GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM

FINA OIL AND CHEMICAL COMPANY
PORT ARTHUR, TEXAS

ARI PROJECT NO. 408-24
FINA P.O. #2730-15S

REPORT PREPARED FOR:

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FINAL TEST REPORT
FEBRUARY 7-9, 1989 TEST SERIES

GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS

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GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS

I. INTRODUCTION AND SUMMARY

ARI Environmental, Inc. was retained by Fina Oil and Chemical Company to conduct an emission compliance test program on the GE Gas Turbine Cogeneration facility located at the Fina refinery in Port Arthur, Texas.

The test program was conducted to satisfy the sampling requirements specified in the Texas Air Control Board (TACB) Permit Nos. PSD-TX-688 and C-16840.

Test methods followed those as detailed in the Code of Federal Regulations, CFR40, Part 60, 1987 Subpart GG and Appendix A, Methods 1-4, 6, 10, 19, 20 and 25A. The test methods and sampling procedures were discussed and approved during a pretest meeting held with the TACB on 9/30/88. The meeting was attended by Mr. Marion Everhart and Mr. Chibuzo Onwuchekua of the TACB Region 10 Beaumont office, Mr. Jim Mahon of Fina Oil and Chemical Company and Mr. L. Goldfine of ARI Environmental, Inc.

Emission testing was conducted by Mr. L. Goldfine, Mr. B. Pacocha and Mr. H. Taylor of ARI Environmental, Inc. from 2-7 to 2-9-89. Also present during the test series to monitor process operations and witness the test series was Mr. Glen Kenney of Fina Oil and Chemical Company. Tests were conducted for the following process conditions:

Test Location	Load Conditions	Fuel	Parameters
Gas Turbine Boiler Stack	100% Load	Natural Gas	NO_x, CO, VOC, SO_2
Gas Turbine Boiler Stack	75% Load	Natural Gas	NO_x, CO
Gas Turbine Boiler Stack	100% Load	Refinery Gas	NO_x, CO, VOC, SO_2
Gas Turbine Boiler Stack	75% Load (Normal steam injection rate)	Refinery Gas	NO_x, CO
Gas Turbine Boiler Stack	75% Load (Increased steam injection rate)	Refinery Gas,	NO_x, CO
Turbine Exhaust Duct (Boiler Inlet) and Turbine Duct	Maximum Combined Firing Rate of Turbine and Duct Burner	Refinery Gas	NO_x, CO, SO_2

The average results of the three emission tests conducted at each load condition are summarized below.

Load Condition	NO_x Conc ppmv, db corrected to 15% O_2 ISO std. day conditions	NO_x (as NO_2) Emission Rate lbs/hr	lbs/mmBTU	CO Emission Rate lbs/hr	SO_2 Emission Rate lbs/hr	VOC as CH_4 Emission Rate lbs/hr
100% Load Natural Gas	30.2	56.7	-	10.1	0.6	0.0
75% Load Natural Gas	38.7	60.7	-	16.2	-	-
100% Load Refinery Gas Normal Steam Injection Rate	76.2	140.0	-	15.9	2.0	0.0
100% Load Refinery Gas Increased Steam Injection Rate	71.1	123.2	-	15.6	6.4	0.0
75% Load Refinery Gas	70.1	102.8	-	10.5	-	-
Maximum Combined Firing Rate						
Turbine Plus Duct Burner	-	144.4	-	12.2	3.6	0.0
Turbine Exhaust	-	142.0	-	23.7	4.6	0.0
Duct Burner	-	6.9	0.004	0.0	0.8	0.0
Allowable (Gas Turbine)						
Natural Gas	50	182	-	69.6	20.3	8.8
Refinery Gas	80	182	-	69.6	20.3	8.8
Allowable (Gas Turbine plus Duct Burner)	-	207	-	77.7	27.2	9.1
Allowable (Duct Burner)	-	49.1	0.12	16.4	13.7	0.6

The results indicate that all parameters were within the allowable emission limitations specified in the Fina TACB Permits for the Cogeneration facility.

II. TESTING AND ANALYTICAL PROCEDURES

A. Natural Gas and Refinery Gas at 75% and 100% Load Conditions

Sampling and analyses were conducted following USEPA Methods 1-4, 6, 10, 20 and 25A as detailed in the Code of Federal Regulations, CFR40, Part 60, 1987 and the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods.

Sampling on the exhaust stack serving the GE Gas Turbine and Duct Burner exhaust streams (while duct burner was out-of-service) was conducted in the four ports provided in the 152.0 inch I.D. exhaust stack.

The sampling point locations for temperature and velocity measurements were determined following EPA Method 1. Specifically, four sampling points were located on each of the four traverses for a total of sixteen sample points. A cyclonic flow check was conducted in accordance with Method 1 prior to beginning the sampling to verify that cyclonic flow did not exist in the stack.

Moisture content of the exhaust gas was determined following EPA Method 4. The CO_2, O_2 and moisture determinations were conducted simultaneously with each NO_x, CO and hydrocarbon test.

Carbon monoxide sampling was conducted following EPA Method 10 using ARI's integrated gas bag collection system. Gas samples were collected in 60 liter Tedlar bags and analyzed immediately after each run for CO_2 and O_2 content prior to analyzing for CO using ARI's Horiba NDIR analyzer. Data was recorded on a strip chart recorder. Certified calibration standards of 150 ppm, 309 ppm and 478 ppm in hydrocarbon free air were used for calibrating the NDIR. The NDIR span was 500 ppm.

Continuous nitrogen oxides (NO_x) and oxygen (O_2) sampling was conducted following EPA Method 20. The NO_x monitor used was ARI's TECO Model 10 NO_x monitor. Oxygen sampling was conducted using a Teledyne O_2 monitor. All monitoring data was recorded on a strip chart recorder.

The Method 20 sample measurement system consisted of a heated stainless steel probe with an out-of-stack heated filter and 3-way calibration valve connected to a heated

Teflon sample line. The sample line connected to a pump followed by a sample manifold. Sample gas passed through ice cooled condensors to remove moisture prior to entering the NO_x and O_2 monitors and Method 10 integrated bag sample system. Calibration gas was introduced directly into the 3-way valve for calibration of the NO_x and O_2 monitors.

A converter efficiency test was conducted prior to beginning the testing following EPA Method 20 procedures. The test was conducted for 30 minutes with less than a 2% change during that time.

A response time test was conducted following Method 20 procedures prior to beginning the formal testing. The average NO_x measurement system response time was 29 seconds. The average O_2 measurement system response time was 37 seconds.

A preliminary O_2 traverse was conducted using ARI's O_2 monitor at 48 points (12 per port) following the sample point locations determined by EPA Method 1. The 8 sample points with the lowest O_2 concentration were used throughout the sampling program.

A pre-test and post-test measurement system bias test and calibration error test were performed using certified NO_x calibration standards of 60 ppm, 119 ppm and 197 ppm NO_x. The NO_x monitor span was set at 250 ppm. Zero and calibration drift test results were well within 3% of span for each calibration gas. The average zero and calibration drift values obtained during each test run on each monitor were used to correct the data for that test run.

The NO_x concentrations were then corrected to 15% O_2 based upon the average O_2 concentration measured during that run. The NO_x data was then corrected to ISO std. day conditions using the following equation in 40CFR, Part 60, NSPS Subpart GG:

$$NO_x = \left(NO_x \text{ at } 15\% \ O_2\right)\left(\frac{P_{ref}}{P_{obs}}\right)^{0.5}\left(e^{19\ (HOBS-0.00633)}\right)\left(\frac{T_{amb}}{288\ ^\circ K}\right)^{-1.53}$$

The P_{ref} values were obtained from GE on a graph of P_{ref} vs. % load. The P_{obs} readings were obtained off of the control panel readout by Fina personnel. The absolute humidity (HOBS) was calculated from the wet bulb and dry bulb temperatures measured by ARI during each run.

Total hydrocarbon (THC) sampling and analysis was conducted on-site following EPA Method 25A procedures. ARI's Ratfisch Model 55 total hydrocarbon analyzer was used to con-

tinuously measure THC emissions. Gas samples were conveyed directly from a separate heated Teflon sample line into the THC analyzer. EPA protocol calibration standards of 31.96 ppm, 49.45 ppm and 90.88 ppm were used to calibrate the analyzer. Calibration gas was introduced at the 3-way calibration valve located at the end of the sample probe.

A response time test was conducted prior to beginning the testing. The average THC measurement system response time was 31 seconds.

Methane sampling was to be conducted following EPA Method 18. Specifically, a Carle Model 211 gas chromatograph equipped with dual sample ports and flame ionization detector (FID) was to be used during the test series. The results of the THC (as CH_4) sampling indicated zero (0) THC emissions from the exhaust stack during 100% load on both natural gas and refinery gas. Therefore, methane sampling and analysis was not required and was not performed.

Sampling at 100% load while burning Refinery gas was conducted at the normal maximum steam injection rate for runs 1, 4 and 5 and at an increased maximum steam injection for runs 2 and 3. The increased maximum steam rate runs were performed to demonstrate compliance in the event the normal maximum steam injection rate tests should exceed the NO_x allowable. It was later determined however, that the normal steam injection rate did achieve compliance with NO_x emissions and that the increased steam injection rate was not a desirable operating condition.

B. <u>Maximum Combined Firing Rate Tests</u>

Three maximum combined firing rate runs were conducted for NO_x, CO and SO_2 while the GE Gas Turbine and Duct Burner were firing the maximum quantity of Refinery gas. Sampling the combined Turbine/Duct Burner gas streams was conducted on the Turbine/Duct Burner exhaust stack at the same sampling points described in Section II.A. Velocity, temperature, CO_2, O_2, moisture, volumetric flow rate, NO_x, CO and SO_2 measurements were obtained during each run as previously described in Section II.A.

Sampling the Gas Turbine exhaust gas was conducted in the Turbine horizontal rectangular exhaust duct (Duct Burner inlet). Sampling was conducted in the one sample port provided in the middle of the duct approximately 3 feet from the duct burner inlet. Emission sampling was conducted in the stack centroid. The NO_x sample measurement system at the turbine exhaust duct was identical to the sample system previously described in Section II.A on the combined stack. Stack gas volumetric flow rate measurements could not be

performed due to the size and geometry of the duct. Emission rates were therefore determined by F factor in accordance with EPA Method 19.

NO_x and O_2 sampling during each of the three Maximum Combined Firing Rate runs was conducted for 30 minutes per run, by alternating sample lines between the exhaust stack and Turbine Duct locations at 1.5 minute intervals. A continuous purge was maintained on the sample line not being sampled to eliminate response time delays. The Turbine exhaust NO_x emission rate in lbs/mmBTU, was calculated by F factor using the equations specified in EPA Method 19 as follows:

(B.1) $E_g = C_d F_d \, (20.9/(20.9 - \% \, O_{2d}))$

where E_g = NO_x emission rate lb/mmBTU
C_d = NO_x concentration lb/dscf
F_d = F Factor for Refinery gas dscf/mmBTU
O_{2d} = Average O_2 concentration, %

The F factor, 8439 dscf/mmBTU was calculated based upon a GC analysis of the refinery fuel gas provided by Mr. Glen Kenney of Fina Oil and Chemical Company.

The NO_x emission rate lbs/mmBTU for the combined Turbine/Duct Burner exhaust stack was calculated by F factor using the above equation and also by the following equation:

(B.2) $E_{co} = C_{co} \, Q_s \, H_{co}$

where E_{co} = NO_x emission rate from combined Turbine/Duct Burner exhaust, (lb/mmBTU)
C_{co} = NO_x conc from combined Turbine/Duct Burner exhaust, (lb/dscf)
Q_s = Stack volumetric flow rate, DSCFM
H_{co} = Heat input from Turbine plus Duct Burner, mmBTU/hr

The combined Turbine plus Duct Burner NO_x emission rate by F factor (equation B.1) provided slightly higher emission rates than equation B.2 and therefore these more conservative values were used. The Duct Burner NO_x emission rate was calculated by the following equation specified in EPA Method 19:

(B.3) $E_b = E_{co} + (H_g/H_b)(E_{co} - E_g)$

where E_b = NO_x emission rate from Duct Burner, lb/mmBTU
E_{co} = NO_x emission rate from combined system, lb/mmBTU
E_g = NO_x emission rate from Gas Turbine, lb/mmBTU
H_b = Heat input to the Duct Burner, lb/mmBTU
H_g = Heat input to the Gas Turbine, lb/mmBTU

Sampling for moisture, SO_2, CO_2 and CO on the Turbine exhaust duct was conducted following the identical procedures previously described in Section II.A of this report. Turbine exhaust and Duct Burner exhaust SO_2 and CO emission rates were calculated based upon equations B.1, B.2 and B.3 as previously described for calculating NO_x emission rates.

III. RESULTS

The results of the emission compliance test program conducted from February 7-9, 1989 on the GE Gas Turbine Cogeneration Facility located at the Fina Oil and Chemical Company refinery in Port Arthur, Texas are presented in Tables III-1 to III-8, as follows:

Table No.	Fuel	Load Condition	Source
III-1	Natural Gas	100%	Gas Turbine
III-2	Natural Gas	75%	Gas Turbine
III-3	Refinery Gas	100%	Gas Turbine
III-4	Refinery Gas	75% (normal steam injection)	Gas Turbine
III-5	Refinery Gas	75% (increased steam injection)	Gas Turbine
III-6	Refinery Gas	Max combined firing rate	Turbine and Duct Burner
III-7	Refinery Gas	Max combined firing rate	Turbine
III-8	Refinery Gas	Max combined firing rate	Duct Burner

All field data, summary calculation data and laboratory analysis data for each load condition are included in Appendix A. All emission monitor strip chart data are included in Appendix B. The graph of P_{ref} vs. Turbine load supplied by GE is also included in Appendix B.

Test equipment calibration data and calibration gas certification sheets are included in Appendix C. All required process data associated with the emission test series is to be submitted separately by Fina Oil and Chemical Company.

The results of the test program indicate that NO_x, CO, SO_2 and NMHC emissions during the test program on the GE Gas Turbine Cogeneration Facility were in compliance with the requirements specified in Fina's TACB Permits PSD-TX-688 and C-16840.

GE GAS TURBINE COGENERATION FACILITY
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FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS
SUMMARY OF EMISSION TEST RESULTS

TABLE: III-1
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Boiler Exhaust Stack
CONDITION: 100% Load Natural Gas
TEST DATE: 2-7-89

TEST RUN:	1	2	3
TEST TIME:	1741-1811	1817-1847	1848-1918
STACK GAS			
Temperature - av. °F	307.3	305.6	308.5
Velocity - av. ft/sec	52.53	51.84	52.53
Volume flow - acfm	397,158	391,942	397,158
Volume flow - dscfh	15,331,402	14,899,643	15,090,925
Moisture - av. % vol	8.1	9.7	9.4
CO_2 - av. % vol, db	3.7	3.7	3.6
O_2 - av. % vol, db	14.8	14.7	14.8
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	31.0	30.9	32.3
ppm by vol, db corrected to 15% O_2 ISO std. day conditions	30.0	29.4	31.3
lbs/dscf x 10^{-6}	3.701	3.689	3.857
Emission rate			
lbs/hr	56.8	55.0	58.2
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	6.8	9.2	11.5
lbs/dscf x 10^{-6}	0.494	0.67	0.84
Emission rate			
lbs/hr	7.6	10.0	12.6
SULFUR DIOXIDE (SO_2)			
Concentration			
ppm by vol, db	0.3	0.2	0.1
lbs/dscf x 10^{-6}	0.050	0.040	0.020
Emission rate			
lbs/hr	0.8	0.6	0.3
TOTAL HYDROCARBONS (as CH_4)			
Concentration			
ppm by vol, db	0.0	0.0	0.0
lbs/scf x 10^{-5}	0.0	0.0	0.0
Emission rate			
lbs/hr	0.0	0.0	0.0

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SUMMARY OF EMISSION TEST RESULTS

TABLE: III-2
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Boiler Exhaust Stack
CONDITION: 75% Load Natural Gas
TEST DATE: 2-7-89

TEST RUN:	1	2	3
TEST TIME:	1517-1547	1550-1620	1622-1652
STACK GAS			
Temperature - av. °F	301.4	299.2	299.9
Velocity - av. ft/sec	50.77	50.57	51.07
Volume flow - acfm	383,852	382,340	386,088
Volume flow - dscfh	15,111,310	15,095,403	15,212,963
Moisture - av. % vol	7.0	7.0	7.1
CO_2 - av. % vol, db	2.6	2.6	2.7
O_2 - av. % vol, db	16.3	16.1	16.3
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	34.6	33.4	32.7
ppm by vol, db corrected to 15% O_2 ISO std. day conditions	40.0	37.9	38.2
lbs/dscf x 10^{-6}	4.131	3.988	3.904
Emission rate			
lbs/hr	62.4	60.2	59.4
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	14.9	15.3	13.9
lbs/dscf x 10^{-6}	1.080	1.112	1.010
Emission rate			
lbs/hr	16.3	16.8	15.4

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SUMMARY OF EMISSION TEST RESULTS

TABLE: III-3
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Boiler Exhaust Stack
CONDITION: 100% Load Refinery Gas - Normal Maximum Steam Injection Rate

TEST DATE:	2-8-89	2-9-89	2-9-89
TEST RUN:	1	4	5
TEST TIME:	1220-1250	1253-1323	1336-1400
STACK GAS			
Temperature - av. °F	302.2	303.8	303.6
Velocity - av. ft/sec	50.46	50.05	49.97
Volume flow - acfm	381,508	378,440	377,803
Volume flow - dscfh	14,978,391	14,962,199	14,957,004
Moisture - av. % vol	7.7	7.1	7.0
CO_2 - av. % vol, db	2.8	2.9	2.8
O_2 - av. % vol, db	15.2	14.7	15.0
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	76.6	78.7	79.7
ppm by vol, db corrected to 15% O_2 ISO std. day conditions	78.4	73.0	77.2
lbs/dscf x 10^{-6}	9.146	9.397	9.516
Emission rate			
lbs/hr	137.0	140.6	142.3
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	9.7	14.6	19.4
lbs/dscf x 10^{-6}	0.705	1.061	1.410
Emission rate			
lbs/hr	10.6	15.9	21.1
SULFUR DIOXIDE (SO_2)			
Concentration			
ppm by vol, db	0.5	0.5	1.4
lbs/dscf x 10^{-6}	0.09	0.08	0.23
Emission rate			
lbs/hr	1.3	1.2	3.4
TOTAL HYDROCARBONS (as CH_4)			
Concentration			
ppm by vol, db	0.0	0.0	0.0
lbs/scf x 10^{-6}	0.0	0.0	0.0
Emission rate			
lbs/hr	0.0	0.0	0.0

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SUMMARY OF EMISSION TEST RESULTS

TABLE: III-4
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Boiler Exhaust Stack
CONDITION: 100% Load Refinery Gas - Increased Maximum Steam Injection Rate

TEST DATE:	2-8-89	2-8-89
TEST RUN:	2	3
TEST TIME:	1413-1443	1447-1517
STACK GAS		
Temperature - av. °F	305.3	304.6
Velocity - av. ft/sec	50.64	50.60
Volume flow - acfm	382,869	382,566
Volume flow - dscfh	14,760,078	14,794,357
Moisture - av. % vol	9.0	8.8
CO_2 - av. % vol, db	3.2	3.2
O_2 - av. % vol, db	15.2	15.3
NITROGEN OXIDES (NO_x as NO_2)		
Concentration		
ppm by vol, db	69.1	70.5
ppm by vol, db corrected to 15% O_2 ISO std. day conditions	70.0	72.1
lbs/dscf x 10^{-6}	8.251	8.418
Emission rate		
lbs/hr	121.8	124.5
CARBON MONOXIDE (CO)		
Concentration		
ppm by vol, db	14.5	14.5
lbs/dscf x 10^{-6}	1.054	1.054
Emission rate		
lbs/hr	15.6	15.6
SULFUR DIOXIDE (SO_2)		
Concentration		
ppm by vol, db	2.0	3.2
lbs/dscf x 10^{-6}	0.330	0.530
Emission rate		
lbs/hr	4.9	7.8
TOTAL HYDROCARBONS (as CH_4)		
Concentration		
ppm by vol, db	0.0	0.0
lbs/scf x 10^{-6}	0.0	0.0
Emission rate		
lbs/hr	0.0	0.0

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SUMMARY OF EMISSION TEST RESULTS

TABLE: III-5
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Boiler Exhaust Stack
CONDITION: 75% Load Refinery Gas
TEST DATE: 2-8-89

TEST RUN:	1	2	3
TEST TIME:	1752-1822	1827-1857	1900-1930
STACK GAS			
Temperature - av. °F	313.8	315.0	314.2
Velocity - av. ft/sec	49.56	49.75	50.64
Volume flow - acfm	374,717	376,140	382,869
Volume flow - dscfh	14,632,528	14,694,089	15,023,302
Moisture - av. % vol	6.8	6.4	6.3
CO_2 - av. % vol, db	2.8	2.8	2.6
O_2 - av. % vol, db	16.3	16.4	16.4
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	58.4	57.8	58.5
ppm by vol, db corrected to 15% O_2 ISO std. day conditions	68.8	70.2	71.4
lbs/dscf x 10^{-6}	6.973	6.906	6.985
Emission rate lbs/hr	102.0	101.5	104.9
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	14.6	9.8	4.9
lbs/dscf x 10^{-6}	1.061	0.712	0.356
Emission rate lbs/hr	15.5	10.5	5.4

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TABLE: III-6
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Exhaust Stack - (Turbine plus Duct Burner)
CONDITION: Maximum Combined Firing Rate Refinery Gas
TEST DATE: 2-9-89

