOWN, TX

Run	Water Flow (lbs/hr)	Inlet Temp. (F)	Basin Temp. (F)	Dry Air Flow (lbs/hr)	Inlet Air Enthalapy (BTUs/lb)	Inlet Air Humidity (lbs/lb)	Outlet Air Humidity (lbs/lb)	Evaporative Heat Loss (mmBTUs/hr)	Hexavalent Chromium Emissions (mgs/mmBTU)	(ugs/gal)
Cooling Tower 68, Standard-Efficiency Drift Eliminator, Counterflow Riser Cell E										
1-1	2,096,500	101	84	1,494,901	40.6	0.018	0.0251	97.22	257.8	99.57
4-1	2,096,500	102	84	1,381,946	42.0	0.019	0.0296	98.05	2.80	1.09
Average	2,096,500	102	84	1,438,424	41.3	0.019	0.0273	97.64	130.28	50.33
Cooling Tower 68, Standard-Efficiency Drift Eliminator, Counterflow Riser Cell F										
2-1	1,755,500	101	85	1,303,267	42.6	0.020	0.0277	84.50	48.7	19.53
3-1	1,755,500	101	84	1,409,990	42.6	0.022	0.0322	91.16	5.79	2.51
Average	1,755,500	101	85	1,356,629	42.6	0.021	0.0299	87.83	27.25	11.02
Cooling Tower 68, Standard-Efficiency Drift Eliminator, Crossflow Riser Cell G										
5-1	3,578,500	101	84	4,044,568	39.6	0.018	0.0264	223.91	261.53	136.32
5-2	3,578,500	101	84	4,269,699	44.8	0.021	0.0296	255.12	28.61	16.99
5-3	3,578,500	101	84	4,191,799	44.8	0.020	0.0277	251.36	10.14	5.94
Average	3,578,500	101	84	4,168,689	43.1	0.020	0.0279	243.46	100.10	53.08
Cooling Tower 84, High-Efficiency Drift Eliminator, Counterflow Riser Cell A										
A-1	2,523,000	100	85	2,637,694	42.0	0.022	0.0315	151.38	28.04	14.01
A-2	2,523,000	100	85	2,710,920	44.8	0.021	0.0283	161.60	2.49	1.33
Average	2,523,000	100	85	2,674,307	43.4	0.022	0.0299	156.49	15.26	7.67
Cooling Tower 84, High-Efficiency Drift Eliminator, Counterflow Riser Cell B										
B-1	2,660,000	99	85	2,752,986	42.0	0.022	0.0309	156.92	4.39	2.16
B-2	2,660,000	99	85	2,851,140	44.8	0.021	0.0309	169.34	1.22	0.65
Average	2,660,000	99	85	2,802,063	43.4	0.022	0.0309	163.13	2.80	1.40
Cooling Tower 84, High-Efficiency Drift Eliminator, Counterflow Riser Cell C										
C-1	3,027,000	100	85	2,517,728	42.0	0.022	0.0334	154.34	58.27	24.75
C-2	3,027,000	100	85	2,523,960	44.8	0.021	0.0322	161.61	2.32	1.03
Average	3,027,000	100	85	2,520,844	43.4	0.022	0.0328	157.98	30.29	12.89
Cooling Tower 84, High-Efficiency Drift Eliminator, Counterflow Riser Cell D										
D-1	3,039,500	99	85	2,424,248	42.0	0.022	0.0309	148.47	1.41	0.58
D-2	3,039,500	99	85	2,194,443	44.8	0.021	0.0328	145.33	68.11	27.13
Average	3,039,500	99	85	2,309,346	43.4	0.022	0.0318	146.90	34.76	13.85

Southern Research Institute 2000 Ninth Avenue South, P.O. Box 55305, Birmingham, Alabama 35255-5305 (205) [illegible]

November 18, 1986

Scott C. Steinsberger
ENTROPY Environmentalists Inc.
P.O. Box 12291
Research Triangle Park, NC 27709-2291

Dear Scott:

Enclosed is a summary table with particle size cut values for the data you sent me from the three cooling tower tests.

If you have any questions, feel free to call me.

Sincerely yours,

Ashley

Ashley D. Williamson
Head, Aerosol Science Division

ADW/fea
Enclosure
Project: 6112

COOLING TOWER DROP SIZING TRAIN RESULTS - EXXON, BAYTOWN REFINERY

	Disc/Nozzle Train Run No.					
	1	2	3	4	5	average
Stack Gas Velocity (ft/s)	34.8	34.2	34.7	34.5	34.4	
Disc Train D50 Cut Size (um)	12.55	12.66	12.56	12.60	12.62	12.60
Disc Train Probe D50 Cut Size (um)	5.07	5.11	5.08	5.09	5.10	5.09

	Absorbent Paper/Impinger Train Run No.								
	1-1	2-1	3-1	5-1	5-2	D-1	D-2	A-1	average
Stack Gas Velocity (ft/s)	21.6	19	20.9	25.9	27.6	20.8	19	22.7	
Absorbent Paper D50 Cut Size (um)	30.46	32.48	30.97	27.82	26.95	31.04	32.48	29.72	30.24

EXAMPLE PARTICULATE TEST CALCULATIONS

Cooling Tower No. 68 - Exxon Refinery
Baytown, TX

Run No. CT-68-1-1

VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

$$Vm(std) = 17.64 * Y * Vm * \frac{(Pbar + Delta\ H/13.6)}{(460 + tm)}$$

$$Vm(std) = 17.64 * 1.0020 * 53.639 * \frac{(30.250 + 0.629/13.6)}{(460 + 92.7)}$$

Vm(std) = 51.968

VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

Vw(std) = 0.04707 * Vlc

Vw(std) = 0.04707 * 44.76 = 2.107 SCF

PERCENT MOISTURE, BY VOLUME, AS MEASURED IN FLUE GAS

%H2O = 100 * Vw(std) / (Vw(std) + Vm(std))

$$\%H2O = 100 * \frac{2.107}{2.107 + 51.968} = 3.9\%$$

DRY MOLE FRACTION OF FLUE GAS

Mfd = 1 - %H2O/100

Mfd = 1 - 3.9% = 0.961

WET MOLECULAR WEIGHT OF FLUE GAS

Ms = (Md * Mfd) + (0.18 * %H2O)

Ms = (28.84 * 0.961)+ (0.18 * 3.9)= 28.42 LB/LB-MOLE

Run No. CT-68-1-1

ABSOLUTE FLUE GAS PRESSURE

$$Ps = Pbar + Pg / 13.6$$

$$Ps = 30.250 + (0.000 / 13.6) = 30.25$$

AVERAGE FLUE GAS VELOCITY [Note: (Delta p)avg is square of avg sq. root]

$$vs = 85.49 * Cp * SQRT\left[\frac{(Delta\ p)avg * (460 + ts)}{Ps * Ms} \right]$$

$$vs = 85.49 * 0.840 * SQRT\left[\frac{0.1429 * (460 + 84.1)}{30.25 * 28.42} \right]$$

$$vs = 21.60 \text{ FT/SEC}$$

DRY VOLUMETRIC FLUE GAS FLOW RATE @ STANDARD CONDITIONS

$$Qsd = \frac{60}{144} * Mfd * vs * A * \frac{Tstd}{ts + 460} * \frac{Ps}{Pstd}$$

$$Qsd = \frac{60}{144} * 0.961 * 21.60 * 37688 * \frac{528}{84.1 + 460} * \frac{30.25}{29.92}$$

$$Qsd = 319{,}789 \text{ SCFM}$$

WET VOLUMETRIC STACK GAS FLOW RATE @ FLUE GAS CONDITIONS

$$Qaw = 60/144 * vs * A$$

$$Qaw = 60/144 * 21.59 * 37688 = 339{,}149 \text{ ACFM}$$

PERCENT OF ISOKINETIC SAMPLING RATE

$$\%I = \frac{Pstd}{Tstd} * \frac{100}{60} * \frac{(ts + 460) * Vm(stsd)}{Ps * vs * Mfd * Theta * \text{Area-Nozzle, sq.ft.}}$$

$$\%I = \frac{29.92}{528} * \frac{100}{60} * \frac{(84.1 + 460) * 51.968}{30.25 * 21.60 * 0.961 * 120.0 * 0.000340}$$

$$\%I = 104.0 \%$$

Run No. CT-68-1-1

GRAINS PER DRY STANDARD CUBIC FOOT : - HEXAVALENT CHROMIUM

$$gr/DSCF = \frac{7000}{453,592} * \frac{ugs}{Vm(std)}$$

$$gr/DSCF = \frac{7000}{453,592} * \frac{65.273}{51.968} = 19.383 \times 10E\text{-}6$$

POUNDS PER HOUR - PMRa

$$PMRa = \frac{Mass}{Time} * \frac{\text{Area of Stack}}{\text{Area of Nozzle}}$$

$$Lb/Hr = \frac{60\ min}{453,592} * \frac{1}{1000} * \frac{ugs}{\text{Theta (min)}} * \frac{\text{Area of Stack}}{\text{Area of Nozzle}}$$

$$Lb/Hr = \frac{60\ min}{453,592} * \frac{1}{1000} * \frac{65.273}{120} * \frac{37,688.0}{0.049}$$

$$Lb/Hr = 55.242 \times 10E\text{-}3$$

Run No. CT-68-1-1

POLLUTANT CONCENTRATION - AIRFLOW

$$\frac{\text{Mass (mg)}}{\text{Vol. Metered (dscf)}} * \frac{35.34\ \text{ft3}}{\text{m3}} = \frac{\text{mg}}{\text{dscm}}$$

$$\frac{0.065273}{51.968} * \frac{35.34\ \text{ft3}}{\text{m3}} = 44.387851\ \text{mg/dscm}$$

POLLUTANT CONCENTRATION - WATER FLOW TO FAN CELL

$$\frac{\text{PMRa (mg/hr)}}{\text{Water Flow Rate (gal/min)}} * \frac{1{,}000\ \text{ug/mg}}{60\ \text{min/hr}}$$

$$\frac{25060}{4{,}193} * \frac{1{,}000\ \text{ug/mg}}{60\ \text{min/hr}} = 99.610\ \text{ug/gal}$$

POLLUTANT CONCENTRATION - EVAPORATIVE HEAT LOSS

$$\text{Evaporative Heat Loss (MMBTU/hr)} = \frac{(L1t1 + Gh1) - (L1 - G(ae2 - ae1)) * t2}{10E6\ \text{BTU/MMBTU}}$$

ae1	=	Entering air humidity (lbs/lb)	0.0180
ae2	=	Exiting air humidity (lbs/lb)	0.0251
G	=	Air flow (lbs dry air/hr)	1,494,901
h1	=	Entering air enthalpy (BTU/lb)	40.6
L1	=	Hot water flow (lbs/hr)	2,096,500
t1	=	Hot water temperature (Degrees F)	101
t2	=	Cold water temperature (Degrees F)	84

Evaporative Heat Loss (MMBTU/hr) = 97.225 MMBTU/hr

$$\frac{\text{mg/hr}}{\text{MMBTU/hr}} = 257.753\ \text{mg/MMBTU}$$

Run No. CT-68-1-1

MASS EMISSION RATE (RATIO OF AREAS) - ABSORBENT PAPERS

$$\frac{\text{Mass (ug)}}{\text{Sample Time (hrs)}} * \frac{.001\ \text{mg}}{\text{ug}} * \frac{\text{Stack Area (in2)}}{\text{Area exposed paper}} * \frac{6.452\ \text{cm2}}{\text{in2}}$$

$$= \frac{16.265}{2} * \frac{.001\ \text{mg}}{\text{ug}} * \frac{37{,}688}{13.2\ \text{cm2}} * \frac{6.452\ \text{cm2}}{\text{in2}}$$

$$= 149.8\ \text{mg/hr}$$

DRIFT RATE - ABSORBENT PAPER

$$\frac{\text{Mass Emission Rate (mg/hr)} * 1\ \text{hr}/60\ \text{min} * 100}{\text{Water conc.(mg/L)} * \text{Water Rate (gpm)} * 3.785\ \text{l/gal}}$$

$$= \frac{149.8 * 1\text{hr}/60\text{min} * 100}{7.66 * 4193 * 3.785\ \text{l/gal}} = 0.0021\%$$

DRIFT RATE - IMPINGER TRAIN

$$\frac{\text{Mass Emission Rate (mg/hr)} * 1\ \text{hr}/60\ \text{min} * 100}{\text{Water conc.(mg/L)} * \text{Water Rate (gpm)} * 3.785\ \text{l/gal}}$$

$$= \frac{25060.0 * 1\text{hr}/60\text{min} * 100}{7.66 * 4193 * 3.785\ \text{l/gal}} = 0.344\%$$

DRIFT RATE - SENSITIVE PAPER

$$\frac{\text{Mass Emission Rate (g/sec)} * 60\text{sec/min} * 100}{\text{Water Rate (gpm)} * 1\ \text{g/ml} * 3{,}785.4\ \text{ml/gal}}$$

$$= \frac{12.4 * 60\ \text{sec/ min} * 100}{4193 * 3.785\ \text{l/gal}} = 0.0047\%$$

Run No. CT-68-1-1

TOTAL CHROMIUM IN IMPINGER AND DI AND NZ SAMPLES

$$B * A * 0.001 \text{ L/gram} = C$$

$$C - L = D$$

$$D * E = F$$

$$H * \frac{2 \text{ g (ml)}}{G} = I$$

$$F \text{ (or D)} + I + J = K$$

A = Sample weight sent for GFAA analysis (grams)
B = Sample concentration (GFAA) (ug/L)
C = Total chromium in GFAA sample (ug)
D = Blank corrected total chromium in GFAA sample (ug)
E = Correction factor for 2 ml taken by NAA (if needed)
F = Adjusted total chromium in GFAA sample (ug)
G = Original sample weight sent for NAA analysis (grams)
H = Total chromium calculated and reported from NAA (ug)
I = Total chromium contribution from 2 ml NAA aliquot (ug)
J = Total chromium contribution from beaker residue (GFAA) (ug)
L = Appropriate blank (ug)
K = Total chromium for sample (ug)

Note: Letters refer to columns in table which follows.

EXXON REFINERY - Baytown, TX

	A	B	C	D	E	F	G	H	I	J	K
Sample I.D.	Sample Wt. grams	Sample Conc. (GFAA) ug/L	Total Cr (GFAA) ug	Blank Corr. Tot. Cr (GFAA) ug	Corr. Factor For 2 ml Taken By NAA	Adjusted Tot. Cr (GFAA) ug	Original Sample Wt. grams	Total Cr calc. 2ml Aliq. (NAA) ug	Total Cr in 2ml Aliq. (NAA) ug	Total Cr in Residue (GFAA) ug	Total Cr per Sample ug
EXX 1-1-abc Impin & Filter	3.9872	4048.0	16.1402	16.0402	1.079	17.3031	27.4020	38.2110	2.7889	45.3730	65.4650
EXX 2-1-a Impin 1 & Rinse	4.5960	116.0	0.5331	0.4331	1.086	0.4703	25.3218	0.0000	0.0000	1.1280	1.5983
EXX 2-1-b Impin 2	5.7761	98.0	0.5661	0.5261	1.084	0.5700	25.9171	0.0000	0.0000	8 7830	9.3530
EXX 2-1-c Impin 3 & Filter	5.0710	37.0	0.1876	0.1676	1.077	0.1805	28.1114	0.2760	0.0196	0.0000	0.2001
EXX 3-1-abc Impin & Filter	4.3544	164.0	0.7141	0.6141	1.083	0.6652	26.0679	2.2120	0.1697	0.5530	1.3879
EXX 4-1-abc Impin & Filter	4.0700	129.0	0.5250	0.4250	1.082	0.4597	26.5272	1.3300	0.1003	0.0400	0.6000
EXX 5-1-abc Impin & Filter	5.5819	3152.0	17.5941	17.4941	1.078	18.8622	27.5749	26.8560	1.9479	45.8730	66.6831
EXX 5-2-a Impin 1 & Rinse	5.5360	474.0	2.6241	2.5241	1.091	2.7543	23.9277	0.5880	0.0491	3.8980	6.7014
EXX 5-2-b Impin 2	3.9242	37.0	0.1452	0.1052	1.088	0.1145	24.6471	0.0000	0.0000	1.8580	1.9725
EXX 5-2-c Impin 3 & Filter	5.5629	33.0	0 1836	0.1636	1.112	0.1820	19.7954	0.0000	0.0000	0.0000	0.1820
EXX 5-3-abc Impin & Filter	4.7916	157.0	0.7523	0.6523	1.079	0.7039	27.2730	2.3830	0.1748	2.0230	2.9017
EXX A-1-a Impin 1 & Rinse	3.9885	176.0	0.7020	0.6020	1.078	0.6488	27.7122	0.0000	0.0000	4.4430	5.0918
EXX A-1-b Impin 2	4.7429	46.0	0.2182	0.1782	1.089	0.1940	24.5078	0.0000	0.0000	1.0030	1.1970
EXX A-1-c Impin 3 & Filter	4.3238	95.0	0.4108	0.3908	1.074	0.4197	29.0468	0.4530	0.0312	0.0000	0.4508
EXX A-2-abc Impin & Filter	5.8390	58.0	0.3387	0.2387	1.082	0.2582	26.3708	0.4530	0.0344	0.4150	0.7076
EXX B-1-abc Impin & Filter	4.3312	86.0	0 3725	0.2725	1.119	0.3049	18.8088	4.0770	0.4335	0.8430	1.5814
EXX B-2-abc Impin & Filter	4.1091	107.0	0.4397	0.3397	1 088	0.3697	24.6307	1.2500	0.1015	0.0580	0.5292
EXX C-1-a Impin 1 & Rinse	3.8370	616.0	2.3636	2.2636	1.085	2.4553	25.6174	0.0000	0.0000	8.2080	10.6633
EXX C-1-b Impin 2	4.9444	76.0	0.3758	0.3358	1.085	0.3644	25.4790	0.0000	0.0000	1.8080	2.1724
EXX C-1-c Impin 3 & Filter	3.9388	88.0	0.3466	0.3266	1.083	0.3539	25.9525	0.8950	0.0690	0.0000	0 4229
EXX C-2-abc Impin & Filter	4.2507	110.0	0.4676	0.3676	1.081	0.3975	26.5968	2 0790	0.1563	0.0000	0.5538
EXX D-1-abc Impin & Filter	4.0658	110.0	0.4472	0.3472	1.090	0.3786	24 1260	0.9670	0.0802	0.0000	0.4588
EXX D-2-abc Impin & Filter	5.0054	497.0	2.4877	2.3877	1.088	2.5971	24.8029	49.8490	4.0196	14.9230	21.5397
EXX Blank 1 Sample Train	4.8572	31.0	0.1506		1.078	0.0000	27.7461	0 4440	0.0320	0.0000	0.0320
EXX Blank 2 Water Blank	4.0529	110.0	0.4458		1.091	0.0000	23.9783	0.2630	0.0219	0.0000	0.0219

	A	B	C	D	E	F	G	H	I	J	K
EXX DI-1f Disc Part. Sizing	6.1437	236.0	1.4499	1.3499			28.5310	2.5010	0.1753	0.0000	1 5252
EXX DI-1p Disc Part. Sizing	5.3081	550.0	2.9195	2.8195			24.8876	2.0320	0.1633	1.1030	4.0857
EXX DI-2f Disc Part. Sizing	4.8507	12755.0	61.8707	61.7707			28.7162	83.0610	5.7850	3.7600	71.3156
EXX DI-2p Disc Part. Sizing	5.8429	348.0	2.0333	1.9333			26.1345	1.1310	0.0866	0.6100	2.6299
EXX DI-3f Disc Part. Sizing	5.4802	4365.0	23.9211	23.8211			25.4153	32.4620	2.5545	2.0230	28 3986
EXX DI-3p Disc Part. Sizing	6.0048	432.0	2.5941	2.4941			24.9680	0.6130	0.0491	1.2530	3.7962
EXX DI-4f Disc Part. Sizing	5.3343	269.0	1.4349	1.3349			24.5252	0 0500	0.0041	0.0000	1.3390
EXX DI-4p Disc Part. Sizing	6.0489	37 0	0.2238	0.1238			24.4289	1.9140	0.1567	0.5680	0 8485
EXX DI-5f Disc Part. Sizing	6.0280	94.0	0.5666	0.4666			24.1605	0.4570	0.0378	0 1650	0.6695
EXX DI-5p Disc Part. Sizing	5.7065	46.0	0.2625	0.1625			24.1451	0.0500	0.0041	1 6180	1.7846
EXX NZ-1 (w/o filter)	5.5912	421.0	2.3539	2.2539			24.8408	1 7210	0.1386	7 4730	9.8655
EXX NZ-2pf Nozzle Train	4.1097	6510.0	26.7541	26.6541			22.1188	5 7110	0.5164	42 5730	69.7435
EXX NZ-3pf Nozzle Train	3.6007	6300.0	22.6844	22.5844			27.6306	15.8120	1.1445	11.1850	34.9139
EXX NZ-4 (w/o filter)	5.7369	287 0	1.6465	1.5465			27.7520	0 0000	0.0000	8.4230	9.9695
EXX NZ-5pf Nozzle Train	4.2465	1208.0	5.1298	5.0298			21.7376	1.5950	0.1468	1.2080	6.3845

	L
	GFAA
	ug
Impin & Filter-Blank Value	0.1
Impin 1 & Rinse-Blank Value	0.1
Impin 2-Blank Value	0.04
Impin 3 & Filt-Blank Value	0.02

APPENDIX B.

FIELD AND ANALYTICAL DATA

Preliminary Field Data

PLANT NAME Exxon - Baytown Refinery

LOCATION Baytown, TX

SAMPLING LOCATION CT-68 Fan Cells # 1, 2, 3

DUCT DEPTH
FROM INSIDE FAR WALL TO OUTSIDE OF PORT —

NIPPLE LENGTH —

DEPTH OF DUCT 219"

WIDTH (RECTANGULAR DUCT) —

EQUIVALENT DIAMETER:

$$D_E = \frac{2 \times DEPTH \times WIDTH}{DEPTH + WIDTH} = \frac{2(\quad)(\quad)}{(\quad + \quad)} = —$$

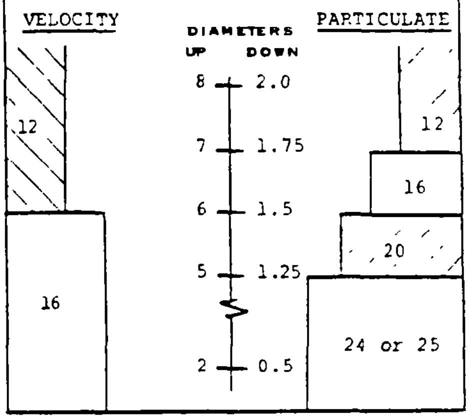
DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE

	UPSTREAM	DOWNSTREAM
FLOW DISTURBANCE		
DIAMETERS		

STACK AREA = $(109.5)^2 \pi$ = 37,668 IN^2

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	4 5/8	—
2	6.7	14 5/8	
3	11.8	25 7/8	
4	17.7	38 3/4	
5	25.0	54 3/4	
6	35.6	78	
7	64.4	141	
8	75.0	164 1/4	
9	82.3	180 1/4	
10	88.2	193 1/8	
11	93.3	204 3/8	
12	97.9	214 3/8	
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EMB RUN NUMBER CT-68-1-1
ADDRESS Baytown, Tx. TIME START 1109
SAMPLING LOCATION CT 68 Fan Cell #1 TIME FINISH 1326
DATE 9-1-86 TEAM LEADER TMS TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 7
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.001 0.000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
N/A PITOTS, PRE-TEST	REAGENT BOX	NOZZLE 206 DIAMETER .250
N/A PITOTS, POST-TEST	METER BOX N/4	T/C READOUT 0009
N/A ORSAT SAMPLING SYSTEM	UMBILICAL U2	T/C PROBE 4-10
N/A TEDLAR BAG	SAMPLE BOX 11	ORSAT PUMP N/A
✓ THERMOCOUPLE @ 80 °F	PROBE 2	TEDLAR BAG N/A

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # N/A	
N/4		$\Delta H_@$	1.72	C FACTOR	
		METER TEMP	95	STACK TEMP	80
		% MOISTURE	2	REF. ΔP	

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	748.104	330	0.11	0.45	0.45	90	4	N/A	55	80	
	5	750.13	330	0.11	0.45	0.45	90	4		58	80	
2	10	752.28	480	0.24	0.95	0.95	90	6		57	80	
	15	754.98	540	0.30	1.19	1.19	91	7		57	81	
3	20	757.98	525	0.29	1.13	1.13	92	7		56	81	
	25	761.25	520	0.28	1.10	1.10	93	6		56	83	
4	30	764.73	460	0.22	0.87	0.87	94	6		58	83	
	35	767.32	440	0.20	0.79	0.79	94	5		57	82	
5	40	769.94	370	0.14	0.56	0.56	93	5		58	82	
	45	772.35	330	0.11	0.45	0.45	93	4		59	82	
6	50	774.14	195	0.04	0.15	0.15	93	2		59	84	
	55	775.48	210	0.05	0.18	0.18	93	3		61	83	
7	60	776.73	205	0.04	0.17	0.17	93	3		60	83	
	65	777.93	193	0.04	0.15	0.15	92	2		60	84	
8	70	779.04	159	0.03	0.10	0.10	92	2		59	84	
	75	780.07	263	0.07	0.28	0.28	93	3		61	87	
9	80	781.68	465	0.22	0.86	0.86	93	6		58	89	
	85	784.31	435	0.19	0.76	0.76	94	6		58	89	
10	90	786.48	366	0.14	0.54	0.54	94	5		61	88	
	95	788.88	424	0.19	0.73	0.73	93	6		63	86	
11	100	791.32	529	0.29	1.12	1.12	93	7		62	89	
	105	794.37	535	0.29	1.16	1.16	94	7		62	86	
12	110	797.71	314	0.10	0.40	0.40	94	4		64	86	
	115	799.60	369	0.14	0.53	0.55	94	5		63	86	
	120/0	801.743										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
53.639	.1429	.629	93	84

COMPANY NAME Exxon - EMB
RUN NUMBER CT68-2-1
ADDRESS Baytown, Tx
TIME START 1417
SAMPLING LOCATION CT 68, FAN CELL #2
TIME FINISH 1623
DATE 9/1/86
TEAM LEADER (MS)
TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.25
STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 6
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.001 0.000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS
N/A PITOTS, PRE-TEST	REAGENT BOX ____ NOZZLE 204 DIAMETER .255
N/A PITOTS, POST-TEST	METER BOX N-14 T/C READOUT 2009
N/A ORSAT SAMPLING SYSTEM	UMBILICAL U2 T/C PROBE 5-7
N/A TEDLAR BAG	SAMPLE BOX ____ ORSAT PUMP N/A
✓ THERMOCOUPLE @ 80 °F	PROBE 2 TEDLAR BAG N/A

FILTER #	TARE	NOMOGRAPH SET-UP	NOMOGRAPH # —
n/a		ΔH@ 1.72	C FACTOR —
		METER TEMP 95	STACK TEMP 80
		% MOISTURE 2	REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	801.832	141	0.02	0.08	0.08	94	2	N/A	58	81	
	5	802.64	153	0.02	0.10	0.10	94	2		56	80	
2	10	803.52	158	0.03	0.10	0.10	94	2		55	81	
	15	804.45	241	0.06	0.24	0.24	94	2		57	81	
3	20	805.73	369	0.14	0.55	0.55	94	4		57	84	
	25	807.93	348	0.13	0.49	0.49	95	4		60	84	
4	30	810.11	403	0.17	0.66	0.66	96	5		62	85	
	35	812.41	406	0.17	0.68	0.68	97	5		60	84	
5	40	814.97	346	0.12	0.48	0.48	97	4		59	90	
	45	817.02	322	0.11	0.41	0.41	98	4		59	91	
6	50	819.93	221	0.05	0.20	0.20	98	3		60	91	
	55	820.41	240	0.06	0.23	0.23	97	2		62	91	
7	60	821.86	145	0.02	0.08	0.08	97	1		62	92	
	65	822.73	158	0.03	0.10	0.10	96	1		63	93	
8	70	823.57	438	0.19	0.75	0.75	96	5		61	96	
	75	826.11	503	0.26	1.00	1.00	96	6		62	94	
9	80	828.92	413	0.17	0.68	0.68	96	5		63	91	
	85	831.51	475	0.23	0.90	0.90	96	6		62	91	
10	90	834.18	446	0.20	0.80	0.80	95	5		64	87	
	95	836.85	476	0.23	0.91	0.91	95	6		64	89	
11	100	839.72	464	0.22	0.88	0.88	96	6		63	85	
	105	842.63	412	0.17	0.69	0.69	96	5		63	86	
12	110	844.97	321	0.11	0.42	0.42	96	4		64	86	
	115	846.99	263	0.07	0.28	0.28	96	3		65	86	
	120/off	848.758										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
46.926	.1101	.488	96	87

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EMB RUN NUMBER CT68-3-1
ADDRESS Baytown, Tx TIME START 0933
SAMPLING LOCATION CT 68, Fan cell # 3 TIME FINISH 1138
DATE 9/2/86 TEAM LEADER RMS TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.2 STATIC PRESSURE, IN. H_2O 1
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 9
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.001 0.000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
N/A PITOTS, PRE-TEST	REAGENT BOX ____	NOZZLE 206 DIAMETER .250
N/A PITOTS, POST-TEST	METER BOX N14	T/C READOUT 0009
N/A ORSAT SAMPLING SYSTEM	UMBILICAL U2	T/C PROBE 5-7
N/A TEDLAR BAG	SAMPLE BOX 11	ORSAT PUMP N/A
✓ THERMOCOUPLE @ 92 °F	PROBE 2	TEDLAR BAG N/A

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # N/A
N/A		ΔH@	1.72	C FACTOR N/A
		METER TEMP	90	STACK TEMP 80
		% MOISTURE	2	REF. ΔP N/A

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	849.072	245	0.06	0.23	0.23	85	4	N/A	52	93	
	5	850.43	207	0.04	0.17	0.17	86	4		54	93	
2	10	851.71	410	0.17	0.65	0.65	86	7		55	94	
	15	853.95	387	0.15	0.58	0.58	87	7		55	94	
3	20	856.39	383	0.15	0.57	0.57	88	7		57	94	
	25	858.52	407	0.17	0.64	0.64	89	7		59	94	
4	30	860.89	434	0.19	0.73	0.73	89	8		58	93	
	35	863.52	421	0.18	0.69	0.69	89	8		58	93	
5	40	865.83	391	0.16	0.60	0.60	90	8		57	92	
	45	868.41	423	0.18	0.70	0.70	90	8		59	91	
6	50	870.73	197	0.04	0.15	0.15	91	3		57	94	
	55	872.19	173	0.03	0.12	0.12	91	2		52	93	
7	60	873.09	192	0.04	0.14	0.14	91	2		58	94	
	65	874.18	195	0.04	0.15	0.15	92	2		59	59	
8	70	875.32	199	0.04	0.16	0.16	92	2		59	88	
	75	876.48	481	0.24	0.94	0.94	93	9		60	83	
9	80	879.17	479	0.24	0.94	0.94	93	9		61	83	
	85	882.28	440	0.20	0.79	0.79	94	9		63	83	
10	90	884.82	453	0.21	0.80	0.80	94	9		61	94	
	95	887.36	472	0.23	0.82	0.82	94	9		61	94	
11	100	890.25	465	0.22	0.84	0.84	94	9		60	96	
	105	892.89	471	0.22	0.87	0.87	94	9	✓	62	95	
12	110	895.73	432	0.19	0.73	0.73	94	8		63	94	
	115	898.29	257	0.07	0.26	0.26	94	4		65	92	
	120 off	900.031										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
50.959	.1316	.555	91	92

Preliminary Field Data

PLANT NAME ~~EWLF~~ - EXXON

LOCATION Baytown, TX

SAMPLING LOCATION CT-6B Fan Cell #4

DUCT DEPTH

FROM INSIDE FAR WALL TO OUTSIDE OF PORT —

NIPPLE LENGTH —

DEPTH OF DUCT 244"

WIDTH (RECTANGULAR DUCT) —

EQUIVALENT DIAMETER:

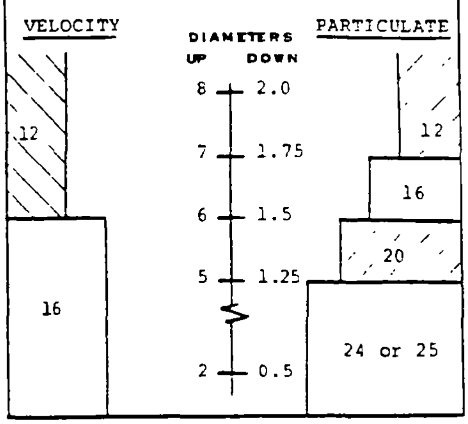
$$D_E = \frac{2 \times \text{DEPTH} \times \text{WIDTH}}{\text{DEPTH} + \text{WIDTH}} = \frac{2(\quad)(\quad)}{(\quad + \quad)} = \_\_\_\_$$

DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE	UPSTREAM	DOWNSTREAM
DIAMETERS		

STACK AREA = $(122)^2\pi$ = 46,759 IN²

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	5 1/8	
2	6.7	16 3/8	
3	11.8	28 3/4	
4	17.7	43 [illegible]	
5	25.0	61	
6	35.6	86 7/8	
7	64.4	157 1/8	
8	75.0	183	
9	82.3	200 3/4	
10	88.2	215 1/8	
11	93.3	227 5/8	
12	97.9	238 7/8	
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EMB
RUN NUMBER CT68-4-1
ADDRESS Baytown, Tx.
TIME START 1229
SAMPLING LOCATION CT 68, Fan Cell 4
TIME FINISH 1446
DATE 9/2/86
TEAM LEADER TMS
TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.2
STATIC PRESSURE, IN. H_2O 1
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 4
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.002 0.

EQUIPMENT CHECKS	
—	PITOTS, PRE-TEST
—	PITOTS, POST-TEST
—	ORSAT SAMPLING SYSTEM
—	TEDLAR BAG
✓	THERMOCOUPLE @ ____ °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 204 DIAMETER .255
METER BOX N14 T/C READOUT 0009
UMBILICAL U2 T/C PROBE 5-2
SAMPLE BOX 12 ORSAT PUMP —
PROBE 2 TEDLAR BAG —

FILTER #	TARE
N/A	

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.72 C FACTOR —
METER TEMP 90 STACK TEMP 90
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	900.204	398	0.16	0.63	0.63	93	4	N/4	53	88	
	5	902.53	352	0.13	0.49	0.49	94	3		54	[illegible]	
2	10	904.87	337	0.12	0.45	0.45	94	3		56	91	
	15	906.76	367	0.14	0.54	0.54	95	3		57	91	
3	20	908.98	435	0.19	0.75	0.75	96	4		57	91	
	25	911.42	354	0.13	0.50	0.50	96	3		58	91	
4	30	913.70	199	0.04	0.16	0.16	96	1		59	90	
	35	915.11	203	0.04	0.16	0.16	96	1		61	91	
5	40	916.30	139	0.02	0.08	0.08	96	1		60	89	
	45	917.09	162	0.03	0.11	0.11	96	1		60	89	
6	50	917.98	143	0.02	0.08	0.08	96	1		61	90	
	55	918.91	155	0.02	0.10	0.10	97	1		62	89	
7	60	919.78	209	0.04	0.19	0.19	97	2		61	89	
	65	921.04	215	0.05	0.20	0.20	97	2		60	88	
8	70	922.39	204	0.04	0.18	0.18	97	2		62	88	
	75	923.72	197	0.04	0.17	0.17	97	2		63	89	
9	80	925.15	237	0.06	0.24	0.24	98	2		64	90	
	85	926.51	283	0.08	0.35	0.35	98	3		65	89	
10	90	928.22	349	0.13	0.53	0.53	97	3		64	87	
	95	930.48	355	0.13	0.55	0.55	96	3		65	86	
11	100	932.72	403	0.17	0.71	0.71	96	4		65	87	
	105	935.50	384	0.16	0.66	0.66	96	[illegible]		66	87	
12	110	937.62	362	0.13	0.57	0.57	97	4		66	88	
	115	939.99	318	0.10	0.44	0.44	95	3		68	88	
	120/off	942.014										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
41.81	.0812	.368	96	89

Preliminary Field Data

PLANT NAME Exxon - Baytown Refinery
LOCATION Baytown, TX
SAMPLING LOCATION CT-68 Fan Cell #5

DUCT DEPTH
FROM INSIDE FAR WALL TO OUTSIDE OF PORT —
NIPPLE LENGTH —
DEPTH OF DUCT 330"
WIDTH (RECTANGULAR DUCT) —

EQUIVALENT DIAMETER:

$$D_E = \frac{2 \times \text{DEPTH} \times \text{WIDTH}}{\text{DEPTH} + \text{WIDTH}} = \frac{2(\quad)(\quad)}{(\quad + \quad)} = \text{—}$$

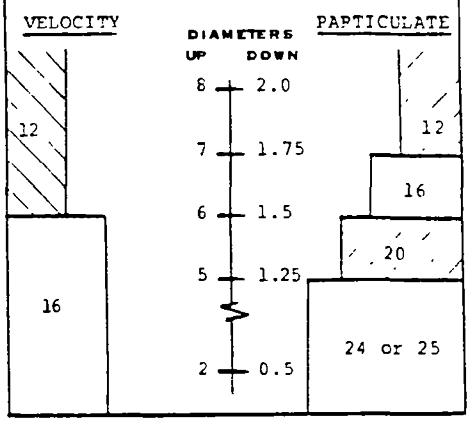
DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE

	UPSTREAM	DOWNSTREAM
DIAMETERS		

STACK AREA = $(165)^2\pi$ = 85530 IN^2

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	6 7/8	—
2	6.7	22 1/8	
3	11.8	39	
4	17.7	58 3/8	
5	25.0	82 1/2	
6	35.6	117 1/2	
7	64.4	212 1/2	
8	75.0	247 1/2	
9	82.3	271 5/8	
10	88.2	291	
11	93.3	307 7/8	
12	97.9	323 1/8	
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

ENTROPY ENVIRONMENTALISTS, INC

PARTICULATE FIELD DATA

COMPANY NAME EXXON | RUN NUMBER CT68-5-1

ADDRESS BAYTOWN, TEXAS | TIME START 1050

SAMPLING LOCATION COOLING TOWER 68 FAN CELL # 5 | TIME FINISH 1328

DATE 9-1-86 | TEAM LEADER DB | TECHNICIANS BB

BAROMETRIC PRESSURE, IN. HG 30.25 | STATIC PRESSURE, IN. H_2O

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 10

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .000 .000

EQUIPMENT CHECKS

+ PITOTS, PRE-TEST
— PITOTS, POST-TEST
— ORSAT SAMPLING SYSTEM
— TEDLAR BAG
✓ THERMOCOUPLE @ ____ °F

IDENTIFICATION NUMBERS

REAGENT BOX 205 | NOZZLE 704 | DIAMETER .249

METER BOX N-10 | T/C READOUT 013

UMBILICAL 50 | T/C PROBE

SAMPLE BOX | ORSAT PUMP —

PROBE | TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP | NOMOGRAPH # —

$\Delta H_@$ 1.68 | C FACTOR —

METER TEMP 80 | STACK TEMP —

% MOISTURE 2 | REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A 1	0	168.400	210	.05	.17	.17	84	2	—	56	86	
2	5	169.670	425	.19	.69	.69	84	5	—	58	85	
3	10	171.900	550	.31	1.17	1.17	85	6	—	58	83	
4	15	174.940	600	.37	1.40	1.40	88	6	—	61	82	
5	20	178.380	600	.38	1.44	1.44	91	6	—	64	77	
6	25	181.830	220	.05	.19	.19	94	2	—	63	81	
12	30/0	183.230	350	.32	1.20	1.20	94	6	—	66	80	
11	5	186.500	660	.45	1.72	1.72	96	7	—	65	83	
10	10	190.250	675	.47	1.80	1.80	98	8	—	64	83	
9	15	194.200	650	.44	1.68	1.68	101	7	—	65	83	
8	20	198.040	510	.27	1.04	1.04	103	6	—	67	82	
7	25	201.310	52	—	.01	.01	104	1	—	67	84	
B 1	60/0	201.630	350	.12	.47	.47	100	3	—	69	94	
2	5	203.665	570	.33	1.24	1.24	100	6	—	68	94	
3	10	206.940	650	.43	1.61	1.61	100	7	—	69	95	
4	15	210.670	610	.38	1.44	1.44	102	6	—	69	92	
5	20	214.350	360	.13	.51	.51	104	4	—	68	89	
6	25	216.570	95	.01	.04	.04	104	1	—	68	84	
12	90/0	217.105	120	.01	.06	.06	99	1	—	70	90	
11	5	217.880	400	.16	.62	.62	98	4	—	70	90	
10	10	220.200	550	.31	1.17	1.17	99	6	—	69	89	
9	15	223.450	630	.41	1.56	1.56	101	7	—	70	87	
8	20	227.110	560	.32	1.26	1.26	103	6	—	70	86	
7	25	230.480	180	.03	.13	.13	104	1	—	71	84	
	120/OFF	231.560										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
63.16	.2047	.943	97	86

