AP42 Section:	13.4
Background Chapter	4
Reference:	5
Title:	Cooling Tower DrifTest Report for Unnamed Client of the Cooling Tower Institute, Houston, Texas, March 1989. Midwest Research Institute (1989).

5

MRI REPORT

Cooling Tower Test Report

[redacted]

[redacted]

7-cell
Mechanical-Draft, Counter-Flow
Cooling Tower

Done

[redacted]

MRI Project No. [redacted]

March 20, 1989

MIDWEST RESEARCH INSTITUTE 425 Volker Boulevard, Kansas City, MO 64110-2299 • (816) 753-7600

SUMMARY

The testing services of Midwest Research Institute (MRI) were retained by [redacted], to conduct drift tests on a [redacted] 7-cell, mechanical-draft, counter-flow cooling tower located at the [redacted] The work was performed by MRI as an independent test contractor.

Cooling tower drift is defined as the percent of water flow through the tower which exits through the fan in the form of water droplets and aerosols. The amount of drift from the tower was determined by isokinetically sampling a representative fraction of the tower airflow and measuring the amount of droplets and aerosol leaving the stack. Inductively coupled argon plasma spectroscopy (ICP), an extremely sensitive detection technique, was then used to measure the concentration of three selected trace constituents (Ca, Mg, Na) in the basin water and water collected from the airflow exiting the fan stack. From the measurements of the selected trace constituents in the isokinetic sampling train and the same trace constituents in the basin water, the drift rate was calculated.

The calculated drift rates lie between 0.0507% and 0.0918% for cell E, depending on which of the three tracers were used. When the results are averaged for all tracers, a drift rate of 0.0657% is obtained for cell E.

The calculated drift rates lie between 0.0394% and 0.0700% for cell F, depending on which of the three tracers were used. When the results are averaged for all tracers, a drift rate of 0.0505% is obtained for cell F.

The average calculated drift rate from cells E and F is 0.0581%.

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE

[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

SECTION 1

INTRODUCTION

The testing services of the Midwest Research Institute (MRI) were retained by [redacted] under Purchase Order No. [redacted] to conduct drift tests using modified EPA Method 13A isokinetic sampling techniques on a [redacted] mechanical-draft, counter-flow cooling tower. The cooling tower is located at [redacted] The work was performed by Mr. Nicholas M. Stich, Mr. Thomas E. Weast, and Mr. Gary Garman of MRI.

The cooling tower was originally constructed approximated six years ago. Because the tower structure, which is constructed of concrete, has deteriorated, [redacted] has recently built a replacement tower approximately 50 ft east of the original tower. The purpose of the tests on the original tower is to document the drift rates for the tower in its present condition before it is removed.

SECTION 2

TEST SITE DESCRIPTION

The [redacted] is located at [redacted] The [redacted] cooling tower provides cooling water to steam condensers. The cooling tower is located on the south side of the plant. A new nonoperating tower has been constructed parallel to and approximately 50 ft east of the tested tower.

The tested cooling tower consists of seven mechanical-draft, counter-flow cells in a continuous straight line with a common cold water basin beneath the tower. Each cell is equipped with a Hudson 40-ft diameter fan driven by a 200-hp motor. The hub seal was 156 in. in diameter. The fan stack was 488 in. in diameter (at the sample plane location), 16 ft 4 in tall, and constructed of concrete.

One 90-in diameter underground concrete conduit returns hot water from the plant to the cooling tower. The main line then tees off to feed seven individual internal cell risers. A pitot tap for water flow measurement was located in the 90-in main line. Plant personnel broke the 2-in valve off the main line while attempting to remove the plug from the valve. Therefore, water flow measurements were then obtained from plant instrumentation using the plant annubar.

The cold water from the cooling tower basin is collected in the pump forebay adjacent to the tower where three pumps are used to return cold water to the plant. A tap with temporary standpipe was used for the collection of basin water samples.

SECTION 3

SAMPLING SEQUENCE

The test sequence for the drift test was as follows:

1. Water flow and fan horsepower measurement were conducted and the tower operations monitored.

2. Drift sample and airflow measurement locations were calculated.

3. A basin water sample was collected.

4. Isokinetic drift sampling of the selected fan stack was conducted.

5. A second basin water sample was collected during the middle of the drift test.

6. Isokinetic drift sampling of the fan was completed.

7. A third basin sample was collected at the conclusion of the test. The three basin samples were composited into one basin water sample.

8. The drift samples were recovered from the sample collection system.

9. The basin composite, water blank, and drift impinger samples were acid-stabilized and transported to the laboratory for analysis.

SECTION 4

DRIFT TEST EQUIPMENT

SAMPLE LOCATION

Since drift is defined as the amount of droplets or aerosols exiting the fan stack, the drift tests must be made at the top of the fan stack. Also, the proximity of the sample locations to the fan required that the station locations be adjusted for the hub effect. Sample locations were determined for 10-point radial traverses using the equation for equal annular areas for fan discharge from Chapter 5 of the CTI Manual.

AIR PITOT-DRIFT PROBE

Since cyclonic flow can bias the drift results, adjustments in the sampling technique must be used to eliminate this bias. A special MRI air pitot-drift probe assembly was developed to allow unbiased sampling. If the sample nozzle is not aligned with the flow, then effective velocity through the nozzle opening is reduced by the cosine of the angle between the flow and stack axis. This results in a sample which is not truly isokinetic and thus the alignment approach must be used for the drift test to eliminate this bias. Since the sample proportionality could be compromised with the alignment approach,[1] proportional sampling needs are then satisfied by adjusting the nominal base sample time by the cosine of the cyclonic flow angle.

Airflow, fan discharge temperature, and the angle of cyclonic flow were measured with this probe assembly. The air pitot-drift probe assembly was equipped with:

1. S-type primary pitot tips which are connected to a manometer to measure air velocity.

2. Secondary pitot tips which are positioned at 90 degrees from the primary pitot tips. The secondary set of pitot tips are connected to a separate manometer to align the probe and compensate for any cyclonic flow effects.

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[1] Peeler, J. W., F. J. Phoenix, and D. J. Grove, "Characterization of Cyclonic Flow and Analysis of Particulate Sampling Approaches at Asphalt Plant," Entropy Environmentalists, Inc.

3. A temperature sensor connected to a digital readout to measure the stack temperature.

4. A protractor attached to the probe assembly to determine the angle that the probe is rotated during the cyclonic flow determination.

5. A stainless steel sample nozzle and flexible Teflon sample probe which are connected to the drift collection train.

DRIFT COLLECTION TRAIN

The drift collection train consists of four high capacity impingers and a filter assembly. Impingers 1 and 2 contained distilled water and were used to scrub out the aerosols and water droplets. The third impinger was used to collect any water droplets that might be carried over from the previous impingers. The filter was used as the final collection media and was placed between impinger 3 which was dry and impinger 4 which contained silica gel. The sampling train was kept iced during testing to help reduce the water vapor pressure and to further improve collection efficiency.

CONTROL CONSOLE AND PUMP

The control console and pump was provided by a High Volume Sampling System (HVSS) consistent with EPA Method 5 requirements. The impinger train is connected to the console via a sample line through the leak-free vacuum pump capable of up to 4 cfm. The modular vacuum pump has two control valves to adjust and maintain the desired sampling rate. The console contains a calibrated dry gas meter, digital temperature readout, manometers, and associated controls.

SECTION 5

DRIFT TEST METHODS

Testing was conducted on [redacted] The tower's circulating water flow was approximately 100% of design and the fan horsepower was 7.5% above the motor nameplate. The test data were acquired in accordance with applicable portions of the CTI ACT-105 (1982) test code. The individual parameters were measured as follows:

- Total circulating water flow was measured using the plant annubar instrumentation.

- Fan motor power was measured with a clamp-on digital kilowatt meter, using the two-watt meter method.

- Air velocity was measured with four 10-point radial traverses of the fan stack using the predetermined sampling locations. At each point the MRI air pitot-drift probe assembly was rotated until the pressure difference across the secondary pitot tips was zero. When this zero differential has been obtained, the primary probe has been aligned with the flow and the protractor read to determine the cyclonic flow angle. The probe assembly was then used to measure the velocity pressure and temperature at the sample point.

- The isokinetic sample rate and proportional sample duration were determined using an Epson HX-20 computer. The previously determined velocity pressure, stack temperature, and cyclonic flow angle were used by the computer program to calculate the required sample volume, isokinetic rate, and the adjusted base sample time.

- Sampling at each traverse location was commenced after the proper sample rate was determined by turning on the sample pump and simultaneously activating the variable timer function of the HX-20 computer. When each sample time had ended the pump was shut off, the air pitot-probe assembly was relocated to the next sample location, and the above procedure repeated until all 40 points had been sampled.

- The drift sample recovery was initialed by using distilled deionized water to rinse the stainless steel nozzle and flexible Teflon probe into the contents of the first impinger. The impinger train was sealed and then removed from the cooling tower to sample recovery location where the remainder of the sample recovery was performed. The impinger volumes and rinse volumes were measured and recorded.

The impinger contents along with all rinses were transferred to sample bottles. A distilled deionized water blank was taken. Both the drift impinger samples and water blank were nitric acid stabilized and then returned to MRI for further analysis.

- Basin water samples were taken at the beginning, the midpoint, and the conclusion of the drift sample. The basin water sample was taken from a thermal well that was installed on the discharge side of the circulating water flow pump. The samples were collected after the thermal well line was purged. The three samples were collected and then combined into one composite basin water sample. The composite basin sample was stabilized with nitric acid in the same manner as were the impinger and water blank samples. The composite basin water sample was returned to MRI for further analysis.

SECTION 6

SAMPLE ANALYSIS

The samples were returned to MRI where custody of the samples was transferred to the analytical section. Quantitative analysis of selected trace elements in both the tower basin water samples and the collected drift samples was then performed by the analytical section. The samples were digested using EPA Method 3050 to ensure that all elements were in solution. A Jarrell-Ash Model 1155A ICP-AES instrument was used to analyze the samples by inductively coupled argon plasma spectroscopy (ICP) using EPA Method 6010. The methods are described below. The laboratory results are presented in the appendices.

METHOD 3050

Method 3050 is an acid digestion procedure used to prepare sediments, sludges, and soil samples for analysis by flame or furnace atomic absorption spectroscopy (FLAA and GFAA, respectively) or by inductively coupled argon plasma spectroscopy (ICP).

A representative sample is digested in nitric acid and hydrogen peroxide. The digestate is then refluxed with either nitric acid or hydrochloric acid. Dilute hydrochloric acid is used as the final reflux acid for (1) the ICP analysis of As and Se, and (2) the flame AA or ICP analysis of Al, Ba, Ca, Cd, Cr, Co, Cu, Fe, Mo, Pb, Ni, K, Na, Tl, V, and Zn. Dilute nitric acid is employed as the final dilution acid for the furnace AA analysis of As, Be, Cd, Cr, Co, Pb, Mo, Se, Tl, and V.

METHOD 6010

Method 6010 describes the procedures for inductively coupled argon plasma spectroscopy (ICP) in determining elements including metals in solution. This method is applicable to a large number of metals and wastes. All matrices, including ground water, aqueous samples, EP extracts, industrial wastes, soils, sludges, sediments, and other solid wastes, require digestion prior to analysis.