TEST RUN:	1	2	3
TEST TIME:	0822-0852	0903-0933	0944-1014
STACK GAS			
Temperature - av. °F	284.5	279.2	279.1
Velocity - av. ft/sec	49.62	50.65	49.69
Volume flow - acfm	375,006	382,944	375,686
Volume flow - dscfh	14,637,705	15,037,884	14,787,910
Moisture - av. % vol	10.6	10.7	10.5
CO_2 - av. % vol, db	3.9	4.0	4.0
O_2 - av. % vol, db	12.9	12.8	12.9
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	78.7	79.7	86.4
lbs/dscf x 10^{-6}	9.397	9.516	10.316
Emission rate			
lbs/hr	137.5	143.1	152.6
lbs/mmBTU	0.21	0.21	0.23
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	14.6	9.7	9.7
lbs/dscf x 10^{-6}	1.058	0.705	0.705
Emission rate			
lbs/hr	15.5	10.6	10.4
lbs/mmBTU	0.023	0.015	0.016
SULFUR DIOXIDE (SO_2)			
Concentration			
ppm by vol, db	2.2	1.8	0.3
lbs/dscf x 10^{-6}	0.36	0.30	0.06
Emission rate			
lbs/hr	5.3	4.5	0.9
lbs/mmBTU	0.008	0.007	0.001

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TABLE: III-7
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: GE Gas Turbine Outlet Duct (Duct Burner Inlet)
CONDITION: Maximum Combined Firing Rate - Refinery Gas
TEST DATE: 2-9-89

TEST RUN:	1	2	3
TEST TIME:	0822-0852	0903-0933	0944-1014
STACK GAS			
Moisture - av. % vol	7.9	8.2	8.1
CO_2 - av. % vol, db	3.2	3.3	3.3
O_2 - av. % vol, db	16.8	16.7	15.6
NITROGEN OXIDES (NO_x as NO_2)			
Concentration			
ppm by vol, db	55.2	55.5	74.2
lb/dscf x 10^{-6}	6.596	6.630	8.854
Emission rate			
lbs/hr	140.7	137.7	147.7
lbs/mmBTU	0.28	0.28	0.29
CARBON MONOXIDE (CO)			
Concentration			
ppm by vol, db	20.2	14.7	14.7
lbs/dscf x 10^{-6}	1.468	1.065	1.065
Emission rate			
lbs/hr	31.2	22.1	17.8
lbs/mmBTU	0.063	0.044	0.035
SULFUR DIOXIDE (SO_2)			
Concentration			
ppm by vol, db	2.5	0.8	0.7
lbs/dscf x 10^{-6}	0.42	0.13	0.12
Emission rate			
lbs/hr	9.0	2.7	2.0
lbs/mmBTU	0.018	0.005	0.004

GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS
SUMMARY OF EMISSION TEST RESULTS

TABLE: III-8
COMPANY: Fina Oil & Chemical Company: Port Arthur, Texas
SOURCE: Duct Burner
CONDITION: Maximum Combined Firing Rate - Refinery Gas
TEST DATE: 2-9-89

TEST RUN:	1	2	3
TEST TIME:	0822-0852	0903-0933	0944-1014
NITROGEN OXIDES (NO_x as NO_2)			
Emission rate			
lbs/hr	3.3	6.3	11.2
lbs/mmBTU	0.017	0.032	0.057
CARBON MONOXIDE (CO)			
Emission rate			
lbs/hr	0.0	0.0	0.0
lbs/mmBTU	0.0	0.0	0.0
SULFUR DIOXIDE (SO_2)			
Emission rate			
lbs/hr	0.0	2.4	0.0
lbs/mmBTU	0.0	0.012	0.0

GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS

APPENDIX A

Field Data, Summary Calculation
Data and Laboratory Data

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GE GAS TURBINE

REPETITION NO.: 1 NAT GAS 100% LOAD

TEST DATE: 2-7-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.7 14.8 81.5

= 29.18 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.07 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.772

Average absolute stack gas temperature

(T_s) avg. = 307.3 °F + 460 = 767.3 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 52.53 ft/sec.

Stack gas volume flow rate

$A_s = 126.01$

$60\ V_s\ A_s$ = 397,158 acfm

Stack gas volume flow rate, dry basis

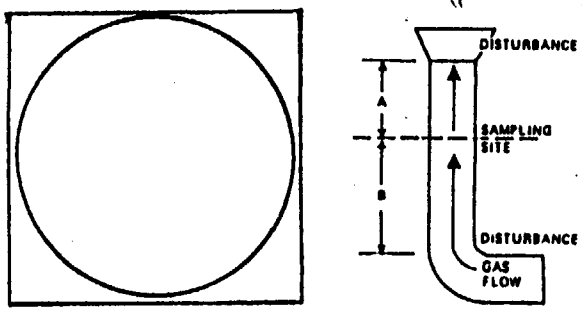
$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 15,331,402 dscfh

= 16,682,701 scfh(wb)

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT: Fina
DATE: 2-1-89
LOCATION: Groves, TX
OPERATOR: BP + HT
STACK NO.: Cogen
RUN NO.: 100% Load 1 of 2 Natural gas only
SAMPLE BOX NO.: RAE
METER BOX NO.: 517

AMBIENT TEMPERATURE: 44°F
BAROMETRIC PRESSURE: 30.42
ASSUMED MOISTURE, %:
PROBE LENGTH, in.:
NOZZLE DIAMETER, in.:
STACK DIAMETER, in.:
PROBE HEATER SETTING:
HEATER BOX SETTING:

METER $\Delta H_@$:
C FACTOR:
PROCESS WEIGHT RATE:

WEIGHT OF PARTICULATE COLLECTED, mg

SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
541 A	1	-.39	308	.61		5.5		706.360	48	44				
546	2 5		309	.62		5.5		07.20	[illegible]	[illegible]				
551	3 5		309	.65		5.5		13.30	[illegible]	[illegible]				
556	4 5		307	.65		5.5		17.20	[illegible]	[illegible]				
601 B	1 5		308	.60		5.5		21.10	51	[illegible]				
606	2 5		307	.60		5.5		25.0	52	[illegible]				
611	3 5		307	.64				728.900						
	4		305	.61										
C	1		309	.60										
	2		308	.59										
	3		308	.59										
	4		303	.58										
D	1		307	.55										
	2		308	.55										
	3		308	.58										
TOTAL	4		306	.52										
AVERAGE			307.3		0.772	5.5		22.540	46.8					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	86	158	100		202
INITIAL	100	100	100		200
LIQUID COLLECTED	14	58	—		
TOTAL VOLUME COLLECTED	44		2		46

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 5 "Hg
post: 0.00 at 5 "Hg

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GE GAS TURBINE
REPETITION NO.: 1 NAT GAS 100% LOAD
TEST DATE: 2-7-89

NO_x average chart reading, % = 12.25

O_2 average chart reading, % = 59.29

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (59.29)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.0 \text{ \%}}$

= 14.82 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (12.25 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.0 \text{ \%}}$ = 31.0 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 31.01 x $\frac{5.9}{20.9 - 14.82}$ = 30.08 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5} e^{19(HOBS - 0.00633)} \left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 30.08 $\left(\frac{160}{166}\right)^{0.5} e^{19\,(0.00336 - 0.00633)} \left(\frac{274.7}{288}\right)^{-1.53}$ = 30.00 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 31.0 x (1.194×10^{-7}) x 15,331,402 = 56.75 lb/hr

$HOBS = 0.623 \frac{RHXE}{P} = 0.623 \frac{(0.81)(0.203)}{30.47} = 0.00336$

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
NAT GAS 100% LOAD
2-7-89
RUN 1

SAMPLE VOLUME

V_m = 22.540 ft^3

T_m = 506.8 °R

P_{bar} = 30.47 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 24.440\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.475 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.475 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m\ (std)}} = 0.005 \times 10^{-5}\ lb/dscf$$

= 0.28 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 0.77 lb/hr

Q_s = 15,331,402 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m(std)}} = 0.005 \times 10^{-5}\ lb/dscf$$

= 0.22 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 0.77 lbs/hr

Q_s = 15,331,402 DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GE GAS Turbine

REPETITION NO.: 1 NAT GAS 100% LOAD

TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{24.440} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.165} \text{ scf}$$

V_{lc} = 46 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{8.1\%}$$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1 - 100% LOAD NATURAL GAS

TEST DATE: 2-7-89

CO average chart reading, % = 1.5 %

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(1.5\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{31.5\ \%}\right)\left(1 - 0.037\right)$$

$$= 6.8\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(6.8\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}331{,}402\ \text{dscfh}\right) = 7.62\ \text{lbs/hr}$$

① Average of pre and post test drift tests

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS Turbine

REPETITION NO.: 2 NAT GAS 100% LOAD

TEST DATE: 2-7-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.7 14.3 81.6

= 29.18 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.10 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.763

Average absolute stack gas temperature

(T_s) avg. = 305.6 °F + 460 = 765.6 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 51.84 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 39,942 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\ avg \cdot P_{std}}\right]$$

= 14,899,643 dscfh

= 16,509,158 scfh(wb)

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
NAT GAS 100% LOAD
2-7-89
RUN 2

SAMPLE VOLUME

V_m = 20.50 ft^3

T_m = 506.5 °R

ΔH = 5.5

P_{bar} = 30.47 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 22.241\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.45 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.40 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_m\ (std)} = 0.004 \times 10^{-5}\ lb/dscf$$

= 0.24 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 0.60 lb/hr

Q_s = 14,899,643 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.002 \times 10^{-5}\ lb/dscf$$

= 0.10 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 0.30 lbs/hr

Q_s = 14,899,643 DSCFH

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 2 NAT GAS 100% LOAD
TEST DATE: 2-7-89

NO_x average chart reading, % = 12.5

O_2 average chart reading, % = 59.1

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (59.1)% - 0 %) x $\frac{13.0 \text{ \% } O_2}{52.2 \text{ \%}}$

= 14.72 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (12.5 % - 0.1 %) x $\frac{119}{47.8 \text{ \%}}$ ppm = 30.9 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 30.9 x $\frac{5.9}{20.9 - 14.72}$ = 29.5 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 29.5 $\left(\frac{160}{166}\right)^{0.5}$ $e^{19(0.0039 - 0.00633)}$ $\left(\frac{274.1}{288}\right)^{-1.53}$ = 29.4 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 30.9 x (1.194×10^{-7}) x 14,899,643 = 55.0 lb/hr

$HOBS = \left(\frac{80 \times 0.1952}{100}\right) \times \frac{0.623}{30.47}$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 NAT GAS 100% LOAD

TEST DATE: 2-7-89

CO average chart reading, % = 2.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(2.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{31.5\ \%}\right)\left(1 - 0.037\right)$$

$$= 9.2\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(9.2\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}899{,}643\ \text{dscfh}\right) = 9.96\ \text{lbs/hr}$$

① Average of pre and post test drift tests

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 NAT GAS 100% LOAD

TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{22.241} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.401} \text{ scf}$$

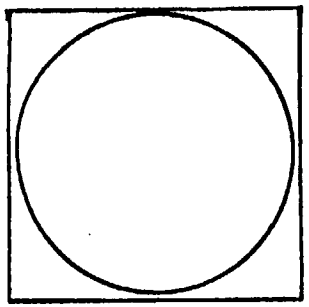
V_{lc} = 51 ml.

Fractional moisture content of stack gas

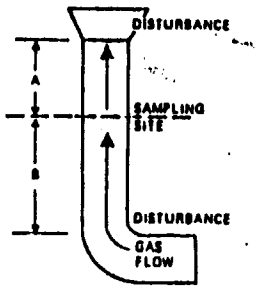
$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{9.7\%}$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT: Fina
DATE: 2-7-89
LOCATION: Groves, TX
OPERATOR: BP + HT
STACK NO.: Cogen
RUN NO.: 100% Load 250 Natural Gas only
SAMPLE BOX NO.: RAC
METER BOX NO.: 597

AMBIENT TEMPERATURE: 45°F
BAROMETRIC PRESSURE: 30.47
ASSUMED MOISTURE, %:
PROBE LENGTH, in.:
NOZZLE DIAMETER, in.:
STACK DIAMETER, in.:
PROBE HEATER SETTING:
HEATER BOX SETTING:

METER $\Delta H_@$:
C FACTOR:
PROCESS WEIGHT RATE:

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
617	A 1	-.34	307	.57		5.5		729.500	50	42		42		
622	5	2	307	.58		5.5		33.4	51	43		42		
627	5	3	306	.64		5.5		37.3	51	42		42		
632	5	4	304	.65		5.5		41.2	51	42		42		
637	5 B 1		306	.56		5.5		45.1	51	42		42		
642	5	2	306	.60		5.5		46.0	51	42		42		
647	5	3	307	.64				750.000						
		4	304	.60										
	C 1		306	.62										
		2	307	.57										
		3	306	.55										
		4	304	.55										
	D 1		306	.55										
		2	305	.59										
		3	305	.56										
TOTAL		4	304	.50										
AVERAGE		-0.34	305.6		0.763	5.5		20.50	46.5					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	90	153	103		207
INITIAL	100	100	100		200
LIQUID COLLECTED	-10	53	3		
TOTAL VOLUME COLLECTED	46		5		51

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00AT 15 "Hg
post: 0.00AT 15 "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 100% LOAD NAT GAS

TEST DATE: 2-7-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.6 14.8 81.6

= 29.17 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.12 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.778

Average absolute stack gas temperature

(T_s) avg. = 308.5 °F + 460 = 768.5 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 52.53 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 397,158 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\ avg \cdot P_{std}}\right]$$

= 15,090,925 dscfh

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
NAT GAS 100% LOAD
2-7-89
RUN 3

SAMPLE VOLUME

V_m = 23.370 ft^3

T_m = 505.8 °R

ΔH = 5.5

P_{bar} = 30.47 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 25,390\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.40 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.50 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_m\ (std)} = 0.002 \times 10^{-5}\ lb/dscf$$

= 0.12 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 0.30 lb/hr

Q_s = 15,090,925 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.005 \times 10^{-5}\ lb/dscf$$

= 0.26 ppm By Volume Dry Basis

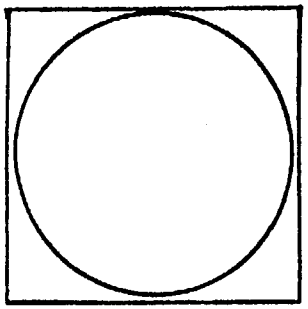
SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 0.75 lbs/hr

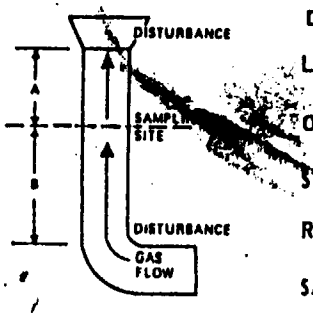
Q_s = 15,090,925 DSCFH

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT Fina

DATE 2-7-84

LOCATION Groves 1A

OPERATOR BP-HT

STACK NO. Logan

RUN NO. 100% Load 350 2

SAMPLE BOX NO. [illegible]

METER BOX NO. 594

AMBIENT TEMPERATURE 41°F

BAROMETRIC PRESSURE

ASSUMED MOISTURE, %

PROBE LENGTH, in.

NOZZLE DIAMETER, in.

STACK DIAMETER, in.

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
648	A	1 -.39	310	.60		5.5		750.130	49	41		[illegible]		
653	5	2	310	.62		5.5		754.00	50	41		41		
658	5	3	309	.67		5.5		57.9	50	41		41		
703	5	4	307	.60		5.5		61.8	51	41		41		
708	5 B	1	309	.58		5.5		65.7	51	42		41		
713	5	2	310	.60		5.5		69.6	51	42		41		
718	5	3	310	.66				773.500						
		4	306	.69										
	C	1	310	.60										
		2	310	.60										
		3	308	.58										
		4	305	.55										
	D	1	307	.55										
		2	309	.56										
		3	310	.54										
TOTAL		4	306	.51										
AVERAGE			308.5		0.772	5.5		23.370	45.8					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	92	158	102		204
INITIAL	100	[illegible]	100		200
LIQUID COLLECTED	-8	158	2		
TOTAL VOLUME COLLECTED	52			4	56

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 AT 15" Hg
post: [illegible] AT 15" Hg

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GASTURBINE
REPETITION NO.: 3 100% LOAD NAT GAS
TEST DATE: 2-7-89

NO_x average chart reading, % = 12.8

O_2 average chart reading, % = 60.5

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (60.5)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{53.0 \text{ \%}}$

= 14.84 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (12.8 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.1 \text{ \%}}$ = 32.3 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 32.3 x $\frac{5.9}{20.9 - 14.84}$ = 31.4 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 31.4 $\left(\frac{160}{166}\right)^{0.5}$ $e^{19(0.00319 - 0.00633)}$ $\left(\frac{274}{288}\right)^{-1.53}$ = 31.3 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 32.3 x (1.194×10^{-7}) x 15,090,925 = 58.2 lb/hr

$$HOBS = \frac{0.80 \times 0.623}{30.47} \times 0.195 = 0.00319$$

MOISTURE CALCULATION SUMMARY

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 3 100% LOAD NAT GAS
TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{25.390} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.636} \text{ scf}$$

V_{lc} = 56 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{9.4\%}$$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 100% LOAD NAT GAS

TEST DATE: 2-7-89

CO average chart reading, % = 2.5

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(2.5\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{31.5\ \%}\right)\left(1 - 0.036\right)$$

$$= 11.5\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(11.5\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}090{,}925\ \text{dscfh}\right) = 12.6\ \text{lbs/hr}$$

① Average of pre and post test drift tests

COMPANY: FINA

TEST DATE: 2-7-89

GAS TURBINE NAT GAS

CO/NO_x MONITOR FIELD DATA SHEET

Pbar = 30.47

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	PPMV	O_2 Chart Reading 5 min Average % of chart	PPMV			CO Chart Reading %	PPMV	T_d	T_w	R_h	COMMENTS
100% LOAD	1 1	1741		12.0		59.4				1.5		35	33	81	CDP = 166
	2	43.5		12.0		59.3									3.7 = CO_2
	3	46		12.0		59.3									
	4	48.5		12.1		59.2									
	5	51		12.4		59.2									
	6	53.5		12.6		59.3									
	7	56		12.5		59.3									
	8	58.5 - 1801		12.4		59.3									
			Ave →	12.3											
				0	0	0	0								
				47.0	119	52.0	13.0								
	2 1	1817		12.5		59.0				2.0		34	32	80	CDP = 166
	2	19.5		12.4		59.0									CO_2 = 3.7
	3	22		12.3		59.0									
	4	24.5		12.3		59.0									
	5	27		12.5		59.1									
	6	29.5		12.7		59.3									
	7	32		12.8		59.2									
	8	34.5 - 37													
		Post CAL		0.2	0	83.9	20.9								
				47.8	119	52.2	130								
						0	0								

COMPANY: FINA

TEST DATE: 2-7-89

NAT GAS FULL LOAD

CO/NO_x MONITOR FIELD DATA SHEET

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading ppmv	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading ppmv			CO Chart Reading %	CO Chart Reading ppmv	T_d	T_w	R_h	COMMENTS
	3 1	1844		12.5		59.5				2.5		34	32		3.6 %CO2
	2	51.5		12.8		60.1									15%O2
	3	54		12.8		60.4									CPD=166
	4	56.5		12.8		60.5									
	5	59.0		12.8		60.8									
	6	01.5		12.8		61.0									
	7	04		12.8		61.0									
	8	06.5-09		12.8		61.0									
	Post CAL			47.1	119	53.0	130			0	0				
				23.3	60	0	0		pre/post CAL	31.5	150				
				99.0	197	84.8	20.9			62.5	309				
										94.	478				

FINA
2-7-89

HYDROCARBON FIELD DATA SHEET

SAMPLING LOCATION	TIME	PEAK NO.	ATTEN.	PEAK AREA	THC CONC. % (~~[illegible]~~) ppm	METHANE CONC. (PPM)	NMHC CONC. (PPM)		COMMENTS
	CAL				90.5 90.8				CPD = 166
					49.5 49.44				
					31.5 31.66				
100% NAT	1741	7			0	0			
LOAD GAS	46				0				
	51				0.2 0.2				
	56				0.2				
	01				0.2				
		CAL							
		1,2	10x4	18.5		31.66			
		3,4	10x4	28.0		49.44			
		5,6	10x4	51.0		90.88			
					29.6 31.66				
					0 0				
RUN 2	1817	8			0 0	0			
100% LOAD	22				0 0				
NAT GAS	27				0 0				
	32				0 0				
	37				0 0				
					50.0 49.44				
					0 0				

FINA
2-7-89

NAT GAS Full LOAD

HYDROCARBON FIELD DATA SHEET

SAMPLING LOCATION	TIME	PEAK NO.	ATTEN.	PEAK AREA	THC CONC. %(~~PPM~~) ppm	METHANE CONC. (PPM)	NMHC CONC. (PPM)		COMMENTS
Stack	1849	9			0 0	0			
	54				0				
	59				0 0				
	04				0 0				
	09				0 0				
	first CAL	1			48.5 49.14				
					30.4 31.86				
					91.0 90.8				

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GASTURBINE

REPETITION NO.: 1-75 % LOAD NAT GAS

TEST DATE: 2-7-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.6 16.25

= 29.07 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.30 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.752

Average absolute stack gas temperature

(T_s) avg. = 301.4 °F + 460 = 761.4 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.77 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 383852 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 15,111,310 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1 - 75% LOAD NAT GAS

TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{25,602} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1.930} \text{ scf}$$

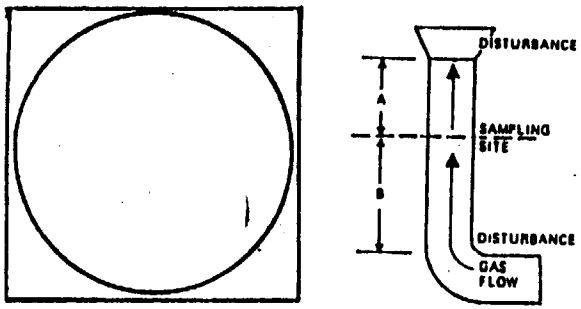
V_{lc} = 41 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{7.0}$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina

DATE 2-7-89

LOCATION Groves, TX

OPERATOR B.P. & H.T.

