EMET

EnvironMETeo Services Inc.
94-463 Ukee Street, Suite A, Waipahu, Hawaii 96797
Telephone (808) 671-8383 FAX (808) 671-7979

Rating = A.

Kapaa Quarry

LFG EFD AP42
12 63 46

Can be used to estimate plant eff

January 19, 1994

Mr. Frank Enos
Laidlaw Gas Recovery Systems
20662 Newport Coast Drive
Irvine, CA 92715

Dear Mr. Enos,

Enclosed are two (2) copies of the stack emissions test report performed at Kappa Generating Partners 3.3 MW Gas Turbine Generator located at Ameron Kapaa Quarry. Submit one (1) copy of the test report to the State of Hawaii, Department of Health, the other copy of the report is for your records.

Also enclosed is the final invoice for emission testing performed on December 28, 1993.

If you should have any questions please call me at 671-8383.

Respectfully,

Clifford How

encl.(3)

SUMMARY

EnvironMETeo (EMET) Services Inc. was retained by Kapaa Generating Partners / Laidlaw Gas Recovery Systems to perform source emission testing at Ameron Kapaa Quarry - 3.3 MW Gas Turbine Generator, located at Kaneohe, Hawaii. Testing was conducted on December 28, 1993.

Emission testing on the 3.3 MW Gas Turbine Generator included testing for sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emissions in accordance with EPA Method 20. EPA Method 1 for sample and velocity traverse, EPA Method 2 for velocity and volumetric flow rate, EPA Method 3 for gas analysis and EPA Method 4 for moisture content were also conducted.

The average emission rate for the test were 0.178 lb/hr of sulfur dioxide and 0.861 lb/hr of nitrogen oxide.

EMET

TABLE OF CONTENTS

INTRODUCTION

EnvironMETeo Services, Inc. (EMET) of Honolulu, Hawaii, conducted source emission tests for Kapaa Generating Partners / Laidlaw Gas Recovery Systems. The tests were performed on Kapaa Generating Partners - 3.3 MW Gas Turbine Generator located at Kapaa Quarry, Kaneohe, Hawaii.

The tests were conducted on December 28, 1993.

The purpose of the tests were to determine compliance with State of Hawaii, Department of Health Special Conditions of Permit to Operate, No. P-761-1190, Application No. P-761-1014. The tests were requested by Mr. Frank Enos of Kapaa Generating Partners / Laidlaw Gas Recovery Systems.

The Department of Health (DOH), Clean Air Branch, of the State of Hawaii was notified at least thirty (30) days prior to the date of the test.

SAMPLING AND ANALYTICAL PROCEDURES

The emission sampling conducted at the Kapaa Generating Partners 3.3 MW Gas Turbine Generator followed the procedures outlined in Appendix A to the Code of Federal Regulations, Title 40, Part 60.

EPA Method 1: Traverse Point Determination

This method cannot be used if the sampling port is located less than two (2) stack diameters downstream or less than a half (1/2) stack diameter upstream from a flow disturbance.

The stack exhaust from the generator is a circular duct of 39 1/2 inches diameter. Two sample ports located at 90 degrees to each other were used. A 12 point traverse with 6 points per diameter was determined in accordance to EPA Method 1.

EPA Method 2: Stack Gas Velocity

The velocity pressure (delta p) and stack gas temperature were measured. A type "S" pitot tube was used for measuring delta p's. Prior to each test the pitot tube was leak checked.

EPA Method 3: Stack Gas Molecular Weight

A continuous gas sample was extracted from the effluent stream and conveyed to instrumental analyzers for the determination of CO_2, CO and O_2.

EPA Method 4: Stack Gas Moisture Determination

The stack gas moisture was determined from the back half impinger train of the condenser system. The volume of water was determined gravimetrically.

EPA Method 20: Sulfur Dioxide and Nitrogen Oxide Concentrations

A continuous gas sample was extracted from the effluent stream and conveyed to an instrumental non-dispersive ultraviolet (NDUV) analyzer for the determination of SO_2 gas concentrations.

A continuous gas sample was extracted from the effluent stream and conveyed to an instrumental chemiluminescent analyzer for the determination of NO_x gas concentrations.

DESCRIPTION OF TEST

Personnel of EMET Services arrived on site at Kapaa Generating Partners, Kaneohe, Hawaii at 11:00 a.m. on Monday, December 27, 1993. The equipment was set up, leak checked, calibrated and readied for emission testing on the 3.3 MW Gas Turbine Generator.

On Tuesday, December 28, 1993 EMET personnel arrived on site at 6:30 a.m. The equipment was readied and calibrated prior to testing. Emissions testing began on the 3.3 MW Gas Turbine Generator. Testing proceeded as follows:

Run #	Time Start	Time Finish	Pollutants Tested
1	0737	0807	SO_2, NO_x
2	0819	0849	SO_2, NO_x
3	0901	0931	SO_2, NO_x

Velocity measurements were taken prior to the start of the first run. Stack gas moisture determination was conducted concurrently with emissions testing.

The sample train was leak checked prior to and after testing of the unit by the introduction of calibration gas at the input of the sample conditioning train. A leak is indicated if the analyzer reads less than the certified concentration of the calibration gas. Calibration gas data is attached (Appendix F).

All analyzers were calibrated before and after each test run using Certified Master calibration gas (+/- 2%) obtained from Scott Specialty Gases, Inc. located in San Bernadino, California. The analyzer zero point was calibrated using cylinder nitrogen as a zero air source.

Calibration data for the pitot tubes and dry gas meters are attached (Appendix G).

No operational or testing difficulties were encountered.

DESCRIPTION OF EQUIPMENT

CONTINUOUS MONITORING INSTRUMENTS

	CARBON DIOXIDE	CARBON MONOXIDE	OXYGEN	SULFUR DIOXIDE	NITROGEN OXIDES
Manufacturer	Automated Custom Systems		Teledyne	Anarad	Thermo Electron
Model No.:	ACS 3400	ACS 3400	MAX-5	Series AR-30	10AR
Detection Principle	NDIR	NDIR	fuel cell	UV	chemiluminescence
Range	0-20%	0-500ppm	0-25%	0-2000ppm	0-1000ppm
Sensitivity, min. detection limit, % of full scale	1	1	1	1	1
Noise level, % of full scale (peak to peak)	0.5	0.5	0.5	0.5	0.5
System response time (minute)	<1.5	<1.5	<1.5	<1.5	<1.5

CONTINUOUS EMISSIONS MONITORING SUMMARY CALCULATIONS

z =	(zf - zi)/n
zc =	z/2 + [z * (t - 1)] + zi
s =	(sf - si) / n
sc =	s/2 + [s * (t - 1)] + si
Ct =	Cs * (Rt - zc) / (sc - zc)