The simultaneous, or sequential, multielemental determination of elements by ICP is measured by element-emitted light by optical spectrometry. Samples are nebulized and the resulting emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the lines are monitored by photomultiplier tubes. Background correction is required for trace element determination.

SECTION 7

RESULTS AND CONCLUSIONS

The following equation is used by MRI to calculate the drift results. additional details are given in the appendices.

$$\% \text{ Drift} = 100 * (NFA * NWT) / (NZA \bullet WFR * EQT * BTC)$$

NFA = Net Fan Area (ft^2)
NWT = Net Weight of Tracer (mcg)
NZA = Nozzle Area (ft^2)
WFR = Waterflow Rate (g/min)
EQT = Equivalent Sample Time (200 min)
BTC = Basin Tracer Concentration (mcg/g)

The table below summarizes the results of the laboratory analysis and drift calculations for fan E.

Tracer Analyzed	Tracer Net wt. (mcg)	Basin Conc. (mcg/g)	Drift % of gpm
Ca	947.3	63.60	0.0918
Mg	180.3	20.30	0.0547
Na	14222.6	1730.0	0.0507

The table below summarizes the results of the laboratory analysis and drift calculations for fan F.

Tracer Analyzed	Tracer Net wt. (mcg)	Basin Conc. (mcg/g)	Drift % of gpm
Ca	752.1	66.20	0.0700
Mg	140.7	20.60	0.0421
Na	11441.5	1790.0	0.0394

The calculated drift rates lie between 0.0507% and 0.0918% for cell E, depending on which of the three tracers were used. When the results are averaged for all tracers, a drift rate of 0.0657% is obtained for cell E.

The calculated drift rates lie between 0.0394% and 0.0700% for cell F, depending on which of the three tracers were used. When the results are averaged for all tracers, a drift rate of 0.0505% is obtained for cell F.

The average drift rate from cells E and F is 0.0581%.

APPENDIX A

SUMMARY OF RESULTS

FAN F

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE

[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

MIDWEST RESEARCH INSTITUTE

DRIFT DATA REDUCTION

RUN #1 FAILURE ANALYSIS - [redacted]

Sample Volume	729	Rinse Volume	183
Water Blank Volume	433	Initial Water Vol.	250

DESCRIPTION	Ca	Mg	Na
Basin Water (mcg/g)	66.20	20.60	1790.00
Impinger (mcg/g)	1.0400	.1930	15.8000
Filter (mcg)	0.0000	0.0000	0.0000
Water Blank (mcg/g)	.0141	0.0000	.1770
Filter Blank (mcg)	0.0000	0.0000	0.0000
CALCULATED VALUES			
Impinger Catch (mcg)	758.2	140.7	11518.2
Filter (mcg)	.0000	.0000	.0000
Water Blank (mcg)	6.107	.000	76.663
Filter Blank (mcg)	.0000	.0000	.0000
Net Sample (mcg)	752.1	140.7	11441.5
Instrument Detection Limit (mcg/g)	.00477	1.24	.00027

FILE NAME : [redacted]
RUN # : 1 PROGRAM VER. [redacted]
LOCATION : [redacted]
DATE :
PROJECT # : [redacted]

INITIAL METER VOLUME (CUBIC FEET)=	936.000
FINAL METER VOLUME (CUBIC FEET)=	1131.390
METER FACTOR=	0.9704
FINAL LEAK RATE (CU FT/MIN)=	0.020
NET METER VOLUME (CUBIC FEET)=	189.603
GAS VOLUME (DRY STANDARD CUBIC FEET)=	190.950
BAROMETRIC PRESSURE (IN. HG)=	29.65
STATIC PRESSURE (INCHES H20)=	-0.20
PERCENT OXYGEN=	20.9
PERCENT CARBON DIOXIDE=	0.0
MOISTURE COLLECTED (ML)=	0.0
PERCENT WATER=	6.8
DRY MOLECULAR WEIGHT=	28.84
WET MOLECULAR WEIGHT=	28.09
AVERAGE METER TEMPERATURE (F.)=	61.3
AVERAGE DELTA H (IN. H20)=	1.52
AVG.SUM of SQR DELTA P (for % ISOKINETIC)=	0.3645
% ISOKINETIC=	106.3
AVERAGE STACK TEMPERATURE (F.)=	101.6
AVG. SUM of COS ANGLE =	0.5873
AVG. SUM of SQR DELTA P * COS of ANGLE (IN. H20)=	0.2251
PITOT COEFFICIENT=	0.84
SAMPLING TIME (MINUTES)=	117.1
NOZZLE DIAMETER (INCHES)=	0.5016
STACK AXIS (INCHES)=	488.0
HUB AXIS (INCHES)=	156.0
CIRCULAR STACK	
NET FREE STACK AREA (SQUARE FEET)=	1166.14
STACK VELOCITY (ACTUAL, FEET/MIN)=	797
FLOW RATE (ACTUAL, CUBIC FT/MIN)=	928,998
FLOW RATE (STANDARD, WET, CUBIC FT/MIN)=	865,106
FLOW RATE (STANDARD, DRY, CUBIC FT/MIN)=	805,898
SPECIFIC VOLUME (CUBIC FT MIX / LB. DRY AIR)	15.3309
AIRFLOW RATE (POUNDS DRY AIR/MIN)=	60,596

FILE NAME : [redacted]
RUN # : 1
LOCATION : [redacted]
DATE : [redacted]
PROJECT # : [redacted]

[redacted] PROGRAM VER. [redacted]

* * METRIC UNITS * *

INITIAL METER VOLUME (CUBIC METERS)=	26.504
FINAL METER VOLUME (CUBIC METERS)=	32.036
METER FACTOR=	0.9704
FINAL LEAK RATE (CU M/MIN)=	0.0006
NET METER VOLUME (CUBIC METERS)=	5.369
GAS VOLUME (DRY STANDARD CUBIC METERS)=	5.407
BAROMETRIC PRESSURE (MM HG)=	753
STATIC PRESSURE (MM H20)=	-5
PERCENT OXYGEN=	20.9
PERCENT CARBON DIOXIDE=	0.0
MOISTURE COLLECTED (ML)=	0.0
PERCENT WATER=	6.8
DRY MOLECULAR WEIGHT=	28.84
WET MOLECULAR WEIGHT=	28.09
AVERAGE METER TEMPERATURE (C.)=	16.3
AVERAGE DELTA H (MM H20)=	38.5
AVG. SUM of SQR DELTA P (for % ISOKINETIC)=	1.84
% ISOKINETIC=	106.3
AVERAGE STACK TEMPERATURE (C.)=	38.7
AVG. SUM of SQR DELTA P * COS of ANGLE (MM H20)=	1.13
PITOT COEFFICIENT=	0.84
SAMPLING TIME (MINUTES)=	117.1
NOZZLE DIAMETER (MM)=	12.74
STACK AXIS #1 (METERS)=	12.395
STACK AXIS #2 (METERS)=	3.962
CIRCULAR STACK	
STACK AREA (SQUARE METERS)=	108.338
STACK VELOCITY (ACTUAL, M/MIN)=	243
FLOW RATE (ACTUAL, CUBIC M/MIN)=	26,306
FLOW RATE (STANDARD, WET, CUBIC M/MIN)=	24,497
FLOW RATE (STANDARD, DRY, CUBIC M/MIN)=	22,821

FILE NAME : [redacted]
RUN # : 1 [redacted] PROGRAM VER. [redacted]
LOCATION : [redacted]
DATE : [redacted]
PROJECT # : [redacted]

POINT #	DELTA P (IN. H20)	DELTA H (IN. H20)	STACK T (F.)	METER T. IN(F.)	METER T. OUT(F.)	ANGLE (DEG)
1	0.240	2.500	98	57	57	52
2	0.190	1.900	99	58	58	60
3	0.230	2.200	99	59	58	41
4	0.270	2.700	100	60	58	11
5	0.250	2.500	101	62	59	26
6	0.210	2.100	101	64	61	28
7	0.220	2.200	101	64	61	30
8	0.220	2.200	102	64	63	30
9	0.240	2.400	103	65	63	32
10	0.250	2.500	103	67	64	35
11	0.010	0.100	100	68	68	85
12	0.060	0.600	104	68	68	45
13	0.060	0.600	104	66	66	63
14	0.150	1.500	104	66	66	42
15	0.160	1.600	104	65	65	54
16	0.220	2.200	105	65	65	72
17	0.210	2.100	105	64	65	74
18	0.060	0.600	105	64	65	63
19	0.010	0.100	105	63	64	75
20	0.010	0.100	105	63	64	56
21	0.150	1.500	101	60	60	65
22	0.280	2.800	102	60	60	48
23	0.120	1.200	102	60	60	52
24	0.220	2.200	102	60	60	53
25	0.200	2.000	102	60	60	55
26	0.320	3.200	102	60	60	46
27	0.250	2.500	103	60	60	50
28	0.200	2.000	103	61	60	38
29	0.090	0.900	103	61	60	47
30	0.010	0.100	103	61	60	42
31	0.040	0.400	90	57	57	62
32	0.150	1.500	96	57	57	72
33	0.170	1.700	99	58	58	75
34	0.160	1.600	99	59	59	73
35	0.120	1.200	99	59	59	65
36	0.100	1.000	100	59	59	54
37	0.090	0.900	101	59	59	60
38	0.070	0.700	102	59	59	58
39	0.040	0.400	103	59	59	63
40	0.010	0.100	104	59	59	40

FILE NAME : [redacted]
RUN # : 1
LOCATION : [redacted]
DATE :
PROJECT # : [redacted]

[redacted] PROGRAM VER.
10/01/88 V2.1

EQUIVALENT SAMPLING TIME (MINUTES)= 200.0

NOZZLE DIAMETER (SQUARE FEET)= 0.00137

NET FREE STACK AREA (SQUARE FEET)= 1166.14

WATERFLOW RATE PER CELL (GPM)= 18,214

AIRFLOW RATE (POUNDS DRY AIR/MIN)= 60,596

---------- DRIFT TEST RESULTS ----------

TRACER ANALYZED	BASIN CONC. (mcg/g)	TRACER NET WT. (mcg)	DRIFT RATE l/min	DRIFT % OF GPM	DRIFT % OF DRY AIR
Ca	66.20	752.1	48.3	0.0700	0.1756
Mg	20.60	140.7	29.0	0.0421	0.1056
Na	1790.00	11441.5	27.2	0.0394	0.0988
AVERAGE DRIFT ALL OF TRACERS			34.8	0.0505	0.1267

APPENDIX B

FIELD DATA SHEETS

FAN E

[redacted]

[redacted]RIFT TESTS
ON THE
[redacted]
7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

MIDWEST RESEARCH INSTITUTE

DRIFT DATA REDUCTION

RUN # 2 [redacted]

Sample Volume	733	Rinse Volume	151
Water Blamk Volume	582	Initial Water Vol.	250

DESCRIPTION	Ca	Mg	Na
Basin Water (mcg/g)	63.60	20.30	1730.00
Impinger (mcg/g)	1.3000	.2460	19.5000
Filter (mcg)	0.0000	0.0000	0.0000
Water Blank (mcg/g)	.0141	0.0000	.1770
Filter Blank (mcg)	0.0000	0.0000	0.0000
CALCULATED VALUES			
Impinger Catch (mcg)	952.9	180.3	14293.5
Filter (mcg)	.0000	.0000	.0000
Water Blank (mcg)	5.648	.000	70.898
Filter Blank (mcg)	.0000	.0000	.0000
Net Sample (mcg)	947.3	180.3	14222.6
Instrument Detection Limit (mcg/g)	.00477	1.24	.00027