STACK NO. Cogen

RUN NO. 75% Moisture Load

SAMPLE BOX NO. RAC

METER BOX NO. 597

AMBIENT TEMPERATURE 46°F

BAROMETRIC PRESSURE

ASSUMED MOISTURE, %

PROBE LENGTH, in.

NOZZLE DIAMETER, in.

STACK DIAMETER, in.

Natural gas only

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg

SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
3:17 A	1	-.42	303	.55	5.5		635.700	46	46		46	-	
3:22	2 5		302	.58	5.5		39.7	48	47		46		
3:27	3 5		302	.68	5.5		43.7	50	47		46		
3:32	4 5		302	.60	5.5		47.7	51	47		46		
3:37 B	1 5		303	.52	5.5		51.4	53	48		46		
3:42	2 5		302	.55	5.5		55.4	53	48		46		
3:47	3 5		301	.65			659.400						
	4		298	.68									
C	1		300	.58									
	2		302	.55									
	3		301	.56									
	4		299	.54									
D	1		303	.50									
	2		303	.52									
	3		302	.55									
TOTAL	4		300	.46									
AVERAGE			301.4	☒	0.752	5.5	23.7		48.7				

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	130	101			210
INITIAL	100	100			200
LIQUID COLLECTED	30	1			
TOTAL VOLUME COLLECTED	31		10		41

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15 "Hg
post: 0.00 at 15 "Hg

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 1- 75% LOAD NAT GAS
TEST DATE: 2-7-89

NO_x average chart reading, % = 14.2

O_2 average chart reading, % = 65.0

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.0)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.0 \text{ \%}}$

= 16.25 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (14.2 % - 0.3 %) x $\frac{119 \text{ ppm}}{47.8 \text{ \%}}$ = 34.60 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 34.6 x $\frac{5.9}{20.9 - 16.25}$ = 43.91 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 43.91 $\left(\frac{125.9}{153}\right)^{0.5}$ $e^{19(0.0034 - 0.00633)}$ $\left(\frac{275.8}{288}\right)^{-1.53}$ = 40.0 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 34.60 x (1.194×10^{-7}) x 15,111,310 = 62.4 lb/hr

$HOBS = \frac{0.1816(0.82)^{0.623}}{30.47}$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1 - 75% LOAD NAT GAS

TEST DATE: 2-7-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(\underline{3.0}\ \% - \underline{0.0}\ \%\right)\left(\frac{150\ \text{ppm CO}}{29.5\ \%}\right)\left(1 - 0.026\right)$$

= 14.86 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.86\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}111{,}310\ \text{dscfh}\right) = 16.32\ \text{lbs/hr}$$

① Average of pre and post test drift tests

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 - 75% LOAD NAT GAS

TEST DATE:

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.6 16.1 81.3

= 29.06 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.29 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.750

Average absolute stack gas temperature

(T_s) avg. = 299.2 °F + 460 = 759.2 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.57 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 382340 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 15,095,403 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 2 - 75% LOAD NAT GAS
TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{25.009} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1.883} \text{ scf}$$

V_{lc} = 40 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{7.0\%}$$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 75% LOAD NAT GAS

TEST DATE: 2-7-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(\frac{3.0}{\%} - \frac{0.0}{\%}\right)\left(\frac{150}{29.5}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - \quad\right)$$

= 15.3 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(15.3\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}095{,}403\ \text{dscfh}\right) = 16.8\ \text{lbs/hr}$$

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO. 2-75% LOAD NAT GAS
TEST DATE: 2-7-89

NO_x average chart reading, % = 13.2

O_2 average chart reading, % = 65.0

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.0)% - 0.0 %) x $\frac{130 \text{ \% } O_2}{52.5 \text{ \%}}$

= 16.10 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (13.2 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.1 \text{ \%}}$ = 33.4 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 33.4 x $\frac{5.9}{20.9 - 16.1}$ = 41.1 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 41.1 $\left(\frac{125.9}{153.0}\right)^{0.5}$ $e^{19(0.00336 - 0.00633)}$ $\left(\frac{274.7}{288}\right)^{-1.53}$ = 37.9 ppm by vol, db

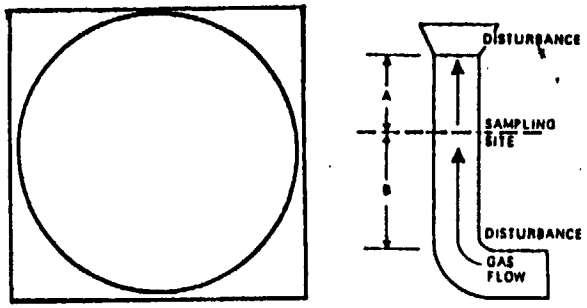
NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 33.4 x (1.194×10^{-7}) x 15,095,403 = 60.2 lb/hr

$$HOBS = \frac{0.81(0.203)\ 0.623}{30.47} = 0.00336$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2 7 - 69
LOCATION Groves TX
OPERATOR [illegible] HT
STACK NO. Logan
RUN NO. 75% Load 2 Moisture
Natural gas only
SAMPLE BOX NO. RAC
METER BOX NO. 597

AMBIENT TEMPERATURE 46°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in.
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
3:50 A	1	-.41	298	.56		5.5		659.620	51	46		46		
3:55	2 5		299	.58		5.5		63.8	52	47		46		
4:00	3 5		300	.65		5.5		68.1	52	47		46		
4:05	4 5		295	.60		5.5		72.1	52	47		46		
4:10 B	1 5		299	.51		5.5		76.1	52	47		46		
4:15	2 5		300	.55		5.5		80.1	52	47		46		
4:20	3 5		301	.64				682.800						
	4		300	.67										
C	1		303	.57										
	2		300	.55										
	3		299	.56										
	4		299	.55										
D	1		299	.51										
	2		299	.52										
	3		300	.54										
TOTAL	4		296	.46										
AVERAGE			299.2		0.750			23.180	49.3					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	132	101			207
INITIAL	100	100			200
LIQUID COLLECTED	32	1			
TOTAL VOLUME COLLECTED	33		7		40

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15 "Hg
post: at "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 75% LOAD NAT GAS

TEST DATE: 2-7-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.7 16.3

= 29.08 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.29 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.757

Average absolute stack gas temperature

(T_s) avg. = 299.9 °F + 460 = 759.9 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.44 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 51.07 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 386,088 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 15,212,963 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 3 75% LOAD NAT GAS
TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{25,237} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1.930} \text{ scf}$$

V_{lc} = 41 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = \underline{7.1\%}$$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 75% LOAD NAT GAS

TEST DATE: 2-7-89

CO average chart reading, % = 2.8

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(2.8\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{29.5\ \%}\right)\left(1 - 0.027\right)$$

$$= 13.9\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(13.9\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}212{,}963\ \text{dscfh}\right) = 15.4\ \text{lbs/hr}$$

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 3 75% LOAD NAT GAS
TEST DATE: 2-7-89

NO_x average chart reading, % = 12.9

O_2 average chart reading, % = 65.0

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.0)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.0 \text{ \%}}$

= 16.25 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (12.9 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.0 \text{ \%}}$ = 32.7 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 32.7 x $\frac{5.9}{20.9 - 16.25}$ = 41.5 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 41.5 $\left(\frac{125.8}{153}\right)^{0.5}$ $e^{19(0.00336 - 0.00633)}$ $\left(\frac{274.7}{288}\right)^{-1.53}$ = 38.2 ppm by vol, db

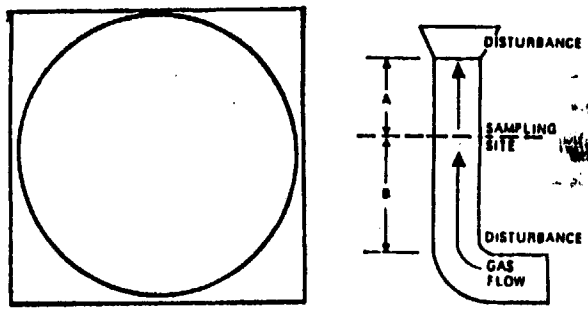
NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 32.7 x (1.194×10^{-7}) x 15213963 = 59.40 lb/hr

$$HOBS = \frac{0.81(0.203)\ 0.623}{30.47} = 0.00336$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-7-89
LOCATION Groves, TX
OPERATOR BP & HT
STACK NO. Cogen
RUN NO. [illegible] 3 Moisture
Natural gas only
SAMPLE BOX NO. RAC
METER BOX NO. 597

AMBIENT TEMPERATURE 46°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in.
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
4:22	A	1 -0.41	303	.50		5.5		682.824	52	46		46		
4:27	5	2	301	.60		5.5		86.70	52	46		46		
4:32	5	3	300	.65		5.5		90.60	52	46		46		
4:37	5	4	300	.54		5.5		94.500	52	46		46		
4:42	5 B	1	303	.58		5.5		98.40	52	46		46		
4:47	5	2	300	.65		5.5		702.30	52	46		46		
4:52	5	3	301	.71				706.200						
		4	298	.68										
	C	1	304	.55										
		2	304	.52										
		3	303	.58										
		4	300	.55										
	D	1	303	.53										
		2	300	.55										
		3	300	.52										
TOTAL		4	295	.49										
AVERAGE			299.9		0.757	5.5		23.376	49.0					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	133	104			204
INITIAL	101	100			200
LIQUID COLLECTED	33	4			
TOTAL VOLUME COLLECTED	37		4		41

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leak check: pre: 0.00 AT 15 "Hg
post: 0.01 AT 15 "Hg

COMPANY: FINA

TEST DATE: 2-7-89

GAS TURBINE NATURAL GAS

CO/NO_x MONITOR FIELD DATA SHEET

Pbar = 30.47

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading PPMV	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading PPMV	CAL NO_x %	CAL O_2	CAL NO_x PPM	CAL O_2 % O_2	CO Chart Reading %	CO Chart Reading PPMV	P T_d	P T_w	P R_h	COMMENTS
1	1-75% LOAD	1514-16.5		13.7			64.9	78.5	82.5	194	20.9	3.0	15	37	35	82	CPD = 153 PSIA
2		16.5-19		13.9			64.9										CO_2 = 2.6%
3		19-21.5		14.2			65.0										O_2 = 16.2%
4		21.5-24		14.5			65.0										E = 0.212
5		24-26.5		14.5			65.0										e = 0.174
6		26.5-29		14.3			65.										HOBS = 0.0036
7		29-31.5		14.1			65.0										317,000 SCFH
8		31.5-34		14.0			64.9										31 MW
	END	1534		14.2			65.0										CPD = 153 PSIA
	POST CAL CHECK			+0.5	0	83.6	20.9										NAT GAS -
				47.8	119	52 0	13.0 0										CPD
1	2-75% LOAD	1550-		13.5			65.0					3.0	15	35	33	81	387,000 SCFH
2		525-		13.5			65.0										153 PSIA
3		55-		13.4			65.0										31 MW
4		515-1600		13.1			65.0										CO_2 = 2.7
5		1600		13.0			65										O_2 = 16.2
6		07.5		13.0			65										E = 0.203
7		05		13.2			65										e = 0.164
8		07.5		13.2			65										HOBS = .623 $\frac{0.164}{30.47}$
		10		13.2			65										= 0.0034
		CAL		0	0	52.5	13.0										
				47.1	119	0	0										

COMPANY: FINA

TEST DATE: 2-7-89

GAS TURBINE NAT GAS

CO/NO_x MONITOR FIELD DATA SHEET

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading PPMV	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading PPMV			CO Chart Reading %	CO Chart Reading PPMV	T_d	T_w	R_h	COMMENTS
1	3-75% LOAD	1623		13		65				2.8		35	33	81	SPD=153
2		1625.5		12.9		65									[illegible]
3		1628		12.9		65									
4		1630.5-33		12.9		65									
5		33-35.5		12.9		65									
6		35.5 38		12.8		65									
7		38-405		12.8		65									
8		405 43		12.8 0		65	1								
		Post CAL		78.0	194	0	0			29.5	150				
				47.0	119	52.0	13.0			6.1	309				
				23.3	60	83.0	20.9			95.5	478				

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1 100% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

2.8% 15.2 82.0

= 29.06 lb/lb-mole

Molecular weight of stack gas, wet basis

$$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$$

= 28.20 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.748

Average absolute stack gas temperature

(T_s) avg. = 302.2 °F + 460 = 762.2 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.62 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.46 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 38,508 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\ avg \cdot P_{std}}\right]$$

= 14,978,391 dscfh

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 1 – 100% LOAD REF GAS
TEST DATE: 2-8-87

NO_x average chart reading, % = 31.1

O_2 average chart reading, % = 61.0

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % – Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (61.0)% – 0.2 %) x $\frac{13 \text{ \% } O_2}{52.0 \text{ \%}}$

= 15.2 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % – Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (31.1 % – 0.4 %) x $\frac{119 \text{ ppm}}{47.7 \text{ \%}}$ = 76.6 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 76.6 x $\frac{5.9}{20.9 - 15.2}$ = 79.3 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 79.3 $\left(\frac{160}{160}\right)^{0.5}$ $e^{19(0.00402 - 0.00633)}\left(\frac{281.9}{288}\right)^{-1.53}$ = 78.4 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 76.6 x (1.194×10^{-7}) x 14,978,391 = 137.0 lb/hr

$HOBS = \frac{0.59(0.3352)^{0.623}}{30.65} = 0.00402$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 1 100% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 2.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(2.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{30.0\ \%}\right)\left(1 - 0.028\right)$$

= 9.7 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(9.7\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14978391\ \text{dscfh}\right) = 10.6\ \text{lbs/hr}$$

① Average of pre and post test drift tests

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA COGEN
100% LOAD REFORS
2-8-89
RUN 1

SAMPLE VOLUME

V_m = 25.536 ft^3

T_m = 533.6 °R

P_{bar} = 30.65 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 26.451\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.6 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.875 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.0085 \times 10^{-5}\ lb/dscf$$

= 0.51 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 1.27 lb/hr

Q_s = 14,978,391 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.052 \times 10^{-5}\ lb/dscf$$

= 2.5 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 7.79 lbs/hr

Q_s = 14,978,391 DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1- 100% LOAD REF GAS

TEST DATE: 2-8-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 26.451 \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 2.401 \text{ scf}$$

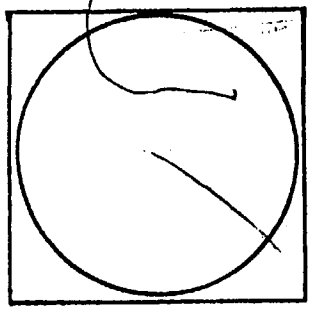
V_{lc} = 51 ml.

Fractional moisture content of stack gas

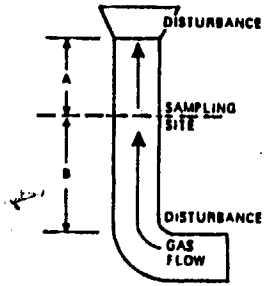
$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = 7.7\%$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT Fina

DATE 2-8-89

LOCATION Groves, TX

OPERATOR P.P. H.T.

STACK NO. Cogen

RUN NO. 100% Load 1 SO_2 Refinery fuel only

SAMPLE BOX NO. RAC

METER BOX NO. 597

AMBIENT TEMPERATURE 51°F

BAROMETRIC PRESSURE 30.65

ASSUMED MOISTURE, %

PROBE LENGTH, in.

NOZZLE DIAMETER, in.

STACK DIAMETER, in.

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.		STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (Vm), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tm_{IN}), °F	OUTLET (Tm_{OUT}), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1220		A1	-.38	303	.55	5.5		773.664	72	72		64		
1225	5	2		302	.55	5.5		78.3	73	72		66		
1230	5	3		302	.60	5.5		83.0	75	72		66		
1235	5	4		302	.59	5.5		87.7	76	72		66		
1240	5	B1		303	.52	5.5		92.4	77	72		66		
1245	5	2		303	.57	5.5		95.7	78	72		66		
1250	5	3		302	.65			799.200						
		4		300	.64									
		C1		303	.55									
		2		302	.54									
		3		303	.55									
		4		299	.56									
		D1		304	.51									
		2		304	.55									
		3		303	.56									
TOTAL		4		300	.48									
AVERAGE			-0.38	302.2	0.748	5.5		25.536	73.6					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	94	152	100		201
INITIAL	100	100	100		200
LIQUID COLLECTED	-6	52			
TOTAL VOLUME COLLECTED	46			5	51

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15 "Hg
post: 0.00 at 15 "Hg

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 2 - 100% LOAD REF GAS (WITH INCREASED STEAM INJECTION RATE)
TEST DATE: 2-8-89

NO_x average chart reading, % = 27.8

O_2 average chart reading, % = 61.0

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (61.0)% - 0.0 %) x $\frac{13 \text{ \% } O_2}{52.1 \text{ \%}}$

= 15.2 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (27.8 % - 0.05 %) x $\frac{119 \text{ ppm}}{47.8 \text{ \%}}$ = 69.1 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 69.1 x $\frac{5.9}{20.9 - 15.2}$ = 71.5 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5} e^{19(HOBS - 0.00633)} \left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 71.5 $\left(\frac{160}{160}\right)^{0.5} e^{19\,(0.00378 - 0.00633)} \left(\frac{282.4}{288}\right)^{-1.53}$ = 70.0 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 69.1 x (1.194×10^{-7}) x 14,760,078 = 121.8 lb/hr

$HOBS = \frac{(0.2966)(0.61)(0.673)}{30.65}$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2- 100% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(3.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{30.0\ \%}\right)\left(1 - 0.032\right)$$

$$= 14.5\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.5\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}760{,}078\ \text{dscfh}\right) = 15.6\ \text{lbs/hr}$$

① Average of pre and post test drift tests

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2-100% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.2 15.2 81.6

= 29.12 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.12 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.84

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.748

Average absolute stack gas temperature

(T_s) avg. = 305.3 °F + 460 = 765.3 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.62 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.64 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 382869 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,760,078 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2-100% LOAD REF GAS

TEST DATE:

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{26,130} \text{ dscf}$$

$$\gamma = \underline{1.009}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.589} \text{ scf}$$

$$V_{lc} = \underline{55} \text{ ml.}$$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{9.0\%}$$

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
GAS TURBINE
2—100% LOAD REF GAS
2-8-89

SAMPLE VOLUME

V_m = 25.018 ft^3

T_m = 529.2 °R

ΔH = 5.5

P_{bar} = 30.65 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 26.130\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01022 (g-eq) /ml

V_t = 2.2 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.30 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_m\ (std)} = 0.033 \times 10^{-5}\ lb/dscf$$

= 1.97 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 4.87 lb/hr

Q_s = 14,760,078 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.033 \times 10^{-5}\ lb/dscf$$

= 1.58 ppm By Volume Dry Basis

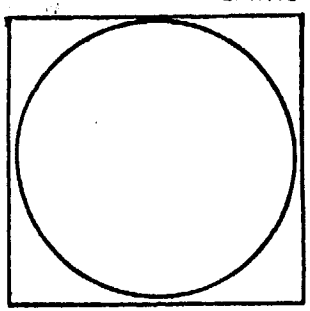
SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 4.87 lbs/hr

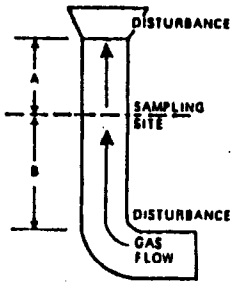
Q_s = 14,760,078 DSCFH

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT: Fina
DATE: 2 8-89
LOCATION: Groves TX
OPERATOR: BP + YT
STACK NO.: Cogen
RUN NO.: 100% Load 2 SO2 Refinery fuel only
SAMPLE BOX NO.: 2AC
METER BOX NO.: 597

AMBIENT TEMPERATURE: 51 °F
BAROMETRIC PRESSURE: 30.65
ASSUMED MOISTURE, %:
PROBE LENGTH, in.:
NOZZLE DIAMETER, in.:
STACK DIAMETER, in.:
PROBE HEATER SETTING:
HEATER BOX SETTING:

METER $\Delta H_@$:
C FACTOR:
PROCESS WEIGHT RATE:

WEIGHT OF PARTICULATE COLLECTED, mg

SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1413	A	1 -.39	306	.55	5.5		799.482	70	70		69		
1418	5	2	307	.55	5.5		803.6	71	68		68		
1423	5	3	306	.61	5.5		07.8	71	66		68		
28	5	4	303	.52	5.5		11.9	72	65		68		
33	5 B	1	307	.55	5.5		15.1	72	65		68		
38	5	2	306	.60	5.5		20.3	74	66		68		
1443	5	3	307	.68			824.500						
		4	305	.70									
	C	1	307	.56									
		2	306	.54									
		3	306	.54									
		4	301	.52									
	D	1	306	.52									
		2	307	.55									
		3	305	.54									
TOTAL		4	300	.45									
AVERAGE		-0.39	305.3	☒ 0.748	5.5		25.018	69.2					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	95	155			205
INITIAL	100	100	100		200
LIQUID COLLECTED	-5	55			
TOTAL VOLUME COLLECTED	50		5		55