Where:

100 Chart Divisions = Full Scale

Cs =	span gas concentration
Ct =	measured gas concentration over time = t
n =	number of observations of time periods
Rt =	average from recorder reading or chart over time = t
s =	upscale calibration gas span from recorder reading or chart divisions
si =	initial span reading or chart divisions - start of test run
sf =	final span reading or chart divisions - end of test run
sc =	corrected span reading or chart divisions over time = t
t =	averaging time period; 1 to n
z =	zero gas reading from recorder reading or chart divisions
zi =	initial zero reading or chart divisions - start of test run
zf =	final zero reading or chart divisions - end of test run
zc =	corrected zero reading or chart divisions over time = t
z drift (%) =	(zf - zi) / (recorder range) * 100 for zi and zf in chart divisions
s drift (%) =	[(sf - zf) - (si - zi)] / (recorder range) * 100 for zi, zf, si, and sf in chart divisions

CO2 - KAPAA GEN. PARTNERS,UNIT: 3.3 MW TURBINE,FUEL: METHANE; TEST DATE: 12/28/93

TEST NUMBER: 1 SPAN GAS CONCENTRATION= 15.010 PERCENT RECORDER CHART SPAN (ENGINEERING UNIT) = 20.00 PERCENT

(UNITS ARE IN PERCENT (%), EXCEPT AS NOTED)

RUN	START	REFVAL	COR.VAL	ZI	SI	ZF	SF	ZC	SC	ZDFT%	SDFT%
1	07:37	3.64	3.59	.06	15.01	.08	15.02	.07	15.02	.10	-.05
2	08:19	3.63	3.57	.08	15.02	.06	15.03	.07	15.02	-.10	.15
3	09:01	3.58	3.55	.06	15.03	.04	14.95	.05	14.99	-.10	-.30

CORRECTED REFERENCE METHOD VALUE FOR THE TEST = 3.57 PERCENT

REFVAL = RECORDED REFERENCE METHOD VALUES, COR.VAL = REFERENCE METHOD VALUES CORRECTED FOR DRIFT.

ZI,ZF and SI,SF = ZERO AND SPAN DRIFT VALUES, ZC,SC = COMPUTED AVERAGE OF ZERO AND SPAN DRIFT CORRECTIONS.

ZDFT% AND SDFT% = ZERO AND SPAN DRIFT CALCULATED IN PERCENT.

NOx -KAPAA GEN. PARTNERS,UNIT: 3.3 MW TURBINE,FUEL: METHANE; TEST DATE: 12/28/93

TEST NUMBER: 2 SPAN GAS CONCENTRATION= 418.000 PPM RECORDER CHART SPAN (ENGINEERING UNIT) = 1000.00 PPM

(UNITS ARE IN PPM, EXCEPT FOR PERCENT (%) DRIFT AND AS NOTED)

RUN	START	REFVAL	COR.VAL	ZI	SI	ZF	SF	ZC	SC	ZDFT%	SDFT%
1	07:37	16.59	16.28	.18	417.70	.15	426.00	.17	421.85	.00	.83
2	08:19	16.69	16.50	.18	418.00	.24	417.50	.21	417.75	.01	-.06
3	09:01	16.86	16.50	.24	417.50	.55	417.60	.39	417.55	.03	-.02

CORRECTED REFERENCE METHOD VALUE FOR THE TEST = 16.43 PPM

REFVAL = RECORDED REFERENCE METHOD VALUES, COR.VAL = REFERENCE METHOD VALUES CORRECTED FOR DRIFT.

ZI,ZF and SI,SF = ZERO AND SPAN DRIFT VALUES, ZC,SC = COMPUTED AVERAGE OF ZERO AND SPAN DRIFT CORRECTIONS.

ZDFT% AND SDFT% = ZERO AND SPAN DRIFT CALCULATED IN PERCENT.

CO -KAPAA GEN. PARTNERS,UNIT: 3.3 MW TURBINE,FUEL: METHANE; TEST DATE: 12/28/93

TEST NUMBER: 3   SPAN GAS CONCENTRATION= 225.000 PPM   RECORDER CHART SPAN (ENGINEERING UNIT) = 500.00 PPM

(UNITS ARE IN PPM, EXCEPT FOR PERCENT (%) DRIFT AND AS NOTED)

RUN	START	REFVAL	COR.VAL	ZI	SI	ZF	SF	ZC	SC	ZDFT%	SDFT%
1	07:37	39.87	39.44	.15	225.20	.70	225.70	.42	225.45	.11	-.01
2	08:19	37.96	38.19	.70	225.70	-1.04	223.30	-.17	224.50	-.35	-.13
3	09:01	34.51	36.99	-1.04	223.30	-3.57	220.00	-2.30	221.65	-.51	-.15

CORRECTED REFERENCE METHOD VALUE FOR THE TEST = 38.20 PPM

REFVAL = RECORDED REFERENCE METHOD VALUES,   COR.VAL = REFERENCE METHOD VALUES CORRECTED FOR DRIFT.

ZI,ZF and SI,SF = ZERO AND SPAN DRIFT VALUES,   ZC,SC = COMPUTED AVERAGE OF ZERO AND SPAN DRIFT CORRECTIONS.

ZDFT% AND SDFT% = ZERO AND SPAN DRIFT CALCULATED IN PERCENT.

SO2 -KAPAA GEN. PARTNERS,UNIT: 3.3 MW TURBINE,FUEL: METHANE; TEST DATE: 12/28/93

TEST NUMBER: 5 SPAN GAS CONCENTRATION= 184.000 PPM RECORDER CHART SPAN (ENGINEERING UNIT) = 200.00 PPM

(UNITS ARE IN PPM, EXCEPT FOR PERCENT (%) DRIFT AND AS NOTED)

RUN	START	REFVAL	COR.VAL	ZI	SI	ZF	SF	ZC	SC	ZDFT%	SDFT%
1	07:37	.15	1.36	.08	185.00	-2.52	184.00	-1.22	184.50	-1.30	.80
2	08:19	3.47	2.88	-.50	184.00	1.69	184.40	.60	184.20	1.10	-.90
3	09:01	4.50	3.07	.41	184.40	2.46	185.57	1.43	184.99	1.02	-.44

CORRECTED REFERENCE METHOD VALUE FOR THE TEST = 2.44 PPM

REFVAL = RECORDED REFERENCE METHOD VALUES, COR.VAL = REFERENCE METHOD VALUES CORRECTED FOR DRIFT.

ZI,ZF and SI,SF = ZERO AND SPAN DRIFT VALUES, ZC,SC = COMPUTED AVERAGE OF ZERO AND SPAN DRIFT CORRECTIONS.