COMPANY NAME EXXON RUN NUMBER CT68-5-2

ADDRESS BAY TOWN TEXAS TIME START 1400

SAMPLING LOCATION COOLING TOWER 68 FAN CELL # 5 TIME FINISH 1631

DATE 9-1-86 TEAM LEADER DB TECHNICIANS DB

BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O —

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 9

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .001 .001

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX 205	NOZZLE 705 DIAMETER .257
— PITOTS, POST-TEST	METER BOX N-10	T/C READOUT 013
— ORSAT SAMPLING SYSTEM	UMBILICAL —	T/C PROBE —
— TEDLAR BAG	SAMPLE BOX —	ORSAT PUMP —
THERMOCOUPLE @ ____ °F	PROBE —	TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$	1.68	C FACTOR	—
METER TEMP	—	STACK TEMP	—
% MOISTURE	—	REF. ΔP	—

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
B 12	0	231.731	440	.20	.84	.84	96	4	—	56	93	
11	5	234.520	460	.22	.91	.91	96	4	—	55	93	
10	10	237.400	570	.33	1.42	1.42	97	6	—	56	91	
9	15	240.888	640	.42	1.79	1.79	99	7	—	57	91	
8	20	244.750	550	.31	1.35	1.35	101	5	—	57	87	
7	25	248.200	200	.04	.18	.18	102	1	—	58	85	
1	30/0	249.472	400	.16	.69	.69	99	4	—	60	96	
2	5	252.100	550	.31	1.31	1.31	99	6	—	58	94	
3	10	255.320	635	.41	1.72	1.72	100	7	—	59	96	
4	15	259.150	640	.42	1.79	1.79	102	7	—	60	93	
5	20	263.100	340	.12	.52	.52	104	3	—	60	87	
6	25	265.280	110	.01	.05	.05	104	1	—	61	86	
A 1	60/0	265.718	230	.05	.23	.23	98	1	—	63	92	
2	5	267.175	440	.20	.84	.84	97	4	—	60	91	
3	10	269.800	540	.30	1.27	1.27	98	5	—	59	92	
4	15	273.050	650	.43	1.86	1.86	99	8	—	61	89	
5	20	276.930	510	.27	1.15	1.15	101	5	—	62	88	
6	25	280.180	310	.10	.43	.43	103	2	—	62	86	
12	90/0	282.295	560	.32	1.40	1.40	100	6	—	66	85	
11	5	285.870	675	.47	2.05	2.05	101	8	—	64	84	
10	10	290.070	700	.51	2.22	2.22	103	8	—	65	83	
9	15	294.450	685	.48	2.11	2.11	104	8	—	67	86	
8	20	298.730	280	.08	.35	.35	105	2	—	69	85	
7	25	300.510	300	.09	.41	.41	104	2	—	69	85	
	120/off	302.448										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
70.717	.2311	1.12	100	89

PARTICULATE FIELD DATA

COMPANY NAME EXXON RUN NUMBER CT 68-5-3
ADDRESS BAYTOWN, TEXAS TIME START 1033
SAMPLING LOCATION COOLING TOWER 68 CELL #5 TIME FINISH 1302
DATE 9-2-80 TEAM LEADER DB TECHNICIANS BB
BAROMETRIC PRESSURE, IN. HG 30.20 STATIC PRESSURE, IN. H_2O —
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 9
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .005 .015

EQUIPMENT CHECKS

— PITOTS, PRE-TEST
— PITOTS, POST-TEST
— ORSAT SAMPLING SYSTEM
— TEDLAR BAG
__ THERMOCOUPLE @ ___ °F

IDENTIFICATION NUMBERS

REAGENT BOX 205 NOZZLE 704 DIAMETER .249
METER BOX N-10 T/C READOUT 013
UMBILICAL — T/C PROBE —
SAMPLE BOX — ORSAT PUMP —
PROBE — TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP NOMOGRAPH # —

ΔH@ 1.68 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE — REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A 1	0	302.700	280	.08	.30	.30	86	2	—	56	87	
2	5	304.360	420	.18	.67	.67	86	2	—	56	88	
3	10	306.500	650	.43	1.62	1.62	88	5	—	58	86	
4	15	310.300	670	.46	1.74	1.74	90	5	—	59	84	
5	20	314.050	520	.28	1.06	1.06	94	3	—	60	84	
6	25	317.140	300	.09	.35	.35	97	2	—	60	84	
12	30/0	318.972	560	.32	1.20	1.20	96	6	—	62	83	
11	5	322.200	675	.47	1.80	1.80	100	8	—	60	84	
10	10	326.110	700	.50	1.94	1.94	102	9	—	59	85	
9	15	330.130	650	.44	1.68	1.68	104	8	—	60	84	
8	20	333.950	270	.07	.29	.29	106	3	—	61	86	
7	25	335.670	160	.03	.10	.10	106	1	—	62	84	
B 1	60/0	336.730	450	.20	.77	.77	102	4	—	65	96	
2	5	339.430	575	.33	1.26	1.26	102	6	—	63	95	
3	10	342.770	650	.43	1.64	1.64	103	8	—	64	91	
4	15	346.685	620	.39	1.49	1.49	106	7	—	64	93	
5	20	350.320	400	.16	.64	.64	107	4	—	66	86	
6	25	352.785	155	.02	.10	.10	106	1	—	66	83	
12	90/0	353.700	180	.03	.13	.13	100	1	—	69	90	
11	5	354.820	400	.16	.62	.62	99	2	—	67	91	
10	10	357.280	545	.30	1.14	1.14	98	2	—	70	90	
9	15	360.390	600	.37	1.41	1.41	99	2	—	70	87	
8	20	363.780	500	.26	.98	.98	100	4	—	70	87	
7	25	366.735	375	.08	.30	.30	100	2	—	70	84	
	120/off	368.340										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
65.64	.2215	.968	99	87

Preliminary Field Data

PLANT NAME EMB - Exxon

LOCATION Baytown, TX

SAMPLING LOCATION Cooling Tower #84

DUCT DEPTH

FROM INSIDE FAR WALL TO OUTSIDE OF PORT —

NIPPLE LENGTH —

DEPTH OF DUCT 287"

WIDTH (RECTANGULAR DUCT) —

EQUIVALENT DIAMETER:

$D_E = \frac{2 \times \text{DEPTH} \times \text{WIDTH}}{\text{DEPTH} + \text{WIDTH}} = \frac{2(\quad)(\quad)}{(\quad + \quad)} =$ —

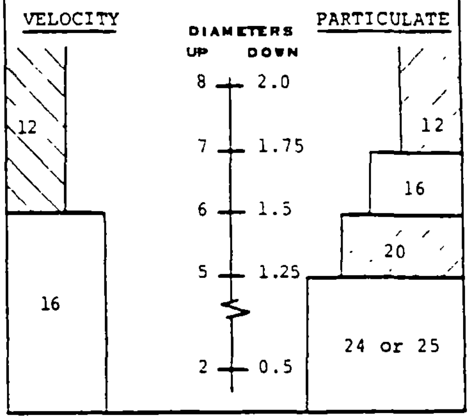
DISTANCE FROM PORTS TO NEAREST FLOW DISTURBANCE

	UPSTREAM	DOWNSTREAM
	—	—
DIAMETERS	—	—

STACK AREA = $(143.5)^2 \pi$ = 64,692 IN^2

DRAW HORIZONTAL LINE THROUGH DIAMETERS

If more than 8 and 2 diameters and if duct dia. is less than 24", use 8 or 9 points.



Point	% OF DUCT DEPTH	DISTANCE FROM INSIDE WALL	DISTANCE FROM OUTSIDE OF PORT
1	2.1	6	
2	6.7	19 1/4	
3	11.8	33 7/8	
4	17.7	50 3/4	
5	25.0	71 3/4	
6	35.6	102 1/8	
7	64.4	184 7/8	
8	75.0	215 1/4	
9	82.3	236 1/4	
10	88.2	253 1/8	
11	93.3	267 3/4	
12	97.9	281	
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			

LOCATION OF TRAVERSE POINTS IN CIRCULAR STACKS

	4	6	8	10	12	14	16	18	20	22	24
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2
7			89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1
8			96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4
9				91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0
10				97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11					93.3	85.4	78.0	70.4	61.2	39.3	32.3
12					97.9	90.1	83.1	76.4	69.4	60.7	39.8
13						94.3	87.5	81.2	75.0	68.5	60.2
14						98.2	91.5	85.4	79.6	73.8	67.7
15							95.1	89.1	83.5	78.2	72.8
16							98.4	92.5	87.1	82.0	77.0
17								95.6	90.3	85.4	80.6
18								98.6	93.3	88.4	83.9
19									96.1	91.3	86.8
20									98.7	94.0	89.5
21										96.5	92.1
22										98.9	94.5
23											96.8
24											98.9

LOCATION OF TRAVERSE POINTS IN RECTANGULAR STACKS

	2	3	4	5	6	7	8	9	10	11	12
1	25.0	16.7	12.5	10.0	8.3	7.1	6.3	5.6	5.0	4.5	4.2
2	75.0	50.0	37.5	30.0	25.0	21.4	18.8	16.7	15.0	13.6	12.5
3		83.3	62.5	50.0	41.7	35.7	31.3	27.8	25.0	22.7	20.8
4			87.5	70.0	58.3	50.0	43.8	38.9	35.0	31.8	29.2
5				90.0	75.0	64.3	56.3	50.0	45.0	40.9	37.5
6					91.7	78.6	68.8	61.1	55.0	50.0	45.8
7						92.9	81.3	72.2	65.0	59.1	54.2
8							93.8	83.3	75.0	68.2	62.5
9								94.4	85.0	77.3	70.8
10									95.0	86.4	79.2
11										95.5	87.5
12											95.8

PARTICULATE FIELD DATA

COMPANY NAME EXXON — RUN NUMBER CT 84-A-1

ADDRESS BAYTOWN, TEXAS — TIME START 0950

SAMPLING LOCATION COOLING TOWER #84 CELL A — TIME FINISH 1200

DATE 9-4-86 — TEAM LEADER DB — TECHNICIANS BD

BAROMETRIC PRESSURE, IN. HG 30.35 — STATIC PRESSURE, IN. H_2O ______

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 10

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .000 .000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX ______ NOZZLE 204	DIAMETER .255
— PITOTS, POST-TEST	METER BOX N-14	T/C READOUT
— ORSAT SAMPLING SYSTEM	UMBILICAL 50	T/C PROBE
— TEDLAR BAG	SAMPLE BOX —	ORSAT PUMP
— THERMOCOUPLE @ ____ °F	PROBE —	TEDLAR BAG

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # —
—	—	$\Delta H_@$	1.72	C FACTOR —
		METER TEMP	—	STACK TEMP —
		% MOISTURE	2 —	REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0	942.924	450	.21	.87	.87	90	5	—	56	89	
	5	945.870	450	.21	.87	.87	91	6	—	56	91	
2	10	948.890	565	.33	1.37	1.37	92	8	—	56	91	
	15	952.100	565	.33	1.37	1.37	95	8	—	57	91	
3	20	955.620	575	.34	1.42	1.42	98	8	—	58	92	
	25	959.210	575	.34	1.42	1.42	99	8	—	59	90	
4	30	962.950	525	.28	1.18	1.18	101	7	—	60	89	
	35	966.225	525	.28	1.18	1.18	102	7	—	60	89	
5	40	969.680	205	.04	.18	.18	104	1	—	60	89	
	45	971.020	205	.04	.18	.18	105	1	—	60	91	
6	50	972.430	155	.02	.10	.10	105	1	—	60	91	
	60/0	973.500	155	.02	.10	.10	107	1	—	63	90	
12	60/0	974.676	340	.12	.51	.51	105	3	—	66	91	
	5	976.970	340	.12	.51	.51	105	3	—	64	92	
11	10	979.210	475	.23	.99	.99	105	6	—	63	93	
	15	982.440	475	.23	.99	.99	106	6	—	63	93	
10	20	985.480	500	.26	1.10	1.10	109	6	—	64	92	
	25	988.850	500	.26	1.10	1.10	111	6	—	64	93	
9	30	992.160	510	.27	1.14	1.14	112	7	—	66	93	
	35	995.420	510	.27	1.14	1.14	114	7	—	68	95	
8	40	998.870	250	.06	.27	.27	115	2	—	69	94	
	45	000.530	250	.06	.27	.27	115	2	—	70	94	
7	50	002.310	150	.02	.10	.10	115	1	—	70	92	
	55	003.390	150	.02	.10	.10	115	1	—	70	92	
	120 off	004.452										

V_M	$\overline{(\sqrt{\Delta P})}^2$	ΔH	T_M	T_S
61.528	.1553	.769	105	92

COMPANY NAME	EXXON	RUN NUMBER	CT84-A-2
ADDRESS	BAYTOWN, TEXAS	TIME START	1230
SAMPLING LOCATION	COOLING TOWER 84 CELL # A	TIME FINISH	1441
DATE	9-4-86	TEAM LEADER DB	TECHNICIANS DB
BAROMETRIC PRESSURE, IN. HG	30.35	STATIC PRESSURE, IN. H_2O	
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG	15	8	
SAMPLING TRAIN LEAK RATE, CU. FT./MIN.	.000	.000	

EQUIPMENT CHECKS	
–	PITOTS, PRE-TEST
–	PITOTS, POST-TEST
–	ORSAT SAMPLING SYSTEM
	TEDLAR BAG
–	THERMOCOUPLE @ ____ °F

IDENTIFICATION NUMBERS			
REAGENT BOX		NOZZLE 705	DIAMETER .257
METER BOX	N-14	T/C READOUT	–
UMBILICAL	–	T/C PROBE	–
SAMPLE BOX	–	ORSAT PUMP	–
PROBE	–	TEDLAR BAG	–

FILTER #	TARE
–	–

NOMOGRAPH SET-UP		NOMOGRAPH #	–
$\Delta H_@$	1.72	C FACTOR	–
METER TEMP	–	STACK TEMP	–
% MOISTURE	–	REF. ΔP	–

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
12	0	004.697	370	.14	.63	.63	115	4	–	58	90	
	5	007.370	370	.14	.63	.63	115	4	–	57	90	
11	10	009.850	510	.27	1.20	1.20	113	5	–	57	91	
	15	013.200	510	.27	1.20	1.20	112	5	–	58	91	
10	20	016.740	505	.26	1.10	1.10	110	5	–	56	92	
	25	020.000	520	.28	1.25	1.25	112	5	–	56	90	
9	30	023.480	500	.26	1.16	1.16	112	5	–	59	89	
	35	026.880	500	.26	1.16	1.16	114	5	–	60	89	
8	40	030.420	310	.10	.45	.45	114	2	–	62	87	
	45	032.770	270	.08	.34	.34	114	2	–	62	87	
7	50	034.630	190	.03	.15	.15	114	2	–	63	84	
	55	036.100	180	.03	.15	.15	113	2	–	65	85	
1	60/0	037.400	475	.23	1.04	1.04	111	5	–	69	89	
	5	040.750	475	.23	1.04	1.04	110	5	–	66	89	
2	10	044.000	550	.31	1.41	1.41	110	6	–	67	87	
	15	047.620	550	.31	1.41	1.41	111	6	–	69	88	
3	20	051.380	570	.34	1.51	1.51	112	6	–	70	87	
	25	055.800	570	.34	1.51	1.51	112	6	–	71	87	
4	30	059.120	400	.17	.75	.75	113	4	–	70	86	
	35	062.100	400	.18	.78	.78	112	4	–	70	88	
5	40	064.800	185	.04	.16	.16	112	2	–	69	85	
	45	066.510	200	.04	.19	.19	111	2	–	69	86	
6	50	068.000	200	.04	.19	.19	111	2	–	71	86	
	55	069.565	200	.04	.19	.19	110	2	–	71	86	
	120/off	070.942										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
66.245	.1614	.815	112	88

PARTICULATE FIELD DATA

COMPANY NAME Exxon | RUN NUMBER CT84 B-1
ADDRESS Baytown, Texas | TIME START 0850
SAMPLING LOCATION Cooling Tower 84 Cell B | TIME FINISH 1100
DATE 9-5-86 | TEAM LEADER DB | TECHNICIANS BB
BAROMETRIC PRESSURE, IN. HG 30.25 | STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 14
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .001 .000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX	NOZZLE 207 DIAMETER .307
— PITOTS, POST-TEST	METER BOX N14	T/C READOUT
— ORSAT SAMPLING SYSTEM	UMBILICAL —	T/C PROBE
— TEDLAR BAG	SAMPLE BOX —	ORSAT PUMP
— THERMOCOUPLE @ ____ °F	PROBE —	TEDLAR BAG

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # —
—	—	$\Delta H_@$	1.72	C FACTOR —
		METER TEMP	—	STACK TEMP —
		% MOISTURE	—	REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
12	0	080.476	480	.24	2.07	2.07	88	11	~~55~~	55	89	
	5	084.500	480	.24	2.07	2.07	89	11	—	56	89	
11	10	088.710	500	.26	2.27	2.27	91	12	—	58	88	
	15	093.120	500	.26	2.27	2.27	91	12	—	59	89	
10	20	097.570	500	.26	2.27	2.27	96	12	—	61	90	
	25	102.020	540	.30	2.67	2.67	99	13	—	60	90	
9	30	106.850	510	.27	2.38	2.38	102	13	—	60	91	
	35	111.480	510	.27	2.39	2.39	104	13	—	60	91	
8	40	116.300	350	.12	1.12	1.12	105	8	—	60	92	
	45	119.750	300	.09	.83	.83	105	6	—	60	92	
7	60	122.490	270	.07	.67	.67	106	6	—	61	91	
	55	125.210	270	.07	.67	.67	106	6	—	62	91	
1	~~60~~ 10	127.710	400	.16	1.48	1.48	106	9	—	67	90	
	5	131.500	400	.16	1.48	1.48	106	9	—	63	91	
2	10	135.320	500	.25	2.31	2.31	108	12	—	62	92	
	15	139.850	500	.26	2.32	2.32	110	12	—	62	91	
3	20	144.520	530	.29	2.63	2.63	114	13	—	64	91	
	25	149.420	530	.29	2.63	2.63	115	13	—	66	91	
4	30	154.450	450	.21	1.90	1.90	118	11	—	67	92	
	35	158.720	450	.21	1.90	1.90	118	11	—	68	92	
5	40	163.000	210	.05	.42	.42	118	5	—	70	91	
	45	165.060	210	.05	.42	.42	118	5	—	71	91	
6	50	167.310	175	.03	.29	.29	118	4	—	70	90	
	55	169.030	175	.03	.29	.29	116	4	—	70	90	
	120/OFF	170.830										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
90.354	.1691	1.66	106	91

COMPANY NAME EXXON

ADDRESS BAYTOWN, TEXAS

SAMPLING LOCATION COOLING TOWER 84 CELL B

DATE 9-5-86 TEAM LEADER DB TECHNICIANS BB

RUN NUMBER CT84B-2 TIME START 1130 TIME FINISH 1340

BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 10

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. .000 .000

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX	NOZZLE 209 DIAMETER .308
PITOTS, POST-TEST	METER BOX N-14	T/C READOUT —
— ORSAT SAMPLING SYSTEM	UMBILICAL —	T/C PROBE —
— TEDLAR BAG	SAMPLE BOX —	ORSAT PUMP —
THERMOCOUPLE @ ___ °F	PROBE —	TEDLAR BAG

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # —
—	—	$\Delta H_@$	1.72	C FACTOR —
		METER TEMP		STACK TEMP —
		% MOISTURE		REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0	172.800	390	.16	1.42	1.42	109	5	—	54	90	
	5	176.580	410	.17	1.57	1.57	109	6	—	56	90	
2	10	180.520	520	.28	2.51	2.51	110	7	—	56	91	
	15	185.350	530	.29	2.62	2.62	112	7	—	58	91	
3	20	190.380	530	.29	2.63	2.63	114	7	—	58	91	
	25	195.400	530	.29	2.63	2.63	116	7	—	58	92	
4	30	200.440	460	.22	1.98	1.98	115	6	—	58	92	
	35	204.830	465	.22	2.02	2.02	115	6	—	60	92	
5	40	209.700	400	.16	1.49	1.49	114	5	—	60	93	
	45	213.140	365	.14	1.25	1.25	114	5	—	62	91	
6	50	216.750	170	.03	.27	.27	113	2	—	62	91	
	55	218.370	175	.03	.29	.29	112	2	—	64	91	
12	60/0	220.185	420	.18	1.65	1.65	110	6	—	68	90	
	5	224.250	400	.16	1.49	1.49	110	6	—	65	90	
11	10	228.150	550	.31	2.81	2.81	110	8	—	65	91	
	15	233.270	510	.27	2.42	2.42	110	7	—	66	91	
10	20	238.640	550	.31	2.82	2.82	112	8	—	69	91	
	25	243.375	565	.33	2.98	2.98	113	8	—	70	91	
9	30	248.700	520	.28	2.54	2.54	113	8	—	71	90	
	35	253.600	520	.28	2.54	2.54	113	8	—	72	90	
8	40	258.570	340	.12	1.09	1.09	114	5	—	71	90	
	45	261.870	340	.12	1.09	1.09	114	5	—	73	90	
7	50	265.200	210	.05	.42	.42	114	2	—	75	89	
	55	267.450	200	.04	.37	.37	110	2	—	75	90	
	120 OFF	269.515										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
96.715	.1814	1.79	112	91

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EMB RUN NUMBER CT84-C-1
ADDRESS Baytown Tx TIME START 0953
SAMPLING LOCATION CT84, Fan Cell C TIME FINISH 1207
DATE 9-4-86 TEAM LEADER VMS TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.35 STATIC PRESSURE, IN. H_2O 1
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 10 10
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.001 0.001 0.001

EQUIPMENT CHECKS

- PITOTS, PRE-TEST
- PITOTS, POST-TEST
- ORSAT SAMPLING SYSTEM
- TEDLAR BAG
- ✓ THERMOCOUPLE @90 °F

IDENTIFICATION NUMBERS

REAGENT BOX — NOZZLE 206 DIAMETER .250
METER BOX N10 T/C READOUT 0009
UMBILICAL U2 T/C PROBE 4-10
SAMPLE BOX 11 ORSAT PUMP —
PROBE 2 TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.68 C FACTOR —
METER TEMP 95 STACK TEMP 90
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	368.639	469	0.23	0.85	0.85	90	6	N/A	55	91	
1	5	371.40	473	0.23	0.87	0.87	93	6		53	90	
2	10	373.92	568	0.33	1.25	1.25	94	8		55	92	
	15	377.61	566	0.33	1.25	1.25	94	8		56	91	
3	20	380.57	580	0.34	1.31	1.31	94	8		58	91	
	25	384.34	571	0.33	1.27	1.27	95	8		57	91	
4	30	387.72	382	0.15	0.57	0.57	96	5		58	91	
	35	390.41	401	0.16	0.61	0.61	98	5		58	99	
5	40	392.48	176	0.03	0.12	0.12	98	2		59	99	
	45	393.69	158	0.03	0.09	0.09	98	2		61	102	
6	50	394.67	166	0.03	0.10	0.10	100	2		60	103	
	55	395.63	163	0.03	0.10	0.10	100	2		61	104	
12	60	396.691	389	0.15	0.59	0.59	97	5		57	92	396.691
	65	398.91	362	0.13	0.51	0.51	98	5		58	91	396.68[illegible]
11	70	400.98	471	0.23	0.87	0.87	99	6		58	92	
	75	403.87	481	0.24	0.91	0.91	100	7		59	92	
10	80	406.62	496	0.25	0.97	0.97	102	7		61	92	
	85	409.81	503	0.26	1.00	1.00	101	7		60	91	
9	90	412.63	493	0.25	0.96	0.96	102	7		60	91	
	95	415.59	455	0.21	0.82	0.82	102	6		61	90	
8	100	418.52	129	0.02	0.07	0.07	102	1		60	91	
	105	419.61	206	0.04	0.17	0.17	102	2		59	92	
7	110	420.80	133	0.02	0.07	0.07	102	1		60	92	
	115	421.79	143	0.02	0.08	0.08	102	1		62	92	
	120/off	422.680										

53.983	.1424	.642	98	93
V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EmB
RUN NUMBER CT84-C-2
ADDRESS Baytown, Tx
TIME START 1224
SAMPLING LOCATION CT 84, Fan Cell C
TIME FINISH 1442
DATE 9/4/86
TEAM LEADER (TMS)
TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.35
STATIC PRESSURE, IN. H_2O |
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 6
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.010 0.002

EQUIPMENT CHECKS

- — PITOTS, PRE-TEST
- — PITOTS, POST-TEST
- — ORSAT SAMPLING SYSTEM
- — TEDLAR BAG
- ✓ THERMOCOUPLE @ 90 °F

IDENTIFICATION NUMBERS

REAGENT BOX —
NOZZLE 704
DIAMETER .249
METER BOX N 10
T/C READOUT 0009
UMBILICAL U2
T/C PROBE 5-2
SAMPLE BOX 22
ORSAT PUMP —
PROBE 2 —
TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP

NOMOGRAPH # —

$\Delta H_@$ 1.68
C FACTOR —
METER TEMP 95
STACK TEMP 90
% MOISTURE 2
REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
12	0/0	422.570	389	0.15	0.59	0.59	98	3	N/A	53	93	
	5	425.59	362	0.13	0.51	0.51	98	2		55	92	
~~2~~ 11	10	427.51	471	0.23	0.87	0.87	98	2		56	92	
	15	430.42	481	0.24	0.91	0.91	98	3		58	92	
~~3~~ 10	20	432.99	496	0.25	0.97	0.97	98	3		59	92	
	25	436.11	503	0.26	1.00	1.00	99	3		60	91	
~~4~~ 9	30	439.05	493	0.25	0.96	0.96	98	3		59	91	
	35	442.29	455	0.21	0.82	0.82	98	3		59	91	
~~5~~ 8	40	444.73	129	0.02	0.07	0.07	97	1		60	91	
	45	445.64	206	0.04	0.17	0.17	96	1		61	93	
~~6~~ 7	50	447.28	133	0.02	0.07	0.07	96	1		60	94	
	55	447.99	143	0.02	0.08	0.08	96	1		60	93	
~~7~~ 6	60	449.032	163	0.03	0.10	0.10	94	1		58	93	449.032
	65	450.11	166	0.03	0.10	0.10	94	1		60	93	448.918
~~8~~ 5	70	451.10	158	0.03	0.09	0.09	94	1		61	93	
	75	452.08	176	0.03	0.12	0.12	94	1		62	93	
~~9~~ 4	80	453.29	401	0.16	0.61	0.61	93	4		61	93	
	85	455.58	382	0.15	0.57	0.57	93	4		62	93	
~~10~~ 3	90	457.91	571	0.33	1.27	1.27	92	6		63	93	
	95	461.41	580	0.34	1.31	1.31	92	6		64	93	
~~11~~ 2	100	464.72	566	0.33	1.25	1.25	92	6		63	93	
	105	468.16	569	0.33	1.25	1.25	92	6		65	92	
~~12~~ 1	110	471.19	473	0.23	0.87	0.87	92	5		65	91	
	115	474.01	469	0.23	0.85	0.85	92	5		65	92	
	120/off	476.710										

53.726	.1424	.642	95	92
V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S

PARTICULATE FIELD DATA

COMPANY NAME Exxon - EMB RUN NUMBER CT84-D-1
ADDRESS Baytown, Tx. TIME START 0835
SAMPLING LOCATION CT 84, Fan Cell D TIME FINISH 1043
DATE 9-5-86 TEAM LEADER DMD TECHNICIANS TM
BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O 1
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 9
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.009 0.004

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS
— PITOTS, PRE-TEST	REAGENT BOX — NOZZLE 707 DIAMETER .299
— PITOTS, POST-TEST	METER BOX N10 T/C READOUT 0009
— ORSAT SAMPLING SYSTEM	UMBILICAL U2 T/C PROBE 5-7
— TEDLAR BAG	SAMPLE BOX 11 ORSAT PUMP —
✓ THERMOCOUPLE @ 90 °F	PROBE 2- TEDLAR BAG —

FILTER #	TARE
—	—

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.68 C FACTOR —
METER TEMP 93 STACK TEMP 90
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
12	0/0	484.748	276	.08	.61	0.61	90	4	N/A	55	85	
	5	487.09	293	.09	.70	0.61	92	4		56	84	
11	10	489.91	465	.22	1.76	1.76	94	7		58	84	
	15	493.27	472	.23	1.80	1.80	94	7		58	87	
10	20	497.31	483	.24	1.87	1.87	94	7		59	89	
	25	501.19	496	.25	1.96	1.96	94	8		58	90	
9	30	505.23	485	.24	1.87	1.87	95	7		58	91	
	35	509.27	494	.25	1.94	1.94	95	8		57	92	
8	40	513.32	293	.09	0.68	0.68	96	4		58	92	
	45	515.89	274	.08	0.60	0.60	96	3		59	93	
7	50	518.22	132	.02	0.14	0.14	96	1		58	93	
	55	519.36	127	.02	0.13	0.13	96	1		59	93	
6	60	520.37	153	.02	0.19	0.19	96	1		56	92	
	65	521.82	148	.02	0.17	0.17	96	1		57	91	
5	70	523.10	189	.04	0.28	0.28	96	2		58	91	
	75	524.62	206	.04	0.34	0.34	97	2		60	92	
4	80	526.68	489	.24	1.91	1.91	95	8		59	92	
	85	530.52	467	.22	1.74	1.74	93	7		61	91	
3	90	534.15	503	.26	2.02	2.02	94	8		62	92	
	95	538.39	519	.28	2.15	2.15	96	9		64	92	
2	100	542.82	478	.23	1.82	1.82	97	7		63	91	
	105	547.01	486	.24	1.88	1.88	96	8	✓	64	90	
1	110	550.83	316	.10	0.80	0.80	96	4		65	91	
	115	553.56	323	.11	0.83	0.83	95	5		64	90	
	120/off	556.269										

70.521 — V_M .1307 — $(\overline{\sqrt{\Delta P}})^2$ 1.17 — ΔH 95 — T_M 90 — T_S

COMPANY NAME Exxon - EMB RUN NUMBER CT 84-D-2

ADDRESS Baytown, Tx. TIME START 1104

SAMPLING LOCATION CT 84, Fan Cell #D TIME FINISH 1317

DATE 9-5-86 TEAM LEADER DMS TECHNICIANS TM

BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O 1

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 8

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.008 0.005

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS			
— PITOTS, PRE-TEST	REAGENT BOX	—	NOZZLE 707	DIAMETER .299
— PITOTS, POST-TEST	METER BOX	N10	T/C READOUT	0009
— ORSAT SAMPLING SYSTEM	UMBILICAL	U2	T/C PROBE	5-2
— TEDLAR BAG	SAMPLE BOX	21	ORSAT PUMP	—
✓ THERMOCOUPLE @ 90 °F	PROBE	2-	TEDLAR BAG	—

FILTER #	TARE
—	—

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$	1.68	C FACTOR	—
METER TEMP	90	STACK TEMP	90
% MOISTURE	2	REF. ΔP	—

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1	0/0	556.523	379	0.15	1.14	1.14	92	5	N/A	52	90	
	5	559.68	385	0.15	1.18	1.18	94	5		52	90	
2	10	562.93	502	0.26	2.00	2.00	96	8		53	92	
	15	566.97	489	0.24	1.91	1.91	98	8		53	92	
3	20	570.92	479	0.23	1.83	1.83	100	7		55	92	
	25	574.95	483	0.24	1.87	1.87	101	8		58	92	
4	30	579.02	362	0.13	1.05	1.05	102	5		57	92	
	35	582.16	354	0.13	1.01	1.01	100	5		58	9[illegible]	
5	40	585.12	126	0.02	0.13	0.13	101	1		59	92	
	45	586.31	119	0.01	0.11	0.11	102	1		61	92	
6	50	587.35	124	0.02	0.13	0.13	100	1		61	92	
	55	588.60	120	0.01	0.11	0.11	98	1		63	92	
7	60	589.51	[illegible]	0.01	0.11	0.11	96	1		63	95	
	65	590.59	130	0.02	0.13	0.13	96	1		61	94	
8	70	591.76	149	0.02	0.18	0.18	96	2		61	93	
	75	593.07	182	0.03	0.26	0.26	96	2		62	94	
9	80	594.64	453	0.21	1.63	1.63	98	7		64	93	
	85	598.24	499	0.24	1.98	1.98	100	8		65	94	
10	90	602.42	468	0.22	1.73	1.73	98	7		65	94	
	95	606.33	472	0.23	1.77	1.77	99	7		66	94	
11	100	610.18	412	0.17	1.35	1.35	100	6		65	93	
	105	614.01	379	0.15	1.14	1.14	100	5		65	94	
12	110	61[illegible].21	337	0.12	0.90	0.90	99	4		67	94	
	115	619.67	348	0.12	0.96	0.96	97	5		67	93	
	120/off	622.638										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
66.115	.1082	1.03	98	93

PARTICULATE FIELD DATA

COMPANY NAME EMB - Exxon RUN NUMBER CT-68-DI-1
ADDRESS Baytown, TX TIME START 1145
SAMPLING LOCATION Cooling Tower 68 - Fan Cells 1 & 2 TIME FINISH 1554
DATE 09.01.86 TEAM LEADER B. Rudd TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.005 0.004

EQUIPMENT CHECKS

- — PITOTS, PRE-TEST
- — PITOTS, POST-TEST
- — ORSAT SAMPLING SYSTEM
- ✓ TEDLAR BAG
- THERMOCOUPLE @ 80 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE Disc DIAMETER —
METER BOX N-12 T/C READOUT 0009
UMBILICAL U-11 T/C PROBE
SAMPLE BOX 27 ORSAT PUMP —
PROBE 6-0 TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.76 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-4	0/0	468.874	600	0.37	3.52	3.52	94	10	—	59	81	
	15	484.59	↓	↓	↓	3.52	96	10		62	82	
	30	500.38				3.52	99	10		64	84	
	45	516.86				3.52	100	10		65	85	
	60/0	533.69				3.52	100	10		62	87	
	15	547.38				3.52	100	10		64	87	
	30	564.12				3.52	100	10		63	86	
	45	578.71				3.52	100	10		65	86	Leak Check
	120/0	593.670				3.52	100	10		61	85	593.800
	15	609.33				3.52	99	10		63	86	
	30	627.81				3.52	100	10		64	87	
	45	641.07				3.52	100	10		66	85	
	180/0	656.17				3.52	100	10		62	84	
	15	671.87				3.52	101	10		60	86	
	30	687.93				3.52	100	10		63	86	
	45	702.92				3.52	100	10		65	87	
	240/0	718.714										

249.71 V_M 0.37 $(\overline{\sqrt{\Delta P}})^2$ 3.52 ΔH 99 T_M 85 T_S

COMPANY NAME EMB - EXXON RUN NUMBER CT68-DI 2
ADDRESS BAYTOWN, TX TIME START 0950
SAMPLING LOCATION Cooling Tower 68 - FAN Cell #3 TIME FINISH 1351
DATE 09.02.86 TEAM LEADER B. Rudd TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.2 STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 10
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.006 0.003

EQUIPMENT CHECKS

— PITOTS, PRE-TEST
— PITOTS, POST-TEST
— ORSAT SAMPLING SYSTEM
— TEDLAR BAG
✓ THERMOCOUPLE @ 90 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE Disc DIAMETER —
METER BOX N.12 T/C READOUT 0009
UMBILICAL U.11 T/C PROBE 5.5
SAMPLE BOX 27 ORSAT PUMP —
PROBE 6.0 TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.76 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
	0/0	719.600	585	.35	3.21	3.21	88	10	—	63	93	
	15	735.89	↓	↓	↓	3.21	90	10		60	93	
	30	749.06				3.21	94	10		60	93	
	45	763.72				3.21	94	10		58	92	
	60/0	778.58				3.21	98	10		64	91	
	15	794.22				3.21	99	10		66	93	
	30	809.69				3.21	98	10		65	93	
	45	824.42				3.21	99	10		61	93	
	120/0	839.28				3.21	99	10		62	92	
	15	856.14				3.21	99	10		60	93	
	30	872.31				3.21	100	10		57	92	
	45	887.59				3.21	101	10		60	93	
	180/0	900.28				3.21	102	10		62	93	
	15	914.58				3.21	102	10		63	93	
	30	930.09				3.21	104	10		64	92	
	45	945.10				3.21	103	10		62	92	
	240/off	959.240										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
239.64	.35	3.21	98	93

PARTICULATE FIELD DATA

COMPANY NAME EMB - EXXON　　RUN NUMBER CT68-OI-3
ADDRESS BAYTOWN, TX　　TIME START 0910
SAMPLING LOCATION COOLING TOWER 68 - FAN CELL 5　　TIME FINISH 13:10
DATE 09.03.86　　TEAM LEADER R. BRIDGES　　TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.25　　STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15　10
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.013　0.010

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
___ PITOTS, PRE-TEST	REAGENT BOX 1	NOZZLE DISC　DIAMETER —
___ PITOTS, POST-TEST	METER BOX N.12	T/C READOUT 0009
___ ORSAT SAMPLING SYSTEM	UMBILICAL U.11	T/C PROBE 5.5
___ TEDLAR BAG	SAMPLE BOX 27	ORSAT PUMP —
___ THERMOCOUPLE @ ___ °F	PROBE 6.0	TEDLAR BAG —

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH #
		$\Delta H_@$	1.71	C FACTOR
		METER TEMP		STACK TEMP
		% MOISTURE		REF. ΔP

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A·4	0/0	959.405	600	.37	3.54	3.54	88	9	—	65	81	
	15	975.010	↓	↓	↓	3.54	99	9		61	81	
	30	990.510				3.54	100	9		60	84	
	45	006.070				3.54	100	9		61	83	
	60/0	021.960				3.54	103	9		62	83	
	15	037.520				3.54	103	9		64	85	
	30	053.420				3.54	103	9		63	84	
	45	069.240				3.54	103	9		61	83	
	120/0	085.350				3.54	104	9		61	83	
	15	101.165				3.54	104	9		60	84	
	30	117.185				3.54	104	9		61	84	
	45	133.185				3.54	104	9		62	84	
	180/0	149.350				3.54	104	9		62	83	
	15	165.220				3.54	104	9		63	82	
	30	181.150				3.54	104	9		63	82	
	45	197.120				3.54	104	9		65	82	
	240/OFF	213.129										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
253.724	.37	3.54	102	83