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15 "Hg
post: 0.00 at 15 "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 - 100% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.2 15.25 81.55

= 29.12 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.14 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.748

Average absolute stack gas temperature

(T_s) avg. = 304.6 °F + 460 = 764.6 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.62 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.60 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 382566 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,794,357 dscfh

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
COGEN
100% LOAD REF GAS
RUN 3
2-8-89

SAMPLE VOLUME

V_m = 25.685 ft^3

T_m = 529.6 °R

P_{bar} = 30.65 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 26.807\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.925 ml

V_{tb} = 0.350 ml
1.575

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.4 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.053 \times 10^{-5}\ lb/dscf$$

= 3.19 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 7.84 lb/hr

Q_s = 14,794,357 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.035 \times 10^{-5}\ lb/dscf$$

= 1.7 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 5.18 lbs/hr

Q_s = 14,794,357 DSCFH

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 - 100% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(3.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{30.0\ \%}\right)\left(1 - 0.032\right)$$

$$= 14.5\ \text{ppmv, db}$$

CO emission rate

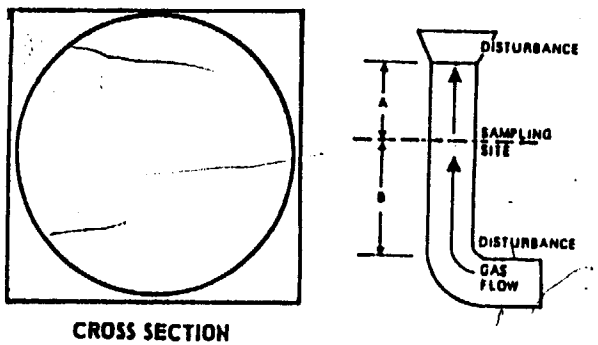
$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.5\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}794{,}357\ \text{dscfh}\right) = 15.6\ \text{lbs/hr}$$

① Average of pre and post test drift tests

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT: Fina
DATE: 2-8-89
LOCATION: Groves
OPERATOR: BP + DT
STACK NO.: Log #1
RUN NO.: Test 350 Recovery Particulate
SAMPLE BOX NO.:
METER BOX NO.: 197

AMBIENT TEMPERATURE: 51°F
BAROMETRIC PRESSURE:
ASSUMED MOISTURE, %:
PROBE LENGTH, in.:
NOZZLE DIAMETER, in.:
STACK DIAMETER, in.:
PROBE HEATER SETTING:
HEATER BOX SETTING:

METER $\Delta H_@$:
C FACTOR:
PROCESS WEIGHT RATE:

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1447	A	1 -.39	306	.55	5.5		824.715	70	66		70		
52	5	2	307	.56	5.5		28.8	73	66		70		
57	5	3	307	.60	5.5		32.9	74	66		69		
1502	5	4	304	.52	5.5		37.0	74	66		69		
07	5	B 1	307	.56	5.5		41.1	74	66		69		
12	5	2	307	.60	5.5		45.2	74	66		69		
1517	5	3	306	.68			850.40						
		4	301	.70									
	C	1	305	.55									
		2	304	.55									
		3	305	.54									
		4	300	.51									
	D	1	305	.53									
		2	305	.54									
		3	304	.54									
TOTAL		4	301	.45									
AVERAGE		-0.39	304.6	0.748			25.685	69.6					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	91	159	101		204
INITIAL	100	100	100		200
LIQUID COLLECTED	-9	59	1		
TOTAL VOLUME COLLECTED	51			4	53

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.0 at 15 "Hg
post: 0.0 at 15 "Hg

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3- 100% LOAD REF GAS

TEST DATE: 2-8-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{26.807} \text{ dscf}$$

$$\gamma = \underline{1.009}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.589} \text{ scf}$$

$$V_{lc} = \underline{55} \text{ ml.}$$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = \underline{8.8\%}$$

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 3 100% LOAD REF GAS (WITH INCREASED STEAM INJECTION)
TEST DATE: 2-8-89

NO_x average chart reading, % = 28.1

O_2 average chart reading, % = 61.1

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (61.1)% - (-0.1 %) x $\frac{13 \text{ \% } O_2}{52.1 \text{ \%}}$

= 15.25 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (28.1 % - (-0.1 %) x $\frac{60 \text{ ppm}}{24.0 \text{ \%}}$ = 70.5 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 70.5 x $\frac{5.9}{20.9 - 15.25}$ = 73.6 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 73.6 $\left(\frac{160}{160}\right)^{0.5}$ $e^{19(0.00368 - 0.00633)}$ $\left(\frac{292.4}{288}\right)^{-1.53}$ = 72.1 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 70.5 x (1.194×10^{-7}) x 14,794,357 = 124.5 lb/hr

$$HOBS = \frac{(0.2966)(0.61)(0.623)}{30.65} = 0.00368$$

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: RUN 4 100% LOAD REF GAS NORMAL STEAM INJECTION RATE
TEST DATE: 2-9-89

NO_x average chart reading, % = 31.56

O_2 average chart reading, % = 60.13

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (60.13)% - 0.0 %) x $\frac{13 \quad \%\ O_2}{53.2 \quad \%}$

= 14.7 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (31.56 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.7 \ \%}$ = 78.7 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 78.7 x $\frac{5.9}{20.9 - 14.7}$ = 74.9 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 74.9 $\left(\frac{160}{158}\right)^{0.5}$ $e^{19\ (0.0296 - 0.00633)}$ $\left(\frac{262.4}{288}\right)^{-1.53}$ = 72.97 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 78.7 x (1.194×10^{-7}) x 14,962,199 = 140.6 lb/hr

$$HOBS = \frac{0.42\ (0.3476)^{0.623}}{30.73}$$

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 4 100% LOAD REF GAS

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{26.647} \text{ dscf}$$

$$\gamma = \underline{1.009}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.024} \text{ scf}$$

$$V_{lc} = \underline{43} \text{ ml.}$$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{7.1\%}$$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 4 100% LOAD REF GAS NORMAL STEAM INJECTION RATE

TEST DATE: 2-9-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(3.0\ \%\ -\ 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{30.0\ \%}\right)\left(1 - 0.029\right)$$

$$= 14.6\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.6\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}962{,}199\ \text{dscfh}\right) = 15.9\ \text{lbs/hr}$$

① Average of pre and post test drift tests

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 4 100% LOAD REF GAS NORMAL STEAM INJECTION RATE

TEST DATE: 2-9-85

Dry molecular weight of stack gas

$$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

2.9 14.7

= 29.05 lb/lb-mole

Molecular weight of stack gas, wet basis

$$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$$

= 28.27 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.743

Average absolute stack gas temperature

(T_s) avg. = 303.8 °F + 460 = 763.8 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.70 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.05 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 378,440 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,962,199 dscfh

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
COGEN
100% LOAD REF GAS
RUN 4
2-9-89

SAMPLE VOLUME

V_m = 25.938 ft^3

T_m = 539.4 °R

P_{bar} = 30.73 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 26.647\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.6 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.0 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.008 \times 10^{-5}\ lb/dscf$$

= 0.50 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 1.20 lb/hr

Q_s = 14962195 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.022 \times 10^{-5}\ lb/dscf$$

= 1.06 ppm By Volume Dry Basis

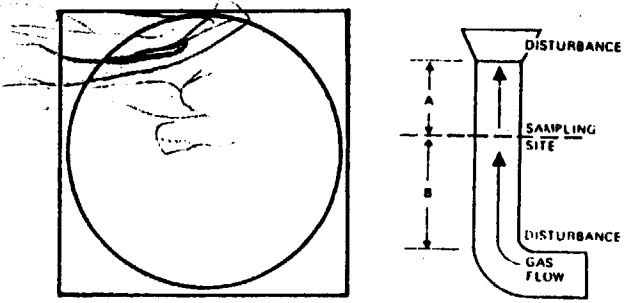
SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 3.29 lbs/hr

Q_s = 14,962,195 DSCFH

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-9-89
LOCATION Groves, TX
OPERATOR BP
STACK NO. Cogen
RUN NO. 100% Load ~~w~~ SO2 Refinery fuel only
SAMPLE BOX NO. [illegible]
METER BOX NO. 597

AMBIENT TEMPERATURE 60°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	VELOCITY HEAD ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tm_{IN}), °F	OUTLET (Tm_{OUT}), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1253		-0.40	306	.50		5.5		012.462	79	79		67		
58	5		307	.58		5.5		16.9	80	79		62		
1303	5		304	.60		5.5		21.4	80	79		62		
08	5		302	.52		5.5		25.9	80	79		60		
13	5		306	.55		5.5		30.4	80	79		60		
18	5		304	.56		5.5		34.9	80	79		60		
1323	5		302	.59				038.400						
			299	.64										
			303	.56										
			303	.55										
			301	.56										
			300	.50										
			306	.52										
			304	.56										
			302	.58										
TOTAL			302	.48										
AVERAGE			303.8		0.743	5.5		25.938	79.4					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	93	145	120		205
INITIAL	100	100	100		200
LIQUID COLLECTED	-7	45			
TOTAL VOLUME COLLECTED	38		5		43

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS: Leak Check
Pre: 0.00 cFM at 15" Hg
Post: 0.00 cFM at 15" Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUNS 100% LOAD REF GAS NORMAL STEAM ~ INJECTION RATE

TEST DATE: 2-9-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.8 15.0 82.2

= 29.05 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.28 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.742

Average absolute stack gas temperature

(T_s) avg. = 303.6 °F + 460 = 763.6 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.70 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 49.97 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 377803 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,957004 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 5 100% LOAD REF GAS NORMAL STEAM INJECTION RATE

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{23,064} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1,742} \text{ scf}$$

V_{lc} = 37 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{7.0\ \%}$$

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: RUN 5 100% LOAD REF GAS NORMAL STEAM INJECTION RATE
TEST DATE: 2-9-89

NO_x average chart reading, % = 31.6

O_2 average chart reading, % = 60.4

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (60.4)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.2 \text{ \%}}$

= 15.0 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (31.6 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.2 \text{ \%}}$ = 79.7 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 79.7 x $\frac{5.9}{20.9 - 15.0}$ = 79.7 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $e^{19(HOBS - 0.00633)}$ $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 79.7 $\left(\frac{160}{159}\right)^{0.5}$ $e^{19(0.00314 - 0.00633)}$ $\left(\frac{283}{288}\right)^{-1.53}$ = 77.2 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 79.7 x (1.194×10^{-7}) x 14,957,004 = 142.3 lb/hr

$H\ OBS = \frac{0.43\ (0.360)\ 0.623}{30.73} = 0.00314$

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 5 100% LOAD RFF GAS

TEST DATE: 2-9-89

CO average chart reading, % = 4.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(\underline{4.0}\ \% - \underline{0.0}\ \%\right)\left(\frac{150}{30}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - 0.028\right)$$

$$= \underline{19.4}\ \text{ppmv, db}$$

CO emission rate

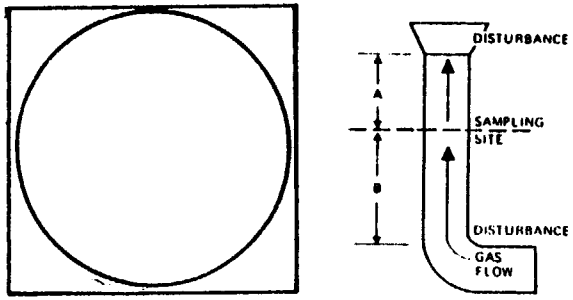
$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(\underline{19.4\ \text{ppmv, db}}\right)\left(7.268 \times 10^{-8}\right)\left(\underline{14{,}957{,}004\ \text{dscfh}}\right) = \underline{21.1}\ \text{lbs/hr}$$

① Average of pre and post test drift tests

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-9-89
LOCATION Groves TX
OPERATOR BP
STACK NO. Cogen
RUN NO. 100% Load SSO_2 Refinery fuel only
SAMPLE BOX NO. RAC
METER BOX NO. 597

AMBIENT TEMPERATURE 65°F
BAROMETRIC PRESSURE 30.73
ASSUMED MOISTURE, %
PROBE LENGTH, in.
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1336		-0.40	306	.52	5.5		038.621	78	78		80		
41	5		304	.54	5.5		43.1	80	78		76		
46	5		302	.58	5.5		47.6	82	79		70		
51	5		302	.60	5.5		52.1	83	79		69		
56	5		306	.56	5.5		56.6	83	79		69		
1401	5		305	.55	5.5		061.100	83	79		69		
1406	5		302	.54									
			303	.58									
			305	.53									
			304	.54									
			302	.52									
			300	.53									
			307	.54									
			306	.60									
			302	.58									
TOTAL			302	.50									
AVERAGE		-0.40	303.6		5.5		22.479	80.1					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	97	135	101		204
INITIAL	100	100	100		200
LIQUID COLLECTED	-3	35	1		
TOTAL VOLUME COLLECTED	33		4		37

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS: Leak Check
Pre: 0.00 CFM at 15" Hg
Post: 0.00 CFM at 15" Hg

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
COGEN
100% LOAD REF GAS
RUN 5
2-9-89

SAMPLE VOLUME

V_m = 22.479 ft^3

T_m = 540.1 °R

P_{bar} = 30.73 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 23.014\ ft^3 \quad \text{Equation 6-1}$$

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.45 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.825 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.023 \times 10^{-5}\ lb/dscf$$

= 1.41 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 3.44 lb/hr

Q_s = 14,957,004 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.019 \times 10^{-5}\ lb/dscf$$

= 0.90 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 2.84 lbs/hr

Q_s = 14,957,004 DSCFH

COMPANY: FINA

TEST DATE: 2-9-89

CO/NO_x MONITOR FIELD DATA SHEET

FULL LOAD Refinery 6/25 (NORMAL STEAM INJECTION RATE)

P_{bar} = 30.73

Sampling Location	Run No.	Time		Convertor Mode	NO_x Chart Reading 5 min average % of chart	PPMV	O_2 Chart Reading 5 min average % of chart	PPMV			CO Chart Reading %	PPMV	T_d	T_w	R_h	COMMENTS
	4	1254	1		32.0		60.0				3		49	40	42	CO_2 = 2.9
			2		32.0		60.0						E = 0.3876			
		59	3		31.5		60.0						e = 0.1460			
			4		31.5		60.0						HOBS = 0.00296			
		1304	5		31.3		60.2						CPD = 158			
			6		31.5		60.4									
		1309	7		31.5		60.4									
			8		31.2		60.0									
		1314			31.56		60.125									
					47.7	119	83.6	20.4								
					0	0	53.2	13.0								
		1337	1		32.2		60.8				4		CPD = 159			
	5		2		32.2		60.8						50	41	43	
		42	3		31.1		60.2						CO_2 = 2.8			
			4		31.0		60.2									
		47	5		31.4		60.2									
			6		31.5		60.2									
		52	7		31.5		60.2									
			8		31.5		60.2									
		57			31.6	0	60.4				0	0				
				CAL	47.2	119	52.2	13			30.0	150				
					60	27.7	0	0			62.2	309				
											96.0	478				

FULL LOAD 12AF CNS 2-9-89

HYDROCARBON FIELD DATA SHEET

SAMPLING LOCATION	TIME	PEAK NO.	ATTEN.	PEAK AREA	THC CONC. (PPM)	METHANE CONC. (PPM)	NMHC CONC. (PPM)		COMMENTS
					91.2 90.88				
					50.0 49.48				
					32.8 31.96				
	1251				0				
	59				0				
	04				0				
	09				0				
	14				0				

COMPANY: FINA

TEST DATE: 2-8-89

FULL LOAD REFGAS RUN 1

CO/NO_x MONITOR FIELD DATA SHEET

P = 30.65

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading 5 min average PPMV	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading 5 min average % ~~PPMV~~			CO Chart Reading %	CO Chart Reading PPMV	T_d	T_w	R_h	COMMENTS
CAL				78.8	197	0						48	42	59	CPD=160
				23.8	60	83.6	20.9					E=0.3352			
				47.8	119	52.1	13					e=0.1978			
				0	0							Hobs=0.0040			CO_2=28%
	1	1221-23.5		30.0		61									
	2	23.5		30.0		61									
	3	26		31.5		61									
	4	28.5		31.5		61									
	5	31		31.5		61									
	6	33.5		31.5		61									
	7	36.0-		31.5		61									
	8	31.5-41		31.5		61									
				31.13		61				2.0	10.0				
				0.4	0	0.2	0								
				47.7	119	52.0	13								
						83.6	20.9								

COMPANY: FIRM

TEST DATE: 2-8-85

FULL LOAD REF GAS STEAM insecticide [illegible]

CO/NO_x MONITOR FIELD DATA SHEET

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading PPMV	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading Average PPMV			CO Chart Reading %	CO Chart Reading PPMV	T_d	T_w	R_h	STE COMMENTS
	2	[illegible]		47.8	119	52	13			3.0					STEAM insecticide rate increased
	1	1413		27.6		61.1									CPD=160
	2	15.5		27.7		61.0									
	3	18		27.7		61.0									
	4	20.5-23		28.3		61.0						49	43	61	
	5	23		28.0		61.0									CO_2=3.2%
	6	25.5		27.7		61.0									
	7	28		27.5		61.0									
	8	30.5		27.5		61.0									
		33		27.8		61.0									
			CAL	0.1	0	52.1	13								
				47.8	119	0	0								
	3 1	1445		27.8		61.0				3.0		49	43	61	CPD=160
	2	47.5		27.4		61.0									CO_2=3.2%
	3	50		27.9		61.1									
	4	52.5		28.3		61.1									
	5	55		28.4		61.1									
	6	57.5		28.4		61.1									
	7	00		28.2		61.1									
	8	02.5-05		28.0		61.1									
		ZCW		-0.1	0	-0.1	0	0		0	0				
		CAL LOW		24.0	60					30.0	150				
		MID		48.0	119	52.0	13			63.0	309				
		HIGH		79.1	197	83.5	20.9			95.6	478				

2-8-89

FINA Full Load REF GAS

HYDROCARBON FIELD DATA SHEET

SAMPLING LOCATION	TIME	PEAK NO.	ATTEN.	PEAK AREA	THC CONC. %(~~PPM~~) PPM	METHANE CONC. (PPM)	NMHC CONC. (PPM)		COMMENTS
	CAL	1,2 CH4	10x4	55.7	91.0 90.88	90.88			
		3,4 CH4	10x4	17.8	31.0 31.66				
		5,6	10x4	29.7	49.05 49.45				
Run 1	1221				0 0				CO_2=2.6
	26				0 0				
	31				0 0				
	36				0 0				
	41				0 0				
				CAL	0 0				
				CAL	50.6 49.45				
Run 2	1413				0 0				
	18				0 0				
	23				0 0				
	28				0 0				
	33				0 0				
				CAL	0 0				
					49.8 49.45				

HYDROCARBON FIELD DATA SHEET

SAMPLING LOCATION	TIME	PEAK NO.	ATTEN.	PEAK AREA	THC CONC. % (~~PPM~~) ppm	METHANE CONC. (PPM)	NMHC CONC. (PPM)		COMMENTS
Run 3	1447				0 0				
	52				0 0				
	57				0 0				
	02				0 0				
	07				0 0				
					52.0 49.45				
					32.11 31.66				
					93.7 90.88				
					0 0				

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: RUN 1 75% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.8 16.3 80.9

= 29.10 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.35 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.731

Average absolute stack gas temperature

(T_s) avg. = 313.8 °F + 460 = 773.8 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.62 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 49.56 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 374,717 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,632,528 dscfh

MOISTURE CALCULATION SUMMARY

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 75% COND REF MS
TEST DATE: 2-7-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{26.606} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1.930} \text{ scf}$$

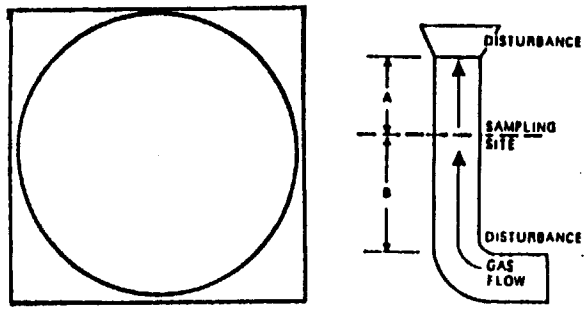
V_{lc} = 41 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = \underline{6.8\%}$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2 8 89
LOCATION Groves, TX
OPERATOR BP + H
STACK NO. Cogen
RUN NO. 75% Load 1 Moisture Refinery fuel only
SAMPLE BOX NO. RAC
METER BOX NO. 597

AMBIENT TEMPERATURE 4
BAROMETRIC PRESSURE 30.65
ASSUMED MOISTURE, %
PROBE LENGTH, in.
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1752	A	1 -.38	315	.52		5.5		851.392	60	60		60		
57	5	2	316	.52		5.5		55.5	62	60		60		
1812	5	3	316	.60		5.5		59.7	63	60		60		
07	5	4	311	.53		5.5		63.9	64	60		60		
12	5 B	1	314	.50		5.5		68.1	65	60		60		
17	5	2	315	.51		5.5		72.3	65	60		60		
1922	5	3	316	.57				876.500						
		4	316	.55										
	C	1	315	.55										
		2	312	.54										
		3	315	.55										
		4	314	.53										
	D	1	314	.51										
		2	314	.55										
		3	310	.55										
TOTAL		4	308	.47										
AVERAGE		-0.38	313.8		0.731	5.5		25.108	61.6					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	134	101			206
INITIAL	100	100			200
LIQUID COLLECTED					
TOTAL VOLUME COLLECTED	35		6		41