ZDFT% AND SDFT% = ZERO AND SPAN DRIFT CALCULATED IN PERCENT.

APPENDIX A

Location of Sampling Points

Location Of Sampling Points

KAPAA GENERATING PARTNERS
3.3 MW GAS TURBINE GENERATOR EXHAUST STACK

Point No.	Distance (in.)	Distance (in.)
1	1.72	1 11/16
2	5.78	5 12/16
3	11.69	11 10/16
4	27.81	27 13/16
5	33.72	33 11/16
6	37.78	37 12/16

APPENDIX B

Nomenclature

NOMENCLATURE

Symbol	Units	Description
A_n	ft^2	Source sampling nozzle cross-sectional area
A_s	ft^2	Stack cross-sectional area (inside stack)
Abs.	Absolute	Abbreviation
ACF	Actual cubic feet	Abbreviation
ACFH	Actual cubic feet per hour	Abbreviation
ACFM	Actual cubic feet per minute	Abbreviation
BCR	lb/hr	Estimated biomass (wet) combustion (feed) rate
B_{ws}	-	Moisture content of stack gas by volume (measured)
C_p	-	Pitot tube calibration coefficient
C_s	gr/DSCF	Particulate concentration at standard conditions*
% CO	%	Carbon monoxide content of stack gas by volume (dry basis)
% CO_2	%	Carbon dioxide content of stack gas by volume (dry basis)
D_n	inches	Source sampling nozzle diameter
DSCF	Dry standard cubic feet	Abbreviation
DSCFH	Dry standard cubic feet per hour	Abbreviation
DSCFM	Dry standard cubic feet per minute	Abbreviation
E	lb/hr	Particulate emission rate
E_{spec}	lb/100 lb	Specific particulate emission rate
% EA	%	Percent excess air

*528°R (68°F), 29.92 inches Hg Abs.

Symbol	Unit	Description
°F	Degrees Fahrenheit	Abbreviation
ft	Feet	Abbreviation
fps	Feet per second	Abbreviation
gr	Grain(s)	Abbreviation
gm	Gram(s)	Abbreviation
Average ΔH	inches H_2O	Average orifice meter pressure drop
Hg	Mercury	Abbreviation
% I	%	Percent isokinetic
K_p	$\left[\frac{(\text{lb/lb-mole})\ (\text{inches Hg})}{(^\circ\text{R})\ (\text{inches } H_2O)}\right]^{1/2}$	Pitot tube equation dimensional constant
lb	Pound(s)	Abbreviation
M_d	lb/lb-mole	Dry molecular weight of stack gas
m_f	mg	Weight of particulates collected in filter
m_o	mg	Weight of particulates in acetone wash from probe, nozzle, cyclone, filter bell and flask
M_s	lb/lb-mole	Wet molecular weight of stack gas
m_{stm}	lb/hr	Main steam flow rate
m_t	mg	Total weight of particulates collected
mg	Milligram(s)	Abbreviation
ml	Milliliter(s)	Abbreviation
% N_2	%	Nitrogen content of stack gas by volume (dry basis)
% O_2	%	Oxygen content of stack gas by volume (dry basis)
Δp_{avg}	inches H_2O	Velocity head of stack gas

Symbol	Unit	Description
P_b	inches Hg Abs.	Barometric pressure
P_m	inches Hg Abs.	Gas meter pressure
°R	Degrees Rankine	Abbreviation
P_s	inches Hg Abs.	Stack pressure
P_{std}	inches Hg Abs.	Standard atmospheric pressure (29.92 inches Hg Abs.)
P_{stm}	psig	Steam pressure
psig	pounds per square inch gage	Abbreviation
Q_a	ACFH or ACFM	Stack gas volumetric flow rate at stack conditions
Q_s	DSCFH or DSCFM	Dry stack gas volumetric flow rate at standard conditions*
SCF	Standard cubic feet	Abbreviation
T_m	°R (°F)	Average gas meter temperature
T_s	°R (°F)	Stack gas temperature
T_{std}	°R (°F)	Standard temperature (528°R (68°F))
T_{stm}	°F	Steam Temperature
V_m	ft^3	Volume of dry gas sampled at meter conditions
$V_{m_{std}}$	DSCF	Volume of dry gas sampled at standard conditions*
v_s	fps	Stack gas velocity at stack conditions
V_{wc}	ft^3	Total volume of water vapor collected at standard conditions*
V_{wi}	ml	Total volume of water collected in impingers
V_{wsg}	gm	Total weight of water absorbed in silica gel
Y_m	-	Dry gas meter correction factor
θ	Minutes	Particulate traverse time
%	Percent	Abbreviation

*528°R (68°F), 29.92 inches Hg Abs.

APPENDIX C

Applicable Equations

APPLICABLE EQUATIONS AND ASSUMPTIONS

1. Volume of dry gas sampled at standard conditions.*

$$V_{m_{std}} = V_m \, Y_m \left[\frac{T_{std}}{T_m}\right] \left[\frac{P_b + \frac{P_m}{13.6}}{P_{std}}\right] \qquad \text{(DSCF)}$$

2. Volume of water vapor collected at standard conditions.*

$$V_{wc} = (0.04707)(V_{wi}) + (0.04715)(V_{wsg}) \qquad \text{(SCF)}$$

3. Moisture content of stack gas by volume (measured).

$$B_{ws} = \frac{V_{wc}}{V_{m_{std}} + V_{wc}}$$

4. Dry molecular weight of stack gas.

$$M_d = \Sigma M_x B_x = 0.44\,(\%\,CO_2) + 0.32\,(\%\,O_2) + 0.28\,(\%\,CO + \%\,N_2) \quad \text{(lb/lb-mole)}$$

5. Wet molecular weight of stack gas.

$$M_s = M_d\,(1 - B_{ws}) + 18\,B_{ws} \qquad \text{(lb/lb-mole)}$$

6. Percent excess air (at sampling point).

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

7. Stack pressure.

$$P_s = P_b \qquad \text{(inches Hg absolute)}$$

8. Stack gas velocity at stack conditions.

$$v_s = K_p C_p \sqrt{\frac{T_s}{P_s M_s}} \; \sqrt{\Delta p} \;\; \text{avg} \qquad \text{(fps)}$$

*528°R (68°F), 29.92 inches Hg Abs.