COMPANY NAME EMB - EXXON RUN NUMBER CT-84 ~~II~~ DI-4

ADDRESS BAYTOWN TX TIME START 1010

SAMPLING LOCATION COOLING TOWER #84 - FAN CELL # D TIME FINISH 1410

DATE 09-04-86 TEAM LEADER B. RADD TECHNICIANS —

BAROMETRIC PRESSURE, IN. HG 30.35 STATIC PRESSURE, IN. H_2O .10

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.017

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX ____	NOZZLE ~~208~~ DISC DIAMETER ~~0.315~~
— PITOTS, POST-TEST	METER BOX N-6	T/C READOUT 0009
— ORSAT SAMPLING SYSTEM	UMBILICAL U-09	T/C PROBE 5-5
— TEDLAR BAG	SAMPLE BOX 24	ORSAT PUMP —
✓ THERMOCOUPLE @ 80 °F	PROBE 6	TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —

ΔH@	1.71	C FACTOR	—
METER TEMP	—	STACK TEMP	
% MOISTURE	2	REF. ΔP	—

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-4	0/0	713.502	590	.36	3.36	3.36	90	8	—	64	88	
	15	728.80	↓	↓	↓	3.36	92	8	—	65	88	
	30	744.42				3.36	94	8	—	65	88	
	45	759.65				3.36	96	8	—	67	88	
	1/60	775.08				3.36	98	8		67	88	
	15	792.49				3.36	99	8		61	89	
	30	806.31				3.36	101	8		59	89	
	45	824.17				3.36	102	8		63	92	
	120/0	837.26				3.36	102	8		66	93	
	15	852.91				3.36	103	8		62	93	
	30	868.73				3.36	103	8		65	93	
	45	884.82				3.36	103	8		64	93	
	180/0	900.11				3.36	103	8		64	93	
	15	915.28				3.36	103	8		64	93	
	30	930.27				3.36	103	8		64	93	
	45	946.27				3.36	103	8		65	93	
	240/off	961.934										

248.432	.136	3.36	100	91
V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S

PARTICULATE FIELD DATA

COMPANY NAME EMB-EXXON RUN NUMBER CT-84 DI.5
ADDRESS BAYTOWN, TX TIME START 0820
SAMPLING LOCATION COOLING TOWER 84- FAN CELL A TIME FINISH 1220
DATE 09.05.86 TEAM LEADER B. ROOD TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.017 0.018

EQUIPMENT CHECKS
- — PITOTS, PRE-TEST
- — PITOTS, POST-TEST
- — ORSAT SAMPLING SYSTEM
- — TEDLAR BAG
- ✓ THERMOCOUPLE @ 85 °F

IDENTIFICATION NUMBERS
REAGENT BOX NOZZLE DISC DIAMETER —
METER BOX N.12 T/C READOUT 0009
UMBILICAL U.11 T/C PROBE 5.5
SAMPLE BOX 27 ORSAT PUMP —
PROBE 6.0 TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —
ΔH@ 1.76 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A.4	0/0	469.307	595	.36	3.45	3.45	98	10	—	63	86	
	15	484.42	↓	↓	↓	3.45	99	10		65	86	
	30	499.49				3.45	101	10		60	87	
	45	514.71				3.45	102	10		58	87	
	60/0	530.00				3.45	102	10		60	88	
	15	545.72				3.45	102	10		63	88	
	30	560.66				3.45	101	10		65	87	
	45	576.01				3.45	101	10		66	87	
	120/0	591.22				3.45	98	10		63	88	
	15	606.64				3.45	98	10		61	87	
	30	621.99				3.45	98	10		65	87	
	45	639.81				3.45	98	11		63	88	
	180/0	652.86				3.45	99	11		66	88	
	15	668.33				3.45	101	11		67	88	
	30	683.70				3.45	101	11		62	88	
	45	698.99				3.45	100	11		59	88	
	240/off	714.331										

245.024 V_M .36 $(\overline{\sqrt{\Delta P}})^2$ 3.45 ΔH 100 T_M 87 T_S

COMPANY NAME EMB - EXXON
RUN NUMBER CT-68-NZ-1

ADDRESS BAYTOWN, TX
TIME START 1145

SAMPLING LOCATION COOLING TOWER 68 - FAN CELLS 1 & 2
TIME FINISH 1554

DATE 09.01.88 TEAM LEADER B. RUDD TECHNICIANS —

BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O

SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15

SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.004 0.002

EQUIPMENT CHECKS

— PITOTS, PRE-TEST
— PITOTS, POST-TEST
— ORSAT SAMPLING SYSTEM
— TEDLAR BAG
✓ THERMOCOUPLE @ 80 °F

IDENTIFICATION NUMBERS

REAGENT BOX NOZZLE 208 DIAMETER 0.316
METER BOX N.6 T/C READOUT 0009
UMBILICAL U.09 T/C PROBE
SAMPLE BOX 26 ORSAT PUMP —
PROBE 6. TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —

$\Delta H_@$ 1.74 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
1 A-4	0/0	958.858	600	0.37	3.52	3.52	85	14	—	61	81	
	15	974.92				3.52	92	14		63	82	
	30	990.86				3.52	97	14		58	84	
	45	1007.54				3.52	98	14		60	85	
	60/0	24.60				3.52	99	14		62	87	
	15	38.66				3.52	99	14		64	87	
	30	55.89				3.52	100	14		60	86	
	45	70.32				3.52	101	14		62	86	LEAK CHECK
#2	120/0	85.450				3.52	98	14		63	85	85.600
	15	101.47				3.52	100	14		65	86	
	30	119.52				3.52	97	14		66	87	
	45	133.29				3.52	99	14		66	85	
	180/0	149.34				3.52	98	14		60	84	
	15	165.27				3.52	99	14		65	86	
	30	181.36				3.52	97	14		62	86	
	45	196.98				3.52	96	14		61	87	
	240/OFF	1212.875										

V_M	$(\sqrt{\Delta P})^2$	ΔH	T_M	T_S
253.867	0.37	3.52	97	85

PARTICULATE FIELD DATA

COMPANY NAME: EMB - EXXON
RUN NUMBER: CTB #NZ-2
ADDRESS: BAYTOWN, TX
TIME START: [illegible]
SAMPLING LOCATION: COOLING TOWER - FAN CELL #3
TIME FINISH: 1351
DATE: 09.02.86
TEAM LEADER: B. RUDD
TECHNICIANS: —
BAROMETRIC PRESSURE, IN. HG: 30.2
STATIC PRESSURE, IN. H_2O:
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG: 15 13
SAMPLING TRAIN LEAK RATE, CU. FT./MIN.: 0.002 0.002

EQUIPMENT CHECKS	
—	PITOTS, PRE-TEST
—	PITOTS, POST-TEST
—	ORSAT SAMPLING SYSTEM
—	TEDLAR BAG
✓	THERMOCOUPLE @ 90 °F

IDENTIFICATION NUMBERS			
REAGENT BOX		NOZZLE	208
		DIAMETER	0.312
METER BOX	N.6	T/C READOUT	0009
UMBILICAL	U.09	T/C PROBE	S.5
SAMPLE BOX	2	ORSAT PUMP	—
PROBE	6	TEDLAR BAG	—

FILTER #	TARE
—	

NOMOGRAPH SET-UP — NOMOGRAPH # —

$\Delta H_@$	1.71	C FACTOR	—
METER TEMP	—	STACK TEMP	—
% MOISTURE	2	REF. ΔP	—

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
	0/0	216.800	585	.35	3.21	3.21	87	13	—	66	93	
	15	233.02	↓	↓	↓	3.21	91	13		60	93	
	30	246.59				3.21	94	13		58	93	
	45	261.81				3.21	94	13		61	92	
	60/0	276.99				3.21	97	13		64	91	
	15	293.01			3	3.21	98	13		64	93	
	30	308.54				3.21	97	13		65	93	
	45	323.56				3.21	97	13		66	93	
	120/0	338.42				3.21	97	13		62	92	
	15	355.63				3.21	98	13		60	93	
	30	372.86				3.21	99	13		61	92	
	45	386.91				3.21	100	13		62	93	
	180/0	400.66				3.21	101	13		63	93	
	15	414.39				3.21	101	13		64	93	
	30	430.28				3.21	103	13		65	92	
	45	446.02				3.21	102	13		62	92	
	240/OFF	460.522										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
244.222	.35	3.21	97	93

COMPANY NAME EMB - EXXON RUN NUMBER CT68-NZ-3
ADDRESS BAYTOWN, TX TIME START 0910
SAMPLING LOCATION COOLING TOWER 68 - FAN CELL #5 TIME FINISH 13:00
DATE 09.03.86 TEAM LEADER B. BRIDGES TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.25 STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.002 0.004

EQUIPMENT CHECKS

- — PITOTS, PRE-TEST
- — PITOTS, POST-TEST
- — ORSAT SAMPLING SYSTEM
- — TEDLAR BAG
- ✓ THERMOCOUPLE @ 80 °F

IDENTIFICATION NUMBERS

REAGENT BOX ____ NOZZLE 208 DIAMETER 0.312
METER BOX N-6 T/C READOUT 0009
UMBILICAL U-09 T/C PROBE 55
SAMPLE BOX 26 ORSAT PUMP —
PROBE 6 TEDLAR BAG —

FILTER #	TARE
—	

NOMOGRAPH SET-UP NOMOGRAPH # —

ΔH@ 1.71 C FACTOR —
METER TEMP — STACK TEMP —
% MOISTURE 2 REF. ΔP —

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-4	0/0	460.657	600	.37	3.54	3.54	88	15	—	66	81	
	15	476.220	↓	↓	↓	3.54	96	15		64	82	
	30	491.940				3.54	99	15		61	83	
	45	507.745				3.54	100	15		60	83	
	60/0	523.640				3.54	101	15		60	83	
	15	539.450				3.54	101	15		62	84	
	30	555.350				3.54	101	15		63	83	
	45	570.160				3.54	102	15		62	83	
	120/0	587.010				3.54	102	15		60	84	
	15	602.810				3.54	101	15		62	84	
	30	618.620				3.54	102	15		64	84	
	45	634.385				3.54	102	15		64	84	
	180/0	650.100				3.54	102	15		64	83	
	15	665.895				3.54	102	15		65	83	
	30	681.650				3.54	102	15		64	83	
	45	697.460				3.54	102	15		63	82	
	240/OFF	713.340										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
252.683	.37	3.54	100	83

PARTICULATE FIELD DATA

COMPANY NAME EMB - EXXON RUN NUMBER CT-84-~~IF~~ NZ 4
ADDRESS BAYTOWN, TX TIME START 1010
SAMPLING LOCATION COOLING TOWER 84 - FAN CELL D TIME FINISH 1410
DATE 09.04.86 TEAM LEADER B. RUDD TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.35 STATIC PRESSURE, IN. H_2O 0.10
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.017 0.0

EQUIPMENT CHECKS	IDENTIFICATION NUMBERS	
— PITOTS, PRE-TEST	REAGENT BOX	NOZZLE ~~D15C~~ 208 DIAMETER .312
— PITOTS, POST-TEST	METER BOX N.12	T/C READOUT 0.009
— ORSAT SAMPLING SYSTEM	UMBILICAL U.11	T/C PROBE 5.5
— TEDLAR BAG	SAMPLE BOX 27	ORSAT PUMP —
✓ THERMOCOUPLE @ 90 °F	PROBE 6.0	TEDLAR BAG —

FILTER #	TARE	NOMOGRAPH SET-UP		NOMOGRAPH # HP41CV
—		$\Delta H_@$ 1.76	C FACTOR —	
		METER TEMP —	STACK TEMP —	
		% MOISTURE 2	REF. ΔP —	

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-4	0/0	213.302	590	.36	3.36	3.36	90	12	—	62	88	
	15	227.04	↓	↓	↓	3.36	92	12	—	64	88	
	30	242.21				3.36	94	12	—	64	88	
	45	257.32				3.36	95	12	—	66	88	
	1/60	272.78				3.36	97	12		66	88	
	15	290.16				3.36	102	13		63	89	
	30	303.96				3.36	106	13		62	89	
	45	321.62				3.36	106	13		65	92	
	120/0	334.82				3.36	107	13		66	93	
	15	350.43				3.36	108	13		62	93	
	30	365.87				3.36	108	13		62	93	
	45	381.86				3.36	108	13		66	93	
	180/0	397.09				3.36	108	13		66	93	
	15	412.24				3.36	108	13		66	93	
	30	427.17				3.36	108	13		66	93	
	45	442.51				3.36	108	13		66	93	
	240/0F	458.782										

V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S
245.48	.36	3.36	103	91

COMPANY NAME EMB-Exxon
ADDRESS Baytown, TX
SAMPLING LOCATION Cooling Tower 84 - Fan Cell A
DATE 09-05-86
RUN NUMBER CT-84-NZ-5
TIME START 0820
TIME FINISH 1220
TEAM LEADER B. Rudd
TECHNICIANS —
BAROMETRIC PRESSURE, IN. HG 30.25
STATIC PRESSURE, IN. H_2O
SAMPLING TRAIN LEAK TEST VACUUM, IN. HG 15 15
SAMPLING TRAIN LEAK RATE, CU. FT./MIN. 0.009 0.014

EQUIPMENT CHECKS	
—	PITOTS, PRE-TEST
—	PITOTS, POST-TEST
—	ORSAT SAMPLING SYSTEM
—	TEDLAR BAG
✓	THERMOCOUPLE @ 85 °F

IDENTIFICATION NUMBERS

REAGENT BOX		NOZZLE 208	DIAMETER 0.312
METER BOX	N-6	T/C READOUT	0009
UMBILICAL	U-09	T/C PROBE	5-5
SAMPLE BOX	26	ORSAT PUMP	—
PROBE	6	TEDLAR BAG	—

FILTER #	TARE
—	

NOMOGRAPH SET-UP

NOMOGRAPH # —

$\Delta H_@$	1.71	C FACTOR	—
METER TEMP	—	STACK TEMP	—
% MOISTURE	2	REF. ΔP	—

SAMPLE POINT	CLOCK TIME, MIN.	DRY GAS METER READING, CU. FT.	Pitot Reading mv	Pitot Reading Δp	ORIFICE SETTING (ΔH), IN. H_2O IDEAL	ORIFICE SETTING (ΔH), IN. H_2O ACTUAL	GAS METER TEMP. °F	PUMP VACUUM IN. HG GAUGE	FILTER BOX TEMP. °F	IMP. EXIT TEMP. °F	STACK TEMP. °F	LK. CHECK READINGS
A-4	0/0	970.905	595	.36	3.45	3.45	94	14	—	62	86	
	15	986.15	↓	↓	↓	3.45	96	14		66	86	
	30	1002.15				3.45	98	15		60	87	
	45	17.29				3.45	99	15		58	87	
	60/0	32.53				3.45	100	15		63	88	
	15	47.07				3.45	101	15		66	88	
	30	61.52				3.45	100	15		65	87	
	45	75.60				3.45	96	15		66	87	
	120/0	89.76				3.45	96	15		62	88	
	15	103.20				3.45	95	15		60	87	
	30	116.53				3.45	95	15		61	87	
	45	131.72				3.45	95	15		63	88	
	180/0	143.17				3.45	97	15		65	88	
	15	156.62				3.45	98	15		61	88	
	30	170.07				3.45	98	15		57	88	
	45	183.36				3.45	98	15		59	88	
	240/off	1196.665										

225.76	.36	3.45	97	87
V_M	$(\overline{\sqrt{\Delta P}})^2$	ΔH	T_M	T_S

EXXON COMPANY, U.S.A., BAYTOWN REFINERY, BAYTOWN, TX
FIELD SAMPLE INVENTORY, COOLING TOWERS 68 AND 84

Sample ID	Date Sampled	Description	Analysis
Blank 1-W	08/29/86	Pre-Br Cooling Water (68)	RTI;Cr+6,Zn,Res.,Minerals
Blank 2-W	09/01/86	Pretest Cooling Water (68)	RTI;Cr+6,Zn,Res.,Minerals
1-1-W	09/01/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
2-1-W	09/01/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
3-1-W	09/02/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
4-1-W	09/02/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
5-1-W	09/01/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
5-2-W	09/01/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
5-3-W	09/02/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.
Blank 3-W	09/03/86	Pretest Cooling Water (84)	RTI;Cr+6,Zn,Res.,Minerals
A-1-W	09/04/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
A-2-W	09/04/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
B-1-W	09/05/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
B-2-W	09/05/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
C-1-W	09/04/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
C-2-W	09/04/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
D-1-W	09/05/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
D-2-W	09/05/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
PS-3-W	09/03/86	Tower 68 Cooling Water	RTI;Cr+6,Zn,Res.,Minerals
PS-4-W	09/04/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.
PS-5-W	09/05/86	Tower 84 Cooling Water	RTI;Cr+6,Zn,Res.,Minerals
1-1-abc	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
2-1-a	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
2-1-b	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
2-1-c	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
3-1-abc	09/02/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
4-1-abc	09/02/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
5-1-abc	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
5-2-a	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
5-2-b	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
5-2-c	09/01/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
5-3-abc	09/02/86	Tower 68 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
A-1-a	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
A-1-b	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
A-1-c	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
A-2-abc	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
B-1-abc	09/05/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
B-2-abc	09/05/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
C-1-a	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
C-1-b	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
C-1-c	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
C-2-abc	09/04/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
D-1-abc	09/05/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
D-2-abc	09/05/86	Tower 84 Sampling Train	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
Blank 1	09/09/86	Sample Train Blank	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
Blank 2	09/09/86	RTI Water Blank	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn

Analysis Code

NAA = Nuclear Activation Analysis at N.C.S.U. for elements listed
RTI;Cr,Zn = Total Chromium and Zinc by Atomic Absorption at RTI
RTI;Cr+6 = Hexavalent Chromium by Colorimetric Determination at RTI
RTI;Res. = Total Chromium of residue after filtration of sample

EXXON COMPANY, U.S.A., BAYTOWN REFINERY, BAYTOWN, TX
FIELD SAMPLE INVENTORY, COOLING TOWERS 68 AND 84

Sample ID	Date Sampled	Description	Analysis
Blank 1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
Blank 2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
1-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
2-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr.Br,Na,Zn
3-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
4-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
5-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
5-2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
5-3-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
Blank 3-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
A-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
A-2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
B-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
B-2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
C-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
C-2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
D-1-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
D-2-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
PS-3-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
PS-4-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
PS-5-F	09/08/86	Cooling Water Filtrate	NAA;Cr,Br,Na,Zn
Blank-4-F	09/08/86	D.I. Water Filtrate	NAA;Cr,Br,Na,Zn
Blank 1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
Blank 2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
1-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
2-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
3-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
4-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
5-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
5-2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
5-3-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
Blank 3-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
A-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
A-2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
B-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
B-2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
C-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
C-2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
D-1-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
D-2-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
PS-3-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
PS-4-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
PS-5-R	09/08/86	Cooling Water Residue	NAA;Cr,Br,Na,Zn
Blank-4-R	09/08/86	D.I. Water Residue	NAA;Cr,Br,Na,Zn

Analysis Code
NAA = Nuclear Activation Analysis at N.C.S.U. for elements listed
RTI;Cr,Zn = Total Chromium and Zinc by Atomic Absorption at RTI
RTI;Cr+6 = Hexavalent Chromium by Colorimetric Determination at RTI
RTI;Res. = Total Chromium of residue after filtration of sample

EXXON COMPANY, U.S.A., BAYTOWN REFINERY, BAYTOWN, TX
FIELD SAMPLE INVENTORY, COOLING TOWERS 68 AND 84

Sample ID	Date Sampled	Description	Analysis
1-1-I	09/01/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
2-1-I	09/01/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
3-1-I	09/02/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
4-1-I	09/02/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
A-1-I	09/04/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
B-1-I	09/05/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
C-2-I	09/04/86	Station. Midget Impinger	NAA;Cr,Br,Na,Zn
PS-DI-1-p	09/01/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-1	09/01/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-2-p	09/02/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-2	09/02/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-3-p	09/03/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-3	09/03/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-4-p	09/04/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-4	09/04/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-5-p	09/05/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-DI-5	09/05/86	Disc Particle Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-NZ-1	09/01/86	Nozzle Part. Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-NZ-2	09/02/86	Nozzle Part. Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-NZ-3	09/03/86	Nozzle Part. Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-NZ-4	09/04/86	Nozzle Part. Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
PS-NZ-5	09/05/86	Nozzle Part. Sizing	RTI;Cr,Zn:NAA;Cr,Br,Na,Zn
QA-1	09/09/86	AP QA Sample	NAA;Cr,Br,Zn
QA-2	09/09/86	XP QA Sample	NAA;Cr,Br,Zn
QA-3	09/09/86	QA Sample 3	RTI;Cr,Zn
QA-4	09/09/86	QA Sample 4	NAA;Cr,Br,Zn
QA-5	09/09/86	QA Sample 5	RTI;Cr,Zn
QA-6	09/09/86	QA Sample 6	NAA;Cr,Br,Zn

Analysis Code
NAA = Nuclear Activation Analysis at N.C.S.U. for elements listed
RTI;Cr = Total Chromium by Atomic Absorption at RTI
RTI;Cr+6 = Hexavalent Chromium by Colorimetric Determination at RTI
RTI;Residue = Total Chromium of residue after filtration of sample

EXXON COMPANY, U.S.A., BAYTOWN REFINERY, BAYTOWN, TX
FIELD SAMPLE INVENTORY, COOLING TOWERS 68 AND 84

Sample ID	Date Sampled	Description	Analysis
1-1-AP	09/01/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
1-1-EW	09/01/86	Stationary Absorb. Paper	NAA;Cr,Br,Na,Zn
1-1-NS	09/01/86	Stationary Absorb. Paper	NAA;Cr,Br,Na,Zn
2-1-AP	09/01/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
2-1-SEX	09/01/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
2-1-NEX	09/01/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
3-1-AP	09/02/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
3-1-EW	09/02/86	Stationary Absorb. Paper	NAA;Cr,Br,Na,Zn
3-1-NS	09/02/86	Stationary Absorb. Paper	NAA;Cr,Br,Na,Zn
4-1-AP	09/02/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
4-1-X10	09/02/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
4-1-X20	09/02/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
4-1-X30	09/02/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
4-1-X60	09/02/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
4-1-XP	09/02/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
5-1-AP	09/01/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
5-2-AP	09/01/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
5-3-X-1	09/02/86	Traversing Ion Exch. Paper	NAA;Cr,Br,Na,Zn
5-3-X2	09/02/86	Traversing Ion Exch. Paper	NAA;Cr,Br,Na,Zn
A-1-AP	09/04/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
A-1-X	09/04/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
A-2-X	09/04/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
B-1-AP	09/05/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
B-2-XP	09/05/86	Traversing Ion Exch. Paper	NAA;Cr,Br,Na,Zn
C-1-AP	09/04/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
C-2-XP	09/04/86	Traversing Ion Exch. Paper	NAA;Cr,Br,Na,Zn
C-1-X	09/04/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
C-2-X	09/04/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
D-1-AP	09/05/86	Traversing Absorb. Paper	NAA;Cr,Br,Na,Zn
D-2-XP	09/05/86	Traversing Ion Exch. Paper	NAA;Cr,Br,Na,Zn
D-1-X	09/05/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
PS-3-X1	09/03/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
PS-3-X2	09/03/86	Stationary Ion Exch. Paper	NAA;Cr,Br,Na,Zn
Blank-AP	09/09/86	Adsorbent Paper Blank	NAA;Cr,Br,Na,Zn
Blank-XP	09/09/86	Ion Exch. Paper Blank	NAA;Cr,Br,Na,Zn

Analysis Code
NAA = Nuclear Activation Analysis at N.C.S.U. for elements listed
RTI;Cr = Total Chromium by Atomic Absorption at RTI
RTI;Cr+6 = Hexavalent Chromium by Colorimetric Determination at RTI
RTI;Residue = Total Chromium of residue after filtration of sample

EXXON REFINERY - BAYTOWN, TX

Beaker No.	Sample ID	Run No.
33	EXX 1-1-abc Impin & Filter	CT68 1-1
34	EXX 2-1-a Impin 1 & Rinse	CT68 2-1
35	EXX 2-1-b Impin 2	CT68 2-1
36	EXX 2-1-c Impin 3 & Filter	CT68 2-1
37	EXX 3-1-abc Impin & Filter	CT68 3-1
38	EXX 4-1-abc Impin & Filter	CT68 4-1
39	EXX 5-1-abc Impin & Filter	CT68 5-1
40	EXX 5-2-a Impin 1 & Rinse	CT68 5-2
41	EXX 5-2-b Impin 2	CT68 5-2
42	EXX 5-2-c Impin 3 & Filter	CT68 5-2
43	EXX 5-3-abc Impin & Filter	CT68 5-3
44	EXX A-1-a Impin 1 & Rinse	CT84 A-1
45	EXX A-1-b Impin 2	CT84 A-1
46	EXX A-1-c Impin 3 & Filter	CT84 A-1
47	EXX A-2-abc Impin & Filter	CT84 A-2
48	EXX B-1-abc Impin & Filter	CT84 B-1
49	EXX B-2-abc Impin & Filter	CT84 B-2
50	EXX C-1-a Impin 1 & Rinse	CT84 C-1
51	EXX C-1-b Impin 2	CT84 C-1
52	EXX C-1-c Impin 3 & Filter	CT84 C-1
53	EXX C-2-abc Impin & Filter	CT84 C-2
54	EXX D-1-abc Impin & Filter	CT84 D-1
55	EXX D-2-abc Impin & Filter	CT84 D-2
56	EXX Blank 1 Sample Train	
57	EXX Blank 2 Water Blank	
92	EXX DI-1f Disc Part. Sizing	CT-68-DI-1
93	EXX DI-1p Disc Part. Sizing	CT-68-DI-1
94	EXX DI-2f Disc Part. Sizing	CT-68-DI-2
95	EXX DI-2p Disc Part. Sizing	CT-68-DI-2
96	EXX DI-3f Disc Part. Sizing	CT-68-DI-3
97	EXX DI-3p Disc Part. Sizing	CT-68-DI-3
98	EXX DI-4f Disc Part. Sizing	CT-84-DI-4
99	EXX DI-4p Disc Part. Sizing	CT-84-DI-4
100	EXX DI-5f Disc Part. Sizing	CT-84-DI-5
101	EXX DI-5p Disc Part. Sizing	CT-84-DI-5

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 11-17-86 DATE ANALYZED 11-17 to 11-20

ANALYST: Wilson CLIENT: Entropy

ANALYTE: Total Cr

RTI #	CLIENT #	GFAA SAMPLE CONCENTRATION ~~Total~~ ug/L	~~ug/g~~	ICP ug/L
33		4050		3650
34		116		98
35		98		100
36		37		51
37		164		120
38		129		102
39		3150		4800
40		474		520
41		37		19
42		33		13
43		157		235
44		176		153
45		46		23
46		95		77
47		58		64
48		86		74
49		107		99
50		616		822

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 11-17-86 DATE ANALYZED 11-17 to 11-20

ANALYST: Wilson CLIENT: Entropy

ANALYTE: Total Cr

RTI #	CLIENT #	GFAA SAMPLE CONCENTRATION ~~Total~~ ug/L	~~ug/g~~	ICP ug/L
51		76		65
52		88		77
53		110		89
54		110		90
55		4970		4370
56		31		32
57		110		63
58		129		130
59		1380		1270
60		5980		6390
61		139		158
62		1080		1300
63		5480		6430

QUALITY CONTROL REPORT FORM

ELEMENT Cr - GFAA

Date 11-17/11-20

Analyst B. M. Wilson

- SRM NBS 1643b or CHECK STD. ______

  Certified or Prepared conc. 18.0

  Average Reported Conc. 18.8

  % Difference 4.3

- DUPLICATES SAMPLE 30

  Concentration A 149 ppb
  Concentration B 140 ppb

  $$\frac{A-B}{(A+B/2)} \times 100 = 6.2\%$$

- RECOVERY Not Applicable (No digestion)

  $$\frac{C\ \text{spiked}\ (\quad) - C\ \text{unspiked}\ (\quad)}{C\ \text{True Spiked}\ (\quad)} \times 100 = \_\_\_\_$$

Method of Standard Additions Employed? yes ______ no X

Highest Std run 50 ppb Flame N/A Flameless ✓

Lowest Std run 25 ppb N_2O/C_2H_2 ——

Detection Limit 1 ppb Air/C_2H_2 ——

Blank levels No SAMPLE PREP BKG. Corr. yes ✓ no ______ Zeeman

COMMENTS:

Figure 3. Quality control report form for method

ATOMIC SPECTROSCOPY ANALYSIS SHEETS

DATE RECEIVED: 11/17/86 DATE ANALYZED: 11/17 - 11/20

ANALYST: B. M. Wilson CLIENT: Entropy

ANALYTE: Chromium ~~ICP~~ GFAA

MATRIX: dilute acid

ATOMIZATION (EXCITATION)

MODE: FLAME a.Conventional____ FLAMELESS d.Furnace X

(check one) b.Hydride____ e.Hg Cold

c.ICAP____ Vapor____

Wavelength 357.8 nm

Slit 0.7 nm

LIGHT SOURCE TYPE: Hollow Cathode ✓

(check one) Electrodeless Discharge____

Other____

ATOMIZATION/EXCITATION CONDITIONS

a. Flame: Fuel____; flow cc/min____

(convention) Oxidant____; flow cc/min____

Burner type;____

b. Flame: Fuel____; flow cc/min____

(hydride) Oxidant____; flow cc/min____

Purge Gas____; flow cc/min____

Sample Vol____ml.

ATOMIZATION CONDITIONS (Continued)

c. Reducing Agent — $NaBH_4$ ____ Zinc ____

d. ICAP — Nebulization Rate ____ cc/min; Torch Height ____ mm; Other ____

e. Furnaces
Dry 30 s @ 140 °C
Char 20 s @ 1650 °C
Atomize ~~2600~~ 5 s @ 2600 °C
Purge Gas ____ s @ 300 °cc/min Argon.

Flow Mode: Interrupt X Normal ____
Cuvette type platform
Matrix Modification $Mg(NO_3)_2$

f. Hg Cold Vapor — Sweep Gas ____ @ ____ cc/min.
Sample Vol. ____ ml
Sample Pretreatment ____
Reducing Agent $NaBH_4$ ____
(check one) $SnCl_4$ ____

Standardization Mode
(check one)
a. direct calibration X
b. spike ____
c. standard additions ____

Standard Analysis:

Concentration	Absorbance			Mean
0 ~~85~~ ppb				~~-0.007~~ 0.026
25 ppb				~~0.131~~ 0.161
50 ppb				0.286

Regression Constants m ____, b ____ auto curve corr.

Correlation Coefficient R= 0.9998

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 11-24-86 DATE ANALYZED 11-24 (ICP) 12-8 (GFAA)

ANALYST: Wilson CLIENT: Entropy

ANALYTE: Total Cr

RTI #	CLIENT #	GFAA SAMPLE CONCENTRATION ~~Total~~ ug/L	~~ug/g~~	ICP ug/L
92		236		249
93		550		596
94		12,800		10,200
95		348		378
96		4380		3920
97		432		473
98		269		262
99		37		66
100		94		81
101		46		86
102		421		401
103		6510		4360, 5120
104		6300		4867
105		287		282
106		221		227
107				
108		1210		940
109		6040		4285
110		51		54
111		43		84
112		80		128
113		414		362

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 11-24-86 DATE ANALYZED 11-26 (ICP) 12-8 (GFAA)

ANALYST: Wilson CLIENT: Entropy

ANALYTE: Total Cr

RTI #	CLIENT #	GFAA SAMPLE CONCENTRATION ~~Total~~ ug/L	~~ug/g~~	ICP ug/L
114		120		111
115		153		167
116		41		52
117		108		122
118		1490		1220
119		8040		5838, 6510
120		149,000 149 ppm		150

QUALITY CONTROL REPORT FORM

ELEMENT Cr - GFAA

Date 12-8-86

Analyst B. M. Wilson

- SRM NBS 1643b or CHECK STD. ______

  Certified or Prepared conc. 18.0

  Average Reported Conc. 18.8, 19.7

  % Difference 4.4, 9.0

- DUPLICATES Ex: #74

  Concentration A 86

  Concentration B 79

  $\frac{A-B}{(A+B/2)} \times 100 =$ 8.4

- RECOVERY (No. digestion involved)

  $\frac{\text{C spiked ( ) - C unspiked ( )}}{\text{C True Spiked ( )}} \times 100 =$ ______

Method of Standard Additions Employed? yes ______ no X

Highest Std run ______ Flame ______ Flameless ______

Lowest Std run ______ N_2O/C_2H_2 ______

Detection Limit ______ Air/C_2H_2 ______

Blank levels ______ BKG. Corr. yes ______ no ______

COMMENTS:

Figure 3. Quality control report form for method validation study.

ATOMIC SPECTROSCOPY ANALYSIS SHEETS

DATE RECEIVED: 12-24-86 DATE ANALYZED: ~~12-78-8-86~~ 12-8-86

ANALYST: B. M. Wilson CLIENT: Entropy

ANALYTE: GFAA - total Cr

MATRIX: dilute nitric acid

____

ATOMIZATION (EXCITATION)

MODE: FLAME a.Conventional ______ FLAMELESS d.Furnace X

(check one) b.Hydride ______ e.Hg Cold

c.ICAP ______ Vapor ______

Wavelength 357.8 nm

Slit 0.7 nm

LIGHT SOURCE TYPE: Hollow Cathode X

(check one) Electrodeless Discharge ______

Other ______

ATOMIZATION/EXCITATION CONDITIONS

a. Flame: Fuel ______; flow cc/min ______

(convention) Oxidant ______; flow cc/min ______

Burner type; ______

b. Flame: Fuel ______; flow cc/min ______

(hydride) Oxidant ______; flow cc/min ______

Purge Gas ______; flow cc/min ______

Sample Vol ______ ml.

QUALITY CONTROL REPORT FORM

ELEMENT Cr

Date 9-29-86

Analyst Grohse/Wilson

- SRM ✓ EPA, NBS 1643b or CHECK STD. ____

  Certified or Prepared conc. 46.0 μg/L, 18.6

  Average Reported Conc. 49.6, 19.9

  % Difference 7.5, 6.