FILE NAME : [redacted]
RUN # : 2 PROGRAM VER. [redacted]
LOCATION : [redacted]
DATE :
PROJECT # : [redacted]

INITIAL METER VOLUME (CUBIC FEET)=	132.000
FINAL METER VOLUME (CUBIC FEET)=	368.870
METER FACTOR=	0.9704
FINAL LEAK RATE (CU FT/MIN)=	0.026
NET METER VOLUME (CUBIC FEET)=	229.854
GAS VOLUME (DRY STANDARD CUBIC FEET)=	229.157
BAROMETRIC PRESSURE (IN. HG)=	29.45
STATIC PRESSURE (INCHES H20)=	-0.20
PERCENT OXYGEN=	20.9
PERCENT CARBON DIOXIDE=	0.0
MOISTURE COLLECTED (ML)=	0.0
PERCENT WATER=	6.4
SATURATED STACK	
DRY MOLECULAR WEIGHT=	28.84
WET MOLECULAR WEIGHT=	28.14
AVERAGE METER TEMPERATURE (F.)=	63.3
AVERAGE DELTA H (IN. H20)=	1.67
AVG.SUM of SQR DELTA P (for % ISOKINETIC)=	0.4034
% ISOKINETIC=	100.6
AVERAGE STACK TEMPERATURE (F.)=	99.2
AVG. SUM of COS ANGLE =	0.6704
AVG. SUM of SQR DELTA P * COS of ANGLE (IN. H20)=	0.2720
PITOT COEFFICIENT=	0.84
SAMPLING TIME (MINUTES)=	133.7
NOZZLE DIAMETER (INCHES)=	0.5016
STACK AXIS (INCHES)=	488.0
HUB AXIS (INCHES)=	156.0
CIRCULAR STACK	
NET FREE STACK AREA (SQUARE FEET)=	1166.14
STACK VELOCITY (ACTUAL, FEET/MIN)=	963
FLOW RATE (ACTUAL, CUBIC FT/MIN)=	1,122,797
FLOW RATE (STANDARD, WET, CUBIC FT/MIN)=	1,043,071
FLOW RATE (STANDARD, DRY, CUBIC FT/MIN)=	976,299
SPECIFIC VOLUME (CUBIC FT MIX / LB. DRY AIR)	15.2991
AIRFLOW RATE (POUNDS DRY AIR/MIN)=	73,390

FILE NAME : [redacted]
RUN # : 2 [redacted] PROGRAM VER.
LOCATION : [redacted]
DATE : [redacted]
PROJECT # : [redacted]

* * METRIC UNITS * *

INITIAL METER VOLUME (CUBIC METERS)=	3.738
FINAL METER VOLUME (CUBIC METERS)=	10.445
METER FACTOR=	0.9704
FINAL LEAK RATE (CU M/MIN)=	0.0007
NET METER VOLUME (CUBIC METERS)=	6.509
GAS VOLUME (DRY STANDARD CUBIC METERS)=	6.489
BAROMETRIC PRESSURE (MM HG)=	748
STATIC PRESSURE (MM H20)=	-5
PERCENT OXYGEN=	20.9
PERCENT CARBON DIOXIDE=	0.0
MOISTURE COLLECTED (ML)=	0.0
PERCENT WATER=	6.4
SATURATED STACK	
DRY MOLECULAR WEIGHT=	28.84
WET MOLECULAR WEIGHT=	28.14
AVERAGE METER TEMPERATURE (C.)=	17.4
AVERAGE DELTA H (MM H20)=	42.4
AVG. SUM of SQR DELTA P (for % ISOKINETIC)=	2.03
% ISOKINETIC=	100.6
AVERAGE STACK TEMPERATURE (C.)=	37.3
AVG. SUM of SQR DELTA P * COS of ANGLE (MM H20)=	1.37
PITOT COEFFICIENT=	0.84
SAMPLING TIME (MINUTES)=	133.7
NOZZLE DIAMETER (MM)=	12.74
STACK AXIS #1 (METERS)=	12.395
STACK AXIS #2 (METERS)=	3.962
CIRCULAR STACK	
STACK AREA (SQUARE METERS)=	108.338
STACK VELOCITY (ACTUAL, M/MIN)=	293
FLOW RATE (ACTUAL, CUBIC M/MIN)=	31,794
FLOW RATE (STANDARD, WET, CUBIC M/MIN)=	29,536
FLOW RATE (STANDARD, DRY, CUBIC M/MIN)=	27,646

FILE NAME : [redacted]
RUN # : 2 PROGRAM VER.
LOCATION : [redacted]
DATE : [redacted]
PROJECT # : [redacted]

POINT #	DELTA P (IN. H20)	DELTA H (IN. H20)	STACK T (F.)	METER T. IN(F.)	METER T. OUT(F.)	ANGLE (DEG)
1	0.230	2.300	97	52	52	67
2	0.210	2.100	99	53	52	55
3	0.200	2.000	100	54	52	53
4	0.120	1.200	100	55	53	45
5	0.140	1.400	100	55	53	40
6	0.210	2.100	100	55	53	48
7	0.150	1.500	100	56	53	50
8	0.100	1.000	100	56	53	51
9	0.110	1.100	101	57	54	50
10	0.090	0.900	101	58	55	55
11	0.100	1.000	97	57	57	59
12	0.150	1.500	99	57	57	63
13	0.200	2.000	100	57	57	51
14	0.110	1.100	100	57	57	28
15	0.100	1.000	100	57	57	45
16	0.090	0.900	101	57	57	41
17	0.210	2.100	101	57	57	47
18	0.240	2.400	101	58	58	45
19	0.230	2.300	101	58	58	46
20	0.180	1.800	99	59	59	45
21	0.140	1.400	87	65	65	78
22	0.150	1.500	93	65	65	64
23	0.160	1.600	95	65	65	60
24	0.150	1.500	95	66	65	38
25	0.190	1.900	96	69	66	40
26	0.210	2.100	96	70	67	32
27	0.250	2.500	96	74	69	33
28	0.180	1.800	96	77	72	35
29	0.110	1.100	97	77	73	34
30	0.060	0.600	100	77	74	59
31	0.300	3.000	103	72	72	40
32	0.180	1.800	102	71	70	62
33	0.170	1.700	101	72	71	51
34	0.140	1.400	100	72	71	45
35	0.130	1.300	100	72	71	40
36	0.170	1.700	101	74	71	37
37	0.200	2.000	101	74	71	33
38	0.180	1.800	102	74	72	33
39	0.230	2.300	104	74	72	42
40	0.210	2.100	104	76	73	39

FILE NAME : [redacted]
RUN # : 2 PROGRAM VER. [redacted]
LOCATION : [redacted]
DATE :
PROJECT # :

EQUIVALENT SAMPLING TIME (MINUTES)= 200.0

NOZZLE DIAMETER (SQUARE FEET)= 0.00137

NET FREE STACK AREA (SQUARE FEET)= 1166.14

WATERFLOW RATE PER CELL (GPM)= 18,214

AIRFLOW RATE (POUNDS DRY AIR/MIN)= 73,390

---------- DRIFT TEST RESULTS ----------

TRACER ANALYZED	BASIN CONC. (mcg/g)	TRACER NET WT. (mcg)	DRIFT RATE l/min	DRIFT % OF GPM	DRIFT % OF DRY AIR
Ca	63.60	947.3	63.3	0.0918	0.1901
Mg	20.30	180.3	37.7	0.0547	0.1134
Na	1730.00	14222.6	34.9	0.0507	0.1049
AVERAGE DRIFT ALL OF TRACERS			45.3	0.0657	0.1361

APPENDIX C

LABORATORY ANALYSIS

CELL F

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE
[redacted]
7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

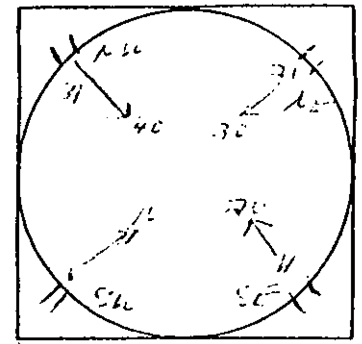
[redacted]

FIELD DATA

RUN NO. 1
PROJECT NO. [redacted]
PLANT [redacted]
DATE [redacted]
SAMPLING LOCATION Fan Stack F
SAMPLE TYPE Drift
OPERATOR Strickland/[illegible]/[illegible]
FILTER NO. Drift #1
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP N/A

PROBE NO. [illegible]
PROBE LENGTH AND TYPE [illegible]
SAMPLE BOX NO. [illegible]
METER BOX NO. [illegible]
TEMP. CONTROLLER NO. [illegible]
TEMP. METER NO. SASS
THERMOCOUPLE I.D. NO. [illegible]
UMBILICAL CORD I.D. NO. [illegible]
UMBILICAL CORD I.D. NO. NA
NOZZLE NO. [illegible]

NOZZLE DIA. .5016
ASSUMED MOISTURE % SAT'D
METER ΔH @ 1.307
METER CORRECTION .97038
PITOT NO. Drift
PITOT COEFFICIENT .84
BAROMETRIC PRESSURE [illegible]
SITE TO BARO. ELEVATION (ft.) [illegible]
CORRECTED B.P. (0.1 in./100 ft.) [illegible]
STATIC PRESSURE [illegible]



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK $\geq 3''$ H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	1240					
PASS/FAIL						

PITOT LEAK CHECK $\geq 3''$ H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	1240	1730			
VACUUM, In. Hg	≥15"	10"	≥15"		≥15"
CFM	.035	.02			
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 936.00
FINAL VOLUME 1131.39
LEAK CHECK VOLUME — 0 —
ADJUSTED FINAL VOLUME 1131.39

COMMENTS

Revision 11/18/86

RUN NO. 1 SAMPLING LOCATION [redacted] p. 1 of 2

DATE [redacted] PROJECT NO. [redacted] OPERATOR Smith / Kincaid / Gipson

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) SAMPLING TIME, min (0 / 1345)	GAS METER READING (V_m), ft³ INITIAL 936.00 DESIRED	GAS METER READING (V_m), ft³ INITIAL 936.00 ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\,out}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	$\sqrt{\Delta p}$	
SW-1	164	945.50	943.58	.24	2.5	2.5	98	57	57	6	—	—	—	—	5.5	
2	333	947.17	947.28	.19	1.9	1.9	97	57	57	6	—	—	—	—	6.0	
3	559	953.05	953.09	.23	2.2	2.3	99	59	58	6	—	—	—	—	4.1	
4	853	966.07	966.15	.27	2.7	2.7	100	60	59	6	—	—	—	—	1.1	
5	1132	975.81	975.83	.25	2.5	2.5	101	62	59	6	—	—	—	—	2.5	
6	1386	984.61	984.67	.21	2.1	2.1	101	64	61	6	—	—	—	—	2.2	
7	1645	993.44	993.85	.22	2.2	2.2	101	64	61	6	—	—	—	—	3.0	
8	1904	1002.29	1002.35	.23	2.3	2.3	102	64	63	6	—	—	—	—	3.0	
9	2158 ↓	1011.34	1011.37	.24	2.4	2.4	103	65	63	6	—	—	—	—	3.2	
10	2403 1410	1020.29	1020.26	.25	2.5	2.5	103	67	64	6	—	—	—	—	3.5	
	PORT	CHANGE														
SE																
11	2429 1425	1020.48	1020.46	.01	.1	.1	100	68	68	5	—	—	—	—	5.5	6.6
12	2641	1024.28	1024.29	.06	.61	.6	104	68	68	4	—	—	—	—	4.5	
13	2917	1028.71	1028.69	.06	.61	.6	104	66	66	4	—	—	—	—	6.3	
14	2999	1030.99	1030.64	.15	1.5	1.5	104	66	66	5	—	—	—	—	4.2	
15	3175	1033.12	1033.09	.16	1.6	1.6	104	65	65	6	—	—	—	—	4.4	
16	3267	1041.36	1041.34	.22	2.2	2.2	105	65	65	5	—	—	—	—	7.2	
17	3349	1044.06	1044.04	.21	2.1	2.1	105	64	65	6	—	—	—	—	7.4	
18	3485	1046.42	1046.46	.06	.61	.6	105	64	65	4	—	—	—	—	6.3	
19	3562 ↓	1046.73	1046.77	.01	.1	.1	105	63	64	3	—	—	—	—	2.5	
20	3729 1510	1048.19	1048.13	.01	.1	.1	105	63	64	3	—	—	—	—	3.2	
	PORT	CHANGE														

COMMENTS

C-3

RUN NO. 1
DATE [redacted]

SAMPLING LOCATION [redacted]
PROJECT NO. [redacted]

p. 2 of 2
OPERATOR Stichtecal / Gar...