9. Stack gas volumetric flow rate at stack conditions.

$$Q_a = (v_s)(A_s)(3600) \qquad \text{(ACFH)}$$

$$= (v_s)(A_s)(60) \qquad \text{(ACFM)}$$

10. Stack gas volumetric flow rate at standard conditions.*

$$Q_s = (v_s)(A_s)(3600)(1 - B_{ws}) \left[\frac{T_{std}}{P_{std}}\right] \left[\frac{P_s}{T_s}\right] \qquad \text{(DSCFH)}$$

$$= (v_s)(A_s)(60)(1 - B_{ws}) \left[\frac{T_{std}}{P_{std}}\right] \left[\frac{P_s}{T_s}\right] \qquad \text{(DSCFM)}$$

11. Percent isokinetic.

$$\% I = \frac{(0.0945)\, T_s\, V_{m(std)}}{P_s\, v_s\, A_n\, \theta\, (1 - B_{ws})} \qquad (\%)$$

12. Total weight of particulates collected and particulate concentration at standard conditions.*

$$m_t = m_f + m_o \qquad \text{(mg)}$$

$$C_s = \frac{m_t\,(0.01543)}{V_{m(std)}} \qquad \text{(gr/DSCF)}$$

13. Particulate emission rate.

$$E = \frac{Q_a\, C_s}{7000} \qquad \text{(lb/hr)}$$

14. Specific particulate emission rate.

$$E_{spec} = \frac{1}{BCR}\, \Sigma\, \frac{Q_a C_s}{7000}$$

*528°R (68°F), 29.92 inches Hg Abs.

APPENDIX D

Velocity and Volumetric Flow Rate

Gas Velocity Traverse Data

Plant LAIDLAW GAS RECOVERY SYSTEMS Date 12/28/93

Plant location KAPAA QUARRY

Sampling location

Operator(s) C. HOW, L. TANGUNAN

Dry molecular weight of stack gas 30 lb/mole. Moisture content 3.73 $\% H_2O$

Pitot tube C_p .840 Barometric pressure 30.0 Stack static pressure

Stack cross-sectional area (A_s) 8.51 ft^2

Sample point no.		Port A Δp H_2O in.	Port A $\sqrt{\Delta p}$	Port A T_s °F	Sample point no.		Port B Δp H_2O in.	Port B $\sqrt{\Delta p}$	Port B T_s °F
1		2.2	1.48	723	1		2.2	1.48	723
2		2.8	1.67		2		2.8	1.67	
3		3.2	1.79		3		3.2	1.79	
4		3.4	1.84		4		3.4	1.84	
5		3.0	1.73		5		3.0	1.73	
6		2.2	1.48		6		2.2	1.48	
7					7				
8					8				
9					9				
10					10				
11					11				
12					12				

$$\text{Average } T_s\,°R(\overline{T}_s\,°R) = \left[\frac{\text{Sum of } T_s\,°F \text{ at each sample point}}{\text{Total no. sample points}}\right] + 460 = \underline{1183}\ °R$$

$$\text{Average } \Delta p\ (\overline{\Delta p}) = \left[\frac{\text{Sum of the } \sqrt{\Delta p} \text{ at each sample point}}{\text{Total no. sample points}}\right]^2 = \underline{2.77} \text{ in. } H_2O$$

$$\text{Average stack gas velocity } (\overline{v}_s) = K_p C_p \sqrt{\frac{\overline{T}_s}{P_s M_s}}\left(\sqrt{\Delta p}\right)_{av} = \underline{137.08} \text{ ft /sec}$$

$$\text{where } K_p = 85.49 \text{ ft./sec.} \sqrt{\frac{\text{lb/lb mole (in. Hg)}}{(°R)\text{ (in. } H_2O)}}$$

Average actual stack gas volumetric flow rate

$$(\overline{Q}_a) = (\overline{v}_s)(A_s) \times 3600 \text{ sec /hr} = \underline{4,199,582.8}\ \text{ACFH}$$

Average dry stack gas volumetric flow rate at standard conditions

$$(Q_s) = (3600 \text{ sec /hr})(1-B_{ws})(\overline{v}_s)(A_s)\ \frac{T_{std}}{P_{std}}\ \frac{P_s}{\overline{T}_s} = \frac{1,809,276.6}{60^{min}}\ \text{DSCFH}^{/hr} = 30,154.6^{dscfm}$$

APPENDIX E

Stack Gas Moisture Determinations

Stack Gas Moisture Determinations

	Meter Indication	Impinger Volume	Silica Gel
Start	9010.00 ft^3	200 ml	231.7 gram
End	9045.00 ft^3	220 ml	238.8 gram
Difference	35.00 ft^3	20 ml	7.1 gram

Stack gas temperature was 723 degrees Fahrenheit.

Stack gas moisture was 3.73 percent.

APPENDIX F

Calculations of Source Test for SO_2 and NO_X Emissions

EMET

EMISSION RATE CALCULATIONS

APPLICABLE CODE: EPA; CODE OF FEDERAL REGULATIONS (CFR), TITLE 40, PART 60, APPENDIX A

PROCEDURE:

Emission rates are calculated from continuously analyzed component concentrations and the btu value of the fuel fired.

APPLICABLE EQUATIONS

C = ppm * MW * K1

EF = C * F * 20.9/(20.9 - O_2%), as measured

ER = EF * I

corrected to 15% O_2 = ppm * (20.9-15) / (20.9 - O_2%)
O_2 as measured

Where:

C =	pollutant concentration, lb/SDCF
EF =	emission rate, lb/mmbtu
ER =	emission rate, lb/hr
F =	emission rate factor, SDCF/mmbtu - 9440) = -7588
I =	unit input, mmbtu/hr
K1 =	conversion factor, 2.59 * 10E -9
MW =	component molecular weight in gram/mole (NO_x = 46.01, CO = 28.01, CO_2 = 44.01, SO_2 = 64.07)
%O_2 =	oxygen concentration, % volume dry

581 BtU/ft³

1852 ft³ / mmBtU

$C_{CO} = (38.20\ ppm)(28.01)(2.59 \times 10^{-9}) = 2.77 \times 10^{-6}\ lb/DSCF$

$COER = (2.77 \times 10^{-6}\ lb/DSCF)(1,809,276.6\ DSCF/hr)$
$= 5.01\ lb/hr$

$CH_4\ FR = 945\ ft^3/min \cdot .532 = 502.7\ ft^3/min$

COER (lb/hr)(ft³ CH_4/min) = 9.97×10^{-3}

TEST EMISSION RATE RESULTS

(SO_2 and NO_x corrected to 15% O_2)

SO_2	(lb/mmbtu)	0.006
SO_2	(lb/hr)	0.178
NO_x	(lb/mmbtu)	0.028
NO_x	(lb/hr)	0.861
CO	(ppm)	38.20
CO_2	(percent)	3.57
O_2	(percent)	17.04
BWS	(percent)	3.73

APPENDIX G

Fuel and Combustion Data

EMET

Fuel and Combustion Data

FUEL FEED RATE

Source	Run	Fuel Feed Rate
3.3 MW Gas Turbine Generator	1	946.9 ACFM
	2	948.3 ACFM
	3	940.0 ACFM
		Average 945.00 ACFM

Fuel flow rate readings were performed by Kapaa Generating Partners personnel.