- DUPLICATES

  Concentration A 9.83

  Concentration B 10.43

  $\frac{A-B}{(A+B/2)} \times 100 =$ 5.9

- RECOVERY

  $\frac{C\ spiked\ (\quad) - C\ unspiked\ (\quad)}{C\ True\ Spiked\ (\quad)} \times 100 =$ ____

Method of Standard Additions Employed? yes ____ no X

Highest Std run 100 Flame ____ Flameless GFA

Lowest Std run 10.0 N_2O/C_2H_2 ____

Detection Limit 0.25 Air/C_2H_2 ____

Blank levels — BKG. Corr. yes X no ____

Zeeman

COMMENTS:

Figure 3. Quality control report form for method

QUALITY CONTROL REPORT FORM

ELEMENT Zn

Date 9-28-86

Analyst Grohse

- SRM ____ or CHECK STD. ✓

  Certified or Prepared conc. 0.200

  Average Reported Conc. 0.199

  % Difference 0.5

- DUPLICATES (NZ-5-pf)

  Concentration A 0.70

  Concentration B 0.73

  $\frac{A-B}{(A+B/2)} \times 100 =$ 4.2

- RECOVERY

  $\frac{\text{C spiked ( ) - C unspiked ( )}}{\text{C True Spiked ( )}} \times 100 =$

Method of Standard Additions Employed? yes ____ no X

Highest Std run 1.0 Flame X Flameless ____

Lowest Std run 0.2 N_2O/C_2H_2 ____

Detection Limit 0.02 Air/C_2H_2 X

Blank levels - BKG. Corr. yes ____ no X

COMMENTS:

Figure 3. Quality control report form for method

WET CHEMICAL ANALYSIS SHEETS

DATE RECEIVED: 9-9-86 DATE ANALYZED 10-8-86

ANALYST: B.M. Wilson CLIENT: Entropy

ANALYTE: hexavalent Chromium

RTI #	CLIENT #	SAMPLE CONCENTRATION Total µg	µg/g	µg/mL
QA-3	QA-3			7.50
BIK-1-W	BIk-1-W			8.30
BIK-2-W	etc.			7.10
BIK-3-W				6.23
1-1-W				7.42
2-1-W				7.17
3-1-W				7.10
4-1-W				7.04
5-1-W				7.17
5-2 W				7.17
5-3-W				7.17
A-1-W				7.17
A-2-W				7.17
B-1-W				7.54
B-2-W				7.67
C-1-W				7.54
C-2-W				7.42
D-1-W				7.79
D-2-W				7.79
PS-3-W				7.54
PS-4-W				7.42
PS-5-W				8.04

QUALITY CONTROL REPORT FORM

ELEMENT Cr^{+6}

Date 10-8-86

Analyst Wilson

- SRM ____ or CHECK STD. ____

  Certified or Prepared conc. ____

  Average Reported Conc. ____

  % Difference ____

- DUPLICATES QA-3

  Concentration A 7.54
  Concentration B 7.46

  $$\frac{A-B}{(A+B/2)} \times 100 = 1.1$$

- RECOVERY

  $$\frac{\text{C spiked ( ) - C unspiked ( )}}{\text{C True Spiked ( )}} \times 100 = \_\_\_\_$$

Method of Standard Additions Employed? yes ____ no X

Highest Std run 0.4 µg/mL Flame Colorimetry Flameless ____

Lowest Std run 0.1 N_2O/C_2H_2 ____

Detection Limit 0.01 Air/C_2H_2 ____

Blank levels - BKG. Corr. yes ____ no ____

COMMENTS: External QA - results compared to that by ICP

Figure 3. Quality control report form for method

10-15-86

Cr Recovery Tests

Sample #	ppm	vol (mL)	µg recovered
EPA 2 WS 378 (72 ppb)	0.0762	—	—
EPA 1 WP 1178 (7.1 ppb)	0.0080	—	—
Reagent Blank	0.0047	25	0.12
Beaker # 319	1.90	"	47.5
" # 320	0.0498	"	1.25
# 321	0.356	"	8.90
# 363	0.0329	"	0.82
# 367	0.1072	"	2.68
# 368-X	0.0867	"	2.16
# 369	1.92	"	47.9
# 372	0.1606	"	4.02
# 373	0.0790	"	1.98
# 374	0.0765	"	1.91
# 375	0.1660	"	4.15
# 358-X	0.1824	"	4.56
# 360	0.0448	"	1.12
# 380	0.1017	"	2.54
# 2107	0.0324	"	0.81
# 179	0.1188		
# 174	0.0874		
# 392	0.3330		
# 396	0.0770		

Sample #	ppm	vol(mL)	µg recovered
2030	0.0253	25	
185	0.0529		
193	0.0356		
196	0.682		
659	0.0851		
679	0.1278		
376	0.0488		
377	0.0481		
2005	0.0291		
682	0.2355		
379	0.0548		
166	0.1538		
2110	0.0274		
307	0.0479		
2132	0.0694		
C-318	0.0917		
656	0.384		
657	1.788		
658	0.5325		
654	0.422		
655	0.1334		
2133	0.0184		
2134	0.0333		
2004	0.0605		

Sample #	ppm	vol. (mL)	μg recovered
2007	0.1658	25	
2008	0.0938		
2031	0.0614		
2033	0.0218		
369	1.848		
162	0.0551		
619	0.0151		
636	0.0345		
637	0.0113		
642	0.0115		
643	0.0124		
007	0.0139		
143	0.0213		
144	0.0557		
146	0.0108		
151-A	0.0152		
160	0.2158		
Reagent Blk	0.0054		

NUCLEAR ENERGY SERVICES

ACTIVATION ANALYSIS REPORT

CLIENT Dr. William G. DeWees
Entropy Environmentalists, Inc.
Box 12291
Research Triangle Park, N.C. 27709

P. O. No. 68-02-4336
Report No. 348783
Date of Report 10/06/86
Phone 781-3550

EXPERIMENTAL PARAMETERS

18 Hr. Irradiation - 1.5×10^{13} n/cm^2-sec.

Monitored Decay

600 And 1000 Sec. Counts On An Ortec 35%, 25%, And 21% GeLi Detectors Coupled To An ND6620 Computerized Gamma Detection System

ANALYSIS RESULTS

DATA TABLES ATTACHED

Issued by: Jack N. Weaver
Jack N. Weaver
Head, Nuclear Services

LOCATED AT:
NUCLEAR ENGINEERING DEPARTMENT/N. C. STATE UNIVERSITY/RALEIGH, N. C.—27695/PHONE: (919) 737-3347

TABLE 1 Continued

NAA Of Trace Elements In Filters And Solutions

(ugrams element/sample)

Sample Description	Br	Na	Cr	Zn
D-1-R	1.734 ± 2.1%	6.938 ± 14.3%	1.869 ± 1.5%	93.464 ± 0.7%
D-2-R	2.052 ± 1.9%	6.580 ± 13.2%	3.436 ± 1.4%	212.47 ± 0.4%
PS-3-R	0.263 ± 6.3%	5.438 ± 14.2%	2.135 ± 1.6%	37.187 ± 1.1%
PS-4-R	1.358 ± 2.2%	3.781 ± 16.1%	2.644 ± 1.5%	26.988 ± 1.3%
PS-5-R	2.027 ± 1.7%	4.781 ± 17.1%	2.537 ± 1.5%	35.187 ± 1.1%
Blank 4-R	0.141 ± 14.3%	5.776 ± 12.3%	1.260 ± 2.3%	151.64 ± 0.5%
QA-1	0.319 ± 8.4%	4.943 ± 10.2%	2.916 ± 1.2%	114.98 ± 0.7%
QA-2	0.447 ± 6.6%	6.569 ± 9.1%	5.287 ± 1.0%	96.408 ± 0.8%
QA-4	0.479 ± 5.3%	2.131 ± 17.0%	6.230 ± 1.1%	117.66 ± 0.8%
1-1-AP	15.549 ± 0.6%	49.339 ± 3.5%	16.340 ± 0.5%	166.12 ± 0.5%
1-1-EW	19.228 ± 0.5%	57.156 ± 3.0%	9.693 ± 0.8%	148.28 ± 0.6%
1-1-NS	27.201 ± 0.7%	79.448 ± 3.9%	7.511 ± 0.9%	136.71 ± 0.6%
2-1-AP	36.805 ± 0.7%	118.42 ± 4.6%	15.816 ± 0.5%	206.48 ± 0.5%
2-1-SEX	87.435 ± 0.5%	235.36 ± 4.2%	49.858 ± 0.3%	48.841 ± 1.1%
2-1-NEX	62.773 ± 0.6%	135.29 ± 4.0%	47.948 ± 0.3%	68.981 ± 0.8%
3-1-AP	18.099 ± 0.9%	90.833 ± 3.3%	8.813 ± 0.8%	151.21 ± 0.5%
3-1-EW	46.011 ± 0.7%	176.48 ± 4.4%	10.357 ± 0.8%	106.09 ± 0.7%
3-1-NS	32.278 ± 0.6%	138.56 ± 3.4%	9.557 ± 0.7%	96.759 ± 0.7%
4-1-AP	26.902 ± 0.6%	110.81 ± 2.4%	12.047 ± 0.7%	111.32 ± 0.8%

TABLE 1 Continued

NAA Of Trace Elements In Filters And Solutions

(ugrams element/sample)

Sample Description	Br	Na	Cr	Zn
4-1-X10	14.288 ± 0.8%	69.121 ± 3.0%	3.579 ± 1.3%	116.66 ± 0.8%
4-1-X20	12.955 ± 1.0%	56.564 ± 4.0%	3.205 ± 1.2%	115.71 ± 0.7%
4-1-X30	35.749 ± 0.6%	135.63 ± 2.2%	8.096 ± 1.0%	127.731 ± 0.7%
4-1-X60	67.724 ± 0.5%	125.95 ± 3.9%	21.105 ± 0.5%	126.94 ± 0.7%
4-1-XP	76.480 ± 0.6%	151.46 ± 3.5%	29.070 ± 0.5%	18.683 ± 2.5%
5-1-AP	30.183 ± 0.6%	87.448 ± 2.9%	8.454 ± 0.9%	110.77 ± 0.8%
5-2-AP	20.001 ± 0.7%	84.268 ± 2.8%	7.042 ± 1.0%	109.72 ± 0.8%
5-3-X-1	116.18 ± 0.5%	94.400 ± 7.5%	31.832 ± 0.4%	27.691 ± 1.9%
5-3-X-2	67.867 ± 0.5%	117.50 ± 4.7%	19.341 ± 0.5%	146.59 ± 0.6%
A-1-AP	48.078 ± 0.5%	108.79 ± 2.7%	4.451 ± 1.4%	19.491 ± 2.3%
A-1-X	117.95 ± 0.5%	190.65 ± 3.1%	9.375 ± 1.1%	98.401 ± 0.9%
A-2-X	94.476 ± 0.5%	157.61 ± 3.6%	9.741 ± 1.0%	32.437 ± 1.8%
B-1-AP	34.401 ± 0.7%	92.500 ± 4.6%	8.106 ± 0.8%	57.865 ± 0.9%
B-2-XP	73.227 ± 0.6%	173.97 ± 3.7%	8.728 ± 0.9%	41.373 ± 1.1%
C-1-AP	23.455 ± 0.7%	49.387 ± 6.0%	3.414 ± 1.4%	182.78 ± 0.5%
C-2-XP	43.552 ± 0.5%	65.506 ± 3.7%	3.419 ± 1.7%	100.56 ± 0.8%
C-1-X	87.851 ± 0.6%	163.20 ± 3.3%	7.624 ± 1.1%	127.26 ± 0.8%
C-2-X	19.738 ± 0.7%	28.704 ± 5.8%	4.144 ± 1.3%	114.36 ± 0.7%
D-1-AP	33.447 ± 0.5%	125.02 ± 2.3%	3.061 ± 1.6%	168.74 ± 0.6%

TABLE 1 Continued

NAA Of Trace Elements In Filters And Solutions

(ugrams element/sample)

Sample Description	Br	Na	Cr	Zn
D-2-XP	25.021 ± 0.5%	32.950 ± 4.8%	3.668 ± 1.2%	29.400 ± 1.4%
D-1-X	32.857 ± 0.5%	52.759 ± 3.5%	13.937 ± 0.8%	150.50 ± 0.7%
PS-3-X1	28.683 ± 0.6%	68.704 ± 3.4%	60.999 ± 0.3%	112.53 ± 0.8%
PS-3-X2	37.060 ± 0.5%	98.745 ± 2.9%	55.810 ± 0.3%	30.120 ± 1.7%
Blank AP	0.272 ± 10.8%	7.791 ± 10.0%	0.075 ± 2.4%	99.070 ± 0.7%
Blank XP	0.145 ± 18.5%	4.100 ± 11.9%	0.304 ± 2.4%	106.467 ± 0.8%

TABLE 2

QA NBS SRM Analyses

(ugrams element/gram SRM)

Sample Description	Br	Na
NBS SRM 1566	54.047 (55.0 ± 6.0)	5052.79 (5100.0 ± 300)
NBS SRM 1566	56.179 (55.0 ± 6.0)	5057.77 (5100.0 ± 300)
NBS SRM 1566	55.782 (55.0 ± 6.0)	5047.40 (5100.0 ± 300)
NBS SRM 1566	56.169 (55.0 ± 6.0)	5071.32 (5100.0 ± 300)
NBS SRM 1566	54.603 (55.0 ± 6.0)	5304.96 (5100.0 ± 300)
NBS SRM 1566	53.400 (55.0 ± 6.0)	5059.36 (5100.0 ± 300)
NBS SRM 1566	54.456 (55.0 ± 6.0)	5081.58 (5100.0 ± 300)
NBS SRM 1566	52.623 (55.0 ± 6.0)	4866.91 (5100.0 ± 300)
NBS SRM 1566	56.616 (55.0 ± 6.0)	5048.41 (5100.0 ± 300)
NBS SRM 1566	56.455 (55.0 ± 6.0)	5201.38 (5100.0 ± 300)
NBS SRM 1566	54.139 (55.0 ± 6.0)	5200.69 (5100.0 ± 300)
NBS SRM 1566	53.962 (55.0 ± 6.0)	5181.34 (5100.0 ± 300)
NBS SRM 1566	53.497 (55.0 ± 6.0)	5179.45 (5100.0 ± 300)
NBS SRM 1084	----	----
NBS SRM 1084	----	----
NBS SRM 1572	7.684 (8.2 ± 1.6)	170.301 (160.0 ± 20.0)
NBS SRM 1577-A	8.772 (9.0 ± 2.0)	2310.30 (2430 ± 130.0)

*QA Note: The values shown in brackets are the certified or best known value for this element in these National Bureau of Standards Reference Materials processed and analyzed along with the unknown samples.

TABLE 2 Continued

QA NBS SRM Analyses

(ugrams element/gram SRM)

Sample Description	Cr	Zn
NBS SRM 1566	0.660 (0.69 ± 0.27)	858.53 (852.0 ± 14.0)
NBS SRM 1566	0.474 (0.69 ± 0.27)	848.30 (852.0 ± 14.0)
NBS SRM 1566	0.606 (0.69 ± 0.27)	845.56 (852.0 ± 14.0)
NBS SRM 1566	0.497 (0.69 ± 0.27)	858.86 (852.0 ± 14.0)
NBS SRM 1566	0.581 (0.69 ± 0.27)	845.10 (852.0 ± 14.0)
NBS SRM 1566	0.496 (0.69 ± 0.27)	845.65 (852.0 ± 14.0)
NBS SRM 1566	0.599 (0.69 ± 0.27)	874.58 (852.0 ± 14.0)
NBS SRM 1566	0.899 (0.69 ± 0.27)	858.57 (852.0 ± 14.0)
NBS SRM 1566	0.501 (0.69 ± 0.27)	856.16 (852.0 ± 14.0)
NBS SRM 1566	0.768 (0.69 ± 0.27)	877.87 (852.0 ± 14.0)
NBS SRM 1566	0.568 (0.69 ± 0.27)	855.53 (852.0 ± 14.0)
NBS SRM 1566	0.559 (0.69 ± 0.27)	843.08 (852.0 ± 14.0)
NBS SRM 1566	0.657 (0.69 ± 0.27)	849.12 (852.0 ± 14.0)
NBS SRM 1084	101.45 (100.0 ± 3.0)	----
NBS SRM 1084	98.472 (100.0 ± 3.0)	----
NBS SRM 1572	0.726 (0.8 ± 0.2)	26.487 (29.0 ± 2.0)
NBS SRM 1577-A	----	121.73 (123.0 ± 8.0)

*QA Note: The values shown in brackets are the certified or best known value for this element in these National Bureau of Standards Reference Materials processed and analyzed along with the unknown samples.

NUCLEAR ENERGY SERVICES

ACTIVATION ANALYSIS REPORT

CLIENT Dr. William G. DeWees
Entropy Environmentalists, Inc.
Box 12291
Research Triangle Park, N.C. 27709

P. O. No.	68-02-4336
Report No.	348762
Date of Report	10/20/86
Phone	781-3550

EXPERIMENTAL PARAMETERS

18 Hr. Irradiation - $1.5 \times 10^{13} n/cm^2$-sec.

Monitored Decay

600 And 1200 Sec. Counts On An Ortec 35%, 25%, And 21% GeLi Detectors Coupled To An ND6620 Computerized Gamma Detection System

ANALYSIS RESULTS

DATA TABLES ATTACHED

Issued by: Jack N. Weaver
Jack N. Weaver
Head, Nuclear Services

LOCATED AT:
NUCLEAR ENGINEERING DEPARTMENT/N. C. STATE UNIVERSITY/RALEIGH, N. C.—27695/PHONE: (919) 737-3347

TABLE 1 Continued

NAA Of Trace Elements In Solutions And Filters

(ugrams element/sample)

Sample Description	Br	Na	Cr	Zn
NZ-4-PF-2	7.152 ± 0.8%	5.250 ± 7.2%	0.782 ± 4.9%	0.535 ± 11.6%
NZ-5-PF	240.60 ± 0.5%	241.29 ± 2.3%	1.855 ± 2.2%	10.259 ± 10.9%
1-1-I	5.302 ± 2.8%	32.468 ± 6.7%	0.289 ± 14.3%	2.362 ± 17.1%
2-1-I	10.889 ± 1.5%	55.227 ± 3.9%	0.793 ± 16.0%	4.491 ± 14.2%
3-1-I	2.745 ± 4.0%	16.045 ± 9.2%	<0.05	<0.20
4-1-I	3.788 ± 3.2%	90.453 ± 3.4%	0.155 ± 15.5%	1.638 ± 15.0%
A-1-I	9.097 ± 2.1%	237.78 ± 2.0%	13.669 ± 2.3%	2.700 ± 17.2%
B-1-I	12.356 ± 1.8%	46.283 ± 5.5%	<0.05	<0.20
C-2-I	8.869 ± 2.0%	24.603 ± 8.4%	<0.05	3.886 ± 15.9%
QA-6	0.800 ± 6.9%	1.742 ± 15.5%	<0.05	1.595 ± 19.3%

TABLE 2

QA NBS SRM Analyses

(ugrams element/gram sample)

Sample Description	Br		Na	
NBS SRM 1566	54.790	(55.0 ± 6.0)	5112.11	(5100.0 ± 300.0)
NBS SRM 1566	55.426	(55.0 ± 6.0)	5130.56	(5100.0 ± 300.0)
NBS SRM 1566	54.303	(55.0 ± 6.0)	5049.29	(5100.0 ± 300.0)
NBS SRM 1566	53.424	(55.0 ± 6.0)	5199.83	(5100.0 ± 300.0)
NBS SRM 1566	53.718	(55.0 ± 6.0)	5116.12	(5100.0 ± 300.0)
NBS SRM 1566	54.587	(55.0 ± 6.0)	5074.01	(5100.0 ± 300.0)
NBS SRM 1566	56.777	(55.0 ± 6.0)	5025.03	(5100.0 ± 300.0)
NBS SRM 1577-A	10.102	(9.0 ± 2.0)	2405.03	(2430.0 ± 130.0)
NBS SRM RM50	------		1296.92	(1100.0 ± 50.0)
NBS SRM 1632-A	38.035	(41.0 ± 4.0)	817.11	(840.0 ± 40.0)

TABLE 2 Continued

QA NBS SRM Analyses

(ugrams element/gram sample)

Sample Description	Cr		Zn	
NBS SRM 1566	0.572	(0.69 ± 0.27)	858.80	(852.0 ± 14.0)
NBS SRM 1566	0.653	(0.69 ± 0.27)	861.44	(852.0 ± 14.0)
NBS SRM 1566	0.806	(0.69 ± 0.27)	848.35	(852.0 ± 14.0)
NBS SRM 1566	0.760	(0.69 ± 0.27)	873.05	(852.0 ± 14.0)
NBS SRM 1566	0.730	(0.69 ± 0.27)	855.23	(852.0 ± 14.0)
NBS SRM 1566	0.624	(0.69 ± 0.27)	857.95	(852.0 ± 14.0)
NBS SRM 1566	0.734	(0.69 ± 0.27)	865.28	(852.0 ± 14.0)
NBS SRM 1577-A	------		121.61	(123.0 ± 8.0)
NBS SRM RM50	------		12.612	(13.6 ± 1.0)
NBS SRM 1632-A	33.235	(34.4 ± 1.5)	------	
NBS SRM 1084	99.248	(100.0 ± 3.0)	------	
NBS SRM 1084	102.08	(100.0 ± 3.0)	------	

*QA NOTE: The values shown in brackets in TABLE 2 are the certified or best known values for these elements in these NBS Standard Reference Materials processed and analyzed along with your unknown samples.

APPENDIX C.

SAMPLING AND ANALYTICAL PROCEDURES

DRAFT METHOD - 6/19/86 For Internal EPA Review Only Do Not Quote or Cite

METHOD ?- DIRECT MEASUREMENT OF GAS VELOCITY AND VOLUMETRIC FLOWRATE UNDER CYCLONIC FLOW CONDITIONS (PROPELLER ANEMOMETER)

1. Applicability and Principle

1.1 Applicability. This method applies to the measurement of gas velocities in locations where cyclonic flow conditions exist and gas temperatures range from 0^{o} to $50^{o}C$ (e.g. cooling tower exhausts).

1.2 Principle. A propeller anemometer is used to measure gas velocity directly. The area of the stack cross section at the sampling location is used to calculate volumetric flowrate, and temperature and pressure measurements are used to correct volumes to standard conditions.

2. Apparatus

Specifications for the apparatus are given below.

2.1 Propeller Anemometer. A vane axial propeller anemometer capable of measuring gas velocities to within 2 percent. The manufacturer's recommended range (all-angle) shall be sufficient for the expected minimum flow rates at the sampling conditions. Temperature, pressure, moisture, corrosive characteristics, and sampling location are factors necessary to consider in choosing a suitable propeller anemometer.

2.2 Data Output Device. A digital voltmeter, analog voltmeter, stripchart recorder, data-logger, or computer capable of displaying propeller anemometer output to within 1 percent and at a minimum frequency of 1 reading per minute.

2.3 Temperature Gauge. Same as Method 2, Section 2.3 for volume correction to standard conditions.

2.4 Barometer. Same as Method 2, Section 2.5 for volume correction to standard conditions.

2.5 Calibration Equipment.

2.5.1 Synchronous Motor. A variable speed synchronous motor capable of providing a known constant rotational speed to the input shaft of the propeller anemometer for purposes of comparing and adjusting the output signal to known values.

2.5.2 Bearing Torque Disc. A variable torque applicator capable of applying a range of torques to the input shaft of the propeller anemometer from 0 to the manufacturer's recommended "poor performance" criterion.

2.5.3 Wind Tunnel. A wind tunnel capable of providing stable velocities over the expected range of velocities to be measured. Air flow should be fully developed turbulent flow in the axial direction only. Means shall be available to quantify ambient temperature and pressure for correction to standard conditions. Means shall also be available to rotate the propeller anemometer, within the wind tunnel, through 180° ($\pm 90^{\circ}$ of the centerline) and note the angle of rotation in 10° increments.

2.5.4 Calibration Pitot Tube. Same as Method 2, Section 2.7 for determination of wind tunnel velocities to within 1 percent.

2.5.5 Differential Pressure Gauge for Calibration Pitot Tube. Same as Method 2, Section 2.8 for use with the standard pitot tube during wind tunnel velocity determinations.

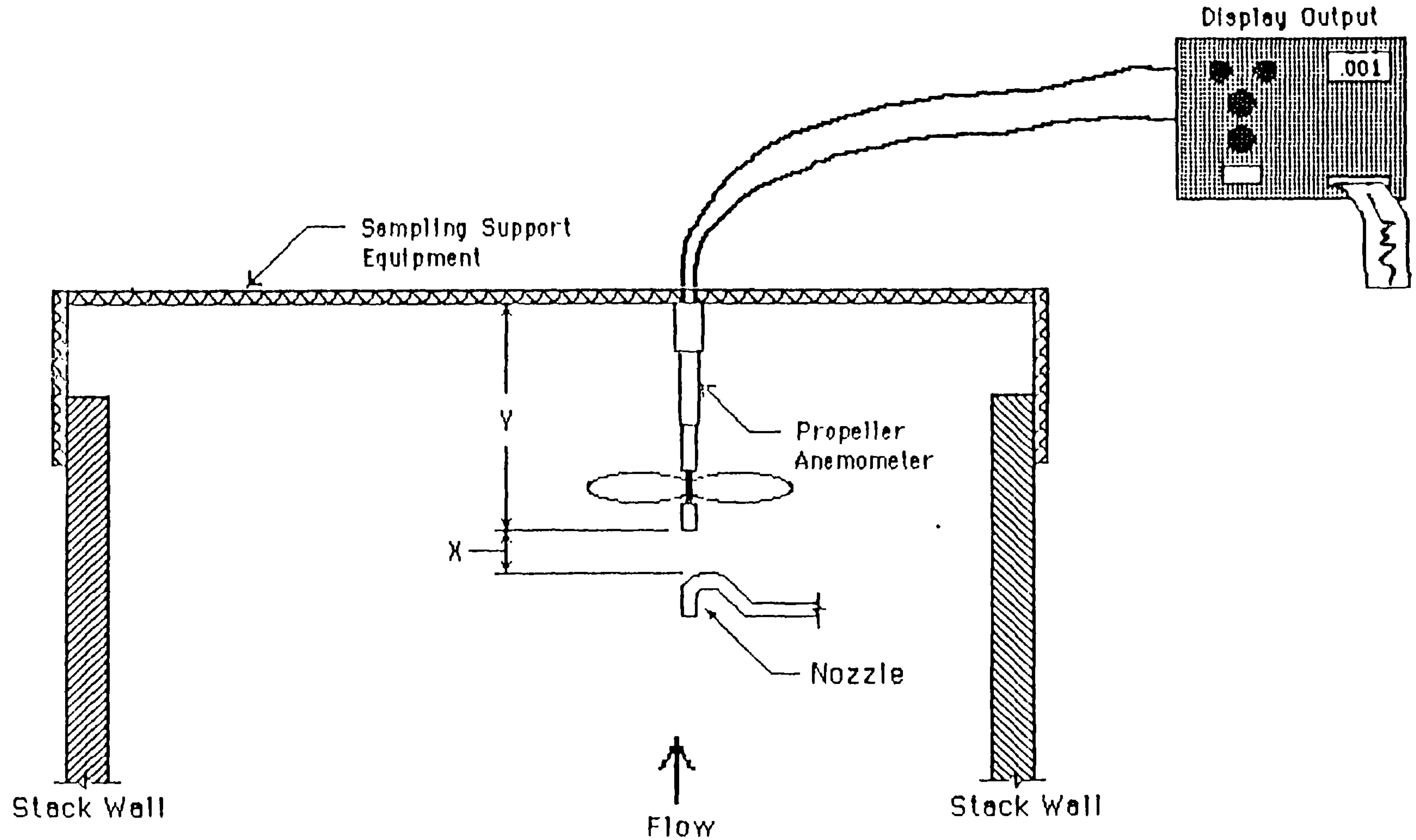
3. Procedure

3.1 Proper Mounting of Propeller Anemometer. Attach the propeller anemometer to a suitable device (probe, rail, rod, etc.) to facililtate traversing the stack/duct cross-section. Ensure that all flow obstructions created by (1) the sampling support equipment (rail, etc.) are a minimum of 2 propeller diameters downstream of the propeller and (2) the sampling equipment (nozzles) are a minimum of 2 inches upstream of the propeller and have a maximum obstructive area (projected area) 10% the size of the propeller's area of rotation. Ensure that the propeller anemometer is properly aligned with the centerline of the stack/duct and stably mounted (vibration and subsequent misalignment will create serious errors in the velocity and volumetric flow rate results). Connect electrical connections for velocity data recording as shown in Figure PA-1.

3.2 Cross Sectional Area. Determine the stack/duct dimensions at the sampling location. Include the total area (at the sampling location) without regard to the velocity in the stack.

3.3 Zero Output System. Zero all recording devices by carefully bringing the propeller anemometer to a stand-still. Record ambient temperature and pressure data and note time and date as shown in the example data sheet Figure PA -2.

3.4 Determination of Gas Velocity. Measure the gas velocity and temperature at the traverse points specified by Method 2 or other applicable method. (Note: Due to the size of most propellers, traverse points within 10 cm of a side-wall will be unmeasureable.) Alternatively, based on the preliminary traverse or the previous measurement, the stack temperature may be



X = 2" Minimum Dimension

Y = 2 Propeller Diameters Minimum Dimension

Figure III-1. Propeller Anemometer Positioning and Mounting in Cooling Tower Fan Stack.

FIGURE ?-2. EXAMPLE VELOCITY AND VOLUMETRIC FLOWRATE DATA SHEET

Plant/Location ______________________________

Date ______________________ Run ______________________

Operators ______________ Time (start/finish) ______________

Stack/duct dimensions ______________________ m (in.)

Cross sectional area ______________________ m^2 (in.^{2})

Anemometer ID no. ______________ Calibration Date ______________

Anemometer electromechanical ratio ______________________

Anemometer axial/rotational velocity ratio ______________________

Ambient Temperature ______ ^oC (^oF) Barometric Pressure ______ mm Hg (in. Hg)

Traverse point no.	Stack/Duct Temp.		Anemometer Output		Gas Velocity
	t_s, ^oC (^oF)	T_s, ^oK (^oR)	V_a, mV	v_r, rpm	v_s, m/s (A/s)

measured at a single point if the gas temperatures at all points were within $5^{o}F$ of the average temperature.

4. Calibration

4.1 Propeller Anemometer. The propeller anemometer shall be calibrated before its initial use in the field. Both electro/mechanical and performance parameters shall be checked during calibration according to the procedures supplied by the manufacturer. Calibration procedures in 4.1.1, 4.1.2 and 4.1.3 shall be conducted before the initial field use. Calibration procedures in 4.1.3 shall be conducted for each propeller in use and whenever the structural integrity of a propeller or shaft/generator housing is in question.

4.1.1 Generator Output Test. To assess the integrity of the electrical output, a variable speed synchronous motor to rotate the propeller anemometer input shaft at known rotational velocities will be required. A minimum of two speeds shall be used to check the electrical output of each shaft/generator housing. The two speeds chosen shall fall on either side of the expected shaft velocities under field use.

Couple the synchronous motor to the anemometer input shaft according to the manufacturer's specifications (to ensure no slippage occurs). Attach an output device to the anemometer electrical outputs and start motor. Obtain the first rotational test speed and record the anemometer output in either mV DC or rpm. Obtain the second rotational test speed and record the anemometer output. Continue with additional rotational test speeds if applicable. Repeat each test speed in order to obtain a total of three output readings for each speed.

Average the three output readings from each rotational test speed applied and compare these results with the manufacturer's specifications (e.g., linear rpm/mV ratio). Results should compare with specifications to within 2 percent.

4.1.2 Bearing Torque Test. To assess the integrity of the mechanical bearings supporting the input shaft, a bearing torque test shall be conducted. Attach to the anemometer input shaft a torque applicator (e.g., bearing torque disc) which will apply a range of known, repeatable torques beyond the manufacturer's "poor performance" criterion. Starting with a 0.1 gm-cm torque, continually increase the applied torque in 0.1 gm-cm increments until the shaft begins to turn. Record the applied torque required to create shaft rotation and repeat two times. Results from all three tests should be below the manufacturer's specification for "poor performance." Conduct this check after the non-axial flow calibration to document the torque required during the calibration.

4.1.3 Non-Axial Flow Test. Assess the representativeness of manufacturer's angular flow calibration curve by conducting a wind tunnel test on each propeller in use and generating a percent response-vs-wind angle curve for comparison. Attach the propeller anemometer to the wind tunnel to allow a full 180° rotation ($\pm 90^{\circ}$ from the center line) within the tunnel. Connect all other apparatus to display/record anemometer outputs.

With the wind tunnel operating at 15 to 25 fps, determine the velocity at the propeller location using a standard pitot, differential pressure gauge, barometric pressure and temperature. Starting with the propeller anemometer oriented into the direction of flow (0°) rotate and record the output readings at 10° increments from 0° to $+ 90^{\circ}$ and 0° to $- 90^{\circ}$. Plot these results on a percent response-vs-wind angle graph and compare to the manufacturer's specifications. Differences should be within 3 percent at each point for the 100% axial flow response. Using the 100% axial flow response compute a velocity result and compare it to the velocity results measured using the standard pitot probe. This difference should be within 3 percent of the pitot probe results at 0°. Repeat this test at a velocity of 25 to 40 fps; compute the percent deviations as above.

Note: If the results of the propeller anemometer initial calibration tests are not within the required specifications, then either corrective maintenance should be implemented to correct the deficiencies or the equipment in question should be considered unsatisfactory and replaced.

4.1.4 Field Use and Recalibration.

4.1.4.1 Field Use. When the propeller anemometer is used in the field, the manufacturer's electromechanical ratio and axial/rotational velocity ratio shall be used to perform the velocity calculations.

4.1.4.2 Recalibration. After each test run, both a bearing torque check and a generator output test shall be conducted. If the bearing torque check is more than twice the torque recorded after calibration or is in the range of "poor performance" as described by the manufacturer, the anemometer must be repaired or replaced and the run repeated. The generator output test results must be within 5 percent of the predicted value or the system must be repaired or replaced and the run repeated. Alternatively the tester may opt to conduct both checks at the conclusion of all runs. However, if both criteria are not met, all runs must be repeated.

If both checks meet the above criteria and a visual inspection of the propeller shows no apparent changes, no additional calibrations must be conducted. Whenever the propeller anemometer fails to meet either of the above requirements or the propeller becomes damaged, a complete recalibration as described in 4.1.1, 4.1.2 and 4.1.3 must be conducted.

4.2 Temperature Gauge. After each test series, check the temperature gauge at ambient temperature. Use an American Society for Testing and Materials (ASTM) mercury-in-glass reference thermometer, or equivalent, as a reference. If the gauge being checked does not agree within 2 percent (absolute temperature) of the reference, the temperature data collected in the field shall be considered invalid or adjustments of the test results shall be made, subject to the approval of the Administrator.

4.3 Barometer. Calibrate the barometer used against a mercury barometer prior to the field test as described in Method 2.

5. <u>Calculations</u>

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

5.1 Nomenclature.

A_s = Stack cross-sectional area, m^2.

C_e = Constant, anemometer manufacturer's electromechanical ratio, rpm/mV.

C_r = Constant, anemometer manufacturer's axial/rotational velocity ratio, cm/rev.

P_{bar} = Barometric pressure, mm Hg.

P_g = Average static pressure, mm Hg.

Q_s = Volumetric flow rate at standard conditions (20°C and 760 mm Hg), m^3/min.

T_s = Absolute stack temperature, °K.

t_s = Stack temperature, °C.

V_a = Anemometer voltage output, mV.

v_r = Rotational velocity, anemometer output, rpm.

v_s = Stack gas velocity, m/sec.

5.2 Velocity.

$$v_r = C_e V_a \qquad \text{(Eq. P4-1)}$$

$$v_s = C_r v_r/100 \qquad \text{(Eq. P4-2)}$$

$$= C_r C_e V_a/100$$

5.3 Volumetric Flow Rate.

$$Q_s = A_s v_s \qquad \text{(Eq. 2-3)}$$

$$= 60\ A_s\ C_r\ C_e\ V_a/100$$

6. Bibliography

1. Gill, G.C., H.W. Carson, and R.M. Holmes. A Propeller-Type Vertical Anemometer. J. Applied Meteorology, December 1964.

2. Gill, G.C. The Helicoid Anemometer. Atmosphere, Vol. 11, No. 4, 1973.

DRAFT METHOD - 1/23/87

METHOD CT - DETERMINATION OF CHROMIUM EMISSIONS FROM COOLING TOWERS

1. Applicability and Principle

1.1 Applicability. This method applies to the determination of total chromium and hexavalent chromium (Cr^{+6}) emissions from cooling towers. The hexavalent chromium emissions are calculated from the total chromium mass emission rate using the ratio of hexavalent-to-total chromium in the cooling water.

1.2 Principle. Chromium emissions are collected from the exit of the cooling tower cell(s) using an impinger train for sample collection and the propeller anemometer for velocity measurement. The impinger train is the same design as described in EPA Method 13 with the exception that the filter is made of Teflon™* and a propeller anemometer is used in place of the pitot tube. The impinger train samples are analyzed for total chromium (1) using Neutron Activation Analysis (NAA) or (2) by solubilizing all the chromium using nitric acid and measuring by Graphite Furnace Atomic Absorption (GFAA) or Inductively-Coupled Argon Plasmography (ICAP). Cooling water samples are also collected and analyzed both for total chromium by NAA, GFAA, or ICAP and hexavalent chromium by the diphenylcarbazide colorimetric method. (See Citations 1, 2, and 3 of Bibliography.)

2. Range, Sensitivity, Precision, and Interferences

2.1 Range. For a minimum analytical accuracy of $\pm$ 15 percent, the lower limit of the range is 0.05 ug total sample catch for chromium. This accuracy can only be obtained when the analytical laboratory is told that the sample concentration is extremely low. There is no upper limit.

2.2 Sensitivity. A minimum detection limit of 0.05 ug of Cr should be observed.

2.3 Precision. The overall precision of the sample collection and analysis for a tower containing 4 ppm of Cr^{+6} (4 ug/ml) in the cooling water and emitting 1 ug/mg Cr^{+6} is about 35 percent with a 95 percent confidence

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* Mention of trade names or specific products does not constitute endorsement by the U. S. Environmental Protection Agency.

interval. A higher chromium content and/or a higher chromium emission rate should improve the precision. No precision measurements have been made for towers emitting less chromium. When less chromium is expected, sampling times should be increased to collect the minimum amount of chromium (0.05 ug).

2.4 Interference. Sodium can interfere with the measurement of chromium by NAA. Since sodium has a short half-life, the sodium interference can be minimized by allowing the samples to radiate for approximately 14 days prior to analysis. In studies conducted by EPA, approximately 100 ppm of sodium in cooling water did not effect the analytical accuracy.

3.0 Apparatus

3.1 Sampling Train. A schematic of the sampling train used in this method is shown in Figure Cr-1. Commercial models of this train are available. All portions of the train that will come into direct contact with the sample should be cleaned with 1:1 HNO_3 and rinsed thoroughly before field use. After each sample is taken in the field, rinse with 0.1 N HNO_3 and follow with a water rinse.

The operating and maintenance procedures for the sampling train are described in APTD-0576 (Citation 3 in the Bibliography). The sampling train consists of the following components:

3.1.1 Probe Nozzle. Stainless steel (316) or glass with sharp, tapered leading edge. The angle of taper shall be $\leq 30^{\circ}$ and the taper shall be on the outside to preserve a constant internal diameter. The probe nozzle shall be of the button-hook or elbow design, unless otherwise specified by the Administrator. If made of stainless steel, the nozzle shall be constructed from seamless tubing; other materials of construction may be used, subject to the approval of the Administrator.

A range of nozzle sizes suitable for isokinetic sampling should be available, e.g., 0.32 to 1.27 cm (1/8 to 1/2 in.)--or larger if higher volume sampling trains are used--inside diameter (ID) nozzles in increments of 0.16 cm (1/16 in.). Each nozzle shall be calibrated according to the procedures outlined in Section 6.

3.1.2 Probe Liner. Borosilicate or quartz glass tubing with a heating system capable of maintaining a gas temperature at the exit end during sampling of $120 \pm 14^{\circ}C$ ($248 \pm 25^{\circ}F$), or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for

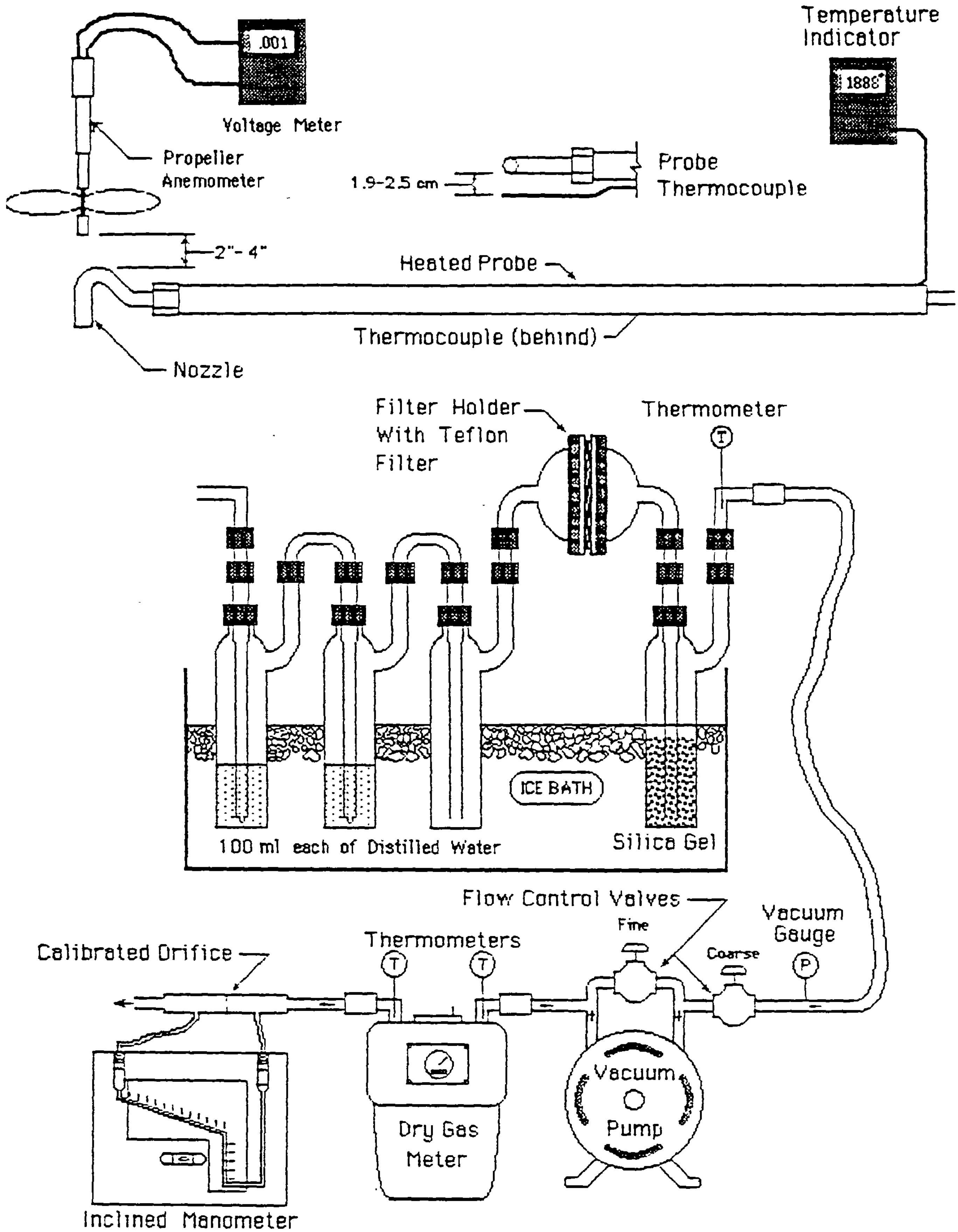


Figure CT-1. Sampling Train for Measuring Cooling Tower Emissions.

a particular application. (The tester may opt to operate the equipment at a temperature lower than that specified.) Since the actual temperature at the outlet of the probe is not usually monitored during sampling, probes constructed according to ATPD-0581 (Citation 5 of Bibliography) and utilizing the calibration curves of APTD-0576 (or calibrated according to the procedure outlined in APTD-0576) will be considered acceptable.

In potentially explosive atmospheres, the probe shall not be heated. If the probe is positioned lower than the sample box, a cyclone or equivalent can be used to collect the condensed water and drift, thus preventing it from dripping back out of the probe into the fan cell.

Whenever practical, every effort should be made to use borosilicate or quartz glass probe liners. Metal liners (e.g., 316 stainless) which contain chromium are not allowed.

3.1.3 Propeller Anemometer. A propeller anemometer as described in Section 2.1 of Method PA, or other device approved by the Administrator. The propeller anemometer shall be attached to the sampling train (as shown in Figure PA-1) to allow constant monitoring of the stack gas velocity. The center of the propeller anemometer shall be placed 2 to 4 inches directly above the nozzle and aligned with the nozzle opening. The propeller anemometer shall have known electromechanical and axial/rotational velocity ratios which have been verified during calibration (see Section 4 of Method PA).

3.1.4 Data Output Device. A digital or analog millivolt meter, stripchart recorder, data-logger, or computer as described in Section 2.2 of Method PA. This output device shall be used for the measurement of the voltage output from the propeller anemometer.