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr.) 1534	GAS METER READING (V_m), ft³ INITIAL — DESIRED	ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O — DESIRED	ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	[illegible]	
21	3855		1056.72	1056.56	.15	1.5	1.5	101	60	60	5	—	—	—	—	65	
22	4655		1059.37	1059.35	.28	2.8	2.8	102	60	60	6	—	—	—	—	48	
23	4339		1063.78	1063.72	.12	1.2	1.2	102	60	60	5	—	—	—	—	52	
24	4419		1070.09	1070.03	.22	2.2	2.2	102	60	60	6	—		—	—	53	
25	4591		1075.65	1075.73	.26	2.6	2.6	102	60	60	6	—	—	—	—	55	
26	4797		1084.15	1084.14	.32	3.2	3.2	102	60	60	6	—	—	—	—	46	
27	4991		1091.09	1091.19	.25	2.5	2.5	103	60	60	6	—	—	—	—	50	
28	5237		1098.72	1098.70	.20	2.0	2.0	103	61	60	6	—	—	—		38	
29	5431		1103.15	1103.20	.09	.9	.9	103	61	60	6	—	—	—		47	
30	5653	1636	1104.75	1104.74	.01	.1	.1	103	61	60	6			—	—	42	
~~Ahu~~	PORT	Change															
31	5093	1652	1106.09	1106.75	.04	.4	.4	96	57	57	4	—	—	—	—	62	
32	5835		1109.36	1109.38	.15	1.5	1.5	96	57	57	5	—	—	—	—	72	
33	5962		1111.65	1111.67	.17	1.7	1.7	96	58	58	5	—		—		75	
34	6049		1114.13	1114.26	.16	1.6	1.6	99	59	59	5		—	—		71	
35	6175		1117.33	1117.40	.12	1.2	1.2	99	59	59	6		—	—	—	65	
36	6351		1121.35	1121.38	.16	1.6	1.6	100	59	59	5	—	—			59	
37	6500		1124.51	1124.60	.09	.9	.9	101	59	59	5		—	—	—	60	
38	6658		1127.60	1127.55	.07	.7	.7	100	59	59	5	—	—	—	—	53	
39	6784		1129.56	1129.53	.04	.4	.4	101	59	59	5	—	—	—	—	53	
40	7023	1715	1131.31	1131.39	.01	.1	.1	104	59	59	5	—	—	—	—	42	

COMMENTS Total Sample Time min = 7023/60 = 117.05 min

C-4

Revision 9-4-86

APPENDIX D

FIELD DATA SHEETS

CELL E

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE
[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

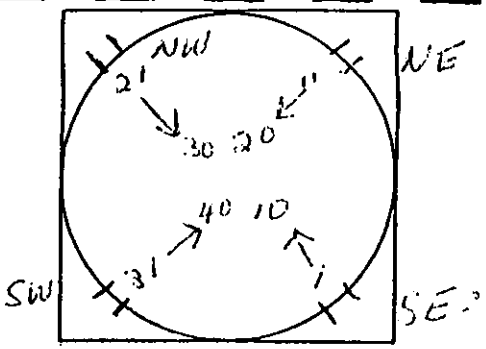
FIELD DATA

2

RUN NO. _____
PROJECT NO. [redacted]
PLANT [redacted]
DATE _____
SAMPLING LOCATION FAN STACK E
SAMPLE TYPE Drift
OPERATOR Stich/Wood / Gagnon
FILTER NO. Drift
RECORD DATA EVERY 5 MIN.
UMBILICAL/SAMPLER HOOKUP Drift

PROBE NO. Drift
PROBE LENGTH AND TYPE Teflon
SAMPLE BOX NO. Drift
METER BOX NO. SASS
TEMP. CONTROLLER NO. NA
TEMP. METER NO. Drift
THERMOCOUPLE I.D. NO. Drift
UMBILICAL CORD I.D. NO. NA
UMBILICAL CORD I.D. NO. NA
NOZZLE NO. B-3

NOZZLE DIA. .5016
ASSUMED MOISTURE % SAT.
METER ΔH@ 1.307
METER CORRECTION .97038
PITOT NO. Drift
PITOT COEFFICIENT .84
BAROMETRIC PRESSURE 29.45
SITE TO BARO. ELEVATION (ft.) -0-
CORRECTED B.P. (0.1 In./100 ft.) 29.45
STATIC PRESSURE -.2



SCHEMATIC OF TRAVERSE POINT LAYOUT

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)	10:00					
PASS/FAIL						

PITOT LEAK CHECK ≥3" H_2O

	INITIAL	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)						
PASS/FAIL						

D-2

SAMPLE TRAIN LEAK CHECKS

	INITIAL	FINAL	INITIAL	FINAL	INITIAL
TIME (24 hr)	10:00	15:40			
VACUUM, In. Hg	≥15"	10" Hg	≥15"		≥15"
CFM	.037	.026			
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

SAMPLE TRAIN LEAK CHECKS

	FINAL	INITIAL	FINAL	INITIAL	FINAL
TIME (24 hr)					
VACUUM, In. Hg		≥15"		≥15"	
CFM					
VOLUMES					
FINAL					
INITIAL					
DIFFERENCE					

INITIAL VOLUME 132.00
FINAL VOLUME 368.67
LEAK CHECK VOLUME -0-
ADJUSTED FINAL VOLUME 368.67

COMMENTS

Revision 11/18/85

RUN NO. 12 | SAMPLING LOCATION [redacted] | p. 1 of 2

DATE [redacted] | PROJECT NO. [redacted] | OPERATOR Strickland / Gannon

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr.) / SAMPLING TIME, min	GAS METER READING (V_m), ft³ INITIAL 132.00		VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	UAW Ang.	
	0 / 1013	DESIRED	ACTUAL		DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F							
1	117	136.00	135.98	.27	2.3	2.3	97	52	52	5	—	—	—	—	67	
2	289	141.61	141.63	.21	2.1	2.1	99	53	52	5	—	—	—	—	55	
3	469	147.34	147.36	.20	2.0	2.0	100	54	52	5	—	—	—	—	53	
4	681	152.58	152.64	.12	1.2	1.2	100	55	53	5	—	—	—	—	45	
5	910	158.69	158.68	.14	1.4	1.4	100	55	53	5	—	—	—	—	40	
6	1110	165.23	165.22	.21	2.1	2.1	100	55	53	5	—	—	—	—	48	
7	1302	170.54	170.61	.15	1.5	1.5	100	56	53	5	—	—	—	—	50	
8	1490	174.79	174.80	.10	1.0	1.0	100	56	53	5	—	—	—	—	51	
9	1682	179.34	179.33	.11	1.1	1.1	101	57	54	6	—	—	—	—	50	
10	1854 11:04	183.04	183.15	.09	.9	.9	101	58	55	6	—	—	—	—	55	
	PORT	CHANGE														
							~~97~~	~~57~~	~~57~~	~~4~~	—	—	—	—	~~57~~	
11	2006 11:38	186.54	186.41	.10	1.0	1.0	97	57	57	4	—	—	—	—	59	
12	2144	190.32	190.42	.15	1.5	1.5	99	57	57	4	—	—	—	—	63	
13	2332	196.35	196.29	.20	2.0	2.0	100	57	57	5	—	—	—	—	51	
14	2536	202.64	202.65	.11	1.1	1.1	100	57	57	5	—	—	—	—	78	
15	2808	207.45	207.51	.10	1.0	1.0	100	57	57	5	—	—	—	—	45	
16	3034	212.31	212.33	.09	.9	.9	101	57	57	5	—	—	—	—	41	
17	3238	219.01	218.85	.21	2.1	2.1	101	57	57	5	—	—	—	—	47	
18	3450	226.47	226.57	.24	2.4	2.4	101	58	58	5	—	—	—	—	45	
19	3658	233.63	233.60	.23	2.3	2.3	101	58	58	5	—	—	—	—	46	
20	3870	240.12	240.26	.18	1.8	1.8	99	59	59	5	—	—	—	—	45	
		PORT	CHANGE													

COMMENTS

D-3

Revision 8-4-88

RUN NO. 2

DATE [redacted]

SAMPLING LOCATION [redacted]

PROJECT NO. [redacted]

p. 2 of 2

OPERATOR Stick Tweed / Garmon

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr.)	GAS METER READING (V_m), ft³ INITIAL ___ DESIRED	ACTUAL	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O DESIRED	ACTUAL	STACK TEMP. (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VAC., in. Hg	IMPINGER TEMP., °F	SAMPLE BOX TEMP., °F	PROBE TEMP., °F	FILTER TEMP., °F	[illegible]	
21	3932	13:04	241.82	241.80	.14	1.4	1.4	87	65	65	5	–	–	–	–	78	
22	4063	↓	245.55	245.41	.15	1.5	1.5	93	65	65	5	–	–	–	–	64	
23	4212		249.11	249.42	.16	1.6	1.6	95	65	65	5	–	–	–	–	60	
24	4448		256.61	256.60	.15	1.5	1.5	95	66	65	5	–	–	–	–	38	
25	4677		263.94	263.79	.19	1.9	1.9	96	69	66	5	–	–	–	–	40	
26	4931		272.51	272.61	.21	2.1	2.1	96	70	67	5	–	–	–	–	32	
27	5182		281.80	281.94	.25	2.5	2.5	96	74	69	5	–	–	–	–	33	
28	5427		289.54	289.52	.18	1.8	1.8	96	77	72	5	–	–	–	–	35	
29	5675	↓	295.67	295.65	.11	1.1	1.1	97	77	73	5	–	–	–	–	34	
30	5829	1410	298.47	298.44	.06	.6	.6	100	77	74	5	–	–	–	–	59	
	PORT		CHANGE														
31	6058	1439	307.76	307.76	.30	3.0	3.0	103	72	72	8	–	–	–	–	40	
32	6198	↓	310.07	310.12	.18	1.8	1.8	102	71	70	6	–	–	–	–	62	
33	6386		317.79	317.81	.17	1.7	1.7	101	72	71	6	–	–	–	–	57	
34	6598		323.64	323.55	.14	1.4	1.4	100	72	71	6	–	–	–	–	45	
35	6827		329.73	329.79	.13	1.3	1.3	100	72	71	6	–	–	–	–	40	
36	7066		337.00	337.09	.17	1.7	1.7	101	74	71	6	–	–	–	–	37	
37	7317		345.29	346.00	.20	2.0	2.0	101	74	71	6	–	–	–	–	33	
38	7568		353.16	353.16	.18	1.8	1.8	102	74	72	6	–	–	–	–	33	
39	7790	↓	361.01	360.94	.23	2.3	2.3	104	74	72	6	–	–	–	–	42	
40	8023	1533	368.91	368.87	.21	2.1	2.1	104	76	73	6	–	–	–	–	39	

COMMENTS

Revision 9-4-86

APPENDIX E

WATER FLOW AND FAN HORSEPOWER DATA

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE

[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

MIDWEST RESEARCH INSTITUTE

FILE NO.: [redacted]

TEST DATE: [redacted]

DATA SHEET "C"

MEAS OF: FAN DRIVER INPUT HORSEPOWER — UNIT: HP

INSTRUMENT IDENTIFICATION — DATE CALIBR.