ZALCO LABORATORIES, INC.
Analytical & Consulting Services

FROM Monty

Lab. No.: 038412_001
Received: Jan 10, 1994
Reported: Jan 10, 1994

Kapaa Generating Partners
909 Kalanianaole Hwy.
Kailua, HI 96734

Attention: Monty O'Brien

Sample Description: Natural Gas

* CHROMATOGRAPHIC ANALYSIS (Z 1535) *

Components	Mole %	Wt %
Hydrogen	0.000	0.000
Carbon Dioxide	40.860	63.818
Oxygen	.017	.019
Nitrogen	5.885	5.351
Carbon Monoxide	0.000	0.000
Hydrogen Sulfide	0.000	0.000
Methane	53.239	30.812
Ethane	0.000	0.000
Propane	0.000	0.000
Isobutane	0.000	0.000
N-Butane	0.000	0.000
Isopentane	0.000	0.000
N-Pentane	0.000	0.000
Hexanes+	0.000	0.000
Totals =	100.000	100.000

CHONS	Wt %
CARBON	40.10
HYDROGEN	7.52
OXYGEN	46.43
NITROGEN	5.85
SULFUR	0.00
Totals	100.00
Total H/C	.19

SPECIFIC GRAVITY (Air = 1)		.9749
SPECIFIC VOLUME, cu.ft./lb	*	13.44
GROSS CALORIFIC VALUE, BTU/cu.ft.	*	530.96
GROSS CALORIFIC VALUE, BTU/cu.ft.	**	540.14
GROSS CALORIFIC VALUE, BTU/lb	**	7259.68
NET CALORIFIC VALUE, BTU/cu.ft.	**	486.34
NET CALORIFIC VALUE, BTU/lb	**	6536.55
DSCF EXHAUST PER SCF FUEL (0% Oxygen)		5.0502
COMPRESSIBILITY FACTOR 'Z' (60 F, 1 ATM)		.9975
EPA 'F' Factor @ 68 F:	9440.018 DSCF / MM Btu.	9440.018
KCAPCD 'F' Factor @ 60 F:	9298.418 DSCF / MM Btu.	9298.418

* Water Saturated

** Dry Gas @ 60 F, 14.73 psia

Michelle Pastaro
Analyst

Jim Etherton
Laboratory Director

4309 Armour Avenue Bakersfield, California 93308
(805) 395-0539 FAX (805) 395-3069

APPENDIX H

Calibration of Equipment

ANDERSEN
SAMPLERS INCORPORATED

12/12/89

This certifies that 'S' Type Pitot Tubes constructed and calibrated by Andersen Samplers, Inc. comply with procedures given in the Environmental Protection Agency Reference Method 2-Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube), Vol. 42, No. 160-Thursday, August 18, 1977. Andersen certifies that at time of shipment baseline coefficient values of 0.84 may be assigned to the pitot tubes.

Nathan D. Canup
Quality Control Manager

4215 WENDELL DRIVE □ ATLANTA, GEORGIA 30336 □ (404) 691-1910 □ TELEX: 54-2523

METERING SYSTEM CALIBRATION DATA

Date: 9/30/92 Pre-test: ✓ Post-test: ______

Metering System I.D.: 01-323606 Temperature Compensated: 60 deg F.

Barometric Pressure Pb: 24.51 "Hg Calibration Vacuum: 4 "Hg.

Orifice manometer setting ΔH in. H_2O	Standard Dry Gas Meter readings (Vw) ft3	Standard Dry Gas Meter volume (Vw) ft3	Dry Gas Meter readings (Vm) ft3	Dry Gas Meter volume (Vm) ft3	Temperatures: Standard DGM t_w °F	Dry Gas Meter Inlet t_i °F	Dry Gas Meter Outlet t_o °F	Dry Gas Meter Average t_m °F	Time θ min
.5	046.3 051.3	5.0	[illegible] [illegible]	5.01	84		60		8.76
1.0	[illegible] [illegible]	5.0	[illegible] [illegible]	5.11	85		60		6.19
1.5	[illegible] [illegible]	5.0	[illegible] [illegible]	5.14	85		60		5.16
2.0	[illegible] [illegible]	5.0	[illegible] [illegible]	5.16	86		60		4.56
2.5	[illegible] [illegible]	5.0	[illegible] [illegible]	5.19	86		60		4.09

Calculations

ΔH in. H_2O	Y $\frac{V_w\ P_b\ (t_m + 460)}{V_m \left[P_b + \frac{\Delta H}{13.6}\right] (t_w + 460)}$	ΔH@ $\frac{0.0317\ \Delta H}{P_b\ (t_o + 460)} \left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
.5	.9415	.9383
1.0	.9313	.9404
1.5	.9247	.9502
2.0	.9147	1.0245
2.5	.9118	1.0252
Average	.9248	.9513

FOR POST-TEST CALIBRATION ONLY.

Percent change of average Y value from pre-test calibration average Y value: ______%

Note: Tolerance for change is 5%.

Difference Of Individual Readings From Average.

ΔH in. H2O	Y	ΔH@
.5	.017	.043
1.0	.006	.041
1.5	.006	.001
2.0	.010	.043
2.5	.013	.044

Notes:

Y = Ratio of reading of std. test meter to dry test meter; tolerance for individual values + or − 0.02 from average

ΔH@ = Orifice pressure differential that equates to 0.75 cfm of air at 68 deg. F and 29.92 inches of mercury, in. Hg.; tolerance for individual values + or − 0.20 from average.