3.1.5 Impingers. Four impingers connected as shown in Figure CT-1 with ground-glass (or equivalent), vacuum-tight fittings. For the third and fourth impingers, use the Greenburg-Smith design, modified by replacing the tip with a 1.3 cm inside diameter (1/2 in.) glass tube extending to 1.3 cm (1/2 in.) from the bottom of the flask. For the second impinger, use a Greenburg-Smith impinger with the standard tip. The tester may use modifications (e.g., flexible connections between the impingers or materials other than glass), subject to the approval of the Administrator. Place a thermometer, capable of measuring temperature to within $1^{\circ}C$ ($2^{\circ}F$), at the outlet of the fourth impinger for monitoring purposes.

3.1.6 Filter Holder. Borosilicate glass, with a glass frit filter support and a silicone rubber gasket. Other materials of construction (e.g., Teflon™, Viton) may be used, subject to the approval of the Administrator. The holder design shall provide a positive seal against leakage from the outside or around the filter. The holder shall be attached between the third and fourth impinger.

3.1.7 Forceps. Plastic.

3.1.8 Metering System. Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3°C (5.4°F), dry gas meter capable of measuring volume to within 2 percent, and related equipment, as shown in Figure CT-1. Other metering systems capable of maintaining sampling rates within 10 percent of isokinetic and of determining sample volumes to within 2 percent may be used, subject to the approval of the Administrator. When the metering system is used in conjunction with a propeller anemometer, the system shall enable checks of isokinetic rates.

Sampling trains utilizing metering systems designed for higher flow rates than that described in APTD-0581 or APTD-0576 may be used provided that the specifications of this method are met.

3.1.9 Barometer. Mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm (0.1 in.) Hg. In many cases, the barometric reading may be obtained from a nearby national weather service station, in which case the station value (which is absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and sampling point shall be applied at a rate of minus 2.5 mm (0.1 in.) Hg per 30 m (100 ft) elevation increase or vice versa for elevation decrease.

3.1.10 Flue Gas Temperature. A temperature sensor as described in Section 2.3 of Method PA. The temperature sensor shall be attached to the sampling probe in a configuration such that the tip of the sensor extends beyond the leading edge of the probe sheath, does not touch any metal, and is in an interference-free arrangement with the nozzle. As an alternative (as described in Method PA), if all points are within 5°F of the average stack temperature, the temperature of the stack may be determined at a single point.

3.1.11 Cooling Water Sample Bottle. A glass or polyethylene bottle 25 ml or greater is required to collect a cooling water sample during each run. Clean with 1:1 HNO_3 and rinse thoroughly before use.

3.1.12 Equipment for Sampling in Potentially Explosive Areas. Class I Division 1 Locations: Currently available equipment cannot be readily modified for use in Class I Division 1 locations.

Class I Division 2 Locations: Two gas monitors are required to continuously monitor the atmosphere both at the cooling tower discharge point and the area around the meter box. The gas monitors must be of the continuous type (LEL meters or similar devices) and equipped with an alarm that indi- cates when 40 percent of the lower explosive limit (LEL) has been reached. The meter box must be equipped with an explosion-proof switch to shutdown all power to the box in case of an emergency. The electrical cord running to the meter box must be SO-type line and must be equipped with an explosion-proof plug.

3.2 Sample Recovery. Clean all items for sample handling or storage with 1:1 HNO_3 and rinse thoroughly before use. The following items are needed:

3.2.1 Probe-Liner and Probe-Nozzle Brushes. Nylon bristle brushes with a handle (at least as long as the probe) of Nylon, Teflon™, or a similar material which does not contain chromium. The brushes shall be properly sized and shaped to brush out the probe liner and nozzle.

3.2.2 Wash Bottles--Two. Glass wash bottles are recommended; polyetheylene wash bottles may be used at the option of the tester.

3.2.3 Glass Sample Storage Containers. Chemically resistant, borosilicate glass bottles, for water washes, 500-ml or 1000-ml. Screw cap liners shall either be rubber-backed Teflon™ or shall be constructed so as to be leak-free. (Narrow mouth glass bottles have been found to be less prone to leakage.) Alternatively, polyethylene bottles may be used.

3.2.4 Forceps. Plastic.

3.2.5 Graduated Cylinder and/or Balance. To measure condensed water to within 1 ml or 1 g. Graduated cylinders shall have subdivisions no greater than 2 ml. Most laboratory balances are capable of weighing to the nearest 0.5 g or less. Any of these balances is suitable for use here and in Section 5.10.2.

3.2.6 Plastic Storage Containers. Air-tight containers to store silica gel.

3.2.7 Funnel and Rubber Policeman. To aid in transfer of silica gel to container; not necessary if silica gel is weighed in the field.

3.2.8 Funnel. Glass or polyethylene, to aid in sample recovery.

3.3 Sample Preparation for Analysis. Clean all items for sample handling or storage with 1:1 HNO_3 and rinse thoroughly before use. The following items are needed:

3.3.1 Beakers. Borosilicate glass in sizes adequate for concentrating aqueous samples (600-ml or larger) and digesting cooling water residue filters (25- to 50-ml).

3.3.2 Hot Plate.

3.3.3 Storage Vials. Borosilicate glass, 40-ml capacity, with cap and Teflon™ liner, such as EPA-approved vials for water analysis.

3.3.4 Analytical Balance. To measure within 0.1 mg.

3.3.5 Vacuum Filter Unit. Plastic or glass, 47-mm in diameter.

3.3.6 Graduated Cylinder. In a size slightly larger than size of cooling water sample bottles.

3.3.7 Glass Sample Storage Containers. Same as 3.2.3.

3.3.8 NAA Vials (Optional). For NAA of cooling water residue only. The laboratory conducting the NAA analysis should be contacted and the proper screw-type vials obtained for the filters used to collect the residue.

3.4 Analysis. Three analytical methods have presently been shown to be satisfactory for analysis of total chromium in cooling tower samples: GFAA, ICAP, and NAA. One of these methods is used for the analysis of the impinger train samples and the residue portion of of the cooling water samples. (Additional specifications will be added to this section upon final selection of the analytical method.) Analysis for hexavalent chromium in the cooling water samples is performed following the Draft Method - "Determination of Hexavalent Chromium Emissions from Stationary Sources." The necessary apparatus is listed in Section 3.3 of the method.

4. Reagents

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

4.1 Sampling. The reagents used in sampling are as follows:

4.1.1 Water. Approximately 300 to 400 ml of deionized water for impinger reagent and for sample cleanup; deionized water is also required for reagent preparation. Significant levels of chromium must not be present in the water. It is recommended that water blanks be checked prior to sampling to ensure that the chromium content is less than 0.1 part per billion (0.1 ug per liter); this can be accomplished by concentrating one liter of the water and analyzing by the appropriate technique.

4.1.2 Filters. Teflon™ or equivalent filters with 0.5-micron or smaller pore size. The filter must have a chromium blank value of less than 0.005 ug chromium per filter. Many glass fiber filters exceed the limit for chromium and should not be used.

4.2 Sample Recovery. The reagents used in sample recovery are as follows:

4.2.1 Water. Approximately 300 to 400 ml of distilled water for impinger reagent and sample cleanup; significant levels of chromium must not be present in the water. (See Section 4.1.1.)

4.2.2 Nitric Acid, 0.1 N. Slowly add 7 ml of concentrated nitric acid (HNO_3) to water in a 1-liter flask; dilute to the mark.

4.3 Sample Preparaton and Analysis. As previously noted in Section 3.4, three analytical methods are presently believed satisfactory for analysis of total chromium in the impinger train samples and the cooling water sample residues. The Draft Method for Hexavalent Chromium is used to measure the hexavalent chromium in the cooling water filtrate. The reagents needed to prepare the impinger train samples and cooling water aliquots for total chromium analysis are listed below. The reagents necessary for the hexavalent chromium analysis of the cooling water filtrate are listed in Section 4.3 of the Draft Method. (Additional specifications for reagents needed for total chromium analysis will be added to this section upon final selection of the analytical method.)

4.3.1 Water. See Section 4.1.1.

4.3.2 Nitric Acid. Concentrated.

4.3.3 Nitric Acid, 1:1 (v/v). Slowly add an equal volume of concentrated nitric acid (HNO_3) to water.

4.3.4 Filters. Teflon, 1.0-um pore size, 47-mm diameter for collecting insoluble residue in cooling water.

4.3.5 Aqua Regia. Slowly add 1 part of concentrated nitric acid to 3 parts concentrated sulfuric acid.

4.3.6 Performance Audit Sample. A performance audit sample shall be obtained from the Quality Assurance Division of EPA and analyzed with the field samples. The mailing address to request the samples is:

U. S. Environmental Protection Agency
Environmental Monitoring System
Quality Assurance Division
Source Branch, Mail Drop 77-A
Research Triangle Park, North Carolina 27711

5. Procedure

5.1 Sampling. The complexity of this method is such that to obtain reliable results, testers should be trained and experienced with the test procedures.

5.1.1 Pretest Preparation. All the components shall be maintained and calibrated according to the procedure described in APTD-0576, unless otherwise specified herein.

Weigh several 200- to 300-g portions of silica gel in air-tight containers to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel need not be preweighed, but may be weighed directly in its impinger or sampling holder just prior to train assembly.

Check filter visually against light for irregularities and flaws or pinhole leaks. Label filters of the proper diameter on the back side near the edge using numbering machine ink. Alternatively, the filter holder, or other means of tracking the filter to ensure that the filter is recovered with the proper sample, may be used. The filters are not preweighed since the analysis is a chemical determination.

5.2 Determination of Measurement Site. Due to the configuration of cooling towers, Method 1 cannot be used to determine measurement sites. Following are several alternatives for determining measurement sites for cooling towers.

5.2.1 Selection of Number of Fan Cells to be Tested. For towers with three or less cells, all cells shall be tested. For towers with 4 or 5 cells, at least 3 cells shall be tested. For towers with 6 or more fan cells, a minimum of half of the cells shall be tested.

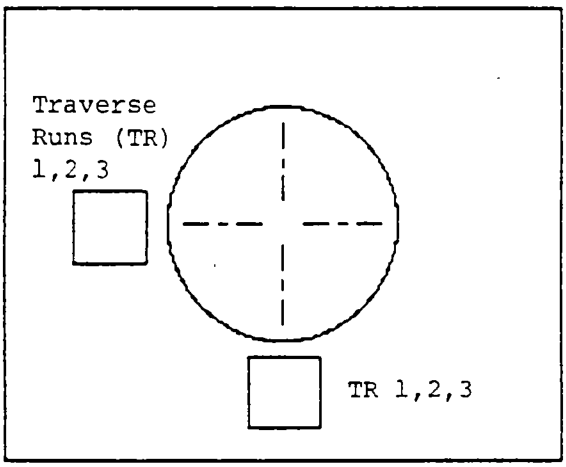
5.2.2 Criteria for Selecting Cells and Traverse Direction. The following criteria must be met:

(a) Every run must consist of two traverses.
(b) Every equal area cell must be represented by at least two runs.
(c) A single traverse direction may be used for all towers containing more than one cell.
(d) Based on the prevailing winds, the extreme inward and outward cells are initially identified and selected for sampling.
(e) After identifying the extreme inward and outward cells, the remaining cells to be sampled (sufficient to equal required minimum) are selected at random.
(f) The mass emission rate for the tower is the sum of the averages for each of the equal area cells.
(g) The traverse direction at the stack exit may be selected by the tester.

(h) The order for sampling the cells may be selected by the tester.
(i) All runs must be consecutive; none may be conducted simultaneously.
(j) When a tower contains two distinctly different types of mist eliminators, the cells with different mist eliminators must be considered in the same manner as if the cells have different areas.

The following six examples are given to better define the approach for selecting the cells to be sampled. Circles represent fan cells, the small rectangles show the recommended location for scaffolding, and the dotted lines indicate traverse directions. Cells on towers with multiple fan cells are selected in pairs to reduce the amount of scaffolding needed to conduct the testing. The order of the sample runs and traverses presented are only examples and the order is left to the tester.

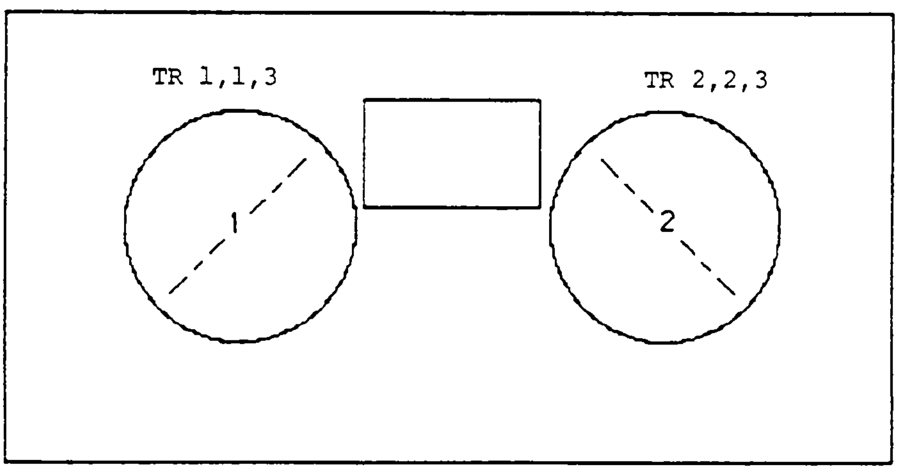
EXAMPLE 1



Prevailing wind direction is not used to select the traverse direction; tester may select the most convenient directions at 90° apart.

- Three runs will be conducted with a traverse in both directions.
- The Mass Emission Rate is the average of the three runs.

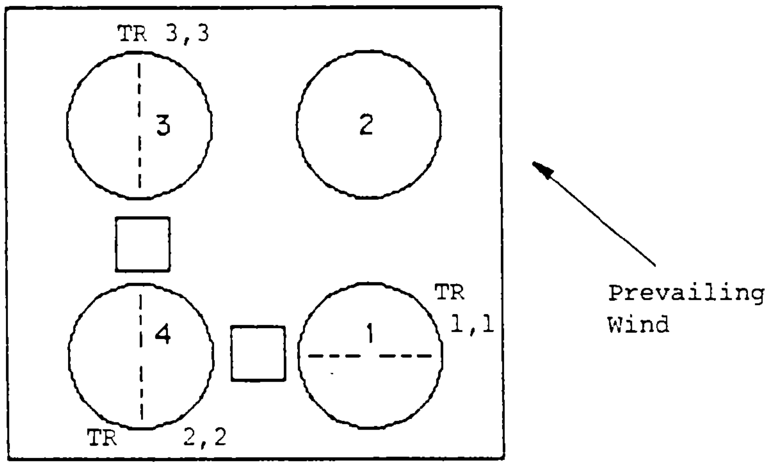
EXAMPLE 2



Prevailing wind direction is not used in the selection of cells; the tester may select the most convenient traverse directions.

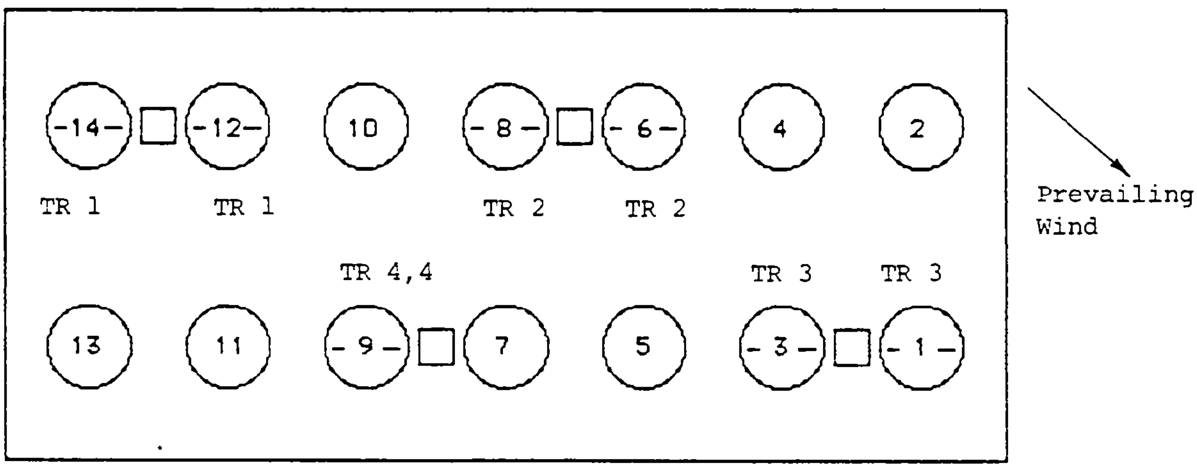
- For Runs 1 and 2 each cell is traversed twice; for Run 3 both cells are traversed once.
- The Mass Emission Rate would be the average of the three runs multiplied by two.

EXAMPLE 3



- Cells 1 and 3 will be tested based on the prevailing winds.
- A coin toss selects Cell 4.
- Each cell is traversed twice.
- The Mass Emission Rate is the average of the three runs calculated using the combined area of all four cells.

EXAMPLE 4

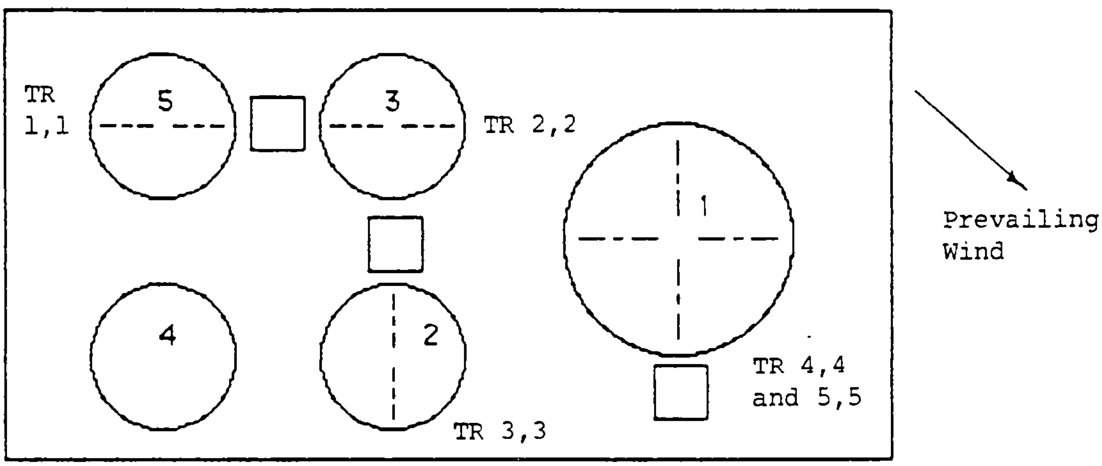


- Cells 1 & 3, and 12 & 14 are selected based on the prevailing winds, which eliminates for selection their representative equal area cell pairs of 4 & 2 and 13 & 11, respectively.
- Cells 5 & 7, 6 & 8, 7 & 9, and 8 & 10 are available for selection.
- Cells 6 & 8 are selected by a random drawing which eliminates their equal area cell pair 7 & 5.
- Therefore, Cell 9 is traversed twice, since it is not yet represented by another equal area cell.
- Run 1 is a traverse of Cells 12 and 14; Run 2 is a traverse of Cells 6 and 8; Run 3 is a traverse of Cells 1 and 3; and Run 4 is two traverses of Cell 9.
- The Mass Emission Rate is the average of Runs 1, 2, and 3 calculated using the area of the twelve cells that they represent plus Run 4, using the area of the two cells it represents.

EXAMPLE 5

Cells 2, 3, 4, and 5 have the same area.

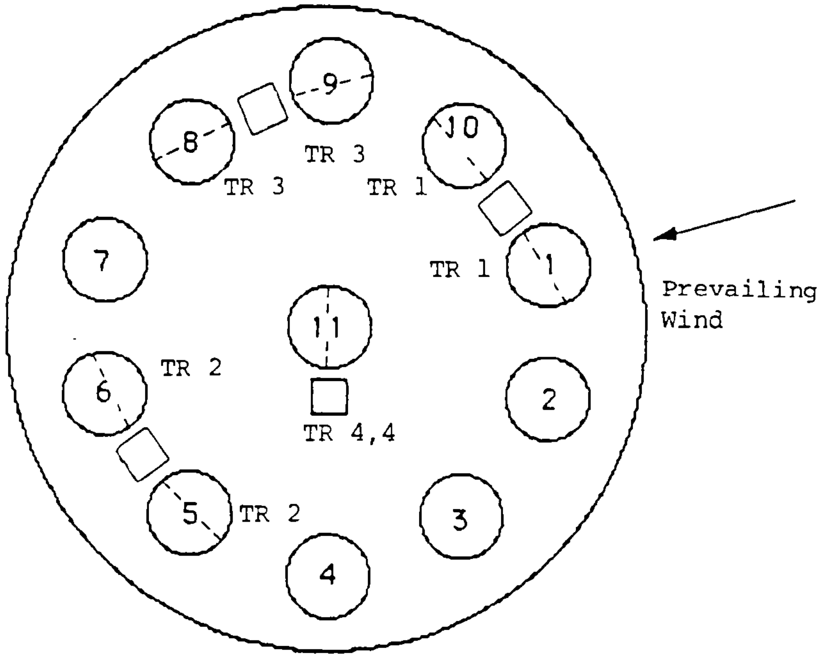
Cell 1 is much larger, but is located on the same tower.



- Cells 2 and 5 are selected based on the prevailing winds.
- Cell 3 was selected by a flip of a coin.
- Cell 1 must be represented by two runs.
- Cells 2, 3, and 5 are traversed twice for Runs 1, 2, and 3, respectively.
- Cell 1 is traversed two times each for Runs 4 and 5.

- The Mass Emission Rate is the average of Runs 1, 2, and 3 calculated using the area of Cells 2, 3, 4, and 5 plus the average of Runs 4 and 5 using the area of Cell 1.

EXAMPLE 6



- Cells 1 & 10 and 5 & 6 were selected based on the prevailing winds.
- Cells 2 & 3, 3 & 4, 7 & 8, and 8 & 9 are available for selection.
- Cells 8 and 9 were selected by random drawing.
- Cell 11 will be traversed twice because it has no other representative cell.
- Run 1 will traverse Cells 1 and 2.
- Run 2 will traverse Cells 5 and 6.
- Run 3 will traverse Cells 8 and 9.
- Run 4 will traverse Cell 11 twice.
- The Mass Emission Rate is the average of Runs 1, 2, and 3 calculated using the area of the 10 cells traversed plus the average of Run 4 calculated using the area of Cell 11.

5.2.3 Criteria for Selecting Traverse Points. The following criteria must be met:

(a) The traverse line may be located in any plane near the exit of the cell. The tester may alternatively select any plane that is not affected by the wind to a greater degree than the cell exit plane (i.e., for a large cells--an access door in the cell stack or a point 2 feet above the cell on a calm day).

(b) Twelve points shall be sampled on each traverse for a minimum of 5 minutes per point. The points shall be located on the traverse line at the percentage of the diameter as shown below:

Point 1 - 2.1%	Point 2 - 6.7%	Point 3 - 11.8%
Point 4 - 17.7%	Point 5 - 25.0%	Point 6 - 35.6%
Point 7 - 63.4%	Point 8 - 75.0%	Point 9 - 82.3%
Point 10 - 88.2%	Point 11 - 93.3%	Point 12 - 97.9%

(c) No point shall be closer than 9 inches from the wall. All points that are calculated at less than 9 inches from the wall shall be relocated at 9 inches from the wall.

5.3 Preliminary Determinations. Select the cells and the sampling points as described in Section 5.2. Determine the stack pressure, temperature and the range of velocities using Method PA . Determine the moisture content with a wet and dry bulb thermometer, or assume saturation at the stack temperature and calculate the moisture.

Select a nozzle based on the range of velocities, such that it is not necessary to change the nozzle size in order to maintain isokinetic sampling rates. During the run, do not change the nozzle size.

Select a total sampling time greater than or equal to the minimum total sampling time based on 5 minutes per point and 2 hours per run.

The sampling time at each point shall be the same. It is recommended that the number of minutes sampled at each point be an integer or an integer plus one-half minute, in order to avoid timekeeping errors.

5.4 Preparation of Collection Train. Clean all portions of the sampling train which will come into direct contact with the sample with 1:1 HNO_3 and rinse thoroughly with water. During preparation and assembly of the sampling train, keep all openings where contamination can occur covered until just prior to assembly or until sampling is about to begin.

Place 100 ml of water in each of the first two impingers, leave the third impinger empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fourth impinger. More silica gel may be used, but care should be taken to ensure that it is not entrained and carried out from the impinger during sampling. Place the container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

Using plastic forceps or clean disposable gloves, place a labeled (identified) filter in the filter holder. Be sure that the filter is properly centered and the gasket properly placed so as to prevent the sample gas stream from circumventing the filter. Check the filter for tears after assembly is completed.

A glass liner or equivalent must be used. Install the selected nozzle using a Viton A O-ring or Teflon™ ferrules. Mark the traverse monorail or other system to denote the proper distance in the exit plane of the cells for each traverse run with equal diameter cells.

Set up the train as in Figure CT-1, using (if necessary) a very light coat of silicone grease on all ground glass joints, greasing only the outer portion (see APTD-0576) to avoid possibility of contamination by the silicone grease.

Place crushed ice around the impingers.

5.4.1 Leak-Check Procedure.

5.4.1.1 Pretest Leak-Check. A pretest leak-check is recommended, but not required. If the tester opts to conduct the pretest leak-check, the following procedure shall be used.

After the sampling train has been assembled, leak-check the train at the sampling site by plugging the nozzle and pulling a 380 mm (15 in.) Hg vacuum. Note: A lower vacuum may be used, provided that it is not exceeded during the test.

The following leak-check instructions for the sampling train described in APTD-0576 and ATPD-0581 may be helpful. Start the pump with bypass valve fully open and coarse adjust valve completely closed. Partially open the coarse adjust valve, and slowly close the bypass valve until the desired vacuum is reached. Do not reverse direction of bypass valve; this will cause water to back up into the probe. If the desired vacuum is exceeded, either leak-check at this higher vacuum or end the leak-check as shown below, and start over.

When the leak-check is completed, first slowly remove the plug from the inlet to the nozzle, and immediately turn off the vacuum pump. This prevents the water in the impingers from being forced backward into the probe and silica gel from being entrained backward into the filter holder.

5.4.1.2 Leak-Checks During Sample Run. If, during the sampling run, a component (e.g., filter assembly or impinger) change becomes necessary, a leak-check shall be conducted immediately before the change is made. The leak-check shall be done according to the procedure outlined in Section 5.4.1.1 above, except that it shall be done at a vacuum equal to or greater than the maximum value recorded up to that point in the test. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction will need to be applied to the total volume of dry gas metered; if, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and plan to correct the sample volume as shown in Section 7.3 of this method, or shall void the sample run.

Immediately after component changes, leak-checks are optional; if such leak-checks are done, the procedure outlined in Section 5.4.1.1 above shall be used.

5.4.1.3 Post-Test Leak-Check. A leak-check is mandatory at the conclusion of each sampling run. The leak-check shall be done in accordance with the procedures outlined in Section 5.4.1.1, except that it shall be conducted at a vacuum equal to or greater than the maximum value reached during the sampling run. If the leakage rate is found to be no greater than 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate (whichever is less), the results are acceptable, and no correction need be applied to the total volume of dry gas metered. If, however, a higher leakage rate is obtained, the tester shall either record the leakage rate and correct the sample volume as shown in Section 7.3 of this method, or shall void the sampling run.

5.4.2 Sampling in Class I Division 2 Locations. The following procedures must be conducted in addition to all plant safety requirements. Plant regulations take precedent over any requirements stated below. The following steps must be taken to allow testing at cooling towers in a Class I Division 2 area (as classified in accordance with API RP 500A):

(1) The plant safety officer must first monitor the area and deem it safe.
(2) Proper personnel safety equipment must be obtained and properly utilized during the test.
(3) A gas monitor (LEL or similar device) must be used to continuously monitor the atmosphere both at the cooling tower discharge and in the area around the meter box. Each gas monitor must have an alarm that is set to indicate when 40% of the lower explosive limit (LEL) is obtained in either area.

(4) The sample collection equipment in the cooling tower discharge stream must not contain any electrical components with the exception of the generator in the propeller anemometer which generates less than one millivolt.

(5) The electrical cord running to the meter box must be a SO-type line and must be equipped with an explosion-proof plug.

(6) The meter box must be equipped with an explosion-proof switch to shutdown all power in case of an emergency.

(7) All power to the meter box must be shutdown using the explosion-proof switch any time the alarm sounds on the LEL meter or the plant alarm sounds.

(8) The testers must evacuate the area of the cooling tower if the LEL alarm sounds and the safety officer must deem the area safe prior to the return of any testing personnel.

5.4.3 Cooling Tower Operation and Ambient Conditions. Based on communications with the Cooling Tower Institute (Citation 5 of the Bibliography), the following guidelines are recommended which relate to tower operating parameters and ambient environmental conditions during testing:

(1) <u>Ambient Wind Speed</u>: Ideally the average wind speed during the drift measurement should be less than 5 to 6 miles per hour. More realistically, the average wind speed, measured in an open and unobstructed location within 100 feet upwind of the tower at a point 5 feet above basin curb elevation, should not exceed 10 miles per hour. Wind gusts should not exceed 15 miles per hour and should not exceed 1 minute duration.

(2) <u>Heat Load</u>: Measurements may be taken with or without heat load (on a mechanical draft cooling tower).

(3) <u>Ambient Temperature and Humidity</u>: Measurements may be taken at any non-freezing ambient temperature/humidity condition.

(4) <u>Stability of Test Conditions</u>: Variations in average ambient air temperatures should not exceed the following limits during the drift measurement period:

***Wet-bulb temperature - 2^{o}F per hour

***Dry-bulb temperature - 5^{o}F per hour

(5) <u>Water Flow</u>: The measurements should be taken at normal operating waterflow conditions, i.e., design flow $\pm$ 10%.

(6) Water Quality: Measurements should not be taken during temporary upset conditions in water chemistry, i.e., the cycles of concentration for the circulating water at the time of the drift measurement should be within a reasonable proximity of normal levels.

5.5 Train Operation. During the sampling run, maintain an isokinetic sampling rate (within 20 percent of true isokinetic unless otherwise specified by the Administrator).

For each run, record the data required on a data sheet such as the one shown in Figure CT-2. Be sure to record the initial dry gas meter reading. Record the dry gas meter readings at the beginning and end of each sampling time increment, when changes in flow rates are made, before and after each leak-check, and when sampling is halted. Take other readings required by Figure CT-2 at least once at each sample point during each time increment and additional readings when significant changes (20 percent variation in velocity head readings) necessitate additional adjustments in flow rate.

To begin sampling, position the nozzle at the first traverse point with the tip pointing parallel to the axis of the fan. Immediately start the pump, and adjust the flow to isokinetic conditions. Standard isokinetic sampling nomographs are designed for use with a Type "S" pitot and will have to be modified for use with the propeller anemometer. Isokinetic sampling rate and calculation programs using the Hewlett-Packard 41 are available from EPA (Citation 6 of Bibliography). Traverse the cell as required by Method PA.

If the pressure drop across the filter becomes too high, making isokinetic sampling difficult to maintain, the filter may be replaced in the midst of the sample run. It is recommended that another complete filter assembly be used rather than attempting to change the filter itself. Before a new filter assembly is installed, conduct a leak-check (see Section 5.4.1.1). The pollutant catch shall include the summation of all the filter assembly catches.

At the end of the sample run, turn off the coarse adjust valve, turn off the pump, remove the probe and nozzle from the stack, record the final dry gas meter reading, and conduct a post-test leak-check, as outlined in Section 5.4.1.2. Also, conduct a bearing torque check on the propeller anemometer and a constant rpm check on the electrical system. The torque must not exceed twice the torque when calibrated. If the torque check does not meet the requirements, clean and/or replace the propeller anemometer and repeat the run. Alternatively, the torque check may be conducted after the last run. If

FIGURE CT-2. CHROMIUM FIELD DATA FORM

Plant ______
City ______
Location ______
Operator ______
Date ______
Run number ______
Sample box number ______
Meter box number ______
Meter ΔH@ ______
Remarks ______

Meter calibration (Y) ______
Probe liner material ______
Probe heater setting ______
Ambient temperature ______
Barometric pressure (P_b) ______ mm (in.) Hg
Assumed moisture ______
Static pressure (P_a) ______ mm (in.) H_2O
Anem. electromechanical ratio ______
Anem. axial/rotational velocity ratio ______

Nozzle identification number ______
Nozzle diameter ______ mm (in.)
Thermometer number ______
Final leak rate ______ m^3/min (cfm)
Vacuum during leak-check ______ mm (in.) Hg
Bearing torque check ______
Constant rpm check ______
Filter number ______

Traverse point number	Sampling time (θ), min	Clock time, (24 h)	Vacuum mm (in.) Hg	Stack temperature (T_s) °C (°F)	Anemometer output, millivolt or rpm	Velocity, m/s (ft/sec)	Pressure differential orifice meter (ΔH), mm (in.) H_2O	Gas sample volume (V_m), m^3 (ft^3)	Gas sample temp. at dry gas meter Inlet, °C (°F)	Gas sample temp. at dry gas meter Outlet, °C (°F)	Temp. of gas leaving condenser or last impinger °C (°F)
	Total		Max	Avg				Total	Avg	Avg	Max

it does not pass, all runs must be repeated. The constant rpm check of the electrical system must be within 5 percent of the calibration value. If the system does not meet the requirements, repair or replace the system and void the run. Alternatively, the check may be conducted after the last run. If it does not pass, all runs must be repeated.

5.6 Calculation of Percent Isokinetic. Calculate percent isokinetic (see Calculations, Section 7) to determine whether the run was valid (80 to 120% isokinetic) or another test run should be made. If there was difficulty in maintaining isokinetic rates due to source conditions, consult with the Administrator for possible variance on the isokinetic rates.

5.7 Collection of Cooling Water Sample. A cooling water sample shall be collected during each run. The sample should be collected once during each run using a glass or polyethylene bottle from a location that would be representative of water entering the cooling tower. Alternatively, the tester may assume that all the chromium in the tower is in the hexavalent state and, therefore, need not collect cooling water samples to correct the data for non-hexavalent chromium.

5.8 Sample Recovery. Begin proper cleanup procedure as soon as the probe is removed from the stack at the end of the sampling period. Wipe off all external matter near the tip of the probe nozzle and place a cap over it to keep from losing part of the sample.

Before moving the sampling train to the cleanup site, remove the probe from the sampling train, wipe off the silicone grease, and cap the open outlet of the probe. Be careful not to lose any condensate, if present. Remove the filter assembly, wipe off the silicone grease from the filter holder inlet, and cap this inlet. Remove the umbilical cord from the last impinger, and cap the impinger. After wiping off the silicone grease, cap off the inlet to the first impinger and any open impinger inlets and outlets. The tester may use ground-glass stoppers, plastic caps, or serum caps to close these openings.

Transfer the probe and filter-impinger assembly to an area that is clean and protected from the wind so that the chances of contaminating or losing the sample is minimized.

Inspect the train before and during disassembly, and note any abnormal conditions. Treat the samples as follows:

5.8.1 Container No. 1 (Probe, Filter, and Impinger Catches). Using a graduated cylinder, measure to the nearest ml, and record the volume of the water in the first three impingers; include any condensate in the probe in this determination. Transfer the impinger water from the graduated cylinder into a polyethylene or glass container. Add the filter to this container. (The filter may be handled separately using procedures subject to the Administrator's approval.) Taking care that dust on the outside of the probe or other exterior surfaces does not get into the sample, rinse all sample-exposed surfaces (including the probe nozzle, probe fitting, probe liner, first three impingers, impinger connectors, and front half of the filter holder) with 0.1 N HNO_3. Use less than 500 ml for the entire wash. Add the washings to the sample container. Perform the 0.1N HNO_3 rinses as follows:

Carefully remove the probe nozzle and rinse the inside surface with 0.1 N HNO_3 from a wash bottle. Brush with a nylon bristle brush, and rinse until the rinse shows no visible particles, after which make a final rinse of the inside surface. Brush and rinse the inside parts of the Swagelok fitting with 0.1 N HNO_3 in a similar way.

Rinse the probe liner with 0.1 N HNO_3. While squirting the solution into the upper end of the probe, tilt and rotate the probe so that all inside surfaces will be wetted. Let the rinse drain from the lower end into the sample container. The tester may use a funnel (glass or polyethylene) to aid in transferring the liquid washes to the container. Follow the rinse with a probe brush. Hold the probe in an inclined position, and squirt 0.1 N HNO_3 into the upper end as the probe brush is being pushed with a twisting action through the probe. Hold the sample container underneath the lower end of the probe, and catch all rinse and particulate matter that is brushed from the probe. Run the brush through the probe three times or more. Rinse the brush with 0.1 N HNO_3, and quantitatively collect these washings in the sample container. After the brushing, make a final rinse of the probe as described above: It is recommended that two people clean the probe to minimize sample losses.

Rinse the inside surface of each of the first three impingers (and connecting glassware) three separate times. Use a small portion of 0.1 N HNO_3 for each rinse, and brush each sample-exposed surface with a nylon bristle brush, to ensure recovery of fine particulate matter. Make a final rinse of each surface and of the brush.

After ensuring that all joints have been wiped clean of the silicone grease, brush and rinse the inside of the filter holder (front-half only) with 0.1 N HNO_3. Brush and rinse each surface three times or more if needed. Make a final rinse of the brush and filter holder.

After all 0.1 N HNO_3 rinsings have been collected in the sample container, tighten the lid so that the liquid will not leak out when it is shipped to the laboratory. Mark the height of the liquid level to determine whether leakage occurs during transport. Label the container clearly to identify its contents.

This cleanup must be conducted for each of the test runs. Between sampling runs, rerinse all the sample-exposed surfaces of the train and the probe and impinger brushes with water. Keep brushes clean and protected from contamination.

5.8.2 Container No. 2 (Sample Blank). Prepare a blank by placing an unused Teflon™ filter in a container and adding a volume of water and 0.1 N HNO_3 equal to the total volume in Container No. 1. Process the blank in the same manner as for Container No. 1. Only one sample blank must be collected for each test series.

5.8.3 Container No. 3 (Silica Gel). Note the color of the indicating silica gel to determine whether it has been completely spent and make a notation of its condition. Transfer the silica gel from the fourth impinger to its original container and seal. The tester may use a funnel to pour the silica gel and a rubber policeman to remove the silica gel from the impinger. It is not necessary to remove the small amount of dust particles that may adhere to the impinger wall and are difficult to remove. Since the gain in weight is to be used for moisture calculations, do not use any water or other liquids to transfer the silica gel. If a balance is available in the field, the tester may follow the analytical procedure for Container No. 3 in 5.10.2.

5.9 Sample Preparation For Analysis. The entire aqueous sample is concentrated to a nominal volume of 25 ml. The specific procedures follow.

Note the liquid levels in Containers No. 1 and No. 2 and confirm on the analytical data form (Figure C-3 or similar form) whether or not leakage occurred during transport. If noticeable leakage has occurred, either void the test run or use methods, subject to the approval of the Administrator, to correct the final results. Treat the contents of each sample container as described below:

5.9.1 Container No. 1 (Probe Filter and Impinger Catch). To condense the sample, place the sample or a portion of the sample, including the Teflon filter, in a beaker; add approximately 10 mls of concentrated HNO_3, cover with a watch glass, and heat to 105°C in a hood. After the liquid contents are removed from the container, rinse the sample container with 0.1 N HNO_3 and add the rinse to the sample. If difficulty is encountered in evaporating the sample without bumping, a few Teflon™ chips may be added. Condense the sample to a nominal 25 ml; do not allow it to go to dryness. Transfer the condensed sample to a clean, tare-weighed storage vial. Rinse the beaker with 4 ml or less of 1:1 HNO_3 and add to the vial. Seal the vial and reweigh. Record the vial tare weight and final weight on the analytical data form. By assuming a specific gravity of 1.0, the difference between the tare and final weights (in g) is used as the sample volume (in ml). This volume is necessary to calculate the total ug of Cr in the sample after analysis using GFAA or ICAP, since the results are on a concentration basis. Transfer the samples to the NAA, GFAA, or ICAP laboratory.