TIME: START — END

	FAN NO	VOLTS	AMPS	P.F.	KW_1	KW_2	KW_T	MOTOR EFF.	HP
1/26	F	466	245						
		466	248						
				.874	115.0	605	1755	.95	223.5
1/27	E	466	230	.878	56.5	1055	1620	.95	206.3
		466	227						
	Average								214.9

TEST AVERAGE INPUT HP

MEAS. OF — UNIT

INSTRUMENT IDENTIFICATION

TIME			WIND, MPH	WIND DIREC.

TEST AVERAGE:

JEW

MEAS. OF: — UNIT

INSTRUMENT IDENTIFICATION — DATE CALIBR.

RUN	TIME					
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TEST AVERAGE:

MEAS. OF: — UNIT

INSTRUMENT IDENTIFICATION — DATE CALIBR.

RUN	TIME					
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TEST AVERAGE:

APPENDIX F

LABORATORY ANALYSIS

SUPPLEMENTARY WIND DATA

COOLING TOWER TEST REPORT

[redacted]

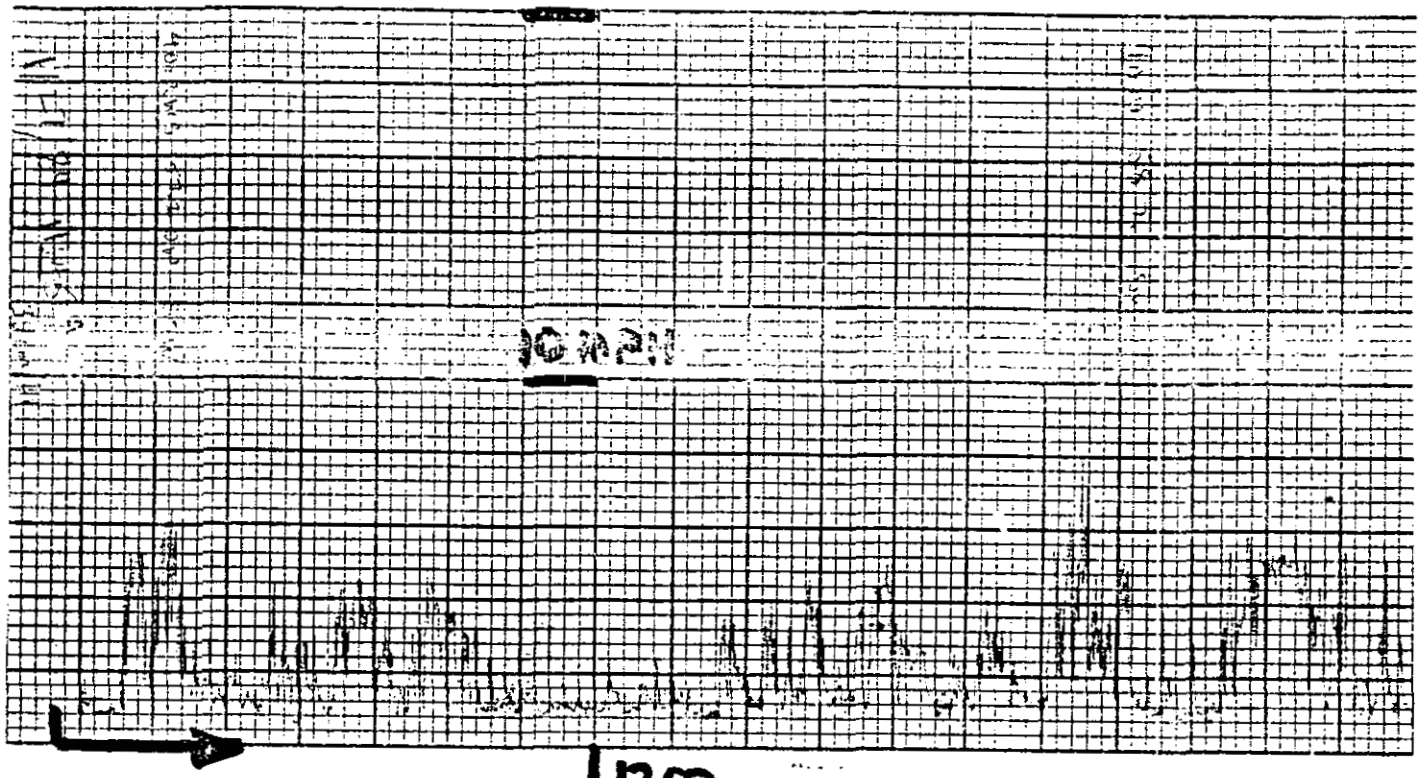
DRIFT TESTS
ON THE

[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

20 MPH



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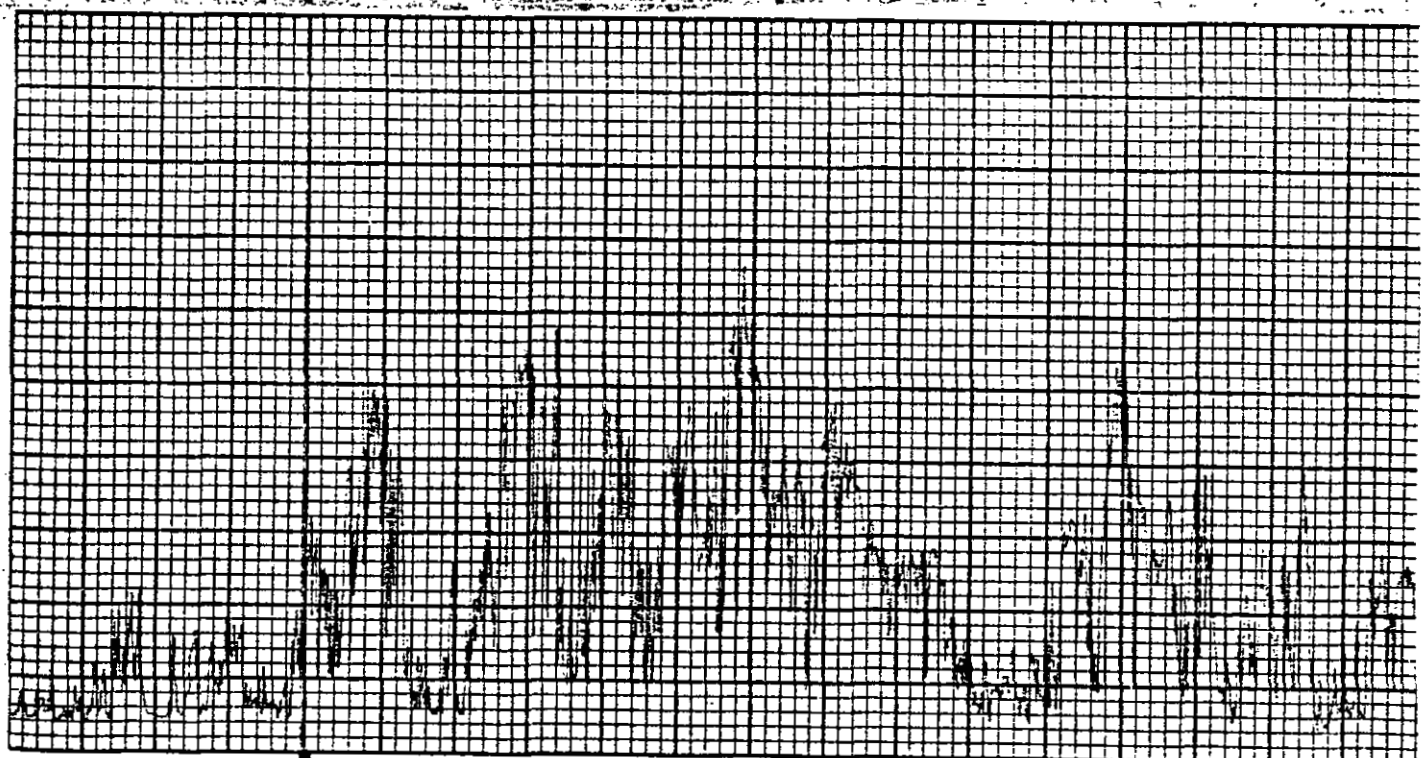