EnvironMETeo Services Inc.
94-453 Ukee Street, Suite A, Waipahu, Hawaii 96797
Telephone (808) 671-8383 FAX (808) 671-7979

STACK EMISSIONS TEST LABORATORY NOTEBOOK

MAGNEHELIC GAUGE CALIBRATION DATA

Date: 9/22/92 Calibrated by: Gary S[illegible]

Scale: 0 - 1" H_2O I.D. Number 01-20912A192

Pressure Side Calibrated	Inclined Manometer (in. ~~Hg.~~) H_2O	Magnehelic Gauge (in. ~~Hg.~~) H_2O	Difference (in. ~~Hg.~~) H_2O
High Pressure +	.15	.15	0
	.40	.40	0
	.75	.75	0
Low Pressure −	.15	.15	0
	.40	.40	0
	.75	.75	0

MAGNEHELIC GAUGE CALIBRATION DATA

Date: 9/22/92 Calibrated by: Gary S[illegible]

Scale: 0 - 3" H_2O I.D. Number 01-41021NH112

Pressure Side Calibrated	Inclined Manometer (in. ~~Hg.~~) H_2O	Magnehelic Gauge (in. ~~Hg.~~) H_2O	Difference (in. ~~Hg.~~) H_2O
High Pressure +	.5	.5	0
	1.25	1.25	0
	2.25	2.25	0
Low Pressure −	.5	.5	0
	1.25	1.25	0
	2.25	2.25	0

EnvironMETeo Services Inc. 94-469 Ukee Street, Suite A, Waipahu, Hawaii 96797 (808) 671-0383, FAX (808) 671-7079

SILICA GEL WEIGHTS — STACK EMISSIONS TEST LABORATORY NOTEBOOK

I.D. Number	Tare	Silica Gel Weights (Tare + Gel)						Net Increase	Test Date and Number	Run Number
		Initial	Analyst	Date	Final	Analyst	Date			
197	69.4	231.7	ky	11/16/93	238.8	27	12/20/93		LAIDLAW 12/21/93	1

APPENDIX I

Calibration Gases

CALIBRATION GASES

GAS	CONCENTRATION	USE
Carbon Dioxide	15.01%	Span
Carbon Monoxide	225 ppm	Span
Nitrogen Oxide	418 ppm	Span
Sulfur Dioxide	184 ppm	Span
Nitrogen	zero grade	Zero gas

APPENDIX J

Chain Of Custody

Chain of Custody

Desiccants and their associated containers are numbered and weighed. Indelible ink is used for all markings. The data are recorded in a laboratory notebook. Desiccants are then placed in a locked container for transportation to the test site.

During the tests, samples are recovered and handled in accordance with the applicable reference methods. Recovered samples area placed in numbered containers and placed in a locked container at the end of each test day. After the completion of the tests, recovered samples are transported in locked containers.

After the completion of each run, the samples were recovered and placed under the custody of Clifford How.

All analyses are performed by EMET Services analytical laboratory which requires no lengthy chain of custody.

Access to the desiccants and recovered samples is limited to authorized personnel. Pre-test preparation and sample analysis are conducted by or under the guidance of the test team leader. All analytical results are recorded in a laboratory notebook or in the appropriate data sheets. These documents are kept in the files of EnvironMETeo Services Inc. and access to these files are controlled.

APPENDIX K

Control Room Records

Plant: KAPAA Gen Partner (Laidlaw) Date: 12/28/93

Plant Operator: BOB Run Number: 1

PROCESS DATA

START Fuel Flow		END		KW Process Information	
Time	Process Meter Readings	Time	Process Meter Readings	~~Cumulative Total lbs. tons~~	Rate (circle one): lbs./hr. tons/hr.
0737	969			2200	
0742	916			2200	
0747	944			2200	
0752	941			2185	
0757	969			2215	
0803	947			2200	
stop 0807	942			2190	

Process readings are to be taken at the start of each run and at 10-minute intervals; also, any time processing stops.

SCRUBBER DATA

START		END		Water Flow Rate (gpm)	Pressure Differential (inches of water)
Time	Water Meter Readings	Time	Water Meter Readings		

Scrubber readings are to be taken at the start of each run and at 15-minute intervals; also, any time water flow stops.

Plant: Kapaa Gen Partner

Date: 12/28/93

Plant Operator: Monty

Run Number: 2

PROCESS DATA

START		END		Process Information	
Time	Process Meter Readings	Time	Process Meter Readings	KW ~~Cumulative~~ Total lbs. tons	Rate (circle one) lbs./hr. tons/hr.
0819	941			2179	
0824	944			2178	
0829	949			2203	
0834	944			2217	
0839	947			2200	
0844	969			2200	
STOP 0849	944			2215	

Process readings are to be taken at the start of each run and at 10-minute intervals; also, any time processing stops.

SCRUBBER DATA

START		END		Water Flow Rate (gpm)	Pressure Differential (inches of water)
Time	Water Meter Readings	Time	Water Meter Readings		

Scrubber readings are to be taken at the start of each run and at 15-minute intervals; also, any time water flow stops.

Plant: Kapaa Generating Partners Date: 12-28-93

Plant Operator: MONTI Run Number: 3

PROCESS DATA

START		END		Process Information	
Time	Process Meter Readings	Time	Process Meter Readings	Kw ~~Cumulative~~ Total lbs. tons	Rate (circle one) lbs./hr. tons/hr.
0901	947			2214	
0906	944			2159	
0911	941			2162	
0916	944			2170	
0921	916			2159	
0926	944			2170	
0931	944			2170	

Process readings are to be taken at the start of each run and at 10-minute intervals: also, any time processing stops.

SCRUBBER DATA

START		END		Water Flow Rate (gpm)	Pressure Differential (inches of water)
Time	Water Meter Readings	Time	Water Meter Readings		

Scrubber readings are to be taken at the start of each run and at 15-minute intervals: also, any time water flow stops.

Health Dept.

APPENDIX L

Field Data

8:00:00

0 4 8 12 16 20 %

300 mm/h

12/28/93

7:40:00

```
7:37:06  12/28/93  PRINTER ON   BATCH 0   MODE 2  300 mm/h   EMET SERVICES
7:32:30  12/28/93  PRINTER OFF  BATCH 0   MODE 2  300 mm/h   EMET SERVICES
```