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15 "Hg
post: 0.0 at 15 "Hg

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 1- 75% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(\underline{3.0}\ \% - \underline{0.0}\ \%\right)\left(\frac{150\ \text{ppm CO}}{30.0\ \%}\right)\left(1 - 0.028\right)$$

= 14.6 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(\underline{14.6\ \text{ppmv, db}}\right)\left(7.268 \times 10^{-8}\right)\left(\underline{14{,}632{,}528\ \text{dscfh}}\right) = \underline{15.5}\ \text{lbs/hr}$$

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 1 – 75% LOAD REFINERY GAS
TEST DATE: 2-8-89

NO_x average chart reading, % = 23.0

O_2 average chart reading, % = 65.25

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % – Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.25)% – 0.0 %) x $\frac{13 \text{ \% } O_2}{52.0 \text{ \%}}$

= 16.31 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % – Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (23.0 % – 0.0 %) x $\frac{119 \text{ ppm}}{46.9 \text{ \%}}$ = 58.4 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 58.4 x $\frac{5.9}{20.9 - 16.31}$ = 75.0 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5} e^{19(HOBS - 0.00633)} \left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 75.0 $\left(\frac{125.9}{149}\right)^{0.5} e^{19\,(0.00450 - 0.00633)} \left(\frac{281.9}{288}\right)^{-1.53}$ = 68.8 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 58.4 x (1.194×10^{-7}) x 14,632,528 = 102.0 lb/hr

$HOBS = \frac{(0.3352)(0.66)(0.623)}{30.65} = 0.00450$

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 - 75% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.8 16.4 80.8

= 29.10 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.98 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.742

Average absolute stack gas temperature

(T_s) avg. = 315.0 °F + 460 = 775.0 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.68 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 49.75 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 376,140 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,694,089 dscfh

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2 - 75% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 2.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(\underline{2.0}\ \% - \underline{0.0}\ \%\right)\left(\frac{150}{30}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - 0.028\right)$$

$$= \underline{9.8}\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(\underline{9.8\ \text{ppmv, db}}\right)\left(7.268 \times 10^{-8}\right)\left(\underline{14{,}694{,}089\ \text{dscfh}}\right) = \underline{10.5}\ \text{lbs/hr}$$

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 2 - 75% LOAD REF GAS
TEST DATE: 2-8-89

NO_x average chart reading, % = 22.7

O_2 average chart reading, % = 65.9

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.9)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.1 \text{ \%}}$

= 16.44 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (22.7 % - 0.0 %) x $\frac{119 \text{ ppm}}{46.7 \text{ \%}}$ = 57.84 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 57.84 x $\frac{5.9}{20.9-16.44}$ = 76.5 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5} e^{19(HOBS - 0.00633)} \left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 76.5 $\left(\frac{125.9}{149}\right)^{0.5} e^{19\,(0.00450 - 0.00633)} \left(\frac{281.9}{288}\right)^{-1.53}$ = 70.2 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 57.84 x (1.194×10^{-7}) x 14,674,089 = 101.5 lb/hr

$$HOBS = \frac{(0.3352)(0.66)(0.633)}{30.65} = 0.00450$$

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 2- 75% LOAD REF GAS

TEST DATE: 2-8-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{26.774} \text{ dscf}$$

$$\gamma = \underline{1.009}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{1.836} \text{ scf}$$

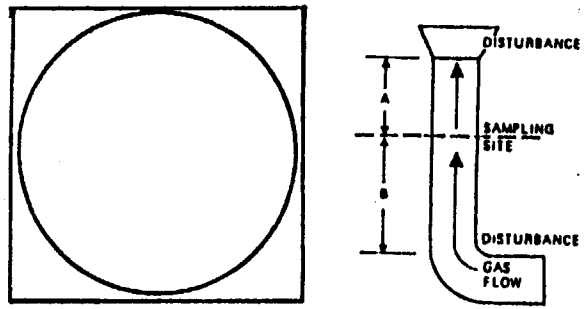
$$V_{lc} = \underline{38} \text{ ml.}$$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = \underline{6.4\%}$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT [illegible]
DATE [illegible] 2-89
LOCATION Groves TX
OPERATOR BP + HT
STACK NO. Cogen
RUN NO. [illegible] Load 3 Moisture Refinery fuel only
SAMPLE BOX NO. [illegible]
METER BOX NO. 597

AMBIENT TEMPERATURE 48°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, In.
NOZZLE DIAMETER, In.
STACK DIAMETER, In.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (In. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) In., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (Vm), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tm_{IN}), °F	OUTLET (Tm_{OUT}), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM In. Hg gauge	VELOCITY fps
1827	A	1 - .38	317	.52	5.5		876.648	62	60		60		
32	5	2	316	.53	5.5		80.9	62	60		60		
37	5	3	316	.60	5.5		85.1	63	60		60		
42	5	4	313	.53	5.5		89.3	63	60		60		
47	5 B	1	316	.55	5.5		93.5	63	60		60		
52	5	2	317	.56	5.5		97.7	63	60		60		
1857	5	3	317	.64			901.900						
		4	314	.61									
	C	1	315	.53									
		2	316	.55									
		3	316	.55									
		4	312	.57									
	D	1	316	.54									
		2	314	.54									
		3	313	.55									
TOTAL		4	312	.50									
AVERAGE			315.0		0.742	5.5	25,252	61.3					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	132	101			205
INITIAL	100	100			200
LIQUID COLLECTED	32	1			
TOTAL VOLUME COLLECTED	33		5		38

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leak check: pre: [illegible] at 15 "Hg
post: [illegible] at 15 "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3- 75% LOAD REF GAS

TEST DATE: 2-8-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

2.6 16.4

= 29.07 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 28.37 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.747

Average absolute stack gas temperature

(T_s) avg. = 314.2 °F + 460 = 774.2 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.62 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.64 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 382,869 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 15,023,302 dscfh

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE
REPETITION NO.: 3 - 75% LOAD REF GAS
TEST DATE: 2-8-89

NO_x average chart reading, % = 22.9

O_2 average chart reading, % = 65.9

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (65.9)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.2 \text{ \%}}$

= 16.41 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (22.9 % - 0.0 %) x $\frac{60 \text{ ppm}}{28.5 \text{ \%}}$ = 58.5 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = 58.5 x $\frac{5.9}{20.9 - 16.41}$ = 76.8 ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5} e^{19(HOBS - 0.00633)} \left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= 76.8 $\left(\frac{125.9}{149}\right)^{0.5} e^{19(0.00472 - 0.00633)} \left(\frac{280.2}{288}\right)^{-1.53}$ = 71.41 ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 58.5 x (1.194×10^{-7}) x 15,023,302 = 104.9 lb/hr

$$HOBS = \frac{(0.78)(0.248)(0.623)}{30.65} = 0.00472$$

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 - 75% LOAD REF GAS

TEST DATE: 2-8-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 26.641 \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 1.789 \text{ scf}$$

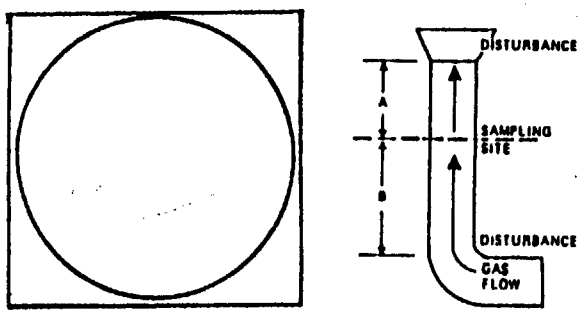
V_{lc} = 38 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} = 6.3\%$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fing

DATE 2-8-87

LOCATION Groves, TX

OPERATOR BP HT

STACK NO. Cogen

RUN NO. 75% Load 3% Moisture

SAMPLE BOX NO. 22

METER BOX NO. 597

AMBIENT TEMPERATURE 60°F

BAROMETRIC PRESSURE 30.65

ASSUMED MOISTURE, % 7%

PROBE LENGTH, in. 84"

NOZZLE DIAMETER, in. —

STACK DIAMETER, in. 12' 8"

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.		STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s) ($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
1900		A	1 -.39	316	.55	5.5		902.050	63	60		60		
1005	5		2	315	.58	5.5		0.3	63	60		60		
10	5		3	315	.60	5.5		10.4	63	60		60		
15	5		4	312	.53	5.5		14.6	63	60		60		
20	5	B	1	315	.57	5.5		18.8	63	61		60		
25	5		2	314	.57	5.5		23.0	64	61		60		
1930	5		3	314	.64			937.200						
			4	312	.70									
		C	1	316	.55									
			2	315	.55									
			3	312	.55									
			4	309	.57									
		D	1	316	.51									
			2	316	.55									
			3	316	.55									
TOTAL			4	314	.50									
AVERAGE			-0.39	314.2	☒	0.747	5.5	25.150	61.8					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	133	101	100		204
INITIAL	100	100	100		200
LIQUID COLLECTED	33	1			
TOTAL VOLUME COLLECTED	34		4		38

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.0 AT 15 "Hg
post: 0.10 AT 15 "Hg

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE

REPETITION NO.: 3 - 75% LOAD REF GAS

TEST DATE: 2-8-89

CO average chart reading, % = 1.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(1.0\ \% - 0.0\ \%\right)\left(\frac{150}{30}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - 0.026\right)$$

$$= 4.9\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(4.9\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}023{,}302\ \text{dscfh}\right) = 5.4\ \text{lbs/hr}$$

① Average of pre and post test drift tests

COMPANY:

TEST DATE: 2-8-89

75% LOAD REFINERY GAS

CO/NO_x MONITOR FIELD DATA SHEET

Pbar = 30.65

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average: % of chart	PPMV	O_2 Chart Reading 5 min average % of chart	PPMV			CO Chart Reading %	PPMV	T_d	T_w	R_h	COMMENTS
	1 1	1751		23.3		65.0						48	43	66	CPD = 149
	2	53.5		23.3		65.1									CO_2 = 2.8
	3	56		23.2		65.1									
	4	58.5 - 1		23.0		65.2									
	5	1800		23.0		65.3									
	6	3		23.0		65.4									
	7	1806		22.7		65.5									
	8	05 - 11		22.8		65.5				3.0					
				0	0	52	13								
				98.3	197	83.6	20.9								
				46.9	119										
	2 1	1827		22.8		65.9						48	43	66	CO_2 = 2.8
	2	29.5		22.7		658									CPD = 149
	3	32		22.5		65.9									CO_2 = 2.6%
	4	34.5		22.4		65.9									
	5	37		22.7		65.9									
	6	39.5		22.8		65.9									
	7	42		22.8		65.9				2.0					
	8	1844.5-47		22.6		65.9									
				22.7		65.9									
				0	0	52.1	13.0								
				46.7	119	83.4	20.9								
						0	0								

COMPANY: FINA

TEST DATE: 2-8-89

75% COND PETGAS

CO/NO_x MONITOR FIELD DATA SHEET

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading PPMV	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading PPMV			CO Chart Reading %	CO Chart Reading PPMV	T_d	T_w	R_h	COMMENTS
	3 1	1900		23.0		65.9				1.0		45	42	78	CPD=14.4
	2	2[illegible]		23.0		65.9									CO=2.6
	3	1950		23.0		65.9									
	4	[illegible]		23.0		65.9									
	5	[illegible]		23.0		65.9									
	6	12[illegible]		22.9		66.0									
	7	15		22.8		66.0									
	8	12[illegible] 20		22.8	22.9	66.0	65.9								
				0	0	83.7	20.9								
				23.5	60	0	0		CAL	30	150				
				80.0	197	52.2	13.0			62.2	309				
				47.3	119	83.5	20.9			95.1	478				
										0	0				

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GE GAS TURBINE DUCT BURNER INLET DUCT

REPETITION NO.: 1 MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 4.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(4.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{24.7\ \%}\right)\left(1 - 0.032\right)$$

$$= 20.2\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(20.2\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(\_\_\_\_\_\ \text{dscfh}\right) = \_\_\_\_\_\ \text{lbs/hr}$$

$$= 1.468 \times 10^{-6}\ \text{lbs/dscf}$$

① Average of pre and post test drift tests

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
TURBINE EXHAUST (Boiler inlet)
MAX COMBINED FIRING RATE
RUN 1
2-9-89

SAMPLE VOLUME

V_m = 23.938 ft^3

T_m = 507.1 °R

ΔH = 2.0

P_{bar} = 30.73 in. Hg

Y = 1.004

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 25.814\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.225 ml

V_{tb} = 0.35 ml
1.190

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.25 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.042 \times 10^{-5}\ lb/dscf$$

= 2.5 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = _____ lb/hr

Q_s = _____ DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.031 \times 10^{-5}\ lb/dscf$$

= 1.5 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = _____ lbs/hr

Q_s = _____ DSCFH

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: TURBINE Exhaust (Boiler inlet)
REPETITION NO.: 1 - MAX combined Firing mode
TEST DATE: 2-9-89

NO_x average chart reading, % = 22.15

O_2 average chart reading, % = 67.08

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (67.08)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.0 \text{ \%}}$

= 16.77 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (22.15 % - 0.1 %) x $\frac{119 \text{ ppm}}{47.5 \text{ \%}}$ = 55.24 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $19(HOBS - 0.00633)\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (____ -0.00633) $\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 55.24 x (1.194×10^{-7}) x _____ = _____ lb/hr

= 6.596×10^{-6} lb/dscF

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: Turbine Exhaust

REPETITION NO.: 1 - Max Combined Firing Rate

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 25.814 \text{ dscf}$$

γ = 1.004

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 2.212 \text{ scf}$$

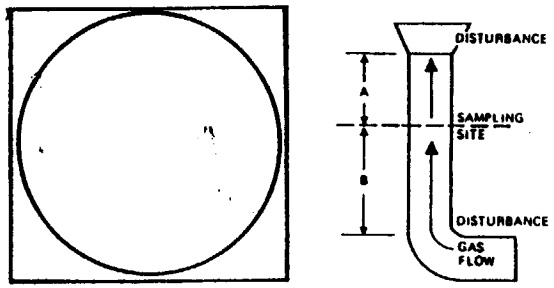
V_{lc} = 47 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = 7.9\ \%$$

SO_2 ~~PARTICULATE~~ FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-9-89
LOCATION Grives, Tx
OPERATOR Hmt
STACK NO. Cogen Boiler Inlet
RUN NO. 1 Combined Fuels
SAMPLE BOX NO. RAC
METER BOX NO. 2390

AMBIENT TEMPERATURE 40°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in. 96
NOZZLE DIAMETER, in. —
STACK DIAMETER, in. —
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	y= GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
	8:22					2.0		525.238	40	40		40	2	
	27					2.0		29.1	45	40		45	2	
	32					2.0		33.0	49	41		49	2	
	37					2.0		37.2	55	42		55	2	
	42					2.0		41.0	60	44		56	2	
	47					2.0		45.1	64	45		56	2	
	8:52							549.176						
TOTAL														
AVERAGE						2.0		23.938	47.1					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	95	145	104		203
INITIAL	100	100	100		200
LIQUID COLLECTED	-5	45	4		
TOTAL VOLUME COLLECTED		44		3	47

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS: Pre 0 cfm 15" Hg
Post 0 cfm 16" Hg

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: TURBINE EXHAUST (BOILER INLET)
REPETITION NO.: 2 - MAX COMBINED FIRING RATE
TEST DATE: 2-9-89

NO_x average chart reading, % = 22.4

O_2 average chart reading, % = 66.93

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (66.9)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.2 \text{ \%}}$

= 16.66 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (22.4 % - 0.0 %) x $\frac{119 \text{ ppm}}{48.0 \text{ \%}}$ = 55.53 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $19(HOBS - 0.00633)\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (____ -0.00633) $\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 55.53 x (1.194×10^{-7}) x _____ = _____ lb/hr

= 6.630×10^{-6} lb/dscfh

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GE GAS TURBINE DUCT BURNER INLET DUCT

REPETITION NO.: 2-MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(3.0\ \% - 0.0\ \%\right)\left(\frac{150}{29.7}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - 0.033\right)$$

= 14.65 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(\_\_\_\_\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(\_\_\_\_\ \text{dscfh}\right) = \_\_\_\_\ \text{lbs/hr}$$

$= 1.065 \times 10^{-6}$ lbs/dscF

① Average of pre and post test drift tests

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
TURBINE EXHAUST (BOILER INLET)
MAX COMBINED FIRING RATE
RUN 2
2-9-89

SAMPLE VOLUME

V_m = 23.792 ft^3

T_m = 517.5 °R

ΔH = 2.0

P_{bar} = 30.23 in. Hg

Y = 1.004

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 25.169\ ft^3 \quad \text{Equation 6-1}$$

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.70 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.5 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_m\ (std)} = 0.013 \times 10^{-5}\ lb/dscf$$

= 0.76 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = _____ lb/hr

Q_s = _____ DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.041 \times 10^{-5}\ lb/dscf$$

= 2.0 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = _____ lbs/hr

Q_s = _____ DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA
SOURCE: Turbine Exhaust
REPETITION NO.: 2 Max Combined Firing Rate
TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 25,169 \text{ dscf}$$

γ = 1.004

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 2.259 \text{ scf}$$

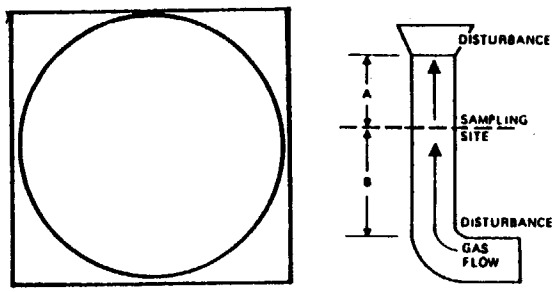
V_{lc} = 48 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = 8.2\%$$

SO_2 ~~PARTICULATE~~ FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Eind
DATE 2-9-89
LOCATION Groves, Tx
OPERATOR HMT
STACK NO. Coffen Boiler Inlet
RUN NO. 2 MAX COMBINED FIRING RATE
SAMPLE BOX NO. RAC
METER BOX NO. 2390

AMBIENT TEMPERATURE 41°F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in. 96
NOZZLE DIAMETER, in. —
STACK DIAMETER, in. —
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	Y= GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
	9:03					2.0		549.395	50	50		43	2	
	08					2.0		53.3	55	52		47	2	
	13					2.0		57.2	60	53		53	2	
	18					2.0		61.2	65	53		57	2	
	23					2.0		65.0	69	54		57	2	
	28					2.0		69.1	73	56		58	2	
	9:33							573.187						
TOTAL														
AVERAGE						2.0		23.792	57.5					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	96	146	104		202
INITIAL	100	100	100		200
LIQUID COLLECTED	-4	46	4		2
TOTAL VOLUME COLLECTED	46		2		48

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS: Pre 0 cfm 15" Hg
Post 0 cfm 17" Hg

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GE GAS TURBINE DUCT BURNER INLET DUCT

REPETITION NO.: 3 — MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(3.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{29.7\ \%}\right)\left(1 - 0.023\right)$$

= 14.65 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.65\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(\_\_\_\_\_\ \text{dscfh}\right) = \_\_\_\_\_\ \text{lbs/hr}$$

$= 1.065 \times 10^{-6}$ lbs/dscf

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: TURBINE EXHAUST (BOILER INLET)
REPETITION NO. 3-MAX COMBINED FIRING RATE
TEST DATE: 2-9-89

NO_x average chart reading, % = 29.6

O_2 average chart reading, % = 62.96

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (62.96)% - 0.0 %) x $\frac{13.0}{52.5}$ $\frac{\%\ O_2}{\%}$

= 15.59 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (29.6 % - 0.0 %) x $\frac{119}{47.5}$ $\frac{ppm}{\%}$ = 74.16 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $19(HOBS - 0.00633)\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (____ -0.00633)$\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db)$\left(\frac{46}{385.26} \times 10^{-6}\right)$(stack vol flow rate, dscfh) = lb/hr

= 74.16 x (1.194×10^{-7}) x _____ = _____ lb/hr

$= 8.854 \times 10^{-6}$ lb/dscf

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
TURBINE Exhaust (Boiler inlet)
Max Combined Firing Rate
RUN 3
2-9-89

SAMPLE VOLUME

V_m = 23.833 ft^3

T_m = 519.3 °R

ΔH = 2.0

P_{bar} = 30.73 in. Hg

Y = 1.004

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 25.103\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.68 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.3 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.012 \times 10^{-5}\ lb/dscf$$

= 0.71 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = _____ lb/hr

Q_s = _____ DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.034 \times 10^{-5}\ lb/dscf$$

= 1.6 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = _____ lbs/hr

Q_s = _____ DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: Turbine Exhaust

REPETITION NO.: 3-MAX Combined Firing Rate

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{25,103} \text{ dscf}$$

$$\gamma = \underline{1.004}$$

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{2.212} \text{ scf}$$

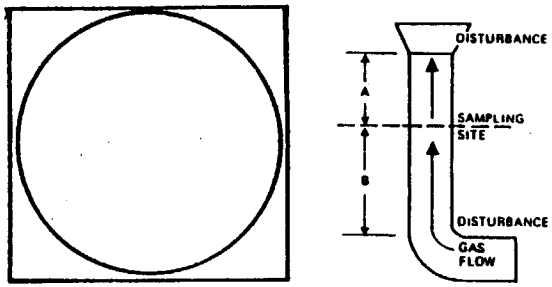
$$V_{lc} = \underline{47} \text{ ml.}$$

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = \underline{8.1\%}$$

SO_2 ~~PARTICULATE~~ FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-9-89
LOCATION Odessa, Texas
OPERATOR Hart
STACK NO. Green Boiler Inlet
RUN NO. 3 Combined Fuels
SAMPLE BOX NO. RAC
METER BOX NO. 2390