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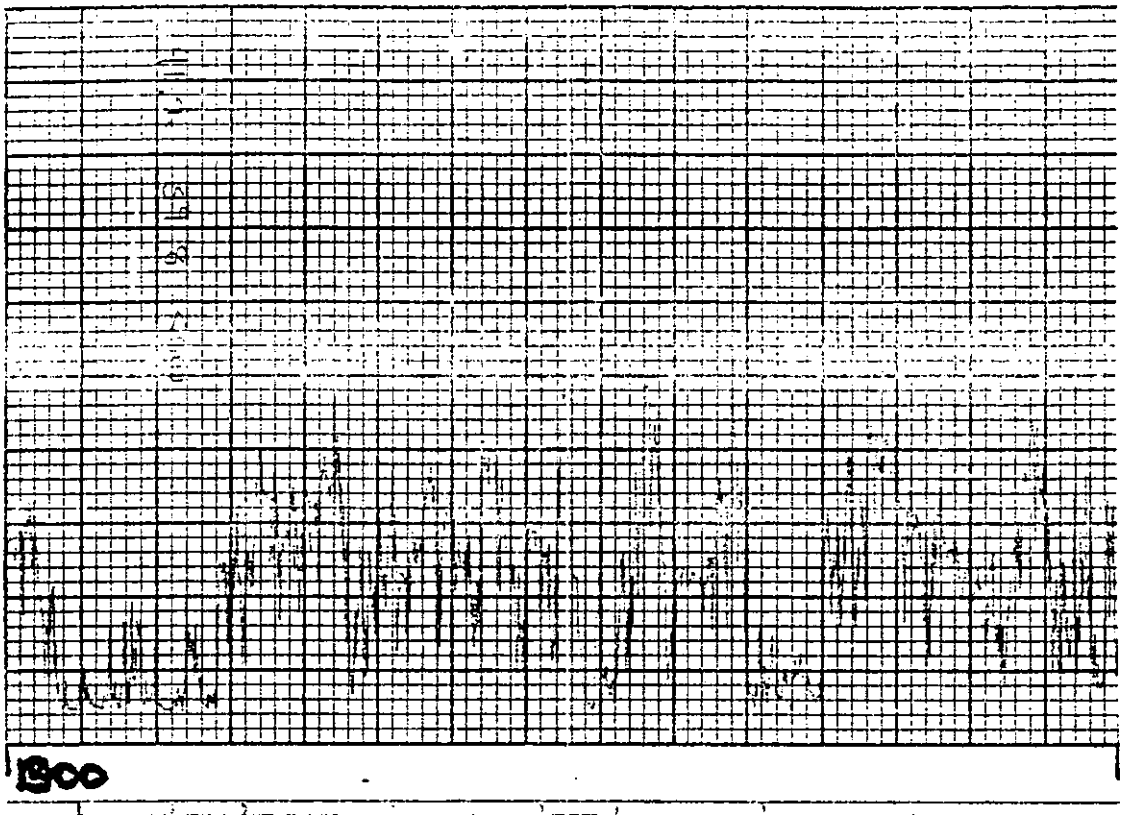
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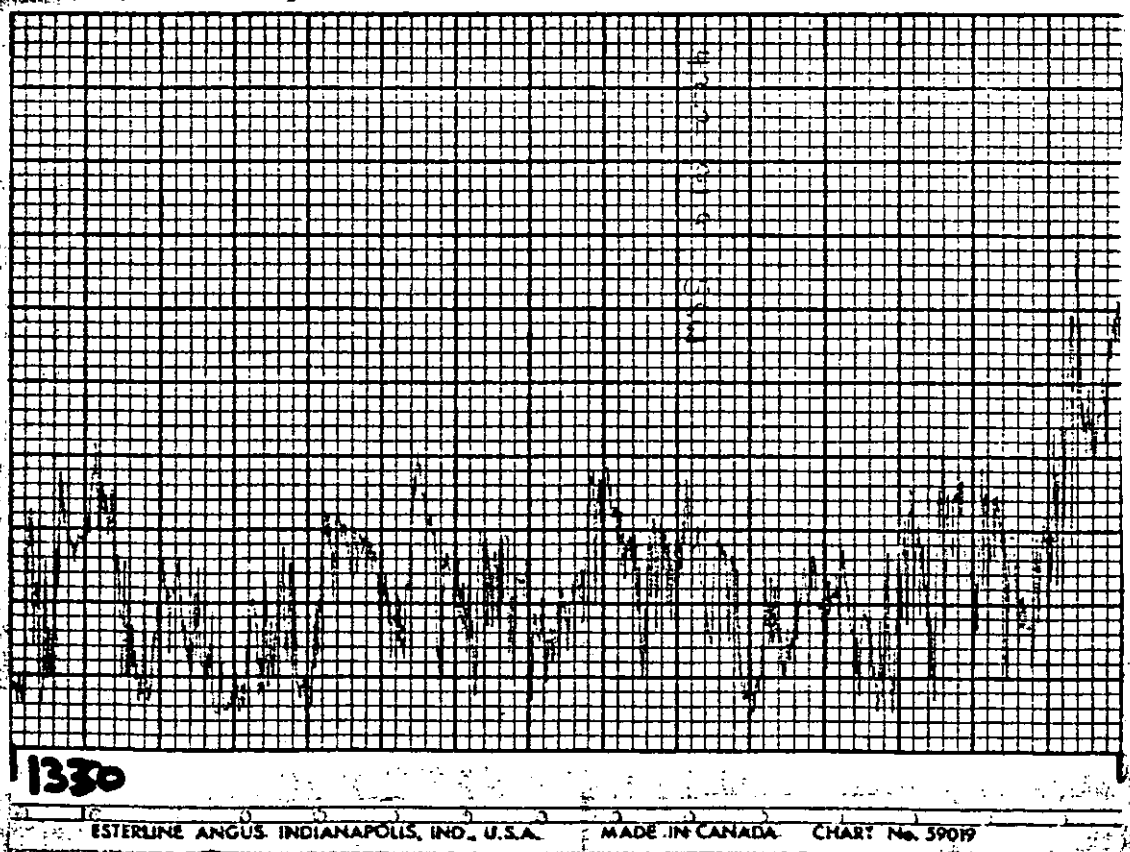
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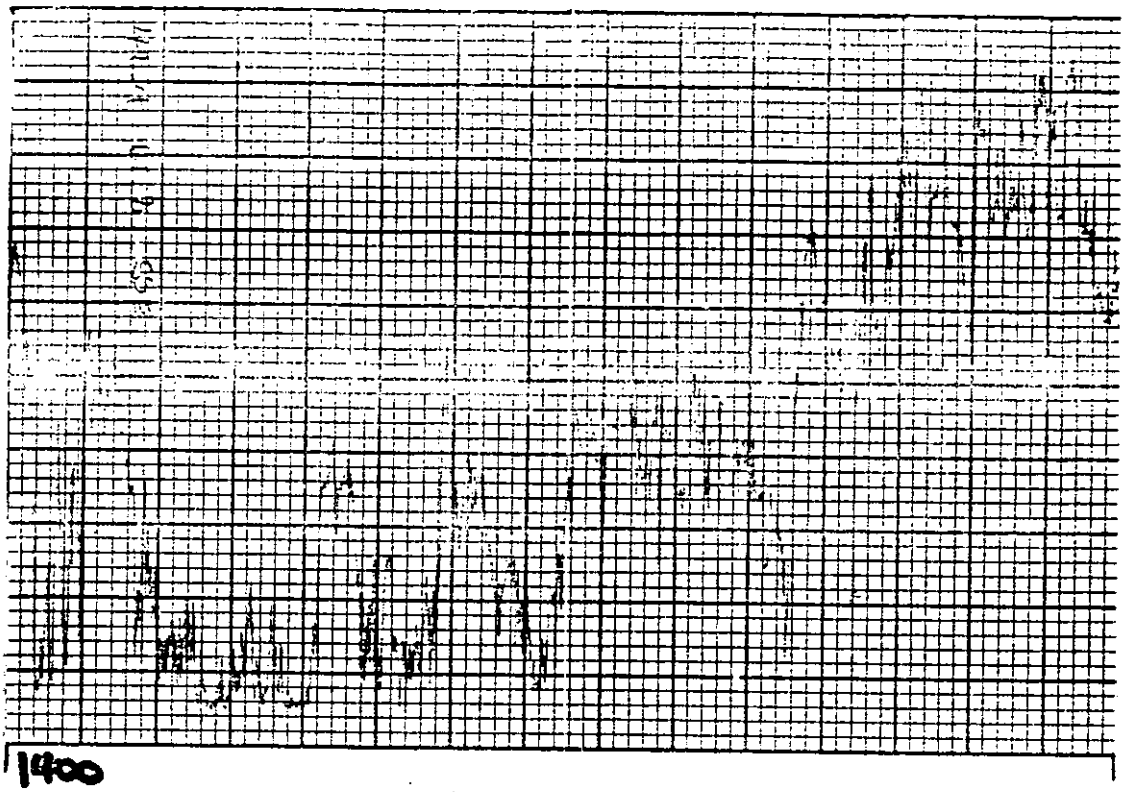

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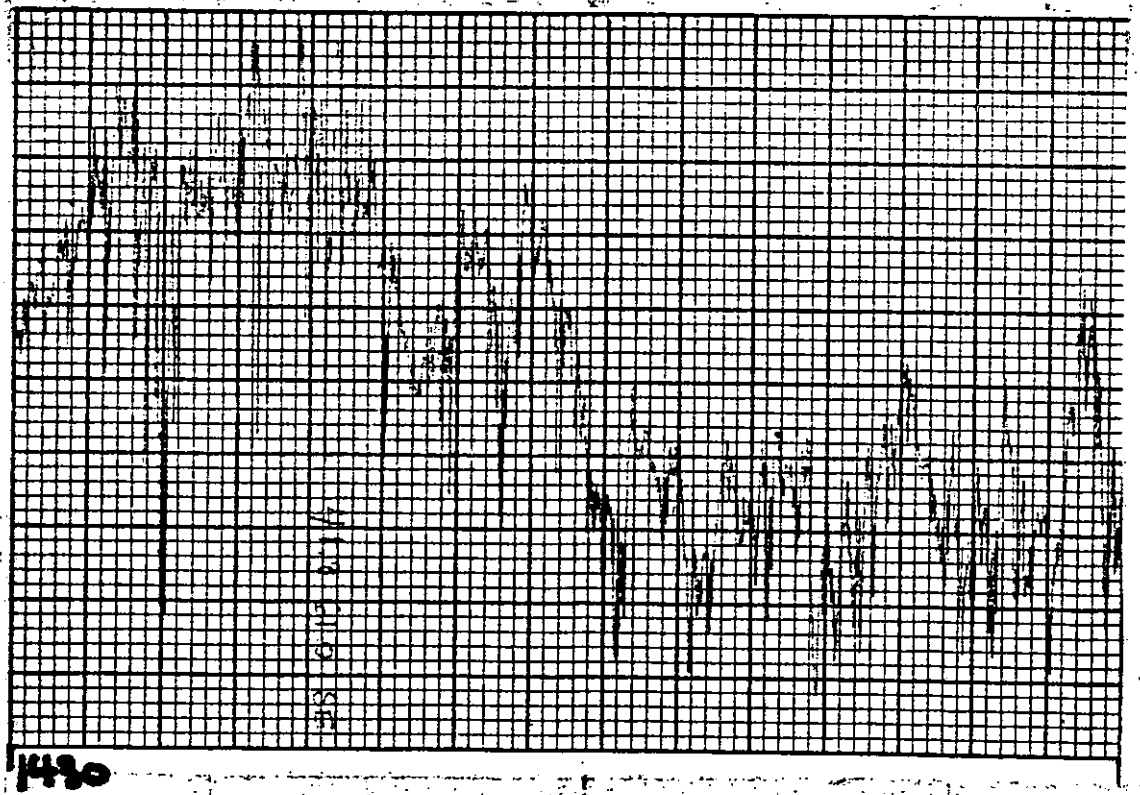