5.9.2 Container No. 2 (Sample Blank). Treat in the same manner as described in Section 5.9.1 above.

5.9.3 Preparation of Cooling Water Samples. Shake the cooling water sample container to suspend any settled solids. Immediately pour through a 1.0 um-pore size Teflon filter in a vacuum filtration unit. When filtration is complete, use some of the filtrate to rinse the sample bottle and filter this rinse through the same filter. Measure the volume of the filtrate using a graduated cylinder and record on the analytical data sheet; transfer the filtrate to a clean sample storage container.

If the impinger samples are to be analyzed by NAA, transfer the Teflon filter holding the filtered residue to a precleaned screw-type vial suitable for NAA. If the samples will be analyzed by GFAA or ICAP, place the filter in a beaker with 5 ml of aqua regia and heat on a hot plate in a hood. Bring to a low boil for approximately 15 minutes. Transfer the solution to a 100-ml volumetric flask, rinsing the filter and the beaker well with water. Dilute to the mark. Take a portion of the solution, transfer it to a 40-ml storage vial, and submit it to the NAA, GFAA, or ICAP laboratory as appropriate.

5.9.4 Preparation of Performance Audit Sample. Pipette the volume of audit sample as indicated in the EPA audit instructions into a cleaned storage vial. The audit sample will be used to assess the accuracy of the analytical procedures.

5.10 Analysis.

5.10.1 NAA, GFAA, or ICAP Analysis. These three analytical methods have presently been shown to be satisfactory for analysis of cooling tower chromium samples. Submit impinger train samples and cooling water residue samples to

FIGURE CT- 3. SAMPLE PREPARATION AND ANALYTICAL DATA FORM

Plant Name ______________________________

Sampling Location ______________________ Sampling Date ________

Total Chromium Analyst ______________ Date _____ NAA ☐ GFAA ☐ ICAP ☐

Hexavalent Chromium Analyst ______________ Date ________

	Run 1	Run 2	Run 3
Run ID Nos.	☐	☐	☐
Silica Gel			
Final wt, g	____	____	____
Initial wt, g (minus)	____	____	____
Wt gained, g	____	____	____
Cooling Water Samples			
Sample ID Nos.	____	____	____
Volume filtered (V_w), ml	____	____	____
GFAA or ICAP results (G_w)*, ug Cr/ml	____	____	____
NAA results (N_w),* ug Cr	____	____	____
Cr in residue (G_w x V_w or N_w), ug Cr	____	____	____
Cr^{+6} results for filtrate (H_w), ug Cr^{+6}	____	____	____
Impinger Train Samples			
Sample ID Nos.	____	____	____
Liquid level checked	____	____	____
Volume of condensed sample (V_s), ml = g	____	____	____
GFAA or ICAP results (G_s)*, ug Cr/ml	____	____	____
NAA results (N_s)*, ug Cr	____	____	____
Cr in sample (G_s x V_s or N_s), ug Cr	____	____	____
Performance Audit Sample			
Sample ID No(s).	____	____	____
Cr^{+6} results, ug Cr^{+6}	____	____	____
GFAA or ICAP results, ug/ml	____	____	____
NA results, ug Cr	____	____	____

*Values should be blank corrected before being entered. Blank value must be less than or equal to 0.01 ug for NAA or 0.00004 ug/ml for GFAA or ICAP. If this value is exceeded, subtract only 0.01 ug or 0.00004 ug/ml for the blank values.

the NAA, GFAA, or ICAP laboratory. (Additional specifications will be added to this section upon final selection of the analytical procedure for this method).

5.10.2 Container No. 3. Weigh the spent silica gel (or silica gel plus impinger) to the nearest 0.5 g using a balance. This step may be conducted in the field.

5.10.3 Cooling Water Filtrate. Analyze a representative portion using the Draft Method - "Determination of Hexavalent Chromium Emissions from Stationary Sources."

6. Calibration

Maintain a laboratory log of all calibrations.

6.1 Probe Nozzle. Probe nozzles shall be calibrated before their initial use in the field. Using a micrometer, measure the inside diameter of the nozzle to the nearest 0.025 mm (0.001 in.). Make three separate measurements using different diameters each time, and obtain the average of the measurements. The difference between the high and low numbers shall not exceed 0.1 mm (0.004 in.). When nozzles become nicked, dented, or corroded, they shall be reshaped, sharpened, and recalibrated before use. Each nozzle shall be permanently and uniquely identified.

6.2 Propeller Anemometer. The propeller anemometer assembly shall be calibrated according to the procedure outlined in Section 4 of Method PA.

6.3 Metering System. Before its initial use in the field, the metering system shall be calibrated according to the procedure outlined in APTD-0576. Instead of physically adjusting the dry gas meter dial readings to correspond to the wet test meter readings, calibration factors may be used to correct mathematically the gas meter dial readings to the proper values. Before calibrating the metering system, it is suggested that a leak-check be conducted. For metering systems having diaphragm pumps, the normal leak-check procedure will not detect leakages within the pump. For these cases the following leak-check procedure is suggested: make a 10-minute calibration run at 0.00057 m^3/min (0.02 cfm); at the end of the run, take the difference of the measured wet test meter and dry gas meter volume; divide the difference by 10, to get the leak rate. The leak rate should not exceed 0.00057 m^3/min (0.02 cfm).

After each field use, the calibration of the metering system shall be checked by performing three calibration runs at a single, intermediate orifice setting (based on the previous field test), with the vacuum set at the maximum value reached during the test series. To adjust the vacuum, insert a valve between the wet test meter and inlet of the metering system. Calculate the average value of the calibration factor. If the calibration has changed by more than 5 percent, recalibrate the meter over the full range of orifice settings, as outlined in APTD-0576.

Alternative procedures, e.g., using the orifice meter coefficients, may be used, subject to the approval of the Administrator.

Note: If the dry gas meter coefficient values obtained before and after a test series differ by more than 5 percent, the test series shall either be voided, or calculations for the test series shall be performed using whichever meter coefficient value (i.e, before or after) gives the lower value of total sample volume.

6.4 Probe Heater Calibration. The probe heating system shall be calibrated before its initial use in the field according to the procedure outlined in APTD-0576. Probes constructed according to APTD-0581 need not be calibrated if the calibrations curves in APTD-0576 are used.

6.5 Temperature Gauges. Use the procedure in Section 4.2 of Method PA to calibrate in-stack temperature gauges. Dial thermometers, such as are used for the dry gas meter and condenser outlet, shall be calibrated against mercury-in-glass thermometers.

6.6 Leak-Check of Metering System Shown in Figure CT-1. That portion of the sampling train from the pump to the orifice meter should be leak-checked prior to initial use and after each shipment. Leakage after the pump will result in less volume being recorded than is actually sampled. The following procedure is suggested (see Figure 5-4 of Method 5): close the main valve on the meter box. Insert a one-hole rubber stopper with rubber tubing attached into the orifice exhaust pipe. Disconnect and vent the low side of the orifice manometer. Close off the low side orifice tap. Pressurize the system to 13 to 18 cm (5 to 7 in.) water column by blowing into the rubber tubing. Pinch off the tubing, and observe the manometer for one minute. A loss of pressure on the manometer indicates a leak in the meter box; leaks, if present, must be corrected.

6.7 Barometer. Calibrate against a mercury barometer as described in Method PA.

6. Calculations

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after the final calculation. Other forms of the equations may be used as long as they give equivalent results.

6.1 Nomenclature

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

A_s = Cross-sectional area of cell(s), m^2 (ft^2).

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

Cr^{+6} = Concentration of hexavalent chromium in cooling water, ug/ml.

Cr = Concentration of total chromium in cooling water, ug/ml.

I = Percent of isokinetic sampling.

L_a = Maximum acceptable leakage rate for either a pretest leak check or for a leak check following a component change; equal to 0.00057 m^3/min (0.02 cfm) or 4 percent of the average sampling rate, whichever is less.

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

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

$M_{Cr^{+6}}$ = Mass of hexavalent chromium in cooling water sample, ug.

M_n = Total amount of chromium matter collected, ug.

$M_{residue}$ = Mass of chromium residue in cooling water sample, ug.

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

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

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

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

R = Ideal gas constant, 0.06236 (mmHg)(m^3)/(^oK)(g-mole) [21.85 (in. Hg)(ft^3)/(^oR)(lb-mole)].

T_m = Absolute average dry gas meter temperature (see Figure CT-2), ^oK (^oR).

T_s = Absolute average stack gas temperature (see Figure CT-2), ^oK (^oR).

T_{std} = Standard absolute temperature, 293^oK (528^oR).

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

V_m = Volume of gas sample as measured by dry gas meter, dm^3 (dcf).

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, dsm^3 (dscf).

$V_{w(std)}$ = Volume of water vapor in the gas sample, corrected to standard conditions, sm^3 (scf).

V_{cw1} = Volume of cooling water sent for NAA or Cr^{+6}, ml.

V_{cw2} = Volume of cooling water which represents residue sent for NAA, ml.

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

Y = Dry gas meter calibration factor.

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

θ = Total sampling time, min.

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

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

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

13.6 = Specific gravity of mercury.

60 = Sec/min.

100 = Conversion to percent.

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

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

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

$$= K_1 \, V_m \, Y \, \frac{P_{bar} + (\Delta H/13.6)}{T_m} \qquad \text{Equation CT-1}$$

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

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

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

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

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

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

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

7.4 Volume of Water Vapor.

$$V_{w(std)} = V_{1c} \frac{\rho_w R T_{std}}{M_w P_{std}} = K_2 V_{1c} \qquad \text{Equation CT-2}$$

Where: K_2 = 0.001333 m^3/ml for metric units.
= 0.94707 ft^3/ml for English units.

$$B_{ws} = \frac{V_{w(std)}}{V_{m(std)} + V_{w(std)}} \qquad \text{Equation CT-3}$$

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

7.6 Total Chromium Weight. Determine the total chromium catch from the sum of the weights obtained from Containers 1 and 2 less the blank (see

Figure CT-3). Note: Refer to Section 4.1.5 to assist in calculation of results involving two or more filter assemblies or two or more sampling trains.

7.7 Conversion Factors.

From	To	Multiply By
scf	m^3	0.02832
g/ft^3	gr/ft^3	15.43
g/ft^3	lb/ft^3	2.205×10^{-3}
g/ft^3	g/m^3	35.31

7.8 Isokinetic Variation.

7.8.1 Calculation From Raw Data.

$$I = \frac{100\ T_s\ [K_3\ V_{1c} + (V_m\ Y/T_m)(P_{bar} + \Delta H/13.6)]}{60\ \theta v_s\ P_s\ A_n} \qquad \text{Equation CT-4}$$

Where: K_3 = 0.003454 (mm Hg)(m^3)/(ml)(^oK) for metric units.
= 0.002669 (in. Hg)(ft^3)/(ml)(^oR) for English unit.

7.8.2 Calculation From Intermediate Values.

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

$$= K_4\ \frac{T_s\ V_{m(std)}}{P_s\ v_s\ A_n\ \theta\ (1-B_{ws})} \qquad \text{Equation CT-5}$$

Where: K_4 = 4.320 for metric units.
= 0.09450 for English units.

7.9 Acceptable Results. If 80 percent $\leq$ I $\leq$ 120 percent, the results are acceptable. If the results are low in comparison to the standard and "I" is beyond the acceptable range, or, if "I" is greater than 120 percent, the Administrator may opt to accept the results. Use Citation 4 to make judgements. Otherwise, reject the results, and repeat the test.

7.10 Concentration of Chromium in Cooling Water.

$$Cr^{+6} = \frac{M_{Cr^{+6}}}{V_{cw_1}} \qquad \text{Equation CT-6}$$

$$Cr = Cr^{+6} + \frac{M_{residue}}{V_{cw_2}} \qquad \text{Equation CT-7}$$

Note: If all the chromium in the cooling water was assumed to be in the hexavalent state, then Cr^{+6} would equal 1.

7.11 Pollutant Mass Rate.

$$PMR_a = \frac{M_n \; A_s \; 60}{\theta \; A_n \; 454{,}000{,}000} \; \frac{Cr^{+6}}{Cr} \qquad \text{Equation CT-8}$$

$$= K_5 \; \frac{M_n \; A_s}{\theta \; A_n} \; \frac{Cr^{+6}}{Cr}$$

Where: $K_5 = 0.1322 \times 10^{-6}$ both units.

8. Bibliography

1. Cox, X. B., R. L. Linton, and F. E. Butler. Determination of Chromium Specialization in Environmental Particles; Multitechnique Study of Ferrochrome Smelter Dust. ES&T, Vol. 19, No. 4, April 1985.

2. Entropy Environmentalists, Inc. Emission Test Report: Munters Corporation, Fort Meyers, FL, ESED 85/02b. Draft report prepared for the U. S. Environmental Protection Agency under Contract No. 68-02-4336, Work Assignment No. 3, June 1986.

3. Butler, F. E., J. E. Knoll, and M. R. Midgett. Chromium Analysis at a Ferrochrome Smelter, A Chemical Plant and a Refractory Brick Plant. JAPCA, 36:581-584, 1986.

4. Rom, Jerome J. Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment. Environmental Protection Agency, Research Triangle Park, NC, APTD-0576, March 1972.

5. Martin, Robert M. Construction Details of Isokinetic Source-Sampling Equipment. Environmental Protection Agency, Research Triangle Park, NC, APTD-0581, April 1971.

6. Letter Communication. From John W. Cooper, Jr., P. E. of the Cooling Tower Institute to Pamela C. Bellin of Midwest Research Institute, concerning cooling tower operating parameters and ambient conditions during emission testing, March 24, 1986.

7. Clay, Frank. Source Test Calculation and Check Programs for Hewlett-Packard 41 Calculators. U. S. Environmental Protection Agency, Research Triangle Park, NC, EPA 340/1-85-018, September 1985.

ESC MEASUREMENTS

Instrumentation - ESC used the following instruments to collect data during test:

1. Sensitive Paper System

   Manufacturer: Environmental Systems Corporation

   Description: A special filter medium is chemically treated to produce a distinct color change when wetted. Droplets impinging on the papers produce blue stains which may be correlated with droplet size. The system operator records updraft velocity and selects exposure times which yield serviceable concentrations of stains. Knowing exposure times and updraft velocities, analysts studying the papers with microscopes can calculate droplet size and size distribution.

2. Air Speed (Updraft at Exit Plane)

   Manufacturer: R. M. Young Company

   Model: 27106 Gill Propeller Anemometer

   Description: A generator-type anemometer with excellent linearity and off-axis response. Used to measure fan updraft velocity to establish isokinetic sampling air flow rate. Readout is by digital voltmeter. In conjunction with this sensor, the operator measures the air flow direction with a vane-type sensor to make a correction for off-axis flow, if necessary.

3. <u>Digital Voltmeter</u>

Manufacturer: John Fluke Manufacturing Company

Model: 8022B

Serial Nos. 2920260, 2920262

Description: Three (3) 1/2 digit DVM used to measure output signals corresponding to fan updraft velocity and velocity vector.

PITOT TUBE MEASUREMENT PROCEDURE

1. Remove tube and inspect - remove tip protection cap.

2. With appropriate couplings connected (typically 2" NPT - male), pull reinforcing sleeve and "stinger" fully inside coupling and screw coupling snugly into gate valve (tighten with pipe wrench).

3. Open valve fully, <u>after</u> making sure once again the stinger is fully retracted. With valve fully open, push pitot tube stinger through the reinforcing sleeve. Lock into place and purge manometer and lines of all air. Zero the manometer (i.e., no differential pressure should be indicated, with total pressure and static pressure ports reading "static" prior to inserting tube in pipe).

4. Slowly insert pitot tube into pipe until a deflection is detected. Mark the tube clearly at the stuffing box. Push tube fully across the pipe until it contacts the other side. Mark tube clearly again and retract until zero deflection is seen again. Check this point with previous mark. Measure distance between marks and add 3/16" to indicated diameter (for offset in static/total sensing port location). Compare this diameter to the nominal diameter of the pipe.

5. Calculate and mark measurement stations. No fewer than 20 stations per diameter should be used for pipes greater than 36" diameter. Check to see if manometer is zeroed and initiate traverse. Visual readings of manometer should be no less than one minute. Periodic checks using 25-50 instantaneous manometer readings averaged and compared with the "eyeball" average at a single point should be conducted.

6. Other perpendicular traverses should be conducted similarly with center-point readings compared from each traverse for consistency.

7. Ambient temperature and water temperature should be measured during traverse to correct manometer balancing fluid and water density, respectively.

8. Pitot tube tip should be inspected for blockage/damage before and after each traverse.

9. Any anomalies or problems, such as vibration, apparent backflow, etc. should be noted.

INSTRUCTIONS FOR USE OF LEOPOLD SIMPLEX PITOT TUBE (OR ROD) AND MANOMETER

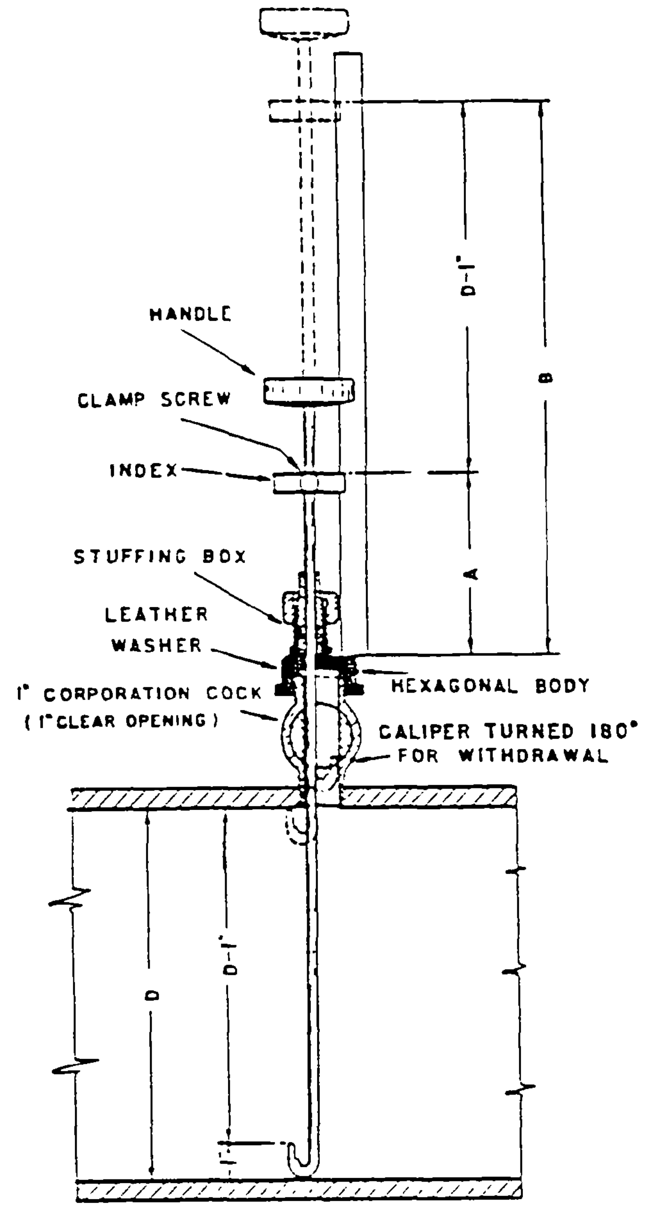


Fig. 1—Pipe Caliper.

In these instructions the various operations are stated in their natural order of progression, and each subject is completely treated in its paragraph for easy reference.

Pipe Caliper—See Fig. 1.

This instrument consists of a brass rod which passes through an eccentric stuffing-box The lower end is hook shaped, and to the other end is attached an index collar and handle.

To attach the caliper, pull the rod all the way up and screw the stuffing-box on the corporation cock, making a water-tight joint with the leather washer.

Open the corporation cock and push the rod in until it touches the pipe. (See Fig. 1.) Turn rod 180°. Measure the distance between index collar and stuffing-box. Pull rod up until hook just touches the pipe. Again measure from stuffing-box to index collar. The inside diameter of pipe is equal to the difference between these two measurements plus one inch, the one inch being added for the length of the hook.

Caution should be taken to push the rod against the walls of the pipe slowly and gently, since the pipe may be coated with tubercles and incrustations, or there may be sand or sediment on the bottom. Should the rod be pushed too forcefully against the pipe, these interior conditions would not be detected. Remember that it is the actual working diameter of pipe, as near as can be determined, that should be used in flow calculations.

SIMPLEX PITOT ROD

Description

The Simplex PFA Pitot Rod illustrated in Fig. 2 is a pair of tubes in a casing One tube transmits the Reference pressure received at the side orifices, and the other tube transmits the impact pressure received at the Impact orifice, which faces the flow.

The Simplex Rod is provided with a split clamp which holds the tube in position and prevents it being pushed out by the water pressure, a stuffing-box which can easily be packed with any suitable packing and a stop collar near the orifice end of the rod to limit the withdrawal of the rod through the stuffing-box.

Rod-Corporation Connection

The threads of the connection nut of the Simplex rod and of the pipe caliper fits a 1" Mueller Corporation Cock The requirements of the corporation cock are for a male thread 1½" O.D—twelve threads per inch and a 1" clear opening Where other makes of corporation cocks are employed, an adapter should be provided having male threads to fit the Simplex item and female threads to fit the corporation cock

Attaching Pitot Rod

Before attaching Pitot Rod to corporation cock, be sure to remove the protecting cap from the orifice end, then see that the tube is fully drawn up so that it will escape corporation plug. Screw connection nut on corporation cock, making a water-tight joint by the leather washer.

Have all cocks on Pitot Rod closed, and then open the corporation. Open the air cocks at top of Pitot Rod to blow the air out of tube and also out of top of pipe, should any be lodged there.

Push the Rod in until it touches the pipe, and measure the distance from index collar to traverse scale flange. Pull the Rod out a distance equal to the radius of the pipe minus 1/8 inch and secure the Rod in this position by tightening the clamp collar, and at the same time being sure that the arrow on the crown casting of Rod points in the direction of the flow.

If the direction of the flow is unknown, this can be determined by the use of the manometer connected to the Pitot Rod. Observe the deflection in manometer when arrow on crown casting points along the pipe in one direction. Then revolve the Pitot Tube 180° so that the arrow points along the pipe in the opposite direction. The water will be flowing in the direction that produces the greater deflection of the liquid in manometer.

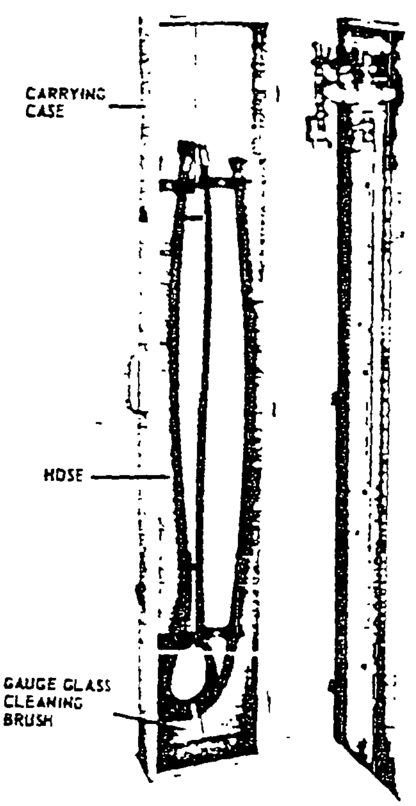


Fig. 3—Manometer.

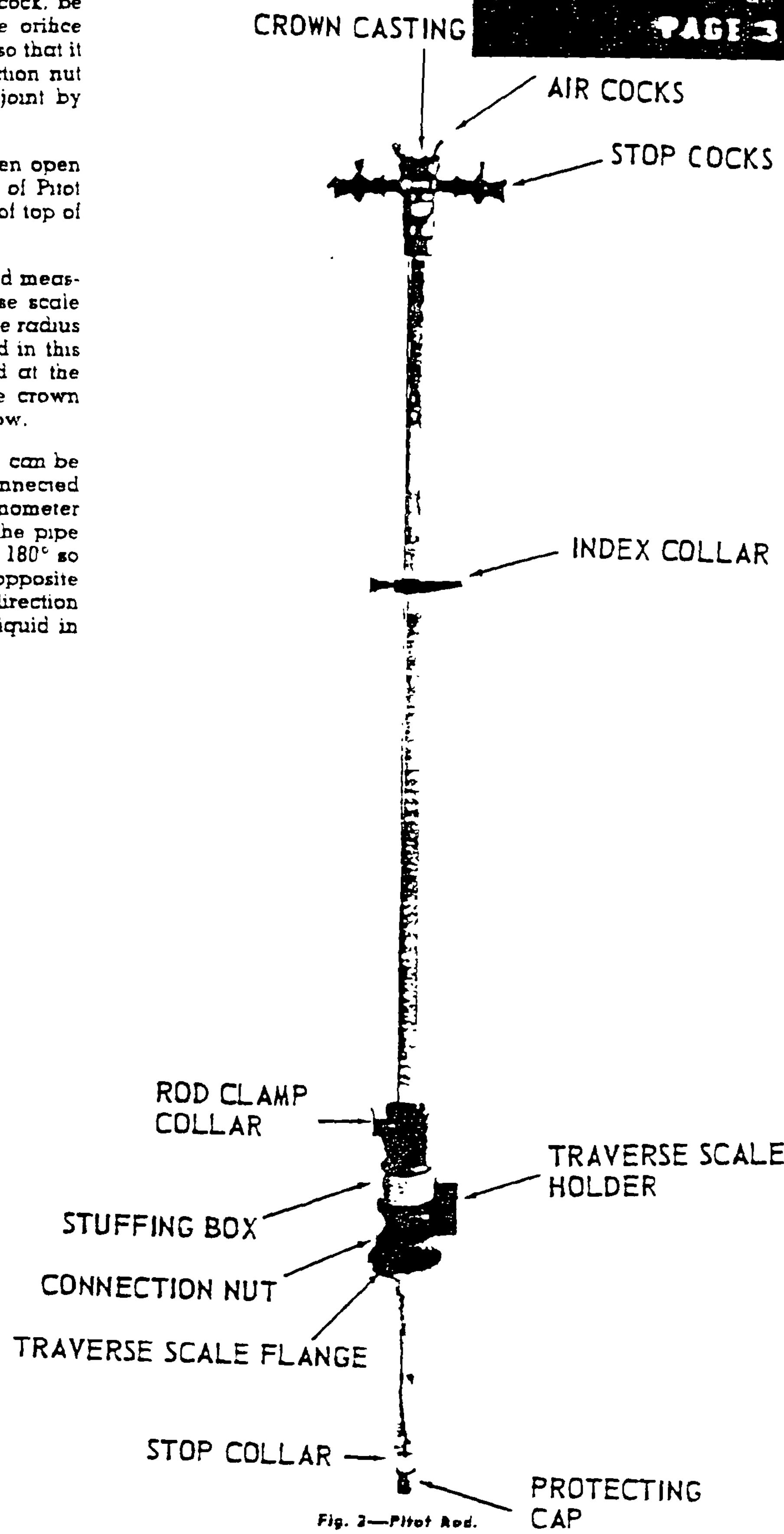


Fig. 2—Pitot Rod.

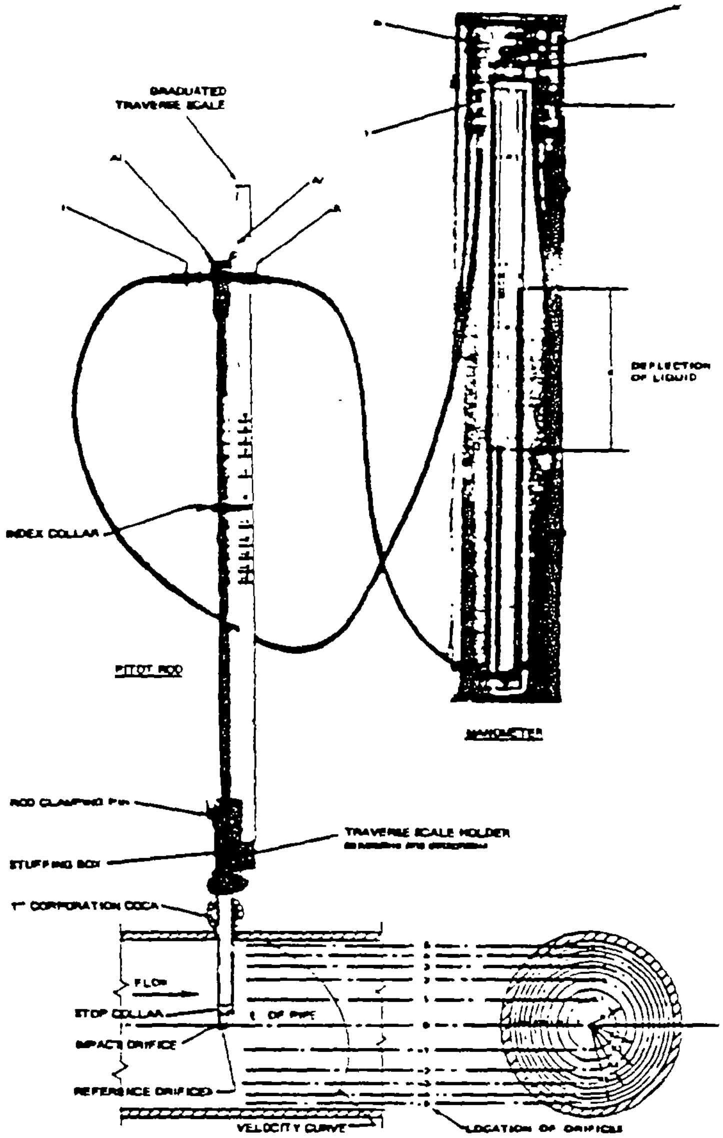


Fig. 4—Traversing—Equal Area Method.

The Pitot Rod located as described above has its orifices at the center of the pipe. This is the usual location for flow determination when connected to recorder or manometer.

MANOMETER—See Figs. 3, 4

Description

In principle this instrument is a U-tube.

The top assembly is provided with fittings which connect to each side and in turn to each other through valve (e). Plug cocks (l) and (r) and air cocks (a_l) and (a_r) are also provided at this point on the manometer. (See Fig. 4.)

The top assembly is easily removable for pouring liquid into manometer or for the insertion of the cleaning brush. The glass should always be clean so that the liquid will not cling to the surface, but will form a clear and even meniscus in each side. This is especially important when the deflection of the liquid is small.

A manometer connected to a Simplex Pitot Rod constitutes one of the simplest forms of a meter for indicating the rate of flow.

Connecting Manometer to Pitot Rod

The manometer may be connected with two lengths of hose, either directly to the Pitot Rod at (I) and (R), as shown in Fig. 4, or it may be connected at (I) and (R) at the Recorder (Fig. 10) when the latter is connected to the Pitot Rod. While using the manometer thus connected, shut off the Recorder by closing cocks (I) and (R) on Recorder. Whenever the manometer is being filled with liquid or is blown off for expelling possible collections of air from it, always first close cocks (I) and (R) at Recorder. Likewise, whenever air is being blown from Recorder always first close cocks (I) and (R), thus shutting off the manometer to prevent the danger of blowing the liquid from same. (See Fig. 10.)

FILLING MANOMETER WITH LIQUID AND BLOWING OUT AIR

Remove wing nut on top of manometer. Lift off top assembly, exposing holes to glass. Pour liquid, previously mixed (as explained on Page 6), through a funnel into either hole.

It is usually desirable to fill the manometer half full of liquid, since the maximum deflection equal to the length of a glass tube will be obtainable by this amount of liquid.

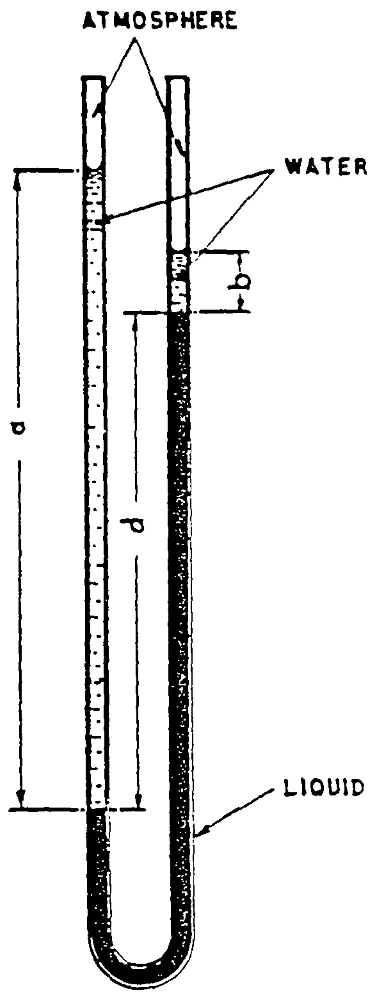
Having poured liquid into manometer, replace the top assembly and tighten wing nut. Fill manometer with water and expel all air from hose connections and manometer. Care must be exercised not to blow out the liquid. To guard against this keep one side of the manometer closed while blowing out air from the other side. For example, to blow air through the impact line, have all cocks at manometer closed except open (a_1) and open (i). Opening and closing (i) several times during the procedure will facilitate filling the gauge glass with water, since this will give more opportunity for the air from the glass to escape through (a_1). Close (i) and (a_1). Likewise, fill the other side with water and expel air by opening (a_2) and (r).

Having thus blown till no air appears, close (r), and finally, to insure that no air is trapped in the by-pass connection, open cock (e) and having (a_2) open, slightly open (r). Close (r) before the liquid reaches the top of the glass. Close (a_2) and (e) and open (i) and (r), when the manometer will be in service and the deflection of the liquid is a measure of the velocity of the water flowing by the orifices of Pitot Tube.

Cock (e) is an equalizing cock and when open the pressures in the two glasses tend to equalize. When (e) is open the liquid in each glass should come to the same level provided either (i) or (r) or both are closed. It is necessary that at least one be closed.

This enables the operator to prove that no air is in the manometer.

When the deflections of the liquid are to be observed for velocity indications, cocks (e), (a_1) and (a_2) are closed and cocks (i) and (r) are open.



$$S = \frac{a-b}{d}$$

Fig. 5—Test for Specific Gravity.

LIQUID FOR MANOMETER

When measuring low velocities use a low specific gravity and for high velocities use a heavier mixture of liquid. If the velocity being measured is so high that it will deflect the liquid in the manometer more than the length of the glass, then it will be necessary to use a heavier liquid.

The liquid usually used in the manometer is a mixture of carbon tetra-chloride and benzine or benzol, colored with a small quantity of red coloring powder. The liquids are mixed in such proportions that the resultant mixture will have any desired specific gravity between the limits of 1.10 and 1.60. Specific gravities of 1.25 and 1.50 are most commonly used.

The specific gravity of carbon tetra-chloride is about 1.60, and if this liquid is too light, then for a heavier liquid use bromoform, whose specific gravity is about 2.96. This likewise can be mixed with carbon tetra-chloride to obtain gravities between 1.60 and 2.96. Bromoform in its commercial state usually contains some alcohol. For this reason it should be washed with water and then filtered through filter paper before using in manometer. Do not inhale its fumes.

For differential pressures too great for the above-named liquids use mercury, whose specific gravity is 13.58.

Specific Gravity Determination

The specific gravity of the liquid or mixture can be determined by pouring same in a glass cylinder and floating a hydrometer in the liquid. The lighter the liquid, the deeper will the hydrometer be submerged. Read the specific gravity on the hydrometer scale at the surface of the liquid.

If a hydrometer is not available or other range of liquid gravity is employed, the specific gravity can easily be determined in the following manner.

Pour the liquid to be checked into the manometer and then pour some water into one side of the manometer, which will deflect the liquid. There may be water in one side only or in both sides of the manometer, and it is only necessary to have more water in one side than in the other so as to produce a deflection of the liquid. In the interest of close accuracy it is advisable to have as large a deflection as possible. It will be understood that for the determination of the specific gravity both legs of the manometer are open to atmosphere, that is, cocks (a_l) and (a_r) are open and cocks (l) and (r) are closed if the manometer is connected to the Pitot Rod. Do this at least twice in order to cross check the result.

The specific gravity of the liquid then is

$$S = \frac{a - b}{d} \text{ when there is water in both sides}$$

$$\text{and } S = \frac{a}{d} \text{ when water is in one side only, in which case b equals zero.}$$

where S = specific gravity of liquid
a = larger water column on liquid
b = smaller water column on liquid
d = deflection of liquid

Temperature affects the specific gravity. Therefore a determination of specific gravity as detailed above will give the proper value only if made directly before and/or after the test.

Mixing Liquids

Having decided on the specific gravity of the liquid mixture to be used, the formula below will be found helpful and time saving.

$$T = \frac{S_m - S_b}{S_t - S_m} \times B$$

where S_m = specific gravity of mixture
S_t = specific gravity of carbon tetra-chloride
S_b = specific gravity of benzol
T = volume of carbon tetra-chloride
B = volume of benzol

For example, if S_t = 1.60, S_b = .87, and it is desired to have S_m = 1.245 of the mixture, then

$$T = \frac{1.245 - .87}{1.60 - 1.245} \times B = \frac{.375}{.355} B$$

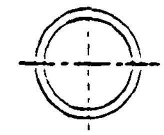
$$T = 1.057 \text{ B}$$

SIMPLEX CONTROLS — Sheet A No. 4
Station No. 2 — Date MAR 5, 1970
Nominal Dia. 16" Calipered Dia. 15 3/4 A 1.363 Sq Ft.
Indicate in circle, position of tap used for this Traverse.

$v = \frac{1.667}{1.840}\sqrt{s-1}\ \sqrt{a''}$

$v = 1.29\ \sqrt{a''}$

Note: For Simplex Round Rod Use 1.667
Flat Rod Use 1.840



looking up-stream

s = Sp. G. of Manometer Liquid 1.60
$G = FV_c$, where F = station factor = 646.300 AC
Trav. coef by this traverse, $C = \frac{V_m}{V_c} = \frac{4.73}{5.49} = .862$
Average of all traverses, C = ______ F = ______
Time of traverse, from 10 AM to 10:15 AM
By whom RDL
Also see sheet B No. 4 and sheets A Nos. 5
Location MIDLAND, WEST OF RT. 17

n	a	ac	V	Vc	Values of V when Vc = 100
6	5.50	17.50	3 02	5.40	.560
5	7 00	17.50	3 41	5.40	.632
4	8.50	19.00	3 76	5 61	.670
3	10.00	17 00	4 07	5.31	.768
2	13 00	17 00	4 65	5.31	.875
1	15.50	20 00	5.04	5.77	.878
-1	23.00	20 00	6.09	5.77	1.025
-2	21.50	21 00	5 99	5.95	1.005
-3	23 00	21.00	6.09	5.95	1.005
-4	17 00	17.50	5 31	5.40	.983
-5	15.00	16 00	5.00	5 15	.970
-6	11.25	14 00	4.32	4.82	.895
		TOTAL	56 75	65.84	
		AVG	4.73	5 49	

107-00905

Fig. 6—Typical Data Sheet A.