AMBIENT TEMPERATURE 41 °F
BAROMETRIC PRESSURE
ASSUMED MOISTURE, %
PROBE LENGTH, in. 96
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
	9:44					2.0		573.365	52	51		43	2	
	49					2.0		77.4	57	51		49	2	
	54					2.0		81.3	62	52		52	2	
	59					2.0		85.2	67	54		53	2	
	10:04					2.0		89.2	73	55		55	2	
	09					2.0		93.1	78	59		55	2	
	10.14							597.198						
TOTAL														
AVERAGE						2.0		23.833	59.3					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	94	145	103		205
INITIAL	100	100	100		200
LIQUID COLLECTED	-6	45	3		
TOTAL VOLUME COLLECTED	42		5		47

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS: Pre O_{CFM} 17" Hg
Post, O_{CFM} 15" Hg

COMPANY: FINA

TEST DATE: 2-9-95

MAY Combined Firing Mode

CO/NO_x MONITOR FIELD DATA SHEET

STACK Turbine + Boiler

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5 min average % of chart	NO_x Chart Reading ppmv	O_2 Chart Reading 5 min average % of chart	O_2 Chart Reading ppmv	Turbine NOx chart %	Turbine NOx chart ppmv	Turbine O_2 chart %	Turbine O_2 chart % CO_2	CO Chart Reading Stack %	CO Chart Reading Stack ppmv	CO Chart Reading Turbine ppmv	T_d	T_w	R_h	COMMENTS
				0	0	0	0					0	0		40	36	68	CPD = 163
				78.8	197	52.1	13.0					29.7	150					E = 0.247
				23.2	60	83.6	20.9					61	8309					e = 0.1680
				47.2	119							95.6	478					HUB = 0.0034
	1	0822	1	31.0		51.8		22.5		66.5								
		25	2	31.5		51.5		22.0		67.0								
		28	3	31.5		51.7		22.0		67.0								
		31	4	31.5		51.7		21.8		67.5								
		34	5	31.8		51.6		21.8		67.5								
		37	6	31.5		51.6		22.4		67								
		40	7	31.6		51.8		22.4		67								
		43	8	31.8		51.8		22.3		67.2		3.0		4.0				
		46		POST		0.0		83.6	20.9									
				47.5		119		52.0	13.0									
	2	0903	1	32.8		51.7		22.8		67.8					42	37		CPD = 163
		06	2	33.5		50.0		22.8		67.8								CO_2 = 4.0% STACK
		09	3	33.5		50.7		23.0		67.3								CO_2 = 3.3% TURBINE
		12	4	31.0		51.8		23.0		67.3								
		15	5	31.0		51.8		21.5		67.2								
		18	6	32		52.0		21.7		67.2								
		21	7	32		52.0		22.2		65.4								
		24	8	31.3		51.8		22.2		65.4		2.0		3.0				
		27	CAL	0 48.0	0 119	83.3 52.2	20.9 13.0											

COMPANY: FIMI

TEST DATE: 2-9-89

MAX COMBINED FIRING RATE

CO/NO_x MONITOR FIELD DATA SHEET

STACK —

Sampling Location	Run No.	Time	Convertor Mode	NO_x Chart Reading 5min average % of chart	NO_x Chart Reading 5min average ppmv	O_2 Chart Reading 5min average % of chart	O_2 Chart Reading 5min average ppmv	TURBINE NO_x % ppm	TURBINE O_2 % O_2	CO Chart Reading STACK %	CO Chart Reading TURBINE %	T_d	T_w	R_h	COMMENTS
	3 1	0944		34		52		29.3	63.0			49	40	42	4% CO2 STACK
	2	47		34		52		29.3	63.0						3.3% CO2 TURBINE
	3	50		34.5		52.1		29.4	63.0						
	4	53		34.5		52.1		29.8	63.0						
	5	56		34.5		52.2		29.8	63.0						
	6	59		34.5		52.1		30.1	62.9						
	7	02		35.0		52.0		30.1	62.9						
	8	05		35.0		52.0		29.0	62.5	2.0	3.0				
		1008			0	83.7	20.9		62.96						
				45	119	+0.2	0.0		62.76						
				80.1	197	52.5	13.0								
				24.0	60										

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE + Boiler

REPETITION NO.: 1 - MAX COMBINED FIRING RATE - REF CMS

TEST DATE: 2-9-89

Dry molecular weight of stack gas

$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$

3.4 0.9

= 29.14 lb/lb-mole

Molecular weight of stack gas, wet basis

$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$ = 27.96 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.742

Average absolute stack gas temperature

(T_s) avg. = 284.5 °F + 460 = 744.5 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.70 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 49.62 ft/sec.

Stack gas volume flow rate

As = 126.01

$60\ V_s\ A_s$ = 375,006 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std}\ .\ P_s}{(T_s)\ avg\ .\ P_{std}}\right]$$

= 14,637,705 dscfh

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GE GAS TURBINE EXHAUST STACK (TURBINE + DUCT BURNER)

REPETITION NO.: 1 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 3.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{, \%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{, \%}}\right)\left(1 - F_{CO_2}\right)$$

$$= \text{ppmv, db}$$

$$\text{CO conc (corrected)} = \left(3.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{24.7\ \%}\right)\left(1 - 0.039\right)$$

$$= 14.56\ \text{ppmv, db}$$

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\cdot\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(14.56\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}637{,}705\ \text{dscfh}\right) = 15.49\ \text{lbs/hr}$$

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: GAS TURBINE + BOILER (STACK LOCATION)
REPETITION NO.: 1 MAX COMBINED FIRING RATE - REF GAS
TEST DATE: 2-9-89

NO_x average chart reading, % = 31.53

O_2 average chart reading, % = 51.69

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (51.69)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.0 \text{ \%}}$

= 12.9 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (31.53 % - 0.1 %) x $\frac{119 \text{ ppm}}{47.5 \text{ \%}}$ = 78.7 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ 19(HOBS -0.00633) $\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (____ -0.00633) $\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 78.7 x (1.194×10^{-7}) x 14,637,705 = 137.5 lb/hr

= 9.397×10^{-6} lbs/dscf

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: GAS TURBINE + BOILER

REPETITION NO.: 1 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 28.684 \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 3.389 \text{ scf}$$

V_{lc} = 72 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = 10.6\%$$

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
TURBINE + Boiler (STACK)
MAX COMBINED FIRING RATE
RUN 1
2-4-89

SAMPLE VOLUME

V_m = 27.040 ft^3

T_m = 522.4 °R

ΔH = 5.5

P_{bar} = 30.73 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 28.684\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.5 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.25 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m\ (std)}} = 0.036 \times 10^{-5}\ lb/dscf$$

= 2.18 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 5.27 lb/hr

Q_s = 14,637,705 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m(std)}} = 0.028 \times 10^{-5}\ lb/dscf$$

= 1.36 ppm By Volume Dry Basis

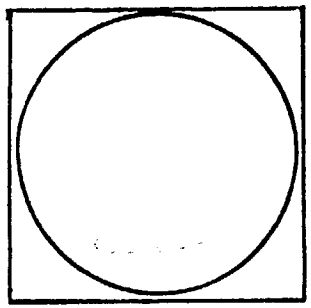
SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 4.10 lbs/hr

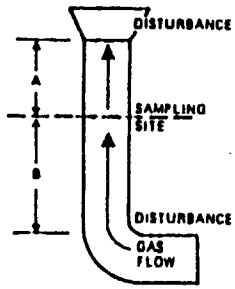
Q_s = 14,637,705 DSCFH

SU2 PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT Fina

DATE 2-9-89

LOCATION Groves TX

OPERATOR BP

STACK NO. Cover

RUN NO. MAX COMBINED FIRING RUN 1

SAMPLE BOX NO. NAE

METER BOX NO. 597

AMBIENT TEMPERATURE 42°F

BAROMETRIC PRESSURE 30.73

ASSUMED MOISTURE, %

PROBE LENGTH, in.

NOZZLE DIAMETER, in.

STACK DIAMETER, in.

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
822		-0.44	283	.50		5.5		929.760	56	56		56		
27	5		285	.56		5.5		34.3	63	62		60		
32	5		287	.56		5.5		38.8	64	62		60		
37	5		282	.46		5.5		43.3	64	63		60		
42	5		283	.54		5.5		47.8	65	64		61		
47	5		284	.58		5.5		52.3	65	65		62		
352	5		286	.55				956.800						
			285	.54										
			283	.58										
			285	.58										
			288	.62										
			284	.56										
			282	.52										
			284	.54										
			287	.60										
TOTAL			284	.54										
AVERAGE			284.5		0.742	5.5		27.04	62.4					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	92	173	103		204
INITIAL	100	100	100		200
LIQUID COLLECTED	-8	73	3		
TOTAL VOLUME COLLECTED	68		4		72

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leak check: pre: 0.00 at 15 "Hg
post: 0.00 at 15 "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: Boiler + Turbine

REPETITION NO.: 2 - Max Combined Firing Rate

TEST DATE: 2-9-89

Dry molecular weight of stack gas

$$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

4.0 12.8

= 29.15 lb/lb-mole

Molecular weight of stack gas, wet basis

$$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$$

= 27.96 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.760

Average absolute stack gas temperature

(T_s) avg. = 279.2 °F + 460 = 739.2 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.70 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 50.65 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 382,944 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\ avg \cdot P_{std}}\right]$$

= 15,037,884 dscfh

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GE GAS TURBINE Exhaust STACK (TURBINE + DUCT BURNER)

REPETITION NO.: 2 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 2.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(2.0\ \% - 0.0\ \%\right)\left(\frac{150}{29.7}\ \frac{\text{ppm CO}}{\%}\right)\left(1 - 0.040\right)$$

= 9.70 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(9.70\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(15{,}037{,}884\ \text{dscfh}\right) = 10.60\ \text{lbs/hr}$$

① Average of pre and post test drift tests

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: Boiler + Turbine
REPETITION NO.: 2 - MAX COMBINED FIRING RATE
TEST DATE: 2-9-89

NO_x average chart reading, % = 32.13

O_2 average chart reading, % = 51.48

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (51.48)% - 0.0 %) x $\frac{13 \text{ \% } O_2}{52.2 \text{ \%}}$

= 12.8 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (32.13 % - 0.0 %) x $\frac{119 \text{ ppm}}{48.0 \text{ \%}}$ = 79.7 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $19(HOBS - 0.00633)\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (_____ -0.00633) $\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 79.7 x (1.194×10^{-7}) x 15,037,884 = 143.1 lb/hr

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
Boiler + TURBINE
MAX COMBINED FIRING RATE
RUN 2
2-9-89

SAMPLE VOLUME

V_m = 27.519 ft^3

T_m = 526.5 °R

ΔH = 5.5

P_{bar} = 30.73 in. Hg

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y\ V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 28.964\ ft^3 \quad \text{Equation 6-1}$$

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.20 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.50 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m\ (std)}} = 0.030 \times 10^{-5}\ lb/dscf$$

= 1.78 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 4.51 lb/hr

Q_s = 15,037,884 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N\ (V_t - V_{tb})\ (V_{soln}/V_a)}{V_{m(std)}} = 0.036 \times 10^{-5}\ lb/dscf$$

= 1.73 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 5.41 lbs/hr

Q_s = 15,037,884 DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: Boiler + Turbine

REPETITION NO.: 2 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = 28.964 \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = 3.483 \text{ scf}$$

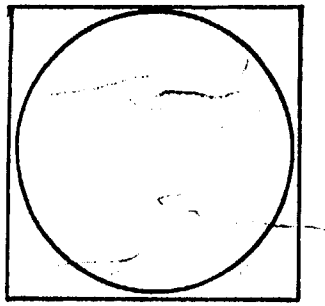
V_{lc} = 74 ml.

Fractional moisture content of stack gas

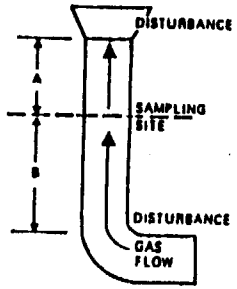
$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = 10.7\%$$

SO2 PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION



PLANT Fina

DATE 2-9-89

LOCATION Groves, TX

OPERATOR BP

STACK NO. Logen

RUN NO. NAX COMBINED FIRING RUN 2

SAMPLE BOX NO. [illegible]

METER BOX NO. 597

AMBIENT TEMPERATURE 45 °F

BAROMETRIC PRESSURE

ASSUMED MOISTURE, %

PROBE LENGTH, in.

NOZZLE DIAMETER, in.

STACK DIAMETER, in.

PROBE HEATER SETTING

HEATER BOX SETTING

METER $\Delta H_@$

C FACTOR

PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
	TOTAL	

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
903		-0.48	282	.54		5.5		957.081	64	64		64		
08	5		[illegible]	.56		5.5		61.5	[illegible]	6		65		
13	5		[illegible]	.58		5.5		66.0	67	66		66		
18	5		277	.52		5.5		70.5	68	66		66		
23	5		282	.52		[illegible]		75.0	68	67		66		
28	5		[illegible]	.58		[illegible]		79.5	69	67		67		
933	[illegible]		[illegible]	.61				984.606						
			[illegible]	.58										
			[illegible]	.56										
			280	.57										
			277	.60										
			276	.62										
			283	.54										
			[illegible]	.59										
			279	.60										
TOTAL			276	.62										
AVERAGE			279.2		0.760	5.5		27.519	66.5					

VOLUME OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	96	170	103		205
INITIAL	100	[illegible]	[illegible]		200
LIQUID COLLECTED	-4	70	3		5
TOTAL VOLUME COLLECTED	69		5		74

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leak check: pre: 0.00 AT 15 "Hg
post: 0.00 AT 15 "Hg

STACK VOLUME FLOW RATE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: TURBINE + Boiler (STACK LOCATION)

REPETITION NO.: 3 - MAX COMBINED FIRING RATE REF GAS

TEST DATE: 2-9-89

Dry molecular weight of stack gas

$$M_d = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2 + \%CO)$$

4.0 12.9 83.1

= 29.16 lb/lb-mole

Molecular weight of stack gas, wet basis

$$Ms = Md\ (1-B_{ws}) + 18\ B_{ws}$$

= 22.98 lb/lb-mole

Pitot tube coefficient

C_p (from calibration curve) = 0.840

Average velocity head of stack gas, inches H_2O

$(\sqrt{\Delta p})$ avg. = 0.746

Average absolute stack gas temperature

(T_s) avg. = 279.1 °F + 460 = 739.1 °R

Absolute stack gas pressure

$P_s = P_b$ + (Static Pressure/13.6) = 30.70 in. H_g

Stack gas velocity

$$(V_s)\ avg. = (85.49)\ C_p\ (\sqrt{\Delta p})\ avg. \sqrt{\frac{(T_s)\ avg.}{P_s\ M_s}}$$

= 49.69 ft/sec.

Stack gas volume flow rate

$60\ V_s\ A_s$ = 375,686 acfm

Stack gas volume flow rate, dry basis

$$Q_s = 3{,}600\ (1-B_{ws})\ V_s\ A_s \left[\frac{T_{std} \cdot P_s}{(T_s)\ avg \cdot P_{std}}\right]$$

= 14,787,910 dscfh

NO_x CALIBRATION CORRECTION DATA SHEET
METHOD 20

COMPANY: FINA
SOURCE: TURBINE + BOILER (STACK LOCATION)
REPETITION NO.: 3-MAX COMBINED FIRING RATE REF GAS
TEST DATE: 2-9-89

NO_x average chart reading, % = 34.5

O_2 average chart reading, % = 52.1

O_2 concentration corrected for zero and calibration drift:

O_2 conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, \% } O_2}{\text{cal drift reading, \%}}$ = % O_2 by vol, db

O_2 conc (corrected) = % O_2 by vol, db

= (52.1)% - 0.0 %) x $\frac{13.0 \text{ \% } O_2}{52.5 \text{ \%}}$

= 12.9 % O_2 by vol, db

NO_x conc (corr.) = (Av. chart reading, % - Av. zero drift reading, %) x $\frac{\text{cal gas conc, ppm}}{\text{cal drift reading, \%}}$ = ppm by vol, db

NO_x $conc_1$ (corr.) = (34.5 % - 0.0 %) x $\frac{119 \text{ ppm}}{47.5 \text{ \%}}$ = 86.4 ppm by vol, db

NO_x $conc_2$ (corr. to 15% O_2) = _____ x $\frac{5.9}{20.9}$ = _____ ppm by vol, db

NO_x conc (corr. to 15% O_2, iso std day conditions) = NO_x $conc_1$ (corr. to 15% O_2) $\left(\frac{Pref}{Pobs}\right)^{0.5}$ $19(HOBS - 0.00633)\left(\frac{T_{amb}}{288°K}\right)^{-1.53}$

= _____ $\left(\frac{\quad}{\quad}\right)^{0.5}$ 19 (____ -0.00633) $\left(\frac{\quad}{288}\right)^{-1.53}$ = _____ ppm by vol, db

NO_x (as NO_2) emission rate (lb/hr) = (NO_x $conc_1$, ppm by vol, db) $\left(\frac{46}{385.26} \times 10^{-6}\right)$ (stack vol flow rate, dscfh) = lb/hr

= 86.4 x (1.194×10^{-7}) x 14,787,910 = 152.6 lb/hr

CO CALIBRATION CORRECTION DATA SHEET

COMPANY: FINA

SOURCE: GAS TURBINE Exhaust STACK (TURBINE + DUCT BURNER)

REPETITION NO.: 3 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

CO average chart reading, % = 2.0

CO concentration corrected for zero and calibration drift:

$$\text{CO conc (corrected)} = \left(\text{Av. chart reading, \%} - \text{Av. zero drift reading}^{①}\text{,\%}\right)\left(\frac{\text{cal gas conc, ppm CO}}{\text{cal drift reading}^{①}\text{,\%}}\right)\left(1 - F_{CO_2}\right)$$

= ppmv, db

$$\text{CO conc (corrected)} = \left(2.0\ \% - 0.0\ \%\right)\left(\frac{150\ \text{ppm CO}}{29.7\ \%}\right)\left(1 - 0.040\right)$$

= 9.70 ppmv, db

CO emission rate

$$\text{CO emission rate, lbs/hr} = \left(\text{CO conc, (corrected) ppmv, db}\right)\left(\frac{28}{385.26} \times 10^{-6}\right)\left(\text{vol flow rate, dscfh}\right)$$

$$\text{CO emission rate, lbs/hr} = \left(9.70\ \text{ppmv, db}\right)\left(7.268 \times 10^{-8}\right)\left(14{,}787{,}910\ \text{dscfh}\right) = 10.43\ \text{lbs/hr}$$

① Average of pre and post test drift tests

SULFUR DIOXIDE CALCULATION FORM
(English Units)

FINA
TURBINE + BOILER
MAX COMBINED FIRING RATE
RUN 3
2-9-89

SAMPLE VOLUME

V_m = 27.066 ft^3

T_m = 529.1 °R

P_{bar} = 30.73 in. Hg

ΔH = 5.5

Y = 1.009

$$V_{m(std)} = 17.64 \frac{°R}{in.\ Hg} \times \frac{Y V_m \left[P_{bar} + \frac{\Delta H}{13.6}\right]}{T_m} = 28.348\ ft^3$$ Equation 6-1

SO_2 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 0.525 ml

V_{tb} = 0.35 ml

V_{soln} = 250 ml

V_a = 20 ml

SO_3 ANALYSIS DATA

N = 0.01023 (g-eq) /ml

V_t = 1.325 ml

V_{tb} = 0.35 ml

V_{soln} = 200 ml

V_a = 20 ml

SO_2 CONCENTRATION IN STACK GAS

$$C_{SO_2} = 7.061 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m\ (std)}} = 0.006 \times 10^{-5}\ lb/dscf$$

= 0.34 ppm by Volume Dry Basis

SO_2 EMISSION RATE

$C_{SO_2} \times Q_s$ = 0.89 lb/hr

Q_s = 14,787,910 DSCFH

SO_3 CONCENTRATION IN STACK GAS

$$C_{SO_3} = 8.826 \times 10^{-5} \frac{N (V_t - V_{tb}) (V_{soln}/V_a)}{V_{m(std)}} = 0.031 \times 10^{-5}\ lb/dscf$$

= 1.50 ppm By Volume Dry Basis

SO_3 EMISSION RATE

$C_{SO_3} \times Q_s$ = 4.58 lbs/hr

Q_s = 14,787,910 DSCFH

MOISTURE CALCULATION SUMMARY

COMPANY: FINA

SOURCE: Turbine + Boiler

REPETITION NO.: 3 - MAX COMBINED FIRING RATE

TEST DATE: 2-9-89

ENGLISH UNITS
(29.92 in. Hg 68°F)

Volume of sample at standard conditions on dry basis

$$V_{mstd} = \left[17.64\right] V_m \gamma \left[\frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}\right] = \underline{28.348} \text{ dscf}$$

γ = 1.009

Volume of water vapor in sample at standard conditions

$$V_{wstd} = \left[0.04707 \frac{\text{cu. ft.}}{\text{ml}}\right] V_{lc} = \underline{3.342} \text{ scf}$$

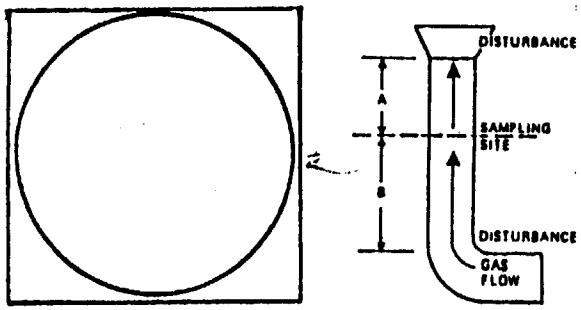
V_{lc} = 71 ml.