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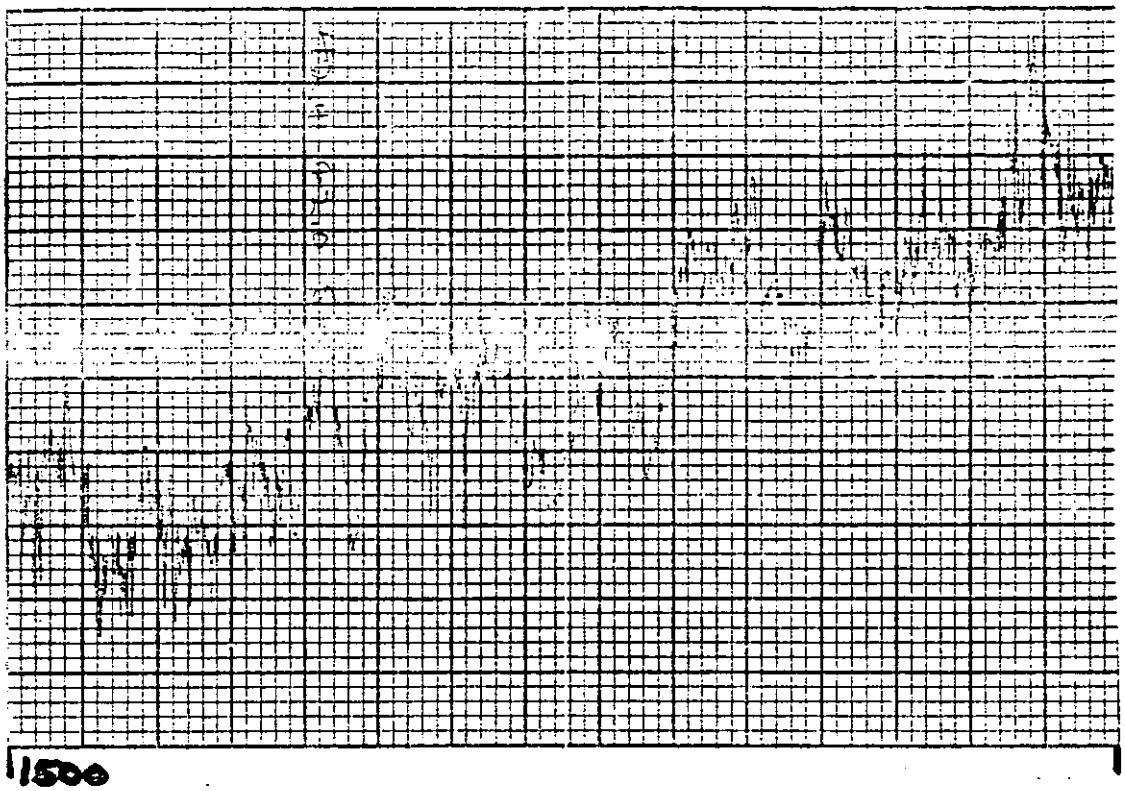

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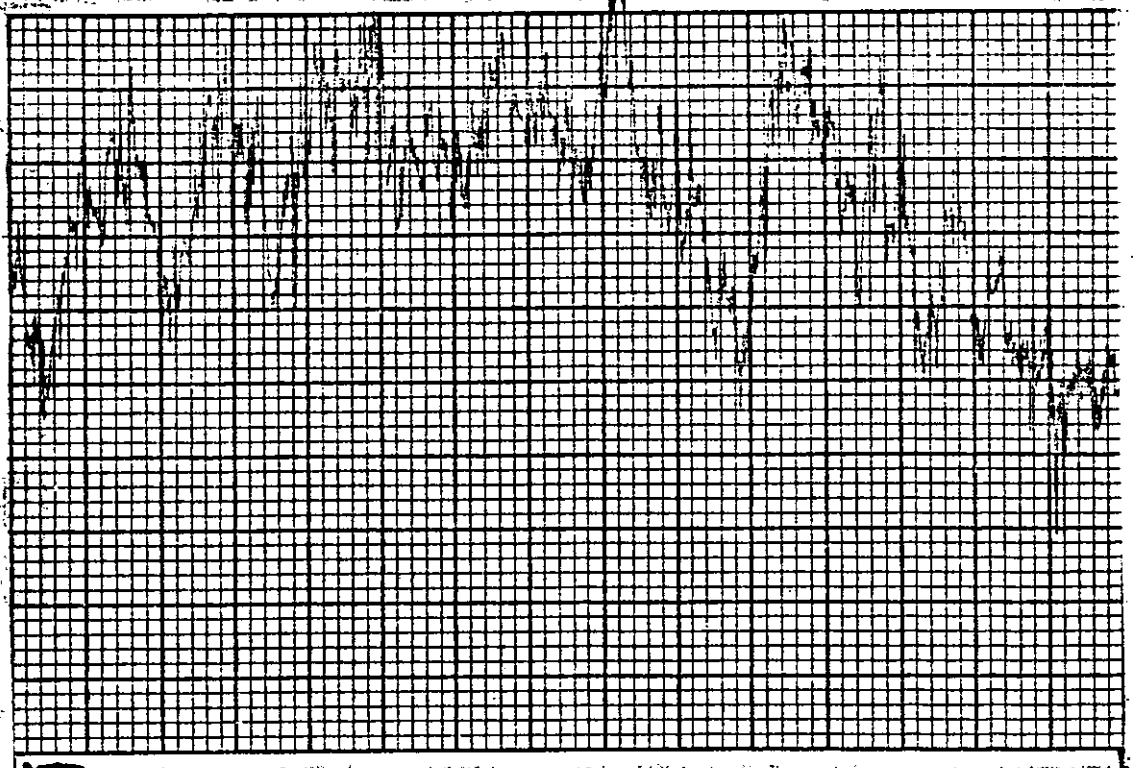

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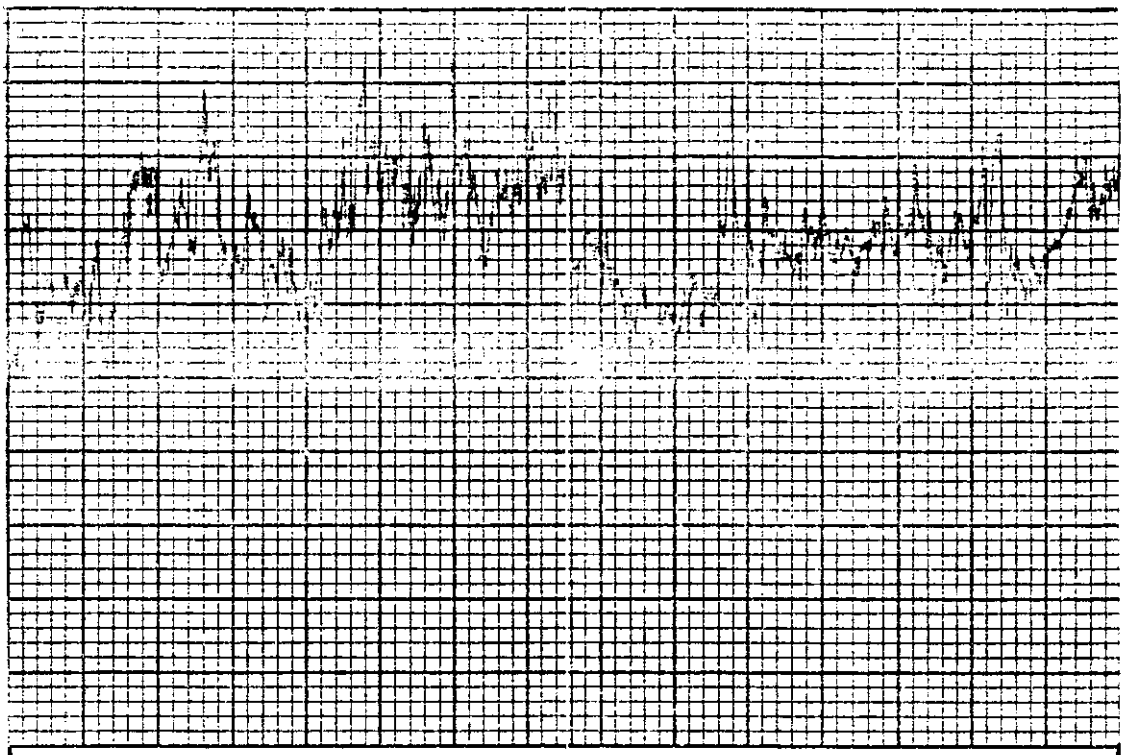

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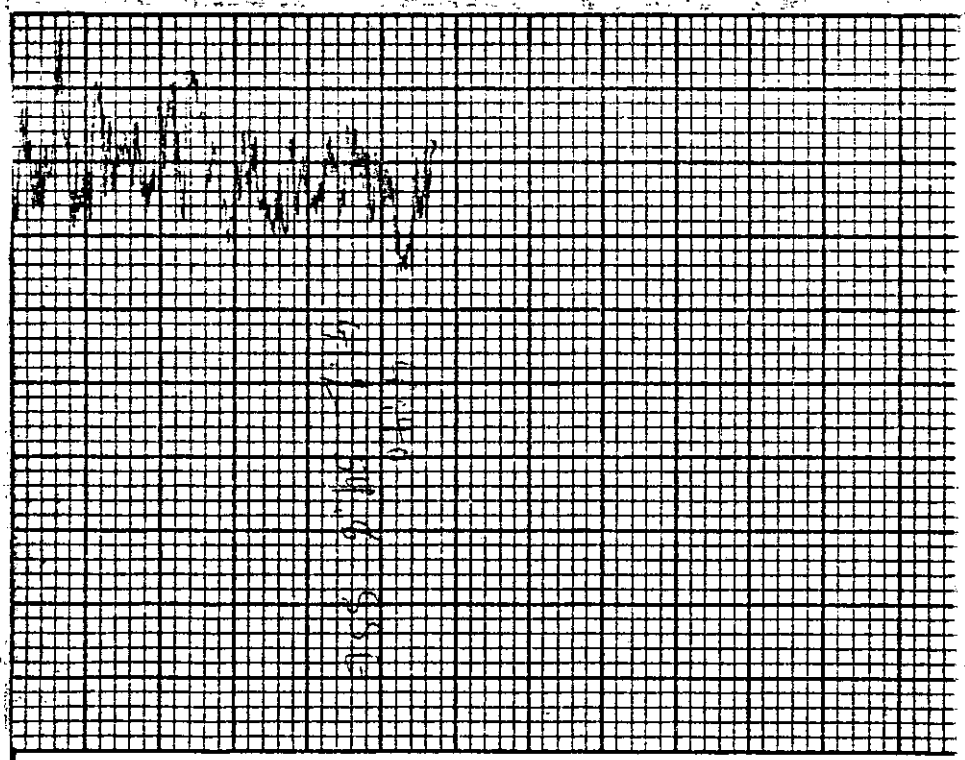

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APPENDIX G

LABORATORY ANALYSIS

COOLING TOWER TEST REPORT

[redacted]

DRIFT TESTS
ON THE

[redacted]

7-CELL, MECHANICAL-DRAFT, COUNTER-FLOW
COOLING TOWER

[redacted]

INTEROFFICE COMMUNICATION

MIDWEST RESEARCH INSTITUTE

March 14. 1989

To: T. Weast

From: E. McClendon EM

Subject: Analysis of Cooling Tower Test Samples for Ca, K, Mg and Na

Enclosed are the results of the inductively coupled argon plasma analysis for Li performed on the cooling tower test samples.

I. Introduction and Request for Analysis

These samples were submitted to determine their calcium, potassium, magnesium and sodium content to calculate the drift from a cooling tower. The analytes of interest were calcium, potassium, magnesium and sodium. The analyses were performed on the Jarrell-Ash Model 1155A inductively coupled argon plasma atomic emission spectrometer.

II. Submission of Samples for Analysis and Sample Preparation

Five solutions for were received in the Atomic Spectroscopy Facility on [redacted] Two of the samples were impinger contents from the trains used and two were samples of the basin water for each drift test run. The final sample was a "blank" consisting of the Milli-Q water used for the impingers.

The samples were prepared according to the atomic absorption section of EPA SW-846 Method 3050. Method modifications are listed in Appendix A. Some dilutions were necessary for analysis and these were prepared with the 10% (v/v) nitric acid (Baker InstraAnalyzed Lot C02069) used to prepare the standards.