For high velocities, where a smaller deflection is desired, use Bromoform, Sp G. = S_b = 2.9[illegible] 70°F. This liquid may be mixed with carbon-te[illegible] chloride to give a mixture lighter than 2.9[illegible] desired, the Sp G. of mixture being determ[illegible] by manometer balancing or by formulas. In latter case

$$T = \frac{S_m - S_t}{S_b - S_m} \times B$$

It must be borne in mind, however, that the specific gravity determined under actual test conditions is the value used in flow calculations

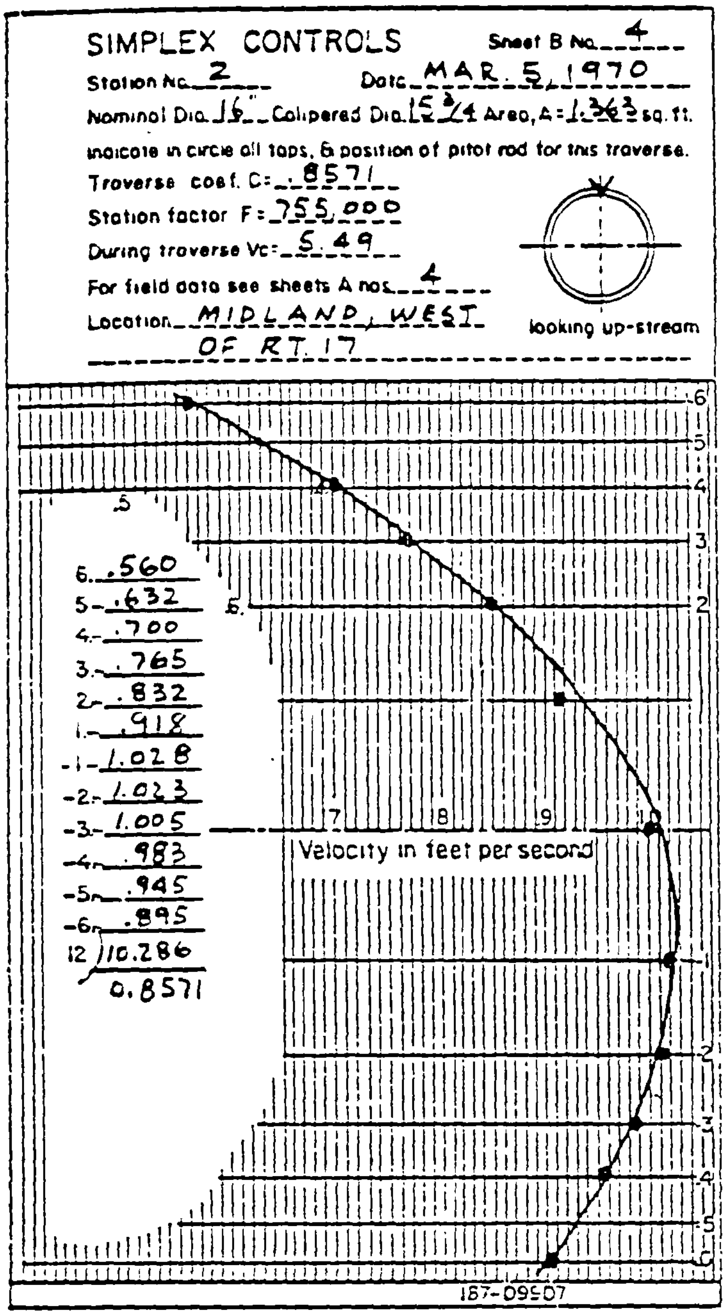


Fig. 7—Typical Plotting of Traverse Curve from Fig. 6. This value (.8571) is the mean relative velocity V and also the Traverse Coefficient $\frac{V_m}{V_c} = C$.

TRAVERSE STATIONS—See Fig. 4

Wherever a main is tapped for the purpose of measuring the flow of water, let it be called a station and named or designated by an assigned number.

When selecting a location for a station always, if possible, select a point in the pipe line where there is a considerable length of straight pipe line, where the flow will be undisturbed by valves, tees, or bends.

Tap the pipe at the selected location for a one-inch corporation cock. The tap is usually made on the top of the pipe. It may, however, be made at the side of the pipe or at any other point on the circumference It is desirable that the pipe be not tapped so deep that the corporation cock will extend through pipes and project beyond the inside surface of the wall of the pipe.

When it is impossible to make tap in a long straight length of pipe, say where the nearest up-stream valve, tee, or bend is less than 20 or 30 diameters from the station, then two taps about 90° apart with one about 4" to 6" ahead of the other should be tapped in the pipe.

For steel pipes first attach a strap service clamp to pipe.

An accurate record should always be made and kept on file giving the location of all stations and the distance of same from at least two fixed landmarks.

PIPE TRAVERSE—See Figs. 4, 6, 7

The object of making the pipe traverse by the use of the Pitot Rod and the manometer is to ascertain the relation between the mean velocity and the center velocity in the pipe. The Pitot Tube measures velocity only at the point in the pipe where the orifices are located. If the orifices of the Pitot Tube be moved along the diameter of the pipe it will be noticed that the velocities are different for different locations of the orifices, and that they gradually increase as we approach the center of the pipe. Therefore, to accurately determine the quantity of water flowing it is necessary to know the traverse coefficient, $C = V_m/V_c$, that is the relation of the mean velocity to the center velocity.

The method to be employed in making the traverse is that of dividing the pipe into imaginary rings or annuli having equal areas, and then taking readings of the deflections of the liquid in the manometer when the orifices of the Pitot Tube are placed at a point i each ring such that a circle through that point wi divide the ring into two equal areas.

This is illustrated in Fig. 4. Refer to the right-ha lower corner where circular cross-section of a pi is shown. Here the pipe is divided into five rings equal area. R_1 is the radius to the orifice locatio for the first ring. R_2 is the radius to the orifice locati for the second ring. R_1 is the radius to the circu ference of ring (a). The area of ring (a) equals the area of ring (b). The rings (a), (b), (c), (d), (e), (f), (g), (h), (i) and (j) have equal areas and the area of any one of these is equal to half the area of any one of rings, 1, 2, 3, 4, or 5.

The orifice locations for any size pipe may be calculated by formula (15) page 13 or they may be selected from the table of orifice locations on page 15.

Southern Research Institute

August 13, 1986

Mr. Bill DeWees
Entropy Environmentalists
P.O. Box 12291
Research Triangle Park, NC 27709-2291

Dear Bill:

I would like to expand on the results I gave you on the phone concerning your tests at Paducah. As I understand it, your team ran the paired trains that we recommended, one train being a conventional isokinetic impinger train and the other an impinger train sampling from a tube with a disk-shaped collar positioned at 90 degrees from the direction of gas flow. Our best estimate on the collection behavior of this train comes from the theory of Zebel (In Recent Developments in Aerosol Science, Edited by David T. Shaw, Wiley, NY, 1978). The only experimental data we know of was for a geometry with a slightly different collar by Liu and Pui (Aerosol Sampling Inlets and Inhalable Particles, Atmospheric Environment, 15, 589-600, 1981). According to Zebel's paper, the collection efficiency of drops by the disk train should be given by the equation below:

$$\mathrm{Eff} = \frac{1}{1 + 1.09\ \mathrm{STK}} \qquad (1)$$

where

$$\mathrm{STK} = V \rho C D^2 / 9 \mu d \qquad (2)$$

and
V = gas stream velocity (cm/sec)
ρ = droplet density (1 gm/cm^3 in this case)
C = Cunningham correction factor ($\approx$ 1 for this size)
D = droplet diameter (cm)
μ = gas viscosity (about 180 x 10^{-6} poise)
d = sampling tube inner diameter (cm)

Although their geometry is slightly different from our setup, the equation fits the data of Liu and Pui fairly well when the correct tube diameter is assumed (see Figure 1). Table 1 contains calculated D_{50} values for the four "90° train" runs. Note that while the calculated D_{50} is on the order of 13-16 μm, the efficiency curves are broad, and significant collection occurs at higher droplet sizes. The calculated collection efficiencies for the velocities encountered by the "90° trains" at Paducah are plotted in Figure 2. I have also done a convolution (see Table II) of the calculated collection efficiency of the 90° train with one of the size distributions reported by ESC. If their size distributions are good in the smaller size range, the 90° trains should collect less than 10 percent of the drift mass. I do have some questions about their technique, though, which I will discuss below.

Although you did not directly ask us to analyze the ESC technique, I felt a word about it was in order. The most definitive experimental work of which we are aware is that of May and Clifford (The Impaction of Aerosol Particles on Cylinders, Spheres, Ribbons and Discs, Ann. Occup. Hyg. 10, 83-95, 1967), which gives efficiency curves for the disk body impactor such as those used for our study. I have enclosed a copy of their results (their Figure 7) which illustrates it. In their plot the parameter $P=\lambda/\ell$ is given by half the value of STK in equation 2 (where d now is the paper disk diameter). Thus P is proportional to the square of the droplet diameter D. Using this data the disk D_{50} value expected for the velocity range covered can be calculated and are included in Table I.

I draw two conclusions from the May and Clifford data. First, it is probably a decent approximation to assume that the sum of the collection by the paper disk and the 90° train will be approximately the same as the isokinetic nozzle train for all sizes, with the greatest error of approximation occurring for particles about 20 μm. The efficiency curves for a disk impactor and those of the 90° sampling train are fairly "sloppy" in terms of particle size separation. The paper disk collects large droplets, and the 90° train collects the smallest droplets, with near unit efficiency. Thus both significant ends of the size spectrum are collected well.

A second point I should emphasize is that the sensitive paper results are subject to some question below about 25-50 μm. While presumably ESC can distinguish spots corresponding to 10-20 μm size droplets, they may underestimate the actual flux of these drops. The Ranz and Wong (IMpaction of Dust and Smoke Particles, Industrial and Engineering Chemistry, 44, 1371-81, 1952) collection efficiency used by ESC to establish correction factors does not seem to be fitted by the experimental data seen on Figure 7 of May and Clifford.

The relative contribution of droplets in the 10-50 µm size range may not be significant for the low efficiency drift eliminators in this study. However, the sensitive paper may significantly underestimate the small droplet flux downstream of higher efficiency collectors or in any duct where a condensation droplet mode exists.

Please let me know if I can be of further help.

Sincerely yours,

Ashley D. Williamson
Head, Aerosol Science Division

ADW/fea
cc: Dan Bivins
Project 6112
SoRI-EAS-86-755

Table I. Calculated D_{50} Values

Run Number	Duct Velocity ft/sec	Calculated D_{50} values, um: Right Angle Train	Paper Disc
1	30.97	13.3	25.5
3	22.25	15.7	30.1
4	21.06	16.1	30.9
5	33.67	12.7	24.4

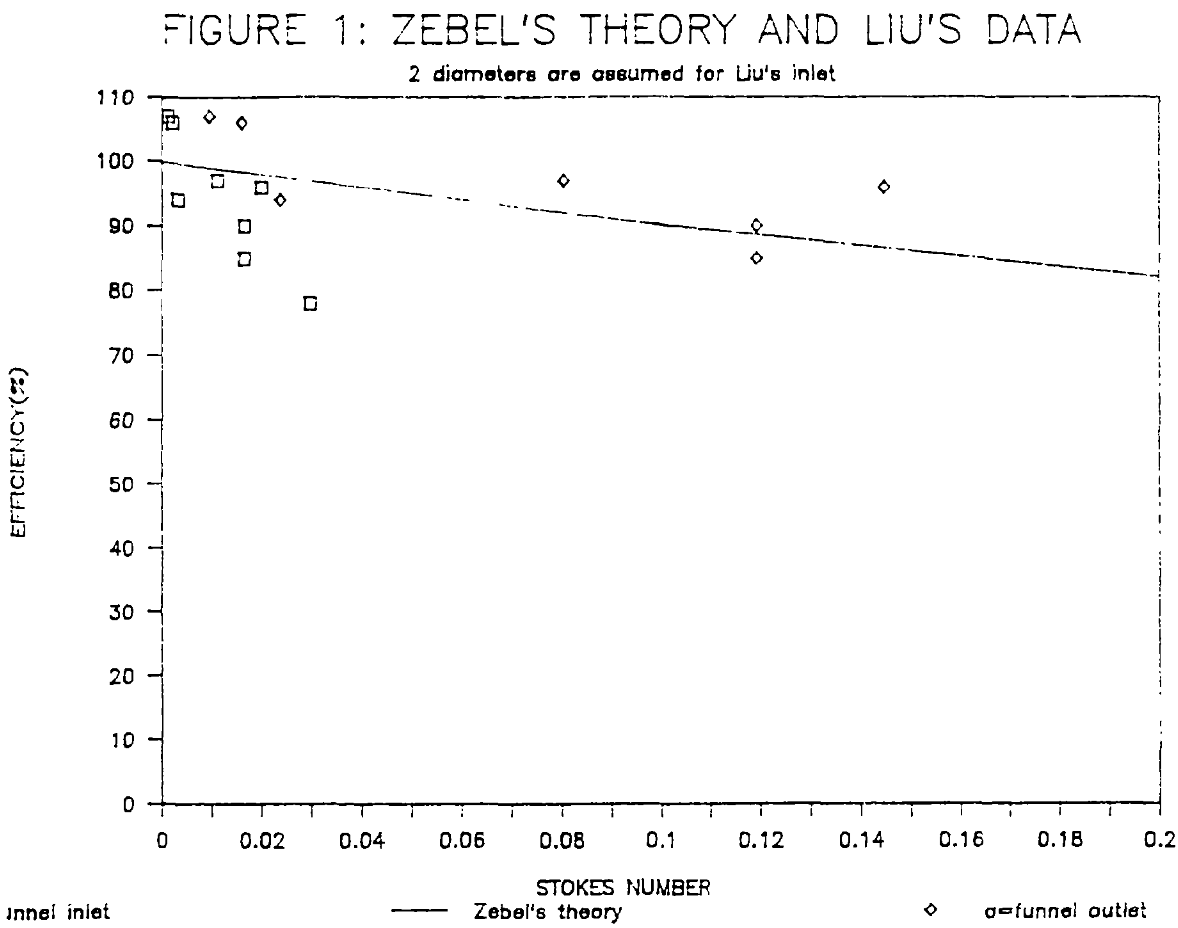


FIGURE 1: ZEBEL'S THEORY AND LIU'S DATA
2 diameters are assumed for Liu's inlet
EFFICIENCY(%)
110
100
90
80
70
60
50
40
30
20
10
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
STOKES NUMBER
innel inlet
Zebel's theory
o=funnel outlet

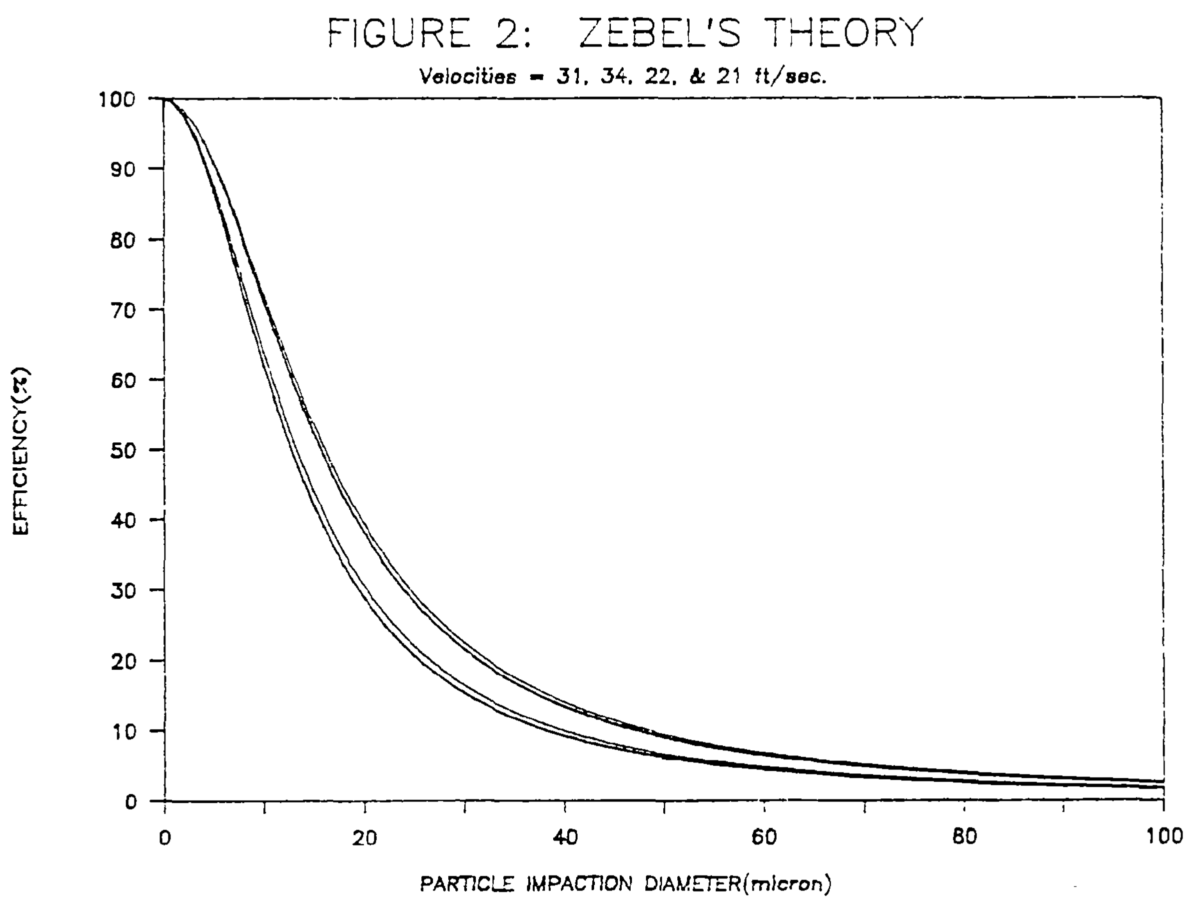


FIGURE 2: ZEBEL'S THEORY
Velocities = 31, 34, 22, & 21 ft/sec.
EFFICIENCY(%)
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
PARTICLE IMPACTION DIAMETER(micron)

BLE II. COLLECTION OF ASSUMED SIZE DISTRIBUTION BY RIGHT ANGLE TRAIN

PART. DIA. (um)	ZEBEL'S ASPIRATION EFF.				SIZE DISTRIBUTION COLLECTED BY RIGHT ANGLE TRAIN				
	v = 31.0	v = 33.7	v = 22.3	v = 21.1	ASSUMED SIZE DIST	v = 31.0	v = 33.7	v = 22.3	v = 21.1
5	88	87	91	91	(800)	701.6	694.1	726.8	730.4
15	44	42	52	54	955	422.2	402.4	500.9	514.0
25	22	21	28	30	573	127.2	119.0	162.9	169.3
35	13	12	17	18	1480	188.0	174.6	249.3	260.9
45	8	7	11	11	2490	201.5	186.4	271.8	285.4
55	6	5	8	8	4650	258.8	238.9	352.6	370.9
65	4	4	6	6	6840	277.0	255.4	379.5	399.7
80	3	2	4	4	1670	45.3	41.7	62.3	65.7
100	2	2	2	3	1830	32.1	29.5	44.3	46.8
120	1	1	2	2	1600	19.6	18.0	27.1	28.6
140	1	1	1	1	1640	14.8	13.6	20.5	21.6
165	1	1	1	1	2080	13.5	12.4	18.8	19.8
195	0	0	1	1	1690	7.9	7.3	11.0	11.6
225	0	0	0	1	1790	6.3	5.8	8.7	9.2
255	0	0	0	0	907	2.5	2.3	3.4	3.6
285	0	0	0	0	1530	3.4	3.1	4.7	4.9
325	0	0	0	0	1890	3.2	2.9	4.4	4.7
375	0	0	0	0	1290	1.6	1.5	2.3	2.4
425	0	0	0	0	937	0.9	0.8	1.3	1.4
475	0	0	0	0	1540	1.2	1.1	1.7	1.8
550	0	0	0	0	484	0.3	0.3	0.4	0.4
650	0	0	0	0	1380	0.6	0.5	0.8	0.9
750	0	0	0	0	894	0.3	0.3	0.4	0.4
850	0	0	0	0	0	0.0	0.0	0.0	0.0
950	0	0	0	0	0	0.0	0.0	0.0	0.0
1100	0	0	0	0	0	0.0	0.0	0.0	0.0
1300	0	0	0	0	5240	0.6	0.5	0.8	0.8
TOTAL PARTICLE FLUX:					46180	2330.2	2212.4	2856.7	2955.3
FRACTION OF PARTICLE MASS COLLECTED:						0.0504	0.0479	0.0618	0.0639

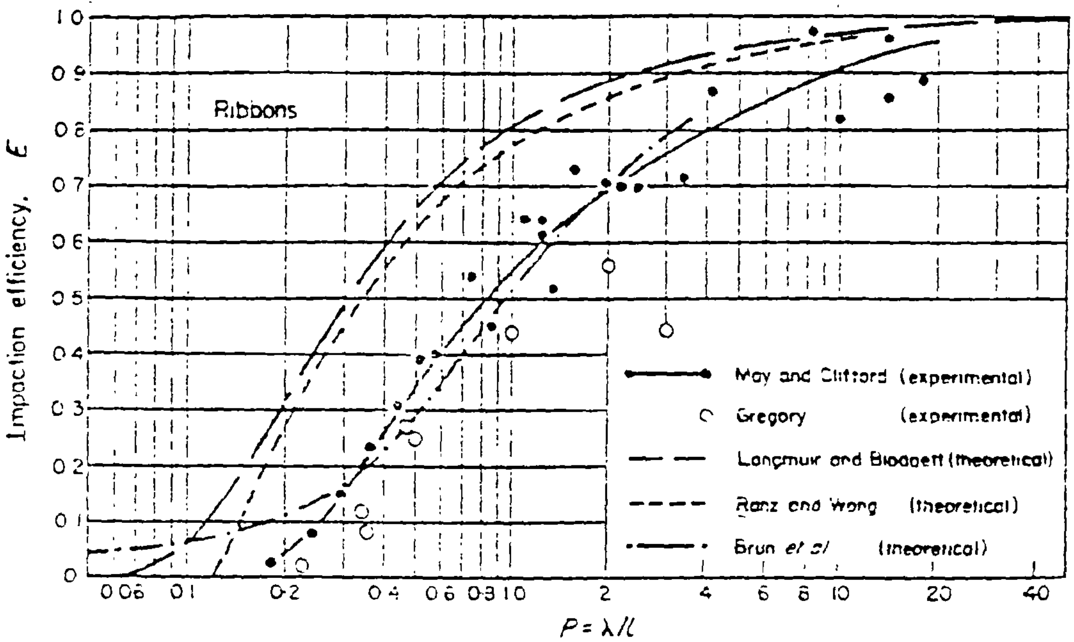


FIG. 6. Experimental and theoretical impaction efficiency of long ribbons.

and HERRMANN (1949) also found that their experimental E was substantially lower than the theoretical prediction.

Discs

Figure 7 shows much the same picture as Fig. 6 in the relation between theory and experiment and needs little further comment except that discs have received less attention in the literature than the other geometrical forms.

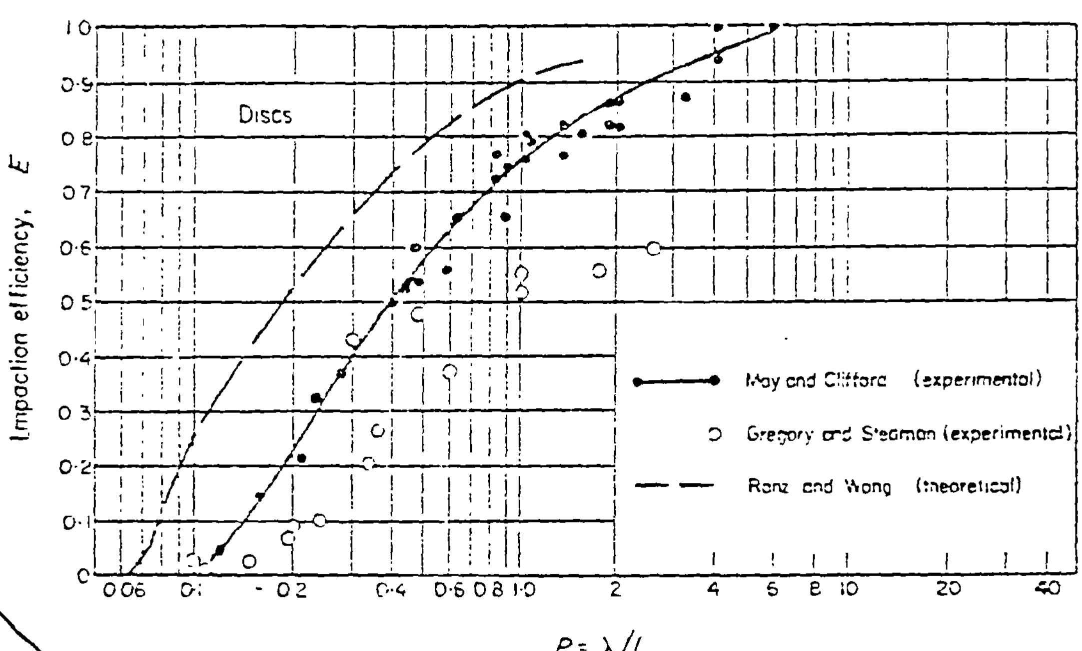


FIG. 7. Experimental and theoretical impaction efficiency of discs.

Accuracy

Scatter of values from the replicate determinations at each point was very small at the lower end of the curves (large objects, small particles, low wind speed) but tended to become much larger at the upper end of the curve, the spread sometimes

APPENDIX D.

CALIBRATION AND QUALITY ASSURANCE DATA

CALIBRATIONS

All measuring equipment Entropy uses is initially calibrated before use. Equipment which can change calibration is both checked upon return from each field use and is also periodically recalibrated in full. When an instrument is found out of calibration, it is so noted in the report and appropriate adjustments are made to the final results. The equipment is then repaired and recalibrated or retired as needed. Specific equipment is handled as follows:

Propeller Anemometer - All propeller anemometers were calibrated and/or checked using the procedures in the draft test method for the use of the propeller anemometer. This included a full calibration in the wind tunnel at 10^{o} increments of flow alignment angles from -90^{o} to $+90^{o}$. The electrical system was checked with a constant rpm motor to ensure proper outputs. The bearing torque on the anemometer shaft was checked with a bearing torque check device. All propeller anemometers used in this program meet the requirements as specified by the EPA draft method.

Dry Gas Meter and Orifice Meter - All Entropy meter boxes are calibrated upon purchase and at least once every six months against a secondary test meter (one calibrated against a wet test meter) according to their usage history. Basic procedures are outlined in the EPA Publication No. APTD-0576. The only differences are in the choice of flow rates used and the volumes metered at each flow rate. After each field use, quick checks are performed to ensure delta H@ changes of less than 5%. These checks compare the orifice against the dry gas meter. If greater than 5% changes occur, recalibration and repair are instituted.

Nozzles - Each nozzle is calibrated upon purchase, and thereafter whenever it becomes apparent that the nozzle has become damaged. Each nozzle is inspected upon return to laboratory from each field use. The diameter is measured on five different axes, with the high and low readings differing by no more than 0.004 inches as a tolerence.

Temperature Measuring Instruments - After each field use, the thermocouples or thermometers are calibrated against an ASTM precision mercury-in-glass thermometer across a wide range of temperatures. If the initial reading is not within $\pm$ 1.5% of the absolute temperature reading of the standard thermometer, the instrument is adjusted until it is in the acceptable range.

Three-Dimensional Pitot Tube - Prior to field use, the 3-D pitot tube was calibrated in the wind tunnel using the procedures described in EPA Method 1A. The pitot tube meets all requirements of the Method.

Magnehelic[R] Gauges - After each field use, each Magnehelic[R] Gauge is calibrated against an inclined manometer at three different settings (low, medium, high) over the range of the individual gauges. If the readings differ more than $\pm$ 5% from the manometer readings, the Magnehelics[R] are recalibrated.

Barometer - After each field use, each barometer is checked against a mercury barometer.

UNITED SENSOR TYPE DAT 3-DIMENSIONAL PROBE

COMPANY NAME	Santee Cooper		
PROBE: I.D.	B1323-7	LENGTH ~~10~~ 7'	SERIAL # 7
DATE OF CALIBRATION	7-2-85	TESTER	
FOR STD. PITOT Δp	0.730 IN. H_2O	C_p	0.99
P_T	0.760 IN. H_2O	$P_T - P_S$ ($\Delta p \times C_p{}^2$)	0.715 IN. H_2O
BARO. PRESSURE	29.6 IN. HG	TEMP 79 °F	VELOCITY ______ FT/SEC

YAW ANGLE TEST

PERCENT OF TOTAL PROBE LENGTH	20	40	60	80	100
INDICATED YAW ANGLE	0	-1	-2	0	-1

avg (-0.8)

PITCH ANGLE TEST

PITCH ANGLE, DEGREES	$P_1 - P_2$ IN. H_2O	±	$P_4 - P_5$ IN. H_2O	P_1 IN. H_2O	$\frac{P_4 - P_5}{P_1 - P_2}$	$\frac{P_T - P_S}{P_1 - P_2}$	$\frac{P_1 - P_T}{P_T - P_S}$
+60	0.330	+	0.610	0.440	1.85	2.17	-0.448
+55	0.460	+	0.640	0.590	1.39	1.55	-0.238
+50	0.530	+	0.520	0.720	0.981	1.35	-0.056
+45	0.590	+	0.420	0.740	0.712	1.21	-0.028
+40	0.650	+	0.340	0.750	0.523	1.10	-0.014
+35	0.710	+	0.260	0.760	0.366	1.01	0
+30	0.730	+	0.200	0.760	0.274	0.980	0
+25	0.730	+	0.150	0.760	0.206	0.980	0
+20	0.710	+	0.110	0.760	0.155	1.01	0
+15	0.690	+	0.070	0.760	0.101	1.04	0
+10	0.680	+	0.050	0.760	0.074	1.05	0
+5	0.670	+	0.020	0.760	0.030	1.07	0
0	0.660	-	0.015	0.760	0.015	1.08	0
-5	0.660	-	0.040	0.760	-0.061	1.08	0
-10	0.660	-	0.060	0.760	-0.091	1.08	0
-15	0.660	-	0.090	0.760	-0.136	1.08	0
-20	0.660	-	0.120	0.760	-0.182	1.08	0
-25	0.660	-	0.170	0.760	-0.258	1.08	0
-30	0.650	-	0.230	0.760	-0.354	1.10	0
-35	0.640	-	0.280	0.750	-0.438	1.12	-0.014
-40	0.640	-	0.350	0.720	-0.547	1.12	-0.056
-45	0.630	-	0.440	0.690	-0.698	1.13	-0.098
-50	0.630	-	0.590	0.640	-0.937	1.13	-0.168
-55	0.510	-	0.610	0.540	-1.20	1.40	-0.31
-60	0.460	-	0.690	0.360	-1.50	1.55	-0.56

ENTROPY

PROBE ID: B1323-7   Date: 070385

Angle	P1-P2	P4-P5	P1	PT	Pt-Ps	=	f1	f2	f3
60	0.3300	0.6100	0.4400	0.7150	0.7600	=	1.8485	2.1667	-0.4476
55	0.4600	0.6400	0.5900	0.7150	0.7600	=	1.3913	1.5543	-0.2378
50	0.5300	0.5200	0.7200	0.7150	0.7600	=	0.9811	1.3491	-0.0559
45	0.5900	0.4200	0.7400	0.7150	0.7600	=	0.7117	1.2119	-0.0280
40	0.6500	0.3400	0.7500	0.7150	0.7600	=	0.5231	1.1000	-0.0140
35	0.7100	0.2600	0.7600	0.7150	0.7600	=	0.3662	1.0070	0.0000
30	0.7300	0.2000	0.7600	0.7150	0.7600	=	0.2740	0.9795	0.0000
25	0.7300	0.1500	0.7600	0.7150	0.7600	=	0.2055	0.9795	0.0000
20	0.7100	0.1100	0.7600	0.7150	0.7600	=	0.1549	1.0070	0.0000
15	0.6900	0.0700	0.7600	0.7150	0.7600	=	0.1014	1.0362	0.0000
10	0.6800	0.0500	0.7600	0.7150	0.7600	=	0.0735	1.0515	0.0000
5	0.6700	0.0200	0.7600	0.7150	0.7600	=	0.0299	1.0672	0.0000
0	0.6600	0.0100	0.7600	0.7150	0.7600	=	0.0152	1.0833	0.0000
-5	0.6600	-0.0400	0.7600	0.7150	0.7600	=	-0.0606	1.0833	0.0000
-10	0.6600	-0.0600	0.7600	0.7150	0.7600	=	-0.0909	1.0833	0.0000
-15	0.6600	-0.0900	0.7600	0.7150	0.7600	=	-0.1364	1.0833	0.0000
-20	0.6600	-0.1200	0.7600	0.7150	0.7600	=	-0.1818	1.0833	0.0000
-25	0.6600	-0.1700	0.7600	0.7150	0.7600	=	-0.2576	1.0833	0.0000
-30	0.6500	-0.2300	0.7600	0.7150	0.7600	=	-0.3538	1.1000	0.0000
-35	0.6400	-0.2800	0.7500	0.7150	0.7600	=	-0.4375	1.1172	-0.0140
-40	0.6400	-0.3500	0.7200	0.7150	0.7600	=	-0.5469	1.1172	-0.0559
-45	0.6300	-0.4400	0.6900	0.7150	0.7600	=	-0.6984	1.1349	-0.0979
-50	0.6300	-0.5900	0.6400	0.7150	0.7600	=	-0.9365	1.1349	-0.1678
-55	0.5100	-0.6100	0.5400	0.7150	0.7600	=	-1.1961	1.4020	-0.3077
-60	0.4600	-0.6900	0.3600	0.7150	0.7600	=	-1.5000	1.5543	-0.5594

NOZZLE NUMBER: 204

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
11-30-82	TWA	.258	.256	.255	.258	.257	0.257"
11-18-83	PLO	.262	.259	.260	.260	.261	0.260"
3-8-84	JNC	.254	.256	.256	.257	.257	0.256"
7-5-84	GMC	.256	.254	.255	.253	.256	0.255"
3-25-85	MRH	.255	.256	.254	.256	.257	0.256"
7-19-85	LWB	.252	.253	.253	.254	.251	0.253"
2.26.86	BB	.253	.251	.254	.252	.253	0.253
3-21-86	LE	.259	.260	.258	.261	.260	0.260
7-1-86	BB	.254	.256	.256	.253	.255	0.255

ENTROPY ENVIRONMENTALISTS, INC.

NOZZLE NUMBER: 206

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
11-30-82	TWA	.255	.255	.256	.256	.256	0.256"
4-15-83	PLO	.260	.260	.259	.258	.259	0.259"
11-18-83	PLO	.257	.258	.259	.259	.257	0.258"
3-8-84	JNC	.253	.254	.255	.253	.252	0.253"
7-5-84	GML	.251	.253	.250	.254	.252	0.252"
3-25-85	MRH	.252	.251	.252	.250	.251	0.251"
7-19-85	RWB	.247	.244	.247	.247	.246	0.246"
2-26-86	BB	.249	.250	.252	.248	.251	0.250
7-1-86	TBB	.249	.250	.250	.251	.251	0.250

NOZZLE NUMBER: 207

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
11-30-82	TWA	.309	.310	.310	.310	.309	0.310"
11-18-83	PLO	.314	.314	.312	.315	.314	0.314"
3-8-84	JNC	.312	.312	.311	.312	.312	0.312"
7-5-84	GMC	.305	.306	.304	.302	.304	0.304"
1/3/85	ATM	.313	.310	.310	.311	.311	0.311"
3-25-85	MRH	.307	.308	.305	.307	.306	0.307"
7-19-85	RWB	.305	.306	.307	.305	.303	0.305"
2.26.86	BB	.310	.311	.308	.309	.307	0.309
7-1-86	BB	.307	.305	.308	.306	.308	0.307

NOZZLE NUMBER: 208

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
11-30-82	TWA	.301	.303	.301	.300	.302	0.301"
4-15-83	PLO	.303	.301	.303	.302	.302	0.302"
11-18-83	PLO	.304	.305	.302	.304	.303	0.303"
3-8-84	JNC	.303	.305	.306	.305	.303	0.304"
7-5-84	GMC	.303	.301	.304	.304	.301	0.303"
3-25-85	MRH	.301	.305	.302	.304	.304	0.303"
7-19-85	RWB	.301	.305	.304	.302	.303	0.303"
2-26-86	BB	.308	.305	.307	.307	.304	0.306
7-1-86	BB	.311	.313	.313	.312	.311	0.312

NOZZLE NUMBER: 209

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
11-30-82	TWA	.312	.311	.310	.309	.310	0.310"
4-15-83	PLO	.313	.314	.313	.315	.313	0.314"
11-18-83	PLO	.315	.313	.316	.313	.315	0.314"
3-8-84	JNC	.308	.312	.312	.310	.308	0.310"
10-23-84	SH	.310	.306	.307	.306	.310	0.308"
1/3/85	ATM	.312	.312	.311	.310	.311	0.311"
3-25-85	MRH	.308	.305	.306	.308	.309	0.307"
7-19-85	RWB	.301	.305	.302	.304	.302	0.303"
2-26-86	BB	.315	.315	.314	.313	.313	0.314
7-1-86	BB	.308	309	308	.306	.307	0.308

ENTROPY ENVIRONMENTALISTS, INC.

NOZZLE NUMBER: 704

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
12-2-82	ST	.239	.243	.242	.242	.243	0.242"
4-6-83	PLO	.246	.244	.244	.243	.245	0.244"
11-18-83	PLO	.244	.246	.244	.246	.245	0.245"
3-8-84	JNC	.244	.245	.245	.247	.244	0.245"
7-6-84	TTM	.247	.247	.248	.247	.246	0.247
10-23-84	ATM	.242	.242	.243	.242	.243	0.242
10.24.85	GC	.246	.246	.248	.249	.247	0.247
2-13-86	T. McD.	.248	.247	.250	.251	.248	0.249

NOTE: All diameters measured in inches.

NOZZLE NUMBER: 705

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
12-2-82	ST	.255	.254	.255	.253	.255	0.254"
4-6-83	PLO	.260	.259	.258	.258	.259	0.259"
11-18-83	PLO	.260	.257	.257	.259	.260	0.259"
3-8-84	JNC	.253	.254	.254	.255	.255	0.254"
7-6-84	TTM	.253	.253	.252	.253	.252	0.253
10-23-84	ATM	.249	.251	.252	.250	.249	0.250
2-19-85	JDE	.251	.252	.250	.252	.253	0.252
10-24-85	GC	.256	.257	.254	.257	.256	0.256
2-13-86	T. McD.	.252	.255	.254	.255	.253	0.254
6-30-86	B.B	257	.255	.258	.255	.259	0.257

NOTE: All diameters measured in inches.

ENTROPY ENVIRONMENTALISTS, INC.

NOZZLE NUMBER: 707

Date	Initials	Dia. 1	Dia. 2	Dia. 3	Dia. 4	Dia. 5	Average
12-2-82	ST	.299	.298	.300	.300	.301	0.300"
11-18-83	FLO	.304	.302	.304	.302	.303	0.303"
3-8-84	JNC	.300	.302	.303	.302	.301	0.302"
7-6-84	TTM	.302	.301	.302	.302	.301	0.302
10-23-84	ATM	.298	.298	.298	.297	.296	0.297
10.24.85	GC	.297	.296	.294	.296	.297	.296
2-13-86	T. McD.	.293	.293	.295	.296	.294	0.294
6-30-86	B.B	.299	.298	.300	.297	.299	0.299

NOTE: All diameters measured in inches.

ENTROPY ENVIRONMENTALISTS, INC.