Fractional moisture content of stack gas

$$B_{ws} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}} \times 100 = \underline{10.5\%}$$

PARTICULATE FIELD DATA

SCHEMATIC OF STACK



CROSS SECTION

PLANT Fina
DATE 2-9-89
LOCATION Groves TX
OPERATOR EP
STACK NO. Crash stack
RUN NO. Max run 3 Combined Flame MP
SAMPLE BOX NO. RAC
METER BOX NO. 597

AMBIENT TEMPERATURE 48°F
BAROMETRIC PRESSURE 30.73
ASSUMED MOISTURE, %
PROBE LENGTH, in.
NOZZLE DIAMETER, in.
STACK DIAMETER, in.
PROBE HEATER SETTING
HEATER BOX SETTING

METER $\Delta H_@$
C FACTOR
PROCESS WEIGHT RATE

WEIGHT OF PARTICULATE COLLECTED, mg		
SAMPLE	FILTER	PROBE WASH
FINAL WEIGHT		
TARE WEIGHT		
WEIGHT GAIN		
TOTAL		

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in. H_2O)	STACK TEMPERATURE (T_s), °F	Static -.42 VELOCITY HEAD (ΔP_s)	($\sqrt{\Delta P_s}$)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H_2O ACTUAL	DESIRED	GAS SAMPLE VOLUME (V_m), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET ($T_{m_{IN}}$), °F	OUTLET ($T_{m_{OUT}}$), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER °F	PUMP VACUUM in. Hg gauge	VELOCITY fps
944		-0.42	276	.54		5.5		984.834	68	69		68		
49	5		277	.56		5.5		89.4	69	68		68		
54	5		280	.56		5.5		93.9	69	68		69		
59	5		283	.54		5.5		98.4	70	68		69		
1004	5		277	.53		5.5		002.9	70	69		69		
09	5		278	.54		5.5		07.4	71	71		69		
1014	5		280	.56				011.900						
			282	.52										
			276	.54										
			278	.56										
			279	.60										
			282	.62										
			277	.50										
			279	.56										
			280	.58										
TOTAL			282	.56										
AVERAGE			279.1		0.746	5.5		27.066	69.1					

~~VOLUME~~ WEIGHT OF LIQUID WATER COLLECTED	IMPINGER VOLUME ml 1	2	3	4	SILICA GEL WEIGHT, g
FINAL	94	170	102		205
INITIAL	100	100	100		200
LIQUID COLLECTED	-6	70	2		
TOTAL VOLUME COLLECTED	66		5		71

ORSAT MEASUREMENT	TIME	CO_2	O_2	CO	N_2
1					
2					
3					
4					

COMMENTS:
Leakcheck: pre: 0.00 at 15" Hg
post: 0.00 at 15" Hg

2989

CALCULATION SUMMARY SHEET

MAXIMUM COMBINED FIRING RATE TESTS

$$F = \frac{10^6(29.7)(3.64) + 70.2(1.53) + 0.1(0.14)}{GCV} = dscF/MMBTU$$

$$GCV = 942.3\ \frac{BTU}{SCF} \times \frac{1}{0.0255\ lb/SCF} = 36{,}900\ BTU/LB$$

$F = 8439\ dscF/MMBTU$

$E = C_d F_d\ (20.9/(20.9 - \%O_{2d}))$

	O_2 conc % db	NOx conc lb/dscF×10⁶	NOx Emissions lbs/MMBTU	NOx Emissions lbs/hr	CO Emissions lbs/MMBTU	CO Emissions lbs/hr	SO_2 Emissions lbs/MMBTU	SO_2 Emissions lbs/hr	Heat input MMBTU/hr
COMBINED									
RUN 1	8.0	9.397	0.207	137.5	0.023	15.5	0.008	5.3	695.8
RUN 2	8.1	9.516	0.207	143.1	0.015	10.6	0.007	4.5	695.5
RUN 3	8.0	10.031	0.227	152.6	0.016	10.4	0.001	0.9	699.0

(Note: Combined stack Emission rate in lbs/MMBTU based on F factor and lbs/hr based on measured vol flow rate.

COMBINED									
RUN 1	16.8	6.596	0.282	140.7	0.063	31.2	0.018	9.0	499.1
RUN 2	16.6	6.630	0.276	137.7	0.044	22.1	0.005	2.7	498.8
RUN 3	15.6	8.854	0.294	147.7	0.035	17.8	0.004	2.0	502.3

Duct Burner $E_b = E_{co} + \left(\frac{H_g}{H_b}\right)(E_{co} - E_g)$

	Heat input MMBTU/hr H_g	Heat input MMBTU/hr H_b	NOx Emission rate lbs/MMBTU	NOx Emission rate lbs/hr	CO Emission rate lbs/MMBTU	CO Emission rate lbs/hr	SO_2 Emission rate lbs/MMBTU	SO_2 Emission rate lbs/hr
RUN 1	499.1	196.7	0.017	3.3	0.0	0.0	0.0	0.0
RUN 2	498.8	196.7	0.032	6.3	0.0	0.0	0.012	2.4
RUN 3	502.3	196.7	0.057	11.2	0.0	0.0	0.0	0.0

COMPANY: FINA

TEST DATE: 2-1-89

PRELIM O2 TRAVERSE

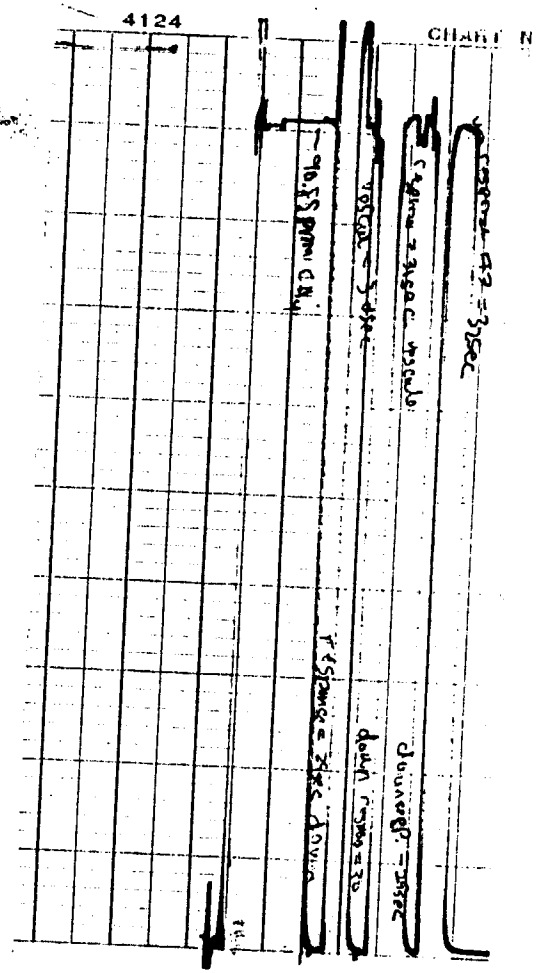
CO/NO_x MONITOR FIELD DATA SHEET

Sampling Location	Run No.	Time	Convertor Mode	O2 Chart Reading 5 min average % of chart	O2 Chart Reading 5 min average % of chart				CO Chart Reading % ppmv	T_d T_w R_h	COMMENTS
Prelim O2 TRAVERSE	1-A			65							
	2			65							
	3			64.9							
	4			64.8							
	5			64.8							
	6			64.8							
	7			64.8							
	8			64.8							
	9			64.7							
	10			64.7							
	11			64.7							
	12			64.9							
	1 B			64.9							
	2			64.9							NOx 734 ppm
	3			64.9							O2 = 16.25
	4			64.7						36 85 91	NOx at 15% = 434 ppm
	5			64.8							CPD = 153
	6			64.9							
	7			64.8						E = 0.212	
	8			64.9						e = 0.193	
	9			64.9							
	10			64.9							
	11			64.9							
	12			64.8							
	1 C			64.8							
	2 C			64.9							
	3			64.9							
	4			64.9							
	5			64.9							
	6			64.9							
	7			64.9							
	8			64.8							
	9			64.8							
	10			64.8							
	11			64.8							
	12			64.8							
	1 D			64.8							
	2			64.8							
	3			64.8							
	4			64.8							
	5			64.8							
	6			64.8							
	7			64.9							
	8			64.8							
	9			64.8							
	10			64.8							
	11			64.9							
	12										

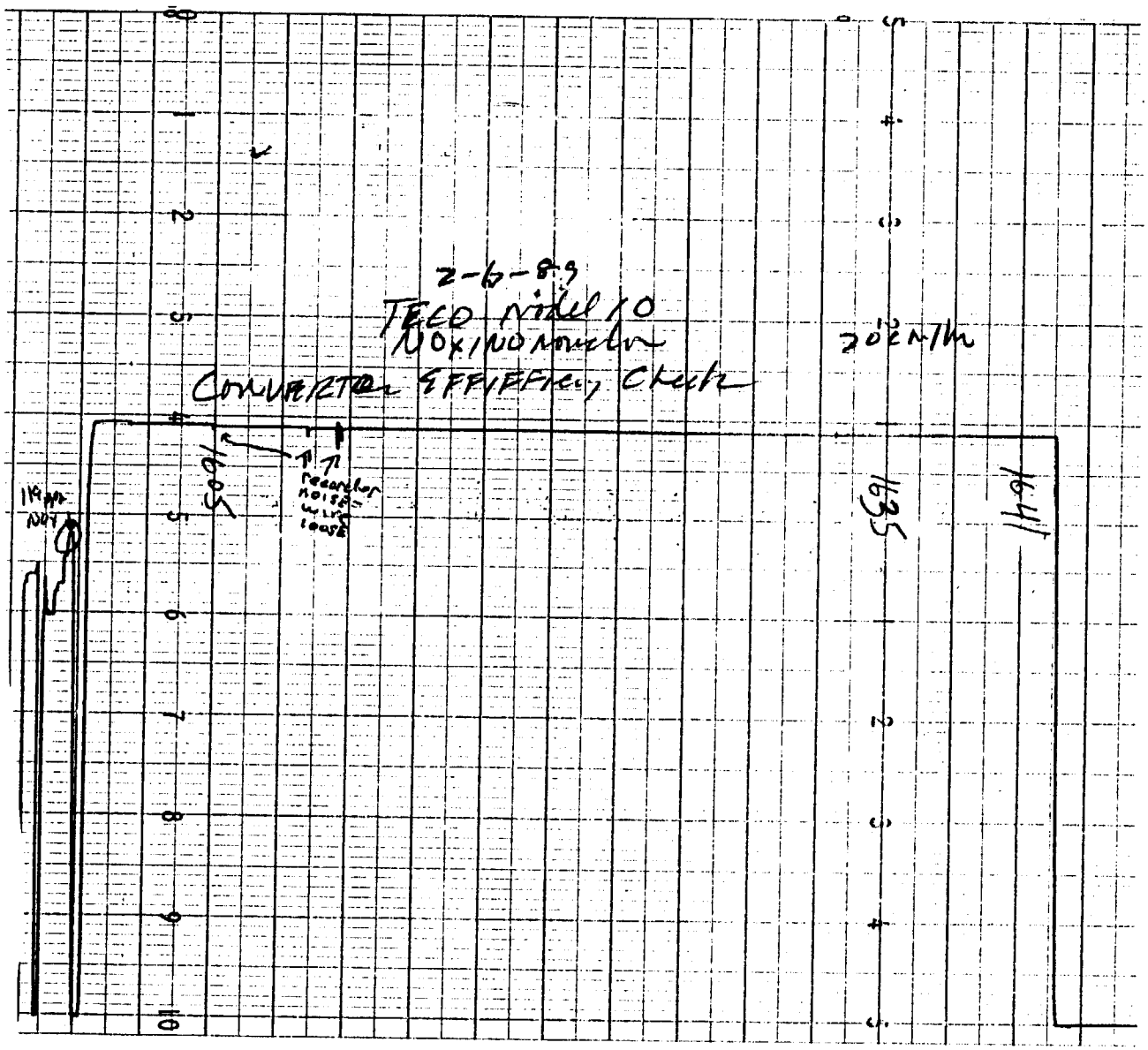
GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS

APPENDIX B

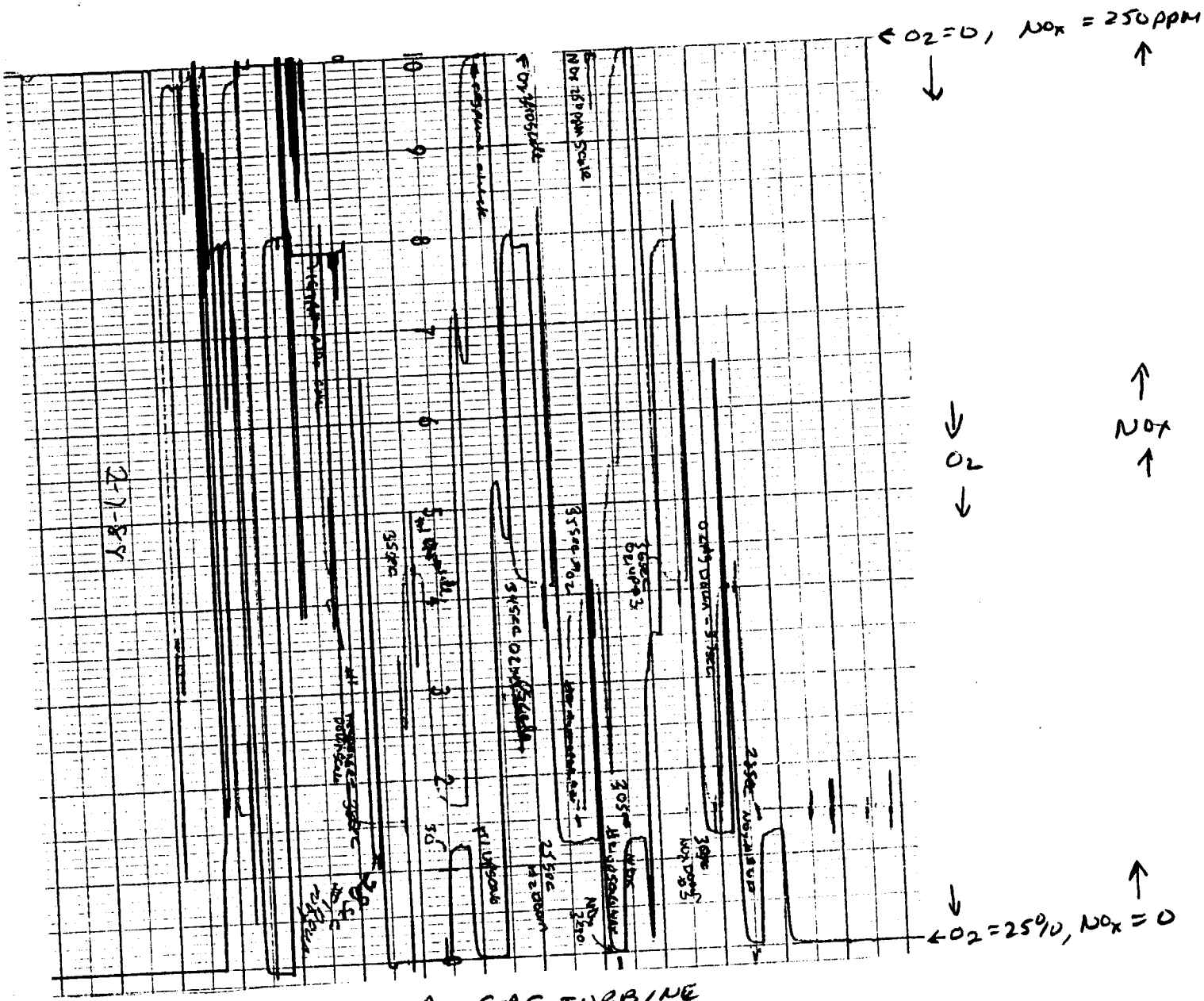
Monitor Strip Chart Data and GE Graph of P_{ref} vs. Turbine Load



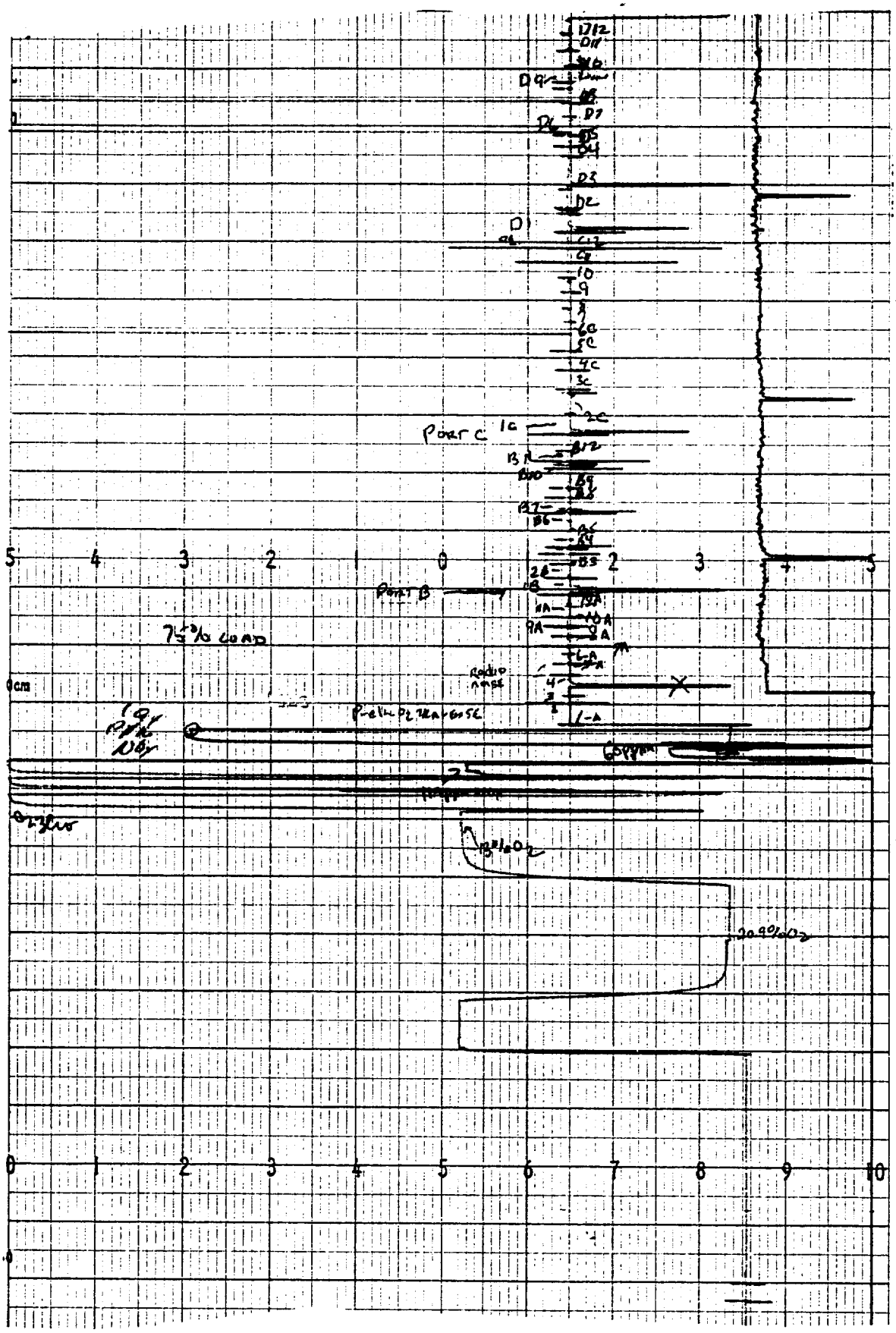
FINA GE GAS TURBINE
RESPONSE TIME TEST
RATFISCH Total Hydrocarbon Analyzer