Run 1

300 mm/h

d_2 2045

1530 Cal

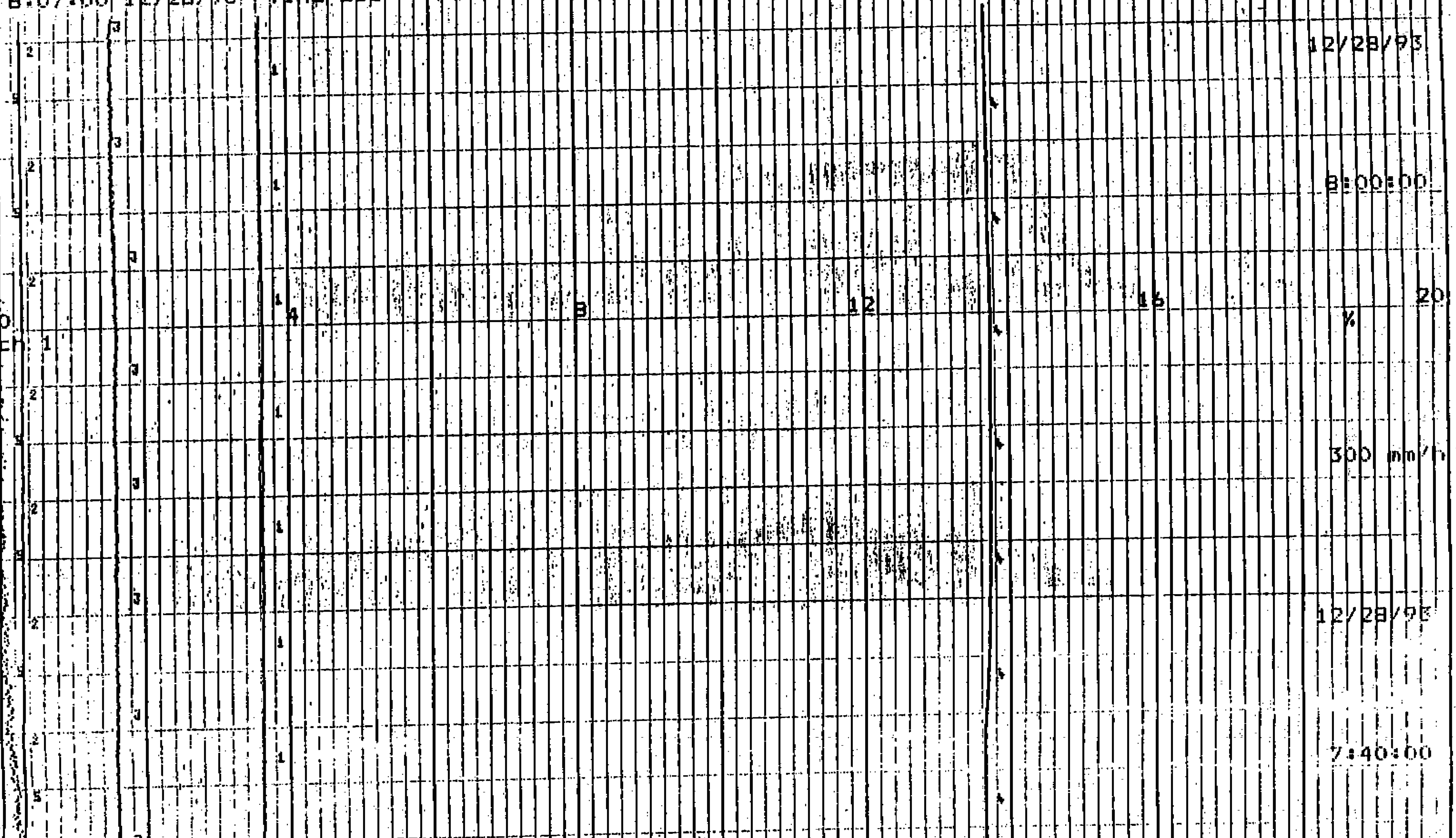
```
7:23:05  12/28/93  PRINTER ON   BATCH 0   MODE 2  300 mm/h   EMET SERVICES
6:37:23  12/28/93  PRINTER OFF  BATCH 0   MODE 2  300 mm/h   EMET SERVICES

6:37:51  300 mm/h
6:37:50  12/28/93  INITIALISED  BATCH 0   MODE 2  300 mm/h   EMET SERVICES
********************************* POWER ON *********************************
```

8:10:01 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
8:07:30 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

Hwo
CO2
O2
Span 20.70

1) 3.650 % 2) 15.93 PPM 3) 39.77 PPM 4) 17.20 % 5) -0.769 PPM 6) 0.008 %
7) OFF PPM 8) OFF dP 9) OFF dP 10) OFF dP 11) OFF dP 12) OFF dP
8:07:00 12/28/93 TIME LOG



7:37:06 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
7:32:30 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

12/28/93 Run 1
737 AM
Ketthead Bev Rackmer

0 100 200 300 CO 400 500 PPM

CH 3

300 mm/h

12/28/93

8:20:00

8:19:01 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
8:17:45 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

200 400 600 800 1000 PPM

CH 2 NOX

Cir 1502

NOX

CO 2

SO2

8:10:01 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
8:07:30 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

1) 3.650 % 2) 15.93 PPM 3) 39.77 PPM 4) 17.20 % 5) -0.769 PPM 6) 0.008 %
7) OFF PPM 8) OFF dP 9) OFF dP 10) OFF dP 11) OFF dP 12) OFF dP
8:07:00 12/28/93 TIME LOG

12/28/93

8:00:00

8:58:59 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

Start Run 3 Koppler Gen

Zero

8:53:28 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES

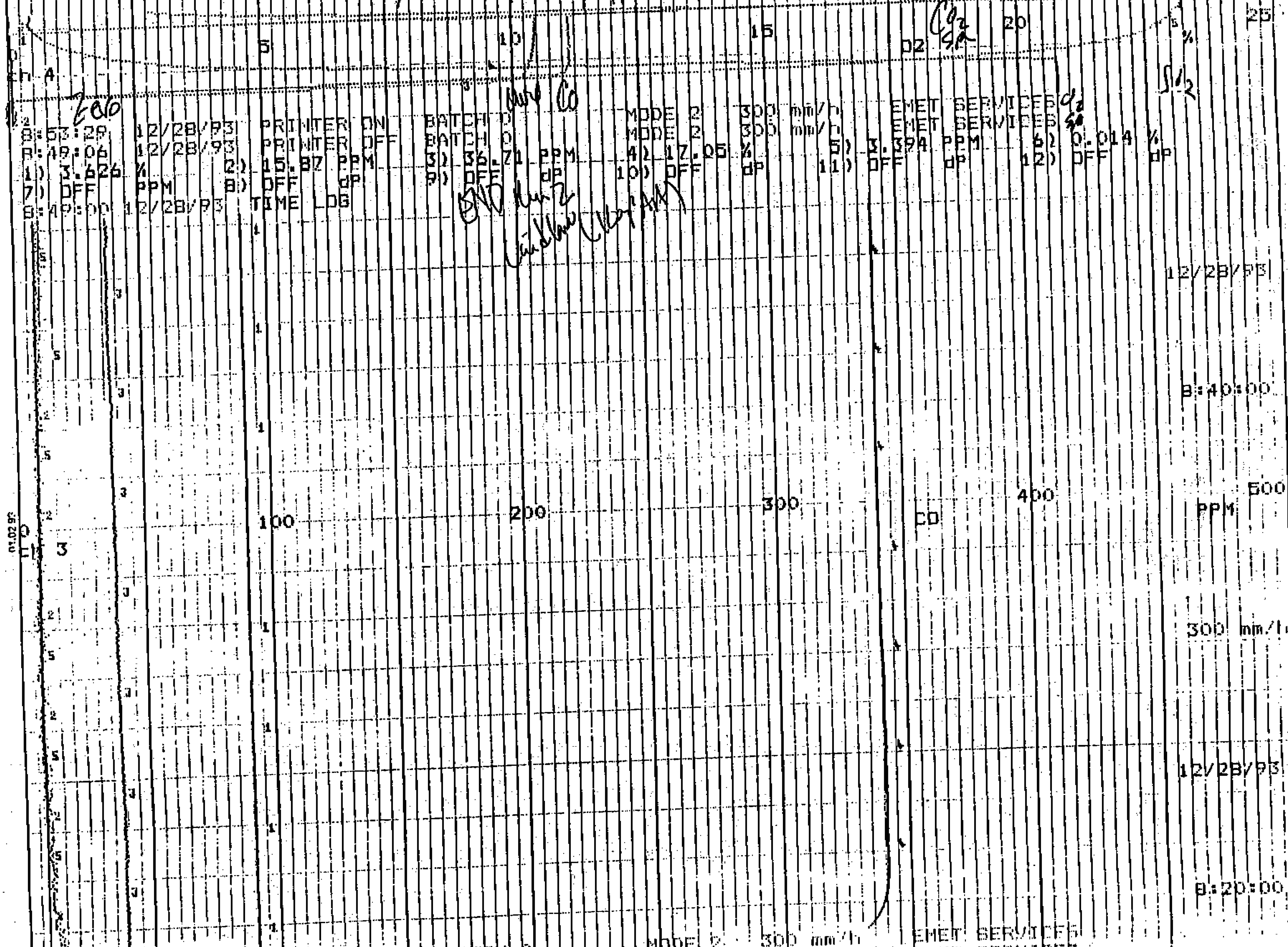
8:49:06 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