TEMPERATURE SENSING EQUIPMENT CALIBRATION DATA

BAROMETRIC PRESSURE: 29.34 DATE: 2-18-86 CALIBRATED BY: TT

MERCURY-IN-GLASS REFERENCE NUMBER: 2012456 AMBIENT TEMP.: 69

B S

CALIBRATION SYSTEM USED	POTENTIOMETER I.D. NUMBER	THERMOCOUPLE/ THERMOMETER I.D. NUMBER	REFERENCE THERMOMETER TEMPERATURE T_o (°F)	T_c (°F)	MEAN TEMPERATURE OF Hg COLUMN T_m (°F)	THERMOCOUPLE/ THERMOMETER TEMPERATURE T_t (°F)	ΔT^B ≤ 1.5
Boiling Water	0009	5-2	210	212	120	213	.15
	0009	5-2	210	212	118	213	.15%
	0009	5-2	210	212	120	213	.15%
	0009	5-9	208	210	110	212	.3%
	0009	5-9	209	211	110	212	.15%
	0009	5-9	210	212	100	212	.0%
	013	5-4	208	210	110	209	.15
	013	5-4	210	212	110	210	.3%
	013	5-4	210	212	110	210	.3%
	005	7-8	208	210	110	213	.45
	005	7-8	210	211	128	213	.3%
	005	7-8	210	212	110	213	.15%
	~~013~~	~~5-1~~	~~210~~		~~120~~		
	~~013~~	~~5-1~~					
	~~013~~	~~5-1~~					
	005	5-50	210	212	120	213	-.15
	005	5-50	210	212	120	213	.15%
	005	5-50	210	212	100	213	.15%
	007	7-4	210	212	120	212	0
	007	7-4	210	212	120	212	0
	007	7-4	210	212	115	212	0
	013	7-2	210	212	96	211	.15%
	013	7-2	210	212	115	211	.15%
	013	7-2	210	212	120	211	.15%
	005	5-51	210	212	100	214	.3%
	005	5-51	210	212	120	214	.3%
	005	5-51	210	212	120	213	.15%

CORRECTED TEMPERATURE = $T_c = T_o + .00009\ (T_o - 20)(T_o - T_m)$

TEMPERATURE DIFFERENCE = $\Delta T = \left[\frac{(T_c, °F + 460) - (Tt, °F + 460)}{T_c, °F + 460}\right] \times 100 \leq 1.5\%$

TEMPERATURE SENSING EQUIPMENT CALIBRATION DATA

BAROMETRIC PRESSURE: 29.32   DATE: 2-19-86   CALIBRATED BY: TT

MERCURY-IN-GLASS REFERENCE NUMBER: 1961851   AMBIENT TEMP.: 70°

B   S

CALIBRATION SYSTEM USED	POTENTIOMETER I.D. NUMBER	THERMOCOUPLE/ THERMOMETER I.D. NUMBER	REFERENCE THERMOMETER TEMPERATURE T_o (°F)	T_c (°F)	MEAN TEMPERATURE OF Hg COLUMN T_m (°F)	THERMOCOUPLE/ THERMOMETER TEMPERATURE T_t (°F)	ΔT ≤1.5
Hot Oil	005	5-4	400	410	106	399	1.26
	005	5-4	400	410	108	399	1.2
	005	5-4	400	410	110	400	1.15
	013	5-2	400	410	106	400	1.15
	013	5-2	400	410	110	400	1.15
	013	5-2	400	410	110	399	1.26
	005	7-2	400	410	116	402	.92
	005	7-2	400	410	110	402	.92
	005	7-2	400	410	116	402	.92
	013	7-4	400	410	112	401	1.03
	013	7-4	400	410	110	400	1.15
	013	7-4	400	410	116	400	1.15
	005	7-8	400	410	112	401	1.03
	005	7-8	400	410	116	403	.8
	005	7-8	400	410	110	402	.92
	013	5-9	400	410	112	396	1.61
	013	5-9	400	410	116	398	1.38
	013	5-9	400	410	110	397	1.49
	005	5-50	400	410	116	401	1.03
	005	5-50	400	410	118	401	1.03
	005	5-50	400	410	114	401	1.03
	013	5-51	400	410	116	399	1.2
	013	5-51	400	410	118	400	1.15
	013	5-51	400	410	114	400	1.15
	~~013~~	~~9-1~~	~~400~~		~~120~~	~~399~~	
	~~013~~	~~9-1~~	~~400~~		~~124~~	~~399~~	
	~~013~~	~~9-1~~	~~400~~		~~122~~	~~399~~	

CORRECTED TEMPERATURE = $T_c = T_o + .00009\ (T_o - 20)(T_o - T_m)$

TEMPERATURE DIFFERENCE = $\Delta T = \dfrac{[(T_c, {}^{\circ}F + 460) - (T_t, {}^{\circ}F + 460)]}{T_c, {}^{\circ}F + 460} \times 100 \le 1.5\%$

TEMPERATURE SENSING EQUIPMENT CALIBRATION DATA

BAROMETRIC PRESSURE: 29.50 DATE: 2-20-86 CALIBRATED BY: TT

MERCURY-IN-GLASS REFERENCE NUMBER: 196/851 AMBIENT TEMP.: 66

B S

CALIBRATION SYSTEM USED	POTENTIOMETER I.D. NUMBER	THERMOCOUPLE/ THERMOMETER I.D. NUMBER	REFERENCE THERMOMETER TEMPERATURE T_o (°F)	T_c (°F)	MEAN TEMPERATURE OF Hg COLUMN T_m (°F)	THERMOCOUPLE/ THERMOMETER TEMPERATURE T_t (°F)	ΔT^B $\leq$1.5
Hot Oil	005	6-2	400	410	120	400	1.15
	005	6-2	400	410	122	401	1.03
	005	6-2	400	410	112	401	1.03
	013	7-2	400	410	126	396	1.61
	013	7-2	400	410	120	396	1.61
	013	7-2	400	410	112	396	1.61
	005	5-11	400	410	116	401	1.03
	005	5-11	400	410	122	400	1.15
	005	5-11	400	409	126	400	1.04
	013	6-3	400	410	116	396	1.61
	013	6-3	400	410	122	394	1.84
	013	6-3	400	409	126	393	1.84
	005	6-1	400	410	116	396	1.61
	005	6-1	400	410	122	398	1.38
	005	6-1	400	410	112	399	1.26
	013	7-1	400	410	116	396	1.61
	013	7-1	400	410	122	398	1.38
	013	7-1	400	410	112	399	1.26
	005	6-0	400	410	118	401	1.03
	005	6-0	400	410	112	401	1.03
	005	6-0	400	410	120	401	1.03
	013	5-7	400	410	118	395	1.72
	013	5-7	400	410	112	395	1.72
	013	5-7	400	410	120	395	1.72
	005	4-10	400	410	114	399	1.26
	005	4-10	400	410	114	402	.92
	005	4-10	400	410	108	403	.8
	013	4-5	400	410	114	398	1.38
	013	4-5	400	410	114	400	1.15
	013	4-5	400	410	108	402	.92

CORRECTED TEMPERATURE = $T_C = T_O \pm .00009\ (T_O-20)(T_O-T_m)$

TEMPERATURE DIFFERENCE = $\Delta T = \dfrac{[(T_C,{}^\circ F + 460) - (T_t,{}^\circ F + 460)]}{T_C,{}^\circ F + 460} \times 100 \leq 1.5\%$

ENTROPY

Meter Box Number: N6

Calibration by: T. Taylor

Standard Meter Number: 1012067 Standard Meter Gamma: 1.002

Date: 6-12-86 Barometric Pressure (P_b): 29.36 in. Hg

*Date: ________ *Barometric Pressure (P_b): ________ in. Hg

PRETEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
4.200	72	10.0	0.50	4.123	75	1.0252	1.61
4.189	72	10.0	0.50	4.133	76	1.0219	1.62
8.206	72	10.0	2.1	8.316	84.5	1.0067	1.74
8.190	72	10.0	2.1	8.369	92.5	1.0130	1.73
12.120	72	10.0	4.8	12.449	95	1.0056	1.79
12.113	72	10.0	4.8	12.503	95.5	1.0016	1.79
					Average	1.0123	1.71

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}} \right]^2$$

Meter Box Number: N10

Calibration by: T. McDaniel

Standard Meter Number: 6838323 Standard Meter Gamma: 1.0042

Date: 4-8-86 Barometric Pressure (P_b): 29.20 in. Hg

*Date: ________ *Barometric Pressure (P_b): ________ in. Hg

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
4.144	72	10.0	0.50	4.330	82	.9779	1.64
4.218	74	10.0	0.50	4.353	77	.9773	1.61
8.345	74	10.0	2.1	8.557	81	.9869	1.71
8.271	74	10.0	2.1	8.562	84	.9830	1.73
12.560	73	10.0	4.8	12.929	88	.9910	1.70
12.504	72	10.0	4.8	12.926	90	.9923	1.70
					Average	.9847	1.68

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

Meter Box Number: N12	Calibration by: T. Taylor

Standard Meter Number: 1017057 Standard Meter Gamma: 1.002

Date: 5-13-86 Barometric Pressure (P_b): 29.55 in. Hg

*Date: ________ *Barometric Pressure (P_b): __________ in. Hg

PRETEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
3.909	70	10.0	.50	4.029	85	.998	1.80
3.921	70	10.0	.50	4.049	87	.995	1.78
8.045	70	10.0	2.1	8.219	83	1.00	1.79
8.024	70	10.0	2.1	8.204	84	1.00	1.80
12.400	70	10.0	4.8	12.371	90.5	1.031	1.70
12.384	70	10.0	4.8	12.374	92.5	1.033	1.70
					Average	1.01	1.76

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

ENTROPY

Meter Box Number: N14	Calibration by: T. Taylor

Standard Meter Number: 1012057 Standard Meter Gamma: 1.002

Date: 6-5-86 Barometric Pressure (P_b): 29.60 in. Hg

*Date: ________ *Barometric Pressure (P_b): ________ in. Hg

PRETEST CALIBRATION

Standard Meter			Meter Box Metering System				
Gas Volume (V_{ds}) ft^3	Temp. (t_{ds}) °F	Time (θ) min.	Orifice Setting (ΔH) in. H_2O	Gas Volume (V_d) ft^3	Temp. (t_d) °F	Coeff. (Y_d)	$\Delta H_@$ in. H_2O
4.044	73	10.0	0.50	4.125	83	.9995	1.71
4.024	73	10.0	0.50	4.131	83.5	.9940	1.72
8.158	73	10.0	2.10	8.182	79.5	1.0060	1.77
8.130	73	10.0	2.10	8.230	82.5	1.0022	1.78
12.543	73.5	10.0	4.8	12.767	88.5	1.00022	1.69
12.519	74	10.0	4.8	12.810	92.5	1.0012	1.69
					Average	1.0005	1.72

$$Y_d = \frac{Y_{ds} * V_{ds} * (t_d + 460) * P_b}{V_d * (t_{ds} + 460) * (P_b + H/13.6)}$$

$$\Delta H_@ = \frac{0.0317 * \Delta H}{P_b * (t_d + 460)} * \left[\frac{(t_{ds} + 460) * \theta}{Y_{ds} * V_{ds}}\right]^2$$

Dry Gas Meter Identification: 1017057   Calibration by: N. Handen

Date: 4-1-86   Barometric Pressure (P_b): 29.86 in. Hg

*Date: ______   *Barometric Pressure (P_b): ______ in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (θ) min.	Flow Rate (Q) cfm	Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
0.40	4.062	78.8	4.062	80	0.85	10.0	0.3971	1.0001	
	4.117	79.3	4.061	80	0.85	10.0	0.4021	1.0130	
	4.189	79.7	4.065	80	0.85	10.0	0.4088	1.0289	
0.60	6.084	79.7	6.035	80	1.3	10.0	0.5938	1.0055	
	6.166	79.7	6.016	80	1.275	10.0	0.6018	1.0223	
	6.102	79.7	6.015	80	1.25	10.0	0.5955	1.0119	
0.80	8.097	79.7	7.996	80	2.35	10.0	0.7902	1.0074	
	8.132	79.7	8.003	80	2.40	10.0	0.7937	1.0107	
	8.114	79.3	7.996	80	2.45	10.0	0.7925	1.0100	
1.0	10.128	78.8	10.119	80	3.875	10.0	0.9901	0.9936	
	10.164	78.8	10.081	80	3.80	10.0	0.9936	1.0011	
	10.173	78.8	10.092	80	3.80	10.0	0.9945	1.0009	
1.2	12.359	78.8	12.305	80	5.5	10.0	1.2082	0.9932	
	12.368	78.8	12.316	80	5.3	10.0	1.2091	0.9935	
	12.313	78.8	12.274	80	5.3	10.0	1.2031	0.9925	

$$Y_{ds} = \frac{(V_s)\ (t_{ds} + 460)\ (P_b)}{(V_{ds})\ (t_s + 460)\ (P_b + (\Delta p / 13.6))}$$

$$Q = (17.64)\ \frac{(P_b)\ (V_s)}{(t_s + 460)\ (\theta)}$$

Dry Gas Meter Identification: 1017057 Calibration by:

Date: 4-1-86 Barometric Pressure (P_b): 25.86 in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

*Date: *Barometric Pressure (P_b): in. Hg

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (θ) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
1.4	14.454	79.7	14.462	81	7.625	10.0	1.4107	0.9834	
	14.444	78.8	14.446	80.5	7.55	10.0	1.4120	0.9847	
	14.391	78.8	14.406	80	7.575	10.0	1.4076	0.9834	

$\bar{Y}_{ds} = 1.002$

$$Y_{ds} = \frac{(V_s)(t_{ds} + 460)(P_b)}{(V_{ds})(t_s + 460)(P_b + (p / 13.6))}$$

$$Q = (17.64) \frac{(P_b)(V_s)}{(t_s + 460)(\theta)}$$

Dry Gas Meter Identification: 6838323 Calibration by: MH

Date: 3-26-86 Barometric Pressure (P_b): 30.12 in. Hg

*Date: 3-27-86 *Barometric Pressure (P_b): 29.85 in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft³	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft³	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (Θ) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
0.30	2.924	82.4	2.906	81	0.40	10.00	0.2864	1.0026	
	2.969	82.8	2.869	81	.40	10.00	.2906	1.0304	
	3.652	83.3	3.501	81	.40	12.00	.3571	1.0377	
* 0.40	4.235	80.6	4.330	77	0.85	10.00	.4125	.9700	
	4.545	80.6	4.370	78	.85	10.00	.4427	1.0328	
	4.417	80.6	4.345	79	.85	10.00	.4302	1.0114	
0.50	5.328	78.8	5.206	75	1.10	10.00	.5271	1.0135	
	5.383	79.7	5.212	77	1.15	10.00	.5317	1.025	
	5.301	79.7	5.166	78	1.15	10.00	.5219	1.020	
* 0.80	8.288	81	8.216	79	2.65	10.00	.8067	.9985	
	8.397	82	8.214	80	2.65	10.00	.8158	1.0119	
	8.352	82.4	8.199	80	2.65	10.00	.8108	1.0075	
1.00	10.638	83.3	10.472	81	4.15	10.00	1.040	1.0014	
	10.656	83.3	10.534	81.5	4.15	10.00	1.042	.9981	
	10.528	83.3	10.450	81.5	4.15	10.00	1.0296	.9941	

$$Y_{ds} = \frac{(V_s)(t_{ds} + 460)(P_b)}{(V \quad (t, \quad 60 \quad) + \quad / \quad))}$$

$$Q = (17.64)\frac{(P_b)(V_s)}{(t_s + 460)(\Theta)}$$

Dry Gas Meter Identification: 6838323 Calibration by: MH

Date: 3-26-86 Barometric Pressure (P_b): 30.12 in. Hg

*Date: 3-27-86 *Barometric Pressure (P_b): 29.85 in. Hg

ENTROPY ENVIRONMENTALISTS, INC.

Approx. Flow Rate (Q) cfm	Spirometer Gas Volume (V_s) ft^3	Spirometer Temp. (t_s) °F	Dry Gas Meter Gas Volume (V_{ds}) ft^3	Dry Gas Meter Temp. (t_{ds}) °F	Pressure (Δp) in. H_2O	Time (Θ) min.	Flow Rate (Q) cfm	Meter Meter Coeff. (Y_{ds})	Avg. Meter Coeff. ($\bar{Y}_{ds}$)
* 1.20	12.304	82.4	12.168	80	5.50	10.00	1.1945	0.9932	
	12.177	82.4	12.065	80	5.50	10.00	1.1821	.9914	
	12.186	82.4	12.100	80	5.50	10.00	1.1830	.9892	
1.35	13.698	82.4	13.494	79.5	6.85	10.00	1.3418	.9931	
	13.552	82.4	13.505	80	6.85	10.00	1.33	.9826	
	13.752	81.5	13.712	80	7.00	10.00	1.35	.9833	

$\bar{Y}_{ds} = 1.0042$

$$Y_{ds} = \frac{(V_s)\,(t_{ds} + 460)\,(P_b)}{(V_{ds})\,(t_s + 460)\,(P_b + (\Delta p / 13.6))}$$

$$Q = (17.64)\,\frac{(P_b)\,(V_s)}{(t_s + 460)\,(\Theta)}$$

Date:	9-4-86	Time:	15:47
Client:	EMB. EXXON BAYTOWN	Auditor:	BB
P_{bar}:	30.35 in. Hg.	Meter Box No.:	N-6
$\Delta H@$:	1.71	Pretest Y:	1.0123

Orifice gauge reading $\Delta H@$ in. H_2O	Dry gas meter reading V_i/V_f ft^3	Meter Temperatures T_i/T_f	Duration of run θ min.
1.71	963.300	88	10
	970.803	90	

Dry Gas meter volume V_m ft^3	Meter temperature average t_m ^oF	Pretest Y 0.97Y 1.03Y	Calculated Y_c	Audit $0.97Y < Y_c < 1.03Y$ Acceptable
7.503	89	0.9819	1.0124	
		1.0427		

Calculated Y_c

$$\frac{10}{V_m}\left(\frac{0.0319\ (tm + 460)}{P_{bar}}\right)^{1/2} = \frac{10}{(7.503)}\left(\frac{0.0319(\ 89\ + 460)}{(\ 30.35\ )}\right)^{1/2}$$

Figure 5.2. Meter box audit.

Date: 9/4/86 Time: 1520

Client: EMB Auditor: T. McDonald

P_{bar}: 30.35 in. Hg. Meter Box No.: N 10

$\Delta H_@$: 1.68 Pretest Y: 0.9847

Orifice gauge reading $\Delta H_@$ in. H_2O	Dry gas meter reading V_i/V_f ft^3	Meter Temperatures T_i/T_f	Duration of run Θ min.
1.68	484.671	88	10
	477.103	88	

Dry Gas meter volume V_m ft^3	Meter temperature average t_m ^oF	Pretest Y 0.97Y 1.03Y	Calculated Y_c	Audit $0.97Y < Y_c < 1.03Y$ Acceptable
7.568	88	0.9552	1.0028	
		1.0142		

Calculated Y_c

$$\frac{10}{V_m}\left[\frac{0.0319\ (tm + 460)}{P_{bar}}\right]^{1/2} = \frac{10}{(7.568)}\left[\frac{0.0319(\ 88 + 460)}{(\ 30.35\ )}\right]^{1/2}$$

Figure 4. Meter box audit.

Date:	09.04.86	Time:	1542
Client:	EMB – EXXON	Auditor:	BFR
P_{bar}:	30.35 in. Hg.	Meter Box No.:	N.12
$\Delta H_@$:	1.76	Pretest Y:	1.01

Orifice gauge reading $\Delta H_@$ in. H_2O	Dry gas meter reading V_i/V_f ft^3	Meter Temperatures T_i/T_f	Duration of run Θ min.
1.76	462.101	89	10
	469.804	90	

Dry Gas meter volume V_m ft^3	Meter temperature average t_m $°F$	Pretest Y 0.97Y 1.03Y	Calculated Y_c	Audit 0.97Y < Y_c < 1.03Y Acceptable
7.703	89.5	0.9797 / 1.0403	0.9866	

Calculated Y_c

$$\frac{10}{V_m}\left[\frac{0.0319\ (t_m + 460)}{P_{bar}}\right]^{1/2} = \frac{10}{(7.703)}\left[\frac{0.0319\ (89.5 + 460)}{(30.35)}\right]^{1/2}$$

Figure 5.2. Meter box audit

Date: 9-4-86 Time: 1530

Client: EMB - Exxon, Baytown Auditor: DB

P_{bar}: 30.35 in. Hg. Meter Box No.: N-14

$\Delta H@$: 1.72 Pretest Y: 1.005

Orifice gauge reading $\Delta H@$ in. H_2O	Dry gas meter reading V_i/V_f ft^3	Meter Temperatures T_i/T_f	Duration of run θ min.
1.72	72.804	100	10
	80.356	103	

Dry Gas meter volume V_m ft^3	Meter temperature average t_m ^oF	Pretest Y 0.97Y 1.03Y	Calculated Y_c	Audit 0.97Y < Y_c < 1.03Y Acceptable
~~7~~.552	101.5	0.97097 / 1.03052	1.0173	

Calculated Y_c

$$\frac{10}{V_m}\left(\frac{0.0319\ (tm + 460)}{P_{bar}}\right)^{1/2} = \frac{10}{(\cancel{7}.552)}\left(\frac{0.0319(\ 101.5 + 460)}{(\ 30.35)}\right)^{1/2}$$

Figure 5.2. Meter box audit.

Instrumentation ... [illegible]

CALIBRATION OF PROPELLER ANEMOMETERS - 6-18-86

DR

ANEMOMETER #1

RPM's	VOLTAGE (mV)	α (rpm/mV)
900	250	3.60
1200	332	3.61
1500	415	3.61
1800	500	3.60

$\alpha = 3.61$

ANEMOMETER #2

RPM's	VOLTAGE (mV)	α (rpm/mV)
900	250	3.60
1200	332	3.61
1500	416	3.61
1800	500	3.60

$\alpha = 3.61$

ANEMOMETER #3

RPM's	VOLTAGE (mV)	α (rpm/mV)
900	250	3.60
1200	333	3.60
1500	416	3.61
1800	500	3.60

$\alpha = 3.60$

CALIBRATION OF PROPELLER ANEMOMETERS 6-18-86

DR

ANEMOMETER #4

RPM's	VOLTAGE (mV)	α (rpm/mV)
900	248	3.63
1200	331	3.63
1500	413	3.63
1800	498	3.61
		$\alpha = 3.63$

ANEMOMETER #5

RPM's	VOLTAGE (mV)	α (rpm/mV)
900	250	3.60
1200	331	3.63
1500	411	3.65
1800	495	3.64
		$\alpha = 3.63$

THE VARIABILITY OF THE RESULTS IS WITHIN THE LIMITS OF THE TEST METHOD. THEREFORE, AN α OF 3.60 rpm/mV SHOULD BE USED FOR ALL FIVE ANEMOMETERS.

BEARING TORQUE TESTS 6-18-86

DR

ANEMOMETER #	DISC TORQUE
1	0.3 gr-CM
2	0.2 gr-CM
3	0.3 gr-CM
4	0.3 gr-CM
5	0.3 gr-CM

NOTE : THE CRITICAL VALUE ASSOCIATED WITH POOR PERFORMANCE WOULD BE 0.9 gr-CM THEREFORE ALL 5 SENSORS ARE IN 'NEW' CONDITION.

ANEMOMETER CALIB. OF ESC =4 FORWARD(AS LEFT)1-7-86

VEL(FPM)=3445.2*VOLTS+ 20.2

VOLTS	V(MPS)	V(FPM)	VPRED(FPM)	ERR(%)	CL(FPM)	CL(%)
0.107	2.00	394	389	1.230	5.205	1.338
0.221	3.98	784	782	0.238	4.330	0.554
0.338	6.00	1181	1185	-0.302	3.557	0.300
0.452	7.99	1573	1577	-0.291	3.019	0.191
0.566	10.01	1971	1970	0.017	2.818	0.143
0.680	11.99	2360	2363	-0.112	3.023	0.128
0.795	14.02	2760	2759	0.028	3.570	0.129
0.908	15.98	3146	3149	-0.085	4.318	0.137
1.021	18.00	3543	3538	0.160	5.183	0.147

M.E. Clark.

Calibration of Two Standard Simplex Pitot Tubes (WF 6 (PFA 2338) and WF 6A) for Environmental Systems Corporation Knoxville, Tennessee

wo 6-ft. long standard Simplex tubes (WF 6 and WF 6A) were alibrated at two speeds between 7 and 10 fps in a 24-in. piral-riveted pipe line (tube lengths are approximate). The ine has a 30-foot test section of 24-inch seamless steel pipe hose thickness is 3/8 inches and whose internal diameter at the raverse location is 1.9378 ft (based on a series of eight nternal diametral measurements at the traverse location). Water as pumped through the pipe line by means of a 20 x 20-in. entrifugal pump driven by a 200 HP synchronous motor running at 00 rpm.

he actual flow rate was obtained volumetrically by timing the ise of a float gage in a tank which had a uniform area of 199.7 q.ft. The elapsed time was indicated by means of a digital top watch reading to 0.01 sec. Rise distances of 8 to 9 ft were mployed. Horizontal and vertical traverses were taken at a test tation some 97 ft downstream from a long radius bend with rough urning vanes and some 14 ft upstream from another bend. Two ets of traverse ports are available: for normal length tubes, ruely vertical and horizontal traverses can be made; for tubes f extended length, the "vertical" port is 20 degrees off from rue vertical so as to allow the tube to extend into a 5-ft deep hannel while the "horizontal" port is 100 degrees from true ertical so as to allow the tube to clear other laboratory ipes. The former ports were used in these calibrations. Each raverse consisted of velocity readings at 17 points. The Pitot ube positions tabulated and used in plotting the accompanying raphs are based on the distance of the impact hole of the Pitot rom the pipe wall on the far side of the pipe from the ttachment device. Pressure differentials were obtained with a ifferential pot-type manometer using carbon tetrachloride as he gage fluid; these observations were read in feet, tenths, nd hundreths. In obtaining manometer differentials, it was ecessary to average the fluctuations over a period of time usually a minute or so).

The calibration coefficients have been evaluated both in terms of a pipe velocity based on the actual pipe area and on an area orrected for the blockage effects of the Pitot tube. The area of the pipe at the test section was evaluated to be 2.9493 q.ft. The area of the Pitot tube exposed to the flow when nserted to each reference position was calculated (see attached lockage calculation sheet). The average of these areas (0.0301 q.ft. for PFA 2338) has been taken as the blockage area. The et area of the pipe for this Simplex was, therefore, Anet = 2.9493 - 0.0301 = 2.9192 sq.ft. The net pipe velocity would be he total flow rate as measured volumetrically divided by this rea; e.g., Vnet = Q/Anet = 30.2027/2.9192 = 10.3461 fps for the traverses at the largest flow rate. The nominal velocity for his flow rate was Vnom = 30.2027/2.9493 = 10.2406 fps.

The gage readings, the velocities calculated therefrom, and ther pertinent information from the test runs are tabulated on he accompanying data sheets and computer printouts. The average indicated velocity from the Pitot tube was calculated by averaging the fourteen velocities determined at the mid-areas of qual-area annuli (values at traverse locations 1, 9, and 17, ot at mid-areas, were excluded). These experimental points were plotted and a smooth curve was drawn through them. These curves ppear in the accompanying figures. Where any of the xperimental points deviated substantially from this smooth curve (usually where there is evidence of vibration), a velocity alue from the smooth curve was substituted for the indicated elocity. These values are also listed on the data (computer) heets as adjusted velocities.

he procedure for averaging the velocity values at equal area nnuli is in accord with an accepted procedure (cf, the ASME report of Fluid Meters). The procedure for substituting curve alues for indicated values is based on the following line of easoning: Manometer readings, at locations where tube vibration or other flow abnormalities occur, can and do vary considerably from normal values. When the tube is vibrating, the manometer eadings usually increase. Inclusion of these higher values in he coefficient calculations reduces the tube coefficient below that which would obtain without the vibration. Since vibration f the tube depends on many factors (tube extension, flow elocity, packing stiffness, mass and elastic characteristics of the rod, flow fluctuation severity, etc.) and since in field use ese factors could well come together differently than in the alibration runs, it is felt that such readings should be replaced with values taken from the smooth curve through the points free of vibration or other abnormalities. From many, any previous calibration runs using this test station, the general shapes of the velocity profiles, modified by Pitot tube blockage, are well known. Accordingly, the smooth curves (drawn gnoring "contaminated" values) can be produced with quite a igh degree of confidence. At the same time, it must be stated that not all velocity determinations suspected on the basis of tactile and/or audible signals of being influenced by vibration urn out to deviate significantly from the smooth curve drawn through the mean of the points. Contrariwise, when there is no tactile or audible evidence, it is not assured that the tube is ibration free and the velocity points might register higher han normal on the velocity profile. In the case of the present tests, tactile and audible evidence of vibration did appear at any of the traverse positions when testing these unreinforced implexes. In fact, for Tube 6A, when the tube was extended towards the opposite wall, the vibrations became quite violent.

net adjusted coefficient has been calculated using the djusted traverse velocities and the average pipe velocity based on the pipe area corrected for Pitot tube blockage. This alibration coefficient is calculated by dividing the net pipe elocity determined volumetrically (10.3461 fps for the example case shown above) by the average adjusted Pitot tube velocity as follows: C = 10.3461/12.4165 = 0.8333 (horizontal high velocity

-averse for PFA 2338 (WF6). In the writer's view, a coefficient based on adjusted Pitot velocities and a pipe velocity corrected for blockage must be used for interpreting measurements made in pipes of other sizes. The following table summarizes the calculation of the coefficients.

second method of interpreting the data which accounts for Pitot tube blockage in each individual velocity determination is presented in Appendix A. This method allows the velocity profile to be plotted free, so to speak, of blockage effects. The profiles shown on the accompanying graph(s) are skewed because of the presence of the rod and concomitant flow blockage. With this second interpretation, this skewedness can be effectively removed. As can be seen in the summary tables, the coefficients are little affected.

Based on the traverses at velocities between 7 and 10 fps, the coefficient recommended for use with standard Simplex tube PFA 2338 (WF6) is 0.8466, for PFA (WF6A), it is 0.8326. In using these values, the flow area should be taken as corrected for Pitot blockage (with tube extended halfway across the pipe or, more precisely, using an average of the blocking areas figured for each reference position. See attached sheets and the BASIC computer program for blockage calculations). If either the nominal or corrected average coefficients are used, the appropriate methods must be used to determine the average indicated or corrected velocity as well as the nominal pipe velocity.

It should be noted that both of these Simplex tubes calibrated on the high side of many Simplex calibrations. Exactly the same procedures are employed in each test. The reason why some tubes calibrate high, some low, some average is not known. Quite possibly, slight differences in geometric configuration are responsible. There is also the possibility that there is a definitive variation of coefficient with pipe velocity. In general, the coefficient of a well-designed Pitot tube is velocity-invariant, unless wide ranges in velocity are considered. In our calibration of Simplex tubes, the coefficient usually appears to decrease with increase in pipe velocity although the variation is never very large - a band of plus or minus one percent contains most of the data points. In these present calibrations, there was a consistent trend in this same direction. The direction of traverse, whether vertical or horizontal, did not seem to be a crucial factor in the calibrations.

Recently, a calibration test of a reinforced Simplex gave a rather clear indication as to a possible reason why some tubes give higher coefficients. At the request of a client who was observing the calibrations and to eliminate the necessity of moving the Simplex rod inside the reinforcing tube, a long 18 to 20 in. nipple was put between the valve and the Pitot. This nipple was some ordinary schedule pipe found in the laboratory. During the course of the calibrations, when the Pitot was taken in and out of the test pipe, the forces of tightening the nipple caused the nipple to distort. By the end of the calibration the nipple was quite bent and showed it. When the results were analyzed, it was found that the coefficient increased gradually and consistently as time of day progressed or as the pipe was becoming more and more distorted. When we retested the same tube ing a heavy schedule nipple of the same length, the libration was right at the average of many tests. To be sure, e same situation did not obtain in these present calibrations with regard to a long nipple. However, the same type of result uld be obtained with a standard unreinforced Simplex if its d was bent so that it did not traverse directly across the pipe on a diameter but went off on some chord of the oss-sectional circle.

te 5/30/86 Signed ____________________

M.E.Clark

Table. Calculation of Pitot Coefficients

Standard Simplex PFA 233B (WF 6)(6 ft. long)

Traverse	Horiz.	Vert.	Horiz.	Vert.
Nom Velocity Q/Apipe fps	7.273	7.273	10.241	10.241
Ave Ind Vel	8.773	8.602	12.627	12.427
Nom Ind C	0.8291	0.8456	0.8110	0.8240
Ave Nom Ind C			0.8274	
Net Velocity Q/Anet fps	7.348	7.348	10.346	10.346
Ave Adj Vel	8.657	8.483	12.416	12.346
Net Adj C	0.8488	0.8662	0.8333	0.8380
Ave Net Adj C			0.8466	
Ave Corr Vel	8.566	8.394	12.286	12.216
Corr Adj C	0.8491	0.8665	0.8335	0.8383
Ave Corr Adj C			0.8468	

Apipe = 2.9493 sq.ft. Anet = 2.9192 sq.ft.

Table. Calculation of Pitot Coefficients

Standard Simplex PFA (WF 6A)(6 ft. long)

Traverse	Horiz.	Vert.	Horiz.	Vert.
Nom Velocity Q/Apipe fps	7.273	7.273	10.348	10.348
Ave Ind Vel	8.856	8.731	12.855	12.552
Nom Ind C	0.7966	0.8159	0.8213	0.8331
Ave Nom Ind C			0.8167	
Net Velocity Q/Anet fps	7.350	7.350	10.348	10.348
Ave Adj Vel	8.703	8.673	12.749	12.518
Net Adj C	0.8445	0.8474	0.8117	0.8267
Ave Net Adj C			0.8326	
Ave Corr Vel	8.610	8.581	12.611	12.384
Corr Adj C	0.8447	0.8477	0.8120	0.8269
Ave Corr Adj C			0.8328	

Apipe = 2.9493 sq.ft. Anet = 2.9192 sq.ft.

CUSTODY SHEET FOR REAGENT BOX # 0205

Date of Makeup 8/15/86 Initials MJD Locked? ✓

Individual Tare of Reagent: 200.0 mls. of DISTILLED H_2O

Individual Tare of Reagent: ______ mls. of ______

Individual Silica Gel Tare Weight 200.0 gms.

PLANT NAME Exxon-Baytown Tx.

SAMPLING LOCATION Cooling Tower 68 fancell #5

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
CT68-5-1	9-1	KGD	✓	9-1	90	KGD	✓
CT68-5-2	9-1	KGD	✓	9-1	90	KGD	✓
CT68-5-3	9-2	KGD	✓	9-2	90	KGD	✓

Received in Lab Date 9/8 Initials J.F.J. Locked? ✓

Zero & Span Balance Initials J.F.J.

Sampling Method: EMB-Special Teflon filter
no tare wts

Filter #	Tare Weight (mgms)	Used on Test

Remarks:

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0215

Date of Makeup 8/26/86 Initials MJP Locked? ______

Individual Tare of Reagent: 200.0 mls. of Distilled H_2O

Individual Tare of Reagent: ______ mls. of ______

Individual Silica Gel Tare Weight 200.0 gms.

PLANT NAME Exxon-Baytown (EMB)

SAMPLING LOCATION cooling tower #68, fan cells 1, 2 & 3

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked
CT68-1-1	9-1	KOD	✓	9-1	90	KOD	✓
CT68-2-1	9-1	KOD	✓	9-1	90	KOD	✓
CT68-3-1	9-2	KOD	✓	9-2	95	KOD	✓

Received in Lab Date 9/8 Initials J.F.J. Locked? ✓

Zero & Span Balance Initials J.F.J.

Sampling Method: M5 w/ Teflon filters - no tare wt.

Filter #	Tare Weight (mgms)	Used on Test

Remarks:

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0218

Date of Makeup 8/26/86 Initials MJD Locked? ✓

Individual Tare of Reagent: 200.0 mls. of Distilled H_2O

Individual Tare of Reagent: ________ mls. of ________

Individual Silica Gel Tare Weight 200.0 gms.

PLANT NAME Exxon Baytown - EMB

SAMPLING LOCATION CT-68, CT-84

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
CT68-N2-1	9-1	KGD	✓	~~9/8~~ 9/2	90	KAD	✓
CT68-DI-1P	9-1	KGD	✓	~~9/8~~ 9/2	85	KAD	✓
CT68-N2-2	9-2	KAD	✓	~~9/8~~ 9/2	90	KAD	✓
CT-68-4	9-2	KAD	✓	9/2	90	KAD	✓
CT68-DI-2	9-2	KGD	✓	9/2	90	KGD	✓
CT-84-C-2	9-4	KGD	✓	9/2	90	KAD	✓

Received in Lab Date 9/8 Initials J.F.J. Locked? ✓

Zero & Span Balance Initials J.F.J.

Sampling Method: EMB - Special Teflon Filter
no the jt.

Filter #	Tare Weight (mgms)	Used on Test

Remarks:

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0228

Date of Makeup 8/26/86 Initials MJD Locked? ✓

Individual Tare of Reagent: 200.0 mls. of Distilled H_2O

Individual Tare of Reagent: ______ mls. of ______

Individual Silica Gel Tare Weight 200.0 gms.

PLANT NAME Exxon Baytown - EMB

SAMPLING LOCATION CT-68 - CT-84

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked
CT-68-DI-1	9-1	KOD	✓	9-1	90	KOD	✓
CT-68-DI-3	9-3	KOD	✓	9-3	90	KOD	✓
CT-68NZ-3	9-3	KOD	✓	9-3	85	KOD	✓
CT-84-C-1	9-4	KOD	✓	9-4	80	KOD	✓
CT-84-A-1	9-4	KOD	✓	9-4	90	KOD	✓
CT-84-A-2	9-4	KOD	✓	9-4	90	KOD	✓

Received in Lab Date 9/8 Initials J.F.J. Locked? ✓

Zero & Span Balance Initials J.F.J.

Sampling Method: MS/w Teflon Filter no tare wt.

Remarks:

Filter #	Tare Weight (mgms)	Used on Test

ENTROPY ENVIRONMENTALISTS, INC.

CUSTODY SHEET FOR REAGENT BOX # 0221

Date of Makeup 8/15/86 Initials MJD Locked? ✓

Individual Tare of Reagent: 200.0 mls. of DISTILLED H_2O

Individual Tare of Reagent: ______ mls. of ______

Individual Silica Gel Tare Weight 200.0 gms.

PLANT NAME Exxon Baytown

SAMPLING LOCATION CT 84

Run Number	Date Used	Initials	Locked?	Date Cleanup	% S. Gel Spent	Initials	Locked?
CT-84-N24	9-4	KGD	✓	9-4	90	KGD	✓
CT-84 DF-4	9-4	KGD	✓	9-4	90	KGD	✓
CT-84-S1-2	9-5	KGD	✓	9-5	90	KGD	✓
CT-84D1-2	9-5	KGD	✓	9-5	85	KGD	✓
Dr. CT-84N25	9-5	KGD	✓	9-5	95	KGD	✓
CT84 DF-5	9-5	KGD	✓	9-5	95	KGD	✓

Received in Lab Date 9/8 Initials J.F.J. Locked? ✓

Zero & Span Balance Initials J.F.J.

Sampling Method: M5/W Teflon Filters Heat wts.

Filter #	Tare Weight (mgms)	Used on Test

Remarks:

D-43

NTROPY ENVIRONMENTALISTS, INC.

APPENDIX E.

MRI PROCESS DATA

APPENDIX F.

TEST PARTICIPANTS AND OBSERVERS

SAMPLING PROGRAM PARTICIPANTS AND OBSERVERS

Name	Organization	Responsibility
Dan Bivins	EPA, Emission Measurement Branch	EPA Task Manager
Barry F. Rudd	Entropy Environmentalists, Inc.	Project Coordinator
Tom McDonald	Entropy Environmentalists, Inc.	Sampling Team Leader
Doug Biggerstaff	Entropy Environmentalists, Inc.	Sampling Technician
Scott Steinsberger	Entropy Environmentalists, Inc.	Sampling Technician
Kent Daeke	Entropy Environmentalists, Inc.	Sampling Technician
Robert W. Bridges	Entropy Environmentalists, Inc.	Sampling Technician
Tony Mastrianni	Entropy Environmentalists, Inc.	Sampling Technician
John Lewis	Environmental Systems Corporation	Field Engineer
David Randall	Midwest Research Institute	Process Monitoring
E. W. Biggers	Exxon Company	Facility Contact

United States
Environmental Protection
Agency

Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711