III. Standard Preparation

Standards for this analysis were prepared at appropriate concentrations from Inorganic Ventures Multielement Custom Plasma Standard Analytical Reference Materials. The standards were prepared in 10% (v/v) nitric acid and the upper instrumental calibration limit was 10 mcg/mL for Ca, while the calibration limit was 5 mcg/mL for Mg and 150 mcg/mL for K and Na. A calibration blank consisting of the stock 10% nitric acid was used.

Instrumental check standards were prepared at a 1 mcg/mL level from custom prepared multielement standards from Spex Industries, Inc..

IV. Instrumental Analysis

The samples were analyzed on the Jarrell-Ash Model 1155A

inductively coupled argon plasma atomic emission spectrometer. The instrument parameters for the analysis can be found in the data packet and the instrument was calibrated according to the manufacturer's suggested two point technique.

V. Sample Analysis Results and Discussion

The samples were analyzed according to EPA SW-846 Method 6010, third edition, with modifications as listed in Appendix A. The tables listed below contain the analytical data for this study.

Table No.	Description
1	Summary of Sample Analysis Results
2	Sample Weighing Data
3	ICAP Sample Analysis Raw and Calculated Data

Table 1 contains the analytical results of the analyses. Table 2 contains the sample weighing data, while table 3 contains the analysis raw and calculated data, including drift and percent difference calculations.

The cell formulas used in these tables are included in the data packet.

VI. Internal Quality Control

The detection limit was determined from the direct output of the Jarrell-Ash Model 1155A. This detection limit was determined from the calibration blank data generated thoughout the sample analysis run.

Analytical quality check samples were prepared from Custom Multielement Plasma Standard Analytical Reference Materials manufactured by Spex Industries, Inc.. The concentration (mcg/mL) found for this solution did not deviate from the stated value by more than 10 percent, except for K, which was less than two times the detection limit.

A midpoint check standard was analyzed at the beginning and the end of the analysis. The percent drift calculated from the instrumental check determination is appended in Table 2. Instrument drift was less than 5 percent, indicating that the instrument was stable throughout the entire sample analyses.

The duplicate determinations showed differences of less than 2 percent and the spike recoveries for Ca, Mg and Na ranged from 102 to 113 percent.

VII. Additional Information

The following raw data accompanies this report. This information is coded by Project Number [redacted] and also contains a part number identifier.

Part Number	Description
9150-50 1	ICP-AES Data Reporting Sheet
9150-50 2	Control Table Editor Output
9150-50 3	DEC Command Files Used

[redacted]4	ICAP Sample Raw Data
[redacted]5	Sample Weighing Sheet - Initial Weights
[redacted]6	Sample Weighing Sheet - Final Weights
[redacted]7	Photocopy of MRI Laboratory Generated Sample Inventory Sheet
[redacted]8	Photocopies of Notebook 1591:21-22, 26

With the exceptions of part [redacted] 8, the photocopies of the notebook 1591:21-22, 26, this file contains the only record of the analysis. This file should therefore be archived as required by the project of as required by MRI policy.

This data has undergone one level of senior review within the Analytical Chemistry Section. The MRI Quality Assurance Unit is yet to review this data.

Approved,

John Stanley, Head
Analytical Chemistry Section

Appendix A
Usual Method Modifications for EPA SW-846 (third edition)

Note: The following modifications are listed by Method number and applicable paragraph. Paragraphs which are not listed are not changed.

Method 3050

Paragraph 1.1 (addition) This method may also be employed for the more rigorous digestion of liquids, with appropriate changes in sample size. This method may be used for the GFAA analysis of lead.

Paragraph 2.1 (addition) ICP may also be performed on the digests prepared as for GFAA in this method.

Paragraph 7.1 Mix the sample thoroughly to achieve homogeneity. For each digestion procedure, weigh to the nearest 0.01 g and transfer to a conical or straight sided beaker an appropriate amount of sample. For solids, transfer between 0.50- to 1.00-g for each 50-g final digestate and for liquids, 50-g for each 50-g final digestate. (Note: the digestion instructions which follow are for the digestion of 0.5-g solid and 50-g liquid samples. If sample sizes are to be larger, increment the reagents and final weights accordingly.)

Paragraph 7.2 Add 10 mL of 1:1 HNO_3, mix the sample, and cover with a watch glass. Heat the liquid samples gently (without boiling) on a hot plate until their volume is reduced to approximately 10 mL. If ribbed watch glasses are not available, remove the watch glasses to accelerate volume reduction while assuring minimal contamination of the samples. After the volume has been reduced, replace the watch glass and proceed with the digestion of all samples. Heat the sample to 95 C and reflux for 10 to 15 minutes without boiling. Allow the sample to cool, add 5 mL of concentrated HNO_3, replace the watch glass, and reflux for 30 minutes. Repeat this last step to ensure complete oxidation. Allow the solution to evaporate to 5 mL without boiling while maintaining a covering of solution over the bottom of the beaker. It may be necessary to conduct this volume reduction without the watch glasses while assuring minimal contamination of the samples if ribbed watch glasses are not available.

Paragraph 7.5 (comment) This paragraph will not be used to complete the digestion of these samples for ICP as samples digested under this portion of the method could not be subsequently be reanalyzed by GFAA due to their HCl content. Instead, the digestion will be completed employing paragraph 7.6.

Paragraph 7.6 If the sample is being prepared for ICP analysis

or the furnance analysis of As, Be, Cd, Cr, Co, Pb, Mo, Se, Tl, and V, continue heating the acid-peroxide digestate carefully without watch glasses unitl the volume has been reduced to approximately 5 mL. After cooling, dilute to 50-g with Type II water. Particluates in the digestate should then be removed by filtrateion, by centrifugation, or by allowing the sample to settle.

Method 6010

Paragraph 5.4 Mixed Calibration Standard Solutions: MRI will use commercially available multielement standards, since use and preparation of individually prepared standards is not cost effective. These standard solutions will be prepared in 10 percent nitric acid.

Paragraph 5.5.1 The calibration blank will be prepared so as to contain 10 percent nitric acid to match the calibration standards in paragraph 5.4.

Paragraph 5.7 The interference check solution is prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. Spike the sample with the elements of interest at a 1 mcg/mL level. In the absence of measurable analyte, overcorrection could go undetected because a negative value could be reported as zero. If the particular instrument will display overcorrection as a negative number, this spiking procedure will not be necessary.

Paragraph 5.8 The quality control sample(s) should be prepared in the same acid matix as the calibration standards at a 1 mcg/mL level from standards from an alternate lot than the calibration standards.

Paragraph 8.6.2.1 (addition) The expected value is defined to be the concentration obtained for the check standard analyzed subsequent to the calibration of the instrument.

Table 1. Summary of Sample Analysis Results

Project No.: [redacted]
Lotus File: 22889
Analyst: E. McClendon
Analysis Date: [redacted]
Data Analyst: E. McClendon
Date: [redacted]
Analytes: Ca, K, Mg, Na
Sample Matrix: 10% HNO3

Sample Analysis Data:

Verified by: Ed McClendon [redacted]

Sample	ASF Bar Code(s)	Element Ca mcg/g	Element K mcg/g	Element Mg mcg/g	Element Na mcg/g
Run #1 Basin Water	06472	66.2	66.5	20.6	1790
Run #2 Basin Water	06473	63.6	64.2	20.3	1730
Run #1 Impinger	06474/06475	1.04	<1.23	0.193	15.8
Run #2 Impinger	06477	1.30	2.27	0.246	19.5
Milli-Q H2O Blank	06478	0.0141	<1.18	<0.00026	0.177

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES.
The final sample concentrations are in units of mcg/g as received.

Table 2. Sample Weighing Data.

Project No.: [redacted]
Lotus File: 22889
Analyst: E. McClendon
Analysis Date: [redacted]
Data Analyst: E. McClendon
Date: [redacted]
Analytes: Ca, K, Mg, Na
Sample Matrix: 10% HNO3

Sample Weighing Data:

Verified by: E. M. McClendon [redacted]

ASF Bar Code	Beaker Wt. (g)	Sample Wt. (g)	Final Wt. (g)	Net Sx Wt. (g)
06471	51.6702		101.0996	49.4294
06472	50.4484	50.3452	100.0714	49.6230
06473	64.6357	50.1596	114.0306	49.3949
06474	61.1208	50.3520	111.9135	50.7927
06475	56.3990	50.8379	106.1098	49.7108
06476	61.4700	51.1215	111.3360	49.8660
06477	67.3772	50.8360	117.1561	49.7789
06478	61.9998	51.8450	111.1253	49.1255

Table 3. ICAP Sample Analysis Raw and Calculated Data.

Project No.: [redacted]
Lotus File: [redacted]
Analyst: E. McClendon
Analysis Date: [redacted]
Data Analyst: E. McClendon
Date: [redacted]
Analytes: Ca, K, Mg, Na
Sample Matrix: 10% HNO3

ICAP Sample Analysis Raw and Calculated Data:
Instrumental Detection Limit: (mcg/mL, see below)

Verified by: Edith McClendon [redacted]

ASF Bar Code	Dilution Factor	Sample Units	Element Ca	Element K *	Element Mg	Element Na
Raw Data:						
06471	1	mcg/mL	0.03920	1.5961	0.01084	0.13418
06472	100	mcg/mL	0.67199	6.9085	0.20898	18.147
06473	100	mcg/mL	0.64607	6.6787	0.20616	17.584
06474	1	mcg/mL	1.0667	-1.2430	0.20300	15.855
06475	1	mcg/mL	1.1054	-1.2430	0.20716	16.313
06476	1	mcg/mL	6.2258	7.2715	0.21418	21.728
06477	1	mcg/mL	1.3663	3.9053	0.26159	20.050
06478	1	mcg/mL	0.05433	-1.2430	0.00872	0.32150
Detection Limit		mcg/mL	0.00477	1.2430	0.00027	0.05236
Calculated Data:						
06471		mcg	1.9376	78.8943	0.53581	6.6324
06472		mcg/g	66.1965	66.5269	20.5876	1788.5365
06473		mcg/g	63.5834	64.1959	20.2910	1731.4604
06474		mcg/g	1.0376	-1.2539	0.19414	15.8620
06475		mcg/g	1.0428	-1.2154	0.19203	15.8209
06476		mcg/g	6.0350	5.5496	0.19844	21.0646
06477		mcg/g	1.2998	2.2722	0.24561	19.5026
06478		mcg/g	0.0141	-1.1778	-0.00026	0.1767
% Difference and Spike Recovery:						
06474		mcg/g	1.0376	-1.2539	0.19414	15.8620
06475		mcg/g	1.0428	-1.2154	0.19203	15.8209
% Difference			0.50	NA	1.09	0.26
06476		mcg/g	6.0350	5.5496	0.19844	21.0646
Spike Level		mcg/g	4.8903	4.8903	NS	4.8903
% Recovery			102	113	NA	107
Instrumental Drift:						
Initial ICS		mcg/mL	4.9078	74.480	2.2914	74.039
ICS1		mcg/mL	4.7780	72.258	2.2617	71.760
% Drift 1			2.64	2.98	1.30	3.08
ICS2		mcg/mL	4.6893	73.189	2.2291	70.572
% Drift 2			4.45	1.73	2.72	4.68

Comments:
These samples were analyzed on a Jarrell-Ash Model 1155A ICP-AES.
A negative number indicates that the sample was less than the detection limit.
* The K values for samples 06472 and 06473 were taken from 1/10 dilutions.

NS = Not Spiked; NA = Not Applicable