1) 3.626 % 2) 15.87 PPM 3) 36.71 PPM 4) 17.05 % 5) 3.394 PPM 6) 0.014 %

7) OFF PPM 8) OFF dP 9) OFF dP 10) OFF dP 11) OFF dP 12) OFF dP

8:49:00 12/28/93 TIME LOG

End Run 2



8:19:01 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES

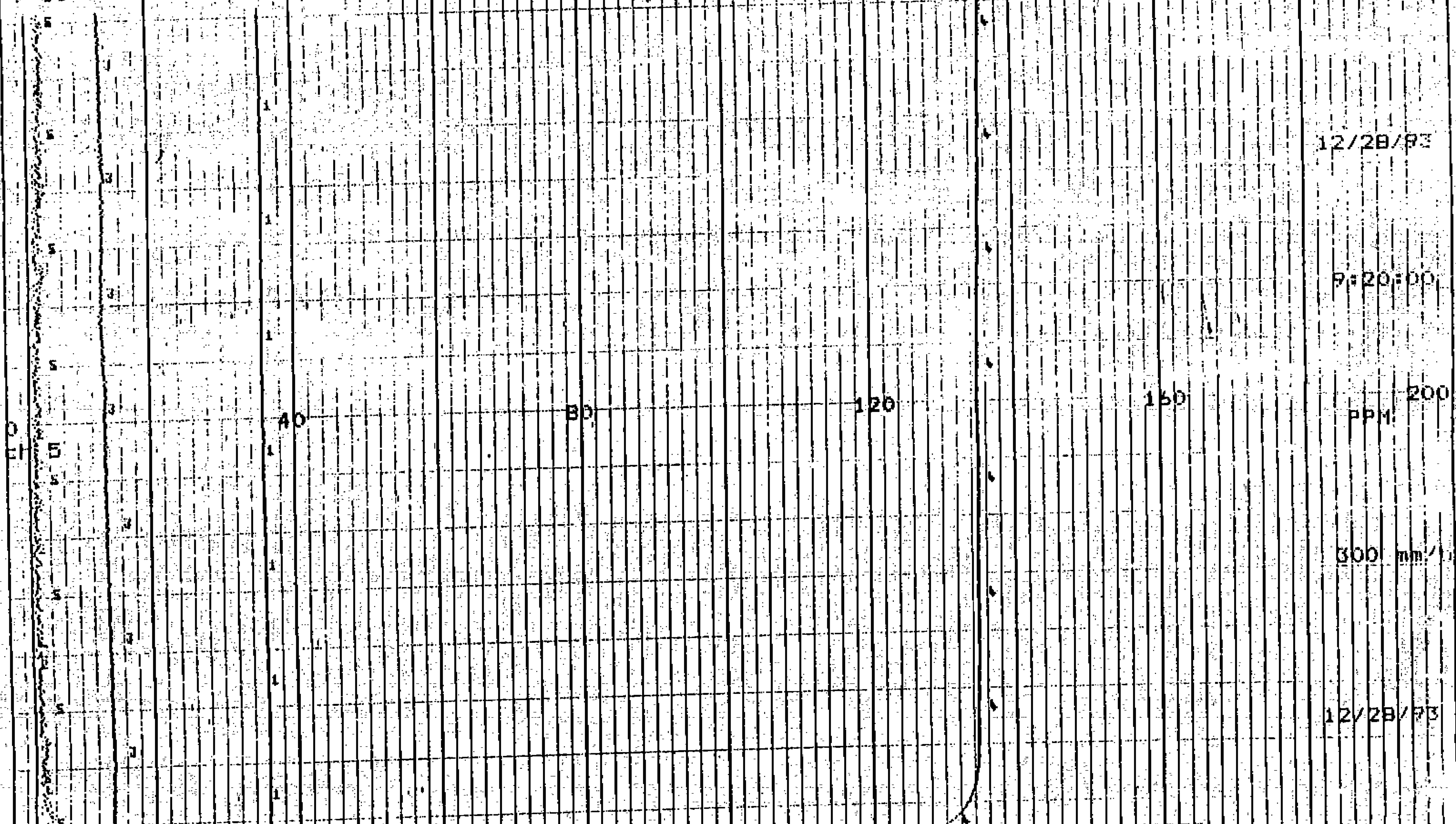
9:39:33 12/28/93 PRINTER DF BATCH

0 4 8 12 16 20

ch 1

NO CO O2 span

9:34:27 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
9:31:08 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES
1) 3.566 % 2) 15.99 PPM 3) 33.54 PPM 4) 17.02 % 5) 4.822 PPM 6) 0.011 %
7) OFF PPM 8) OFF dP 9) OFF dP 10) OFF dP 11) OFF dP 12) OFF dP
9:31:00 12/28/93 TIME LOG



9:01:27 12/28/93 PRINTER ON BATCH 0 MODE 2 300 mm/h EMET SERVICES
8:58:59 12/28/93 PRINTER OFF BATCH 0 MODE 2 300 mm/h EMET SERVICES

(1) 2 Neund 7 Vander Gen