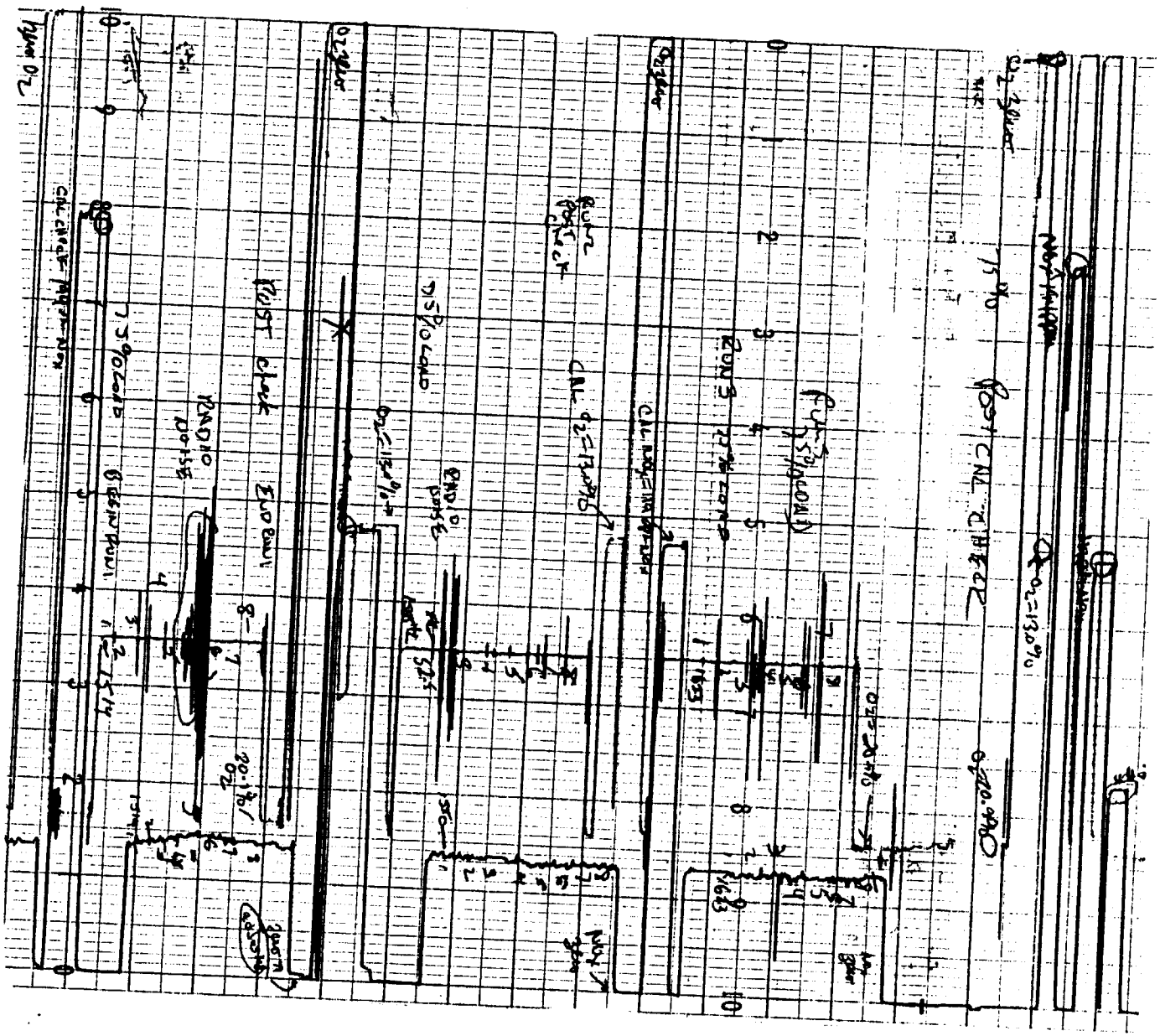
FINA OIL AND CHEMICAL CO.
GE GAS TURBINE
TECO model 10 NOx/NO monitor
CONVERTOR EFFICIENCY CHECK



FINA GAS TURBINE
TECO Model 10 NOx/NO Monitor
Teledyne O2 Monitor
RESPONSE TIME TESTS
2-7-89



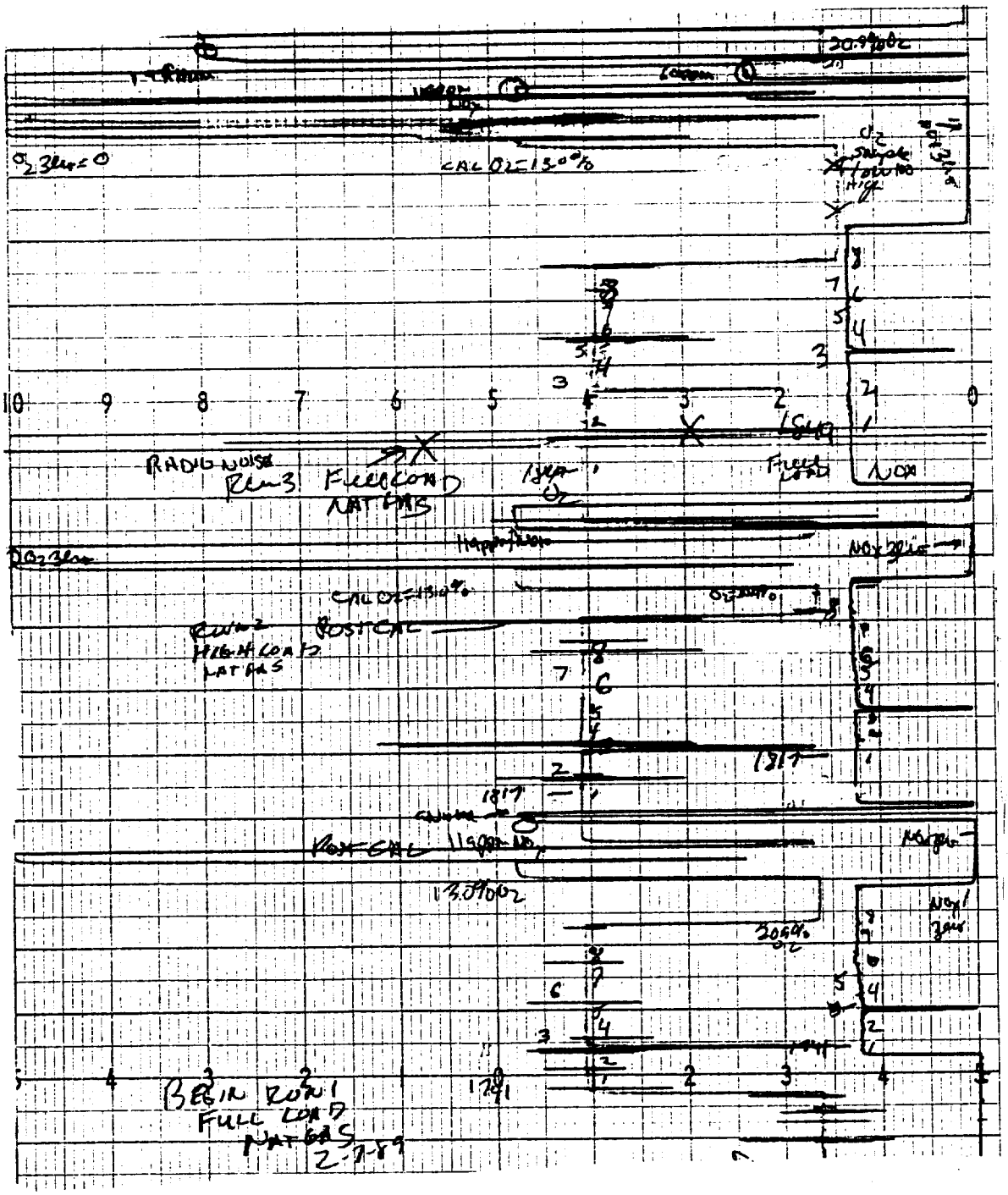
FINA GE GAS TURBINE
Pre-TEST CALIBRATION FOR 75% LOAD NATURAL GAS TEST
AND Preliminary O_2 TENURESE.
2-7-89



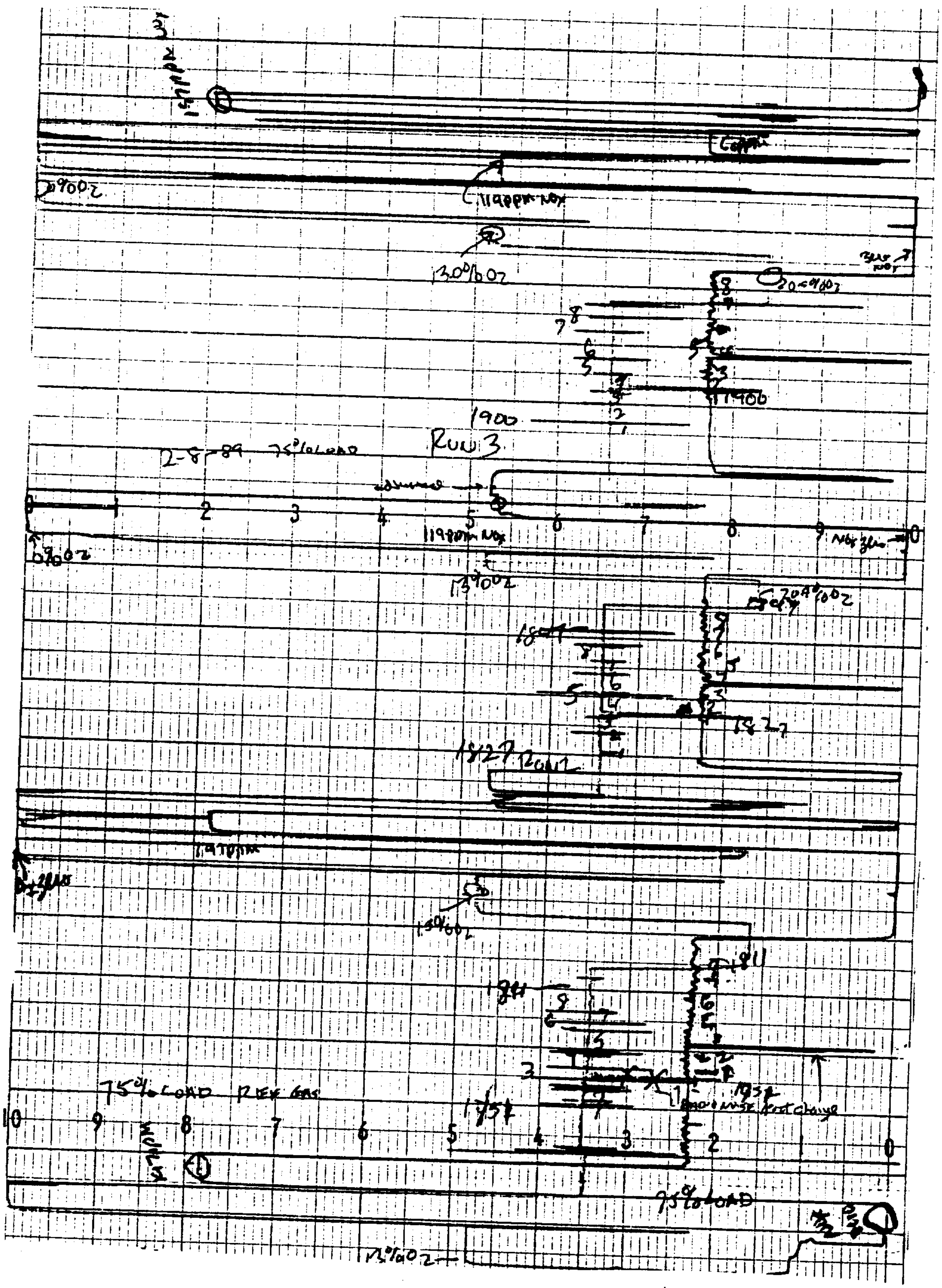
O_2 zero, NO_x = 250 PPM

O_2 = 25%, NO_x = 0

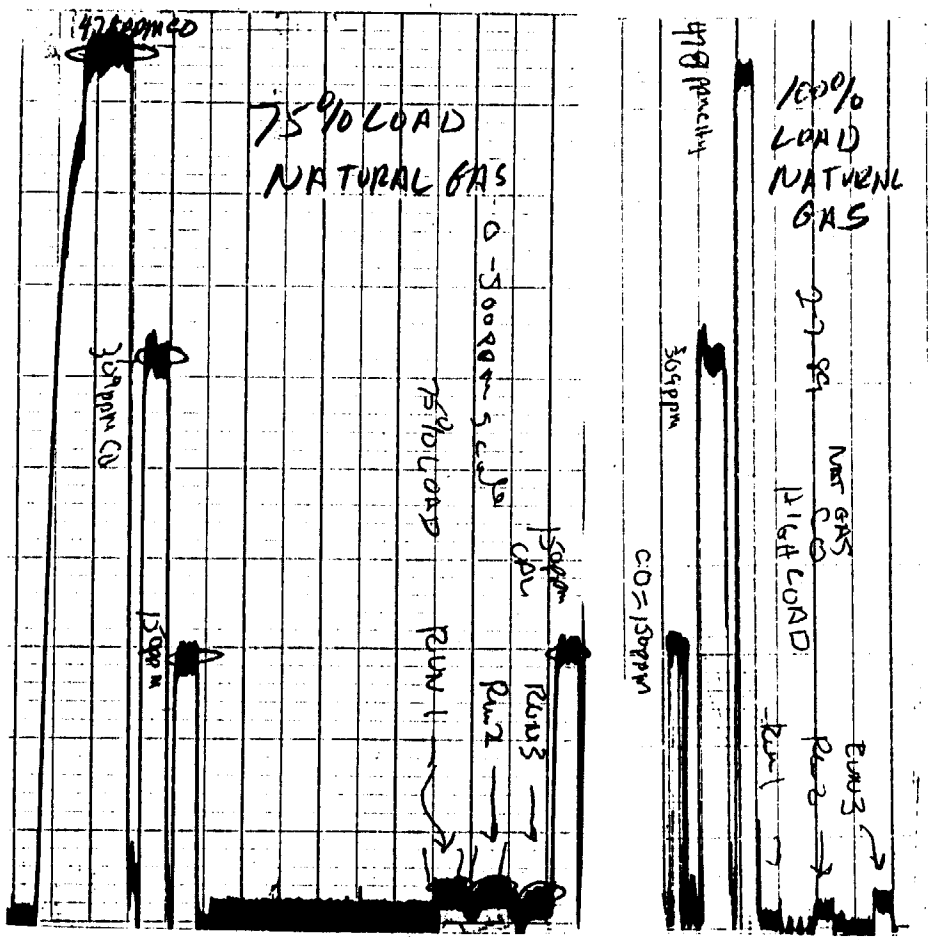
FINA GE GASTURBINE
75% LOAD NATURALGAS RUNS 1-3
AND POST-TEST CALIBRATION
NO_x AND O_2
2-7-89



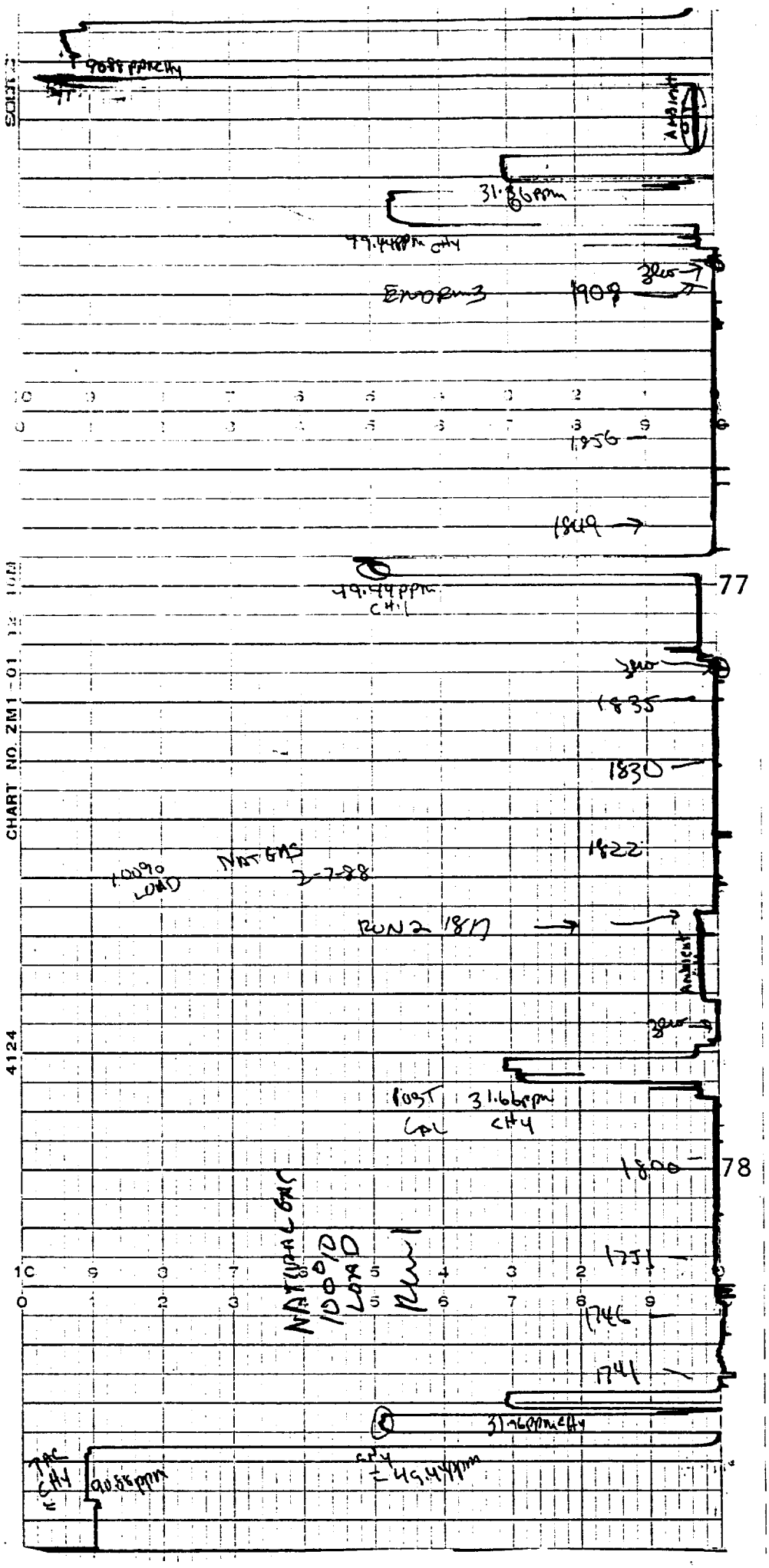
FINAL GE GAS TURBINE
100% LOAD NATURAL GAS RUNS 1-3
AND POST-TEST Calibrations
NOX AND O2
2-7-89



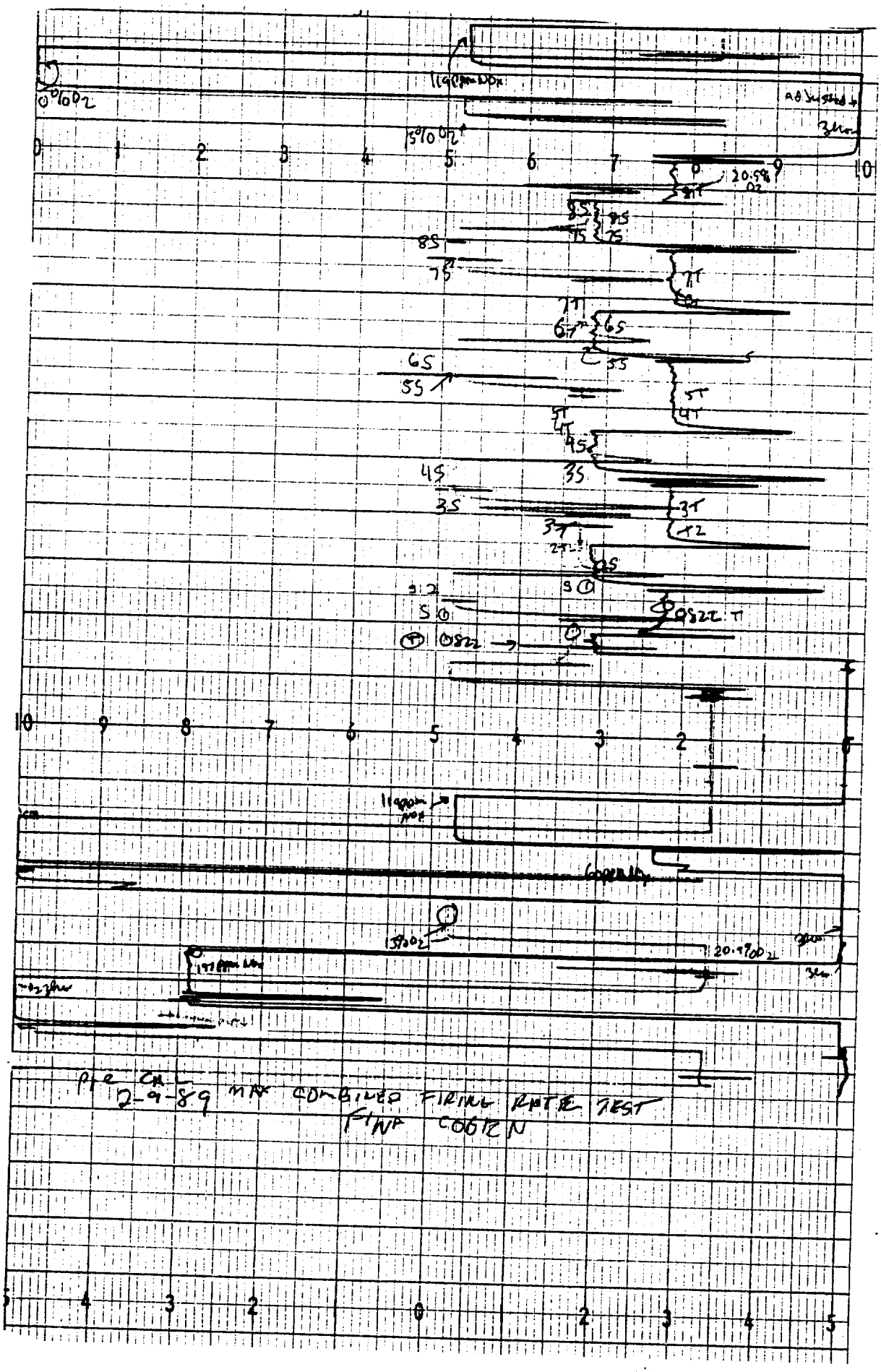
FINA 6E GAS TURBINE
75% REFINERY GAS
RUNS 1-3
2-8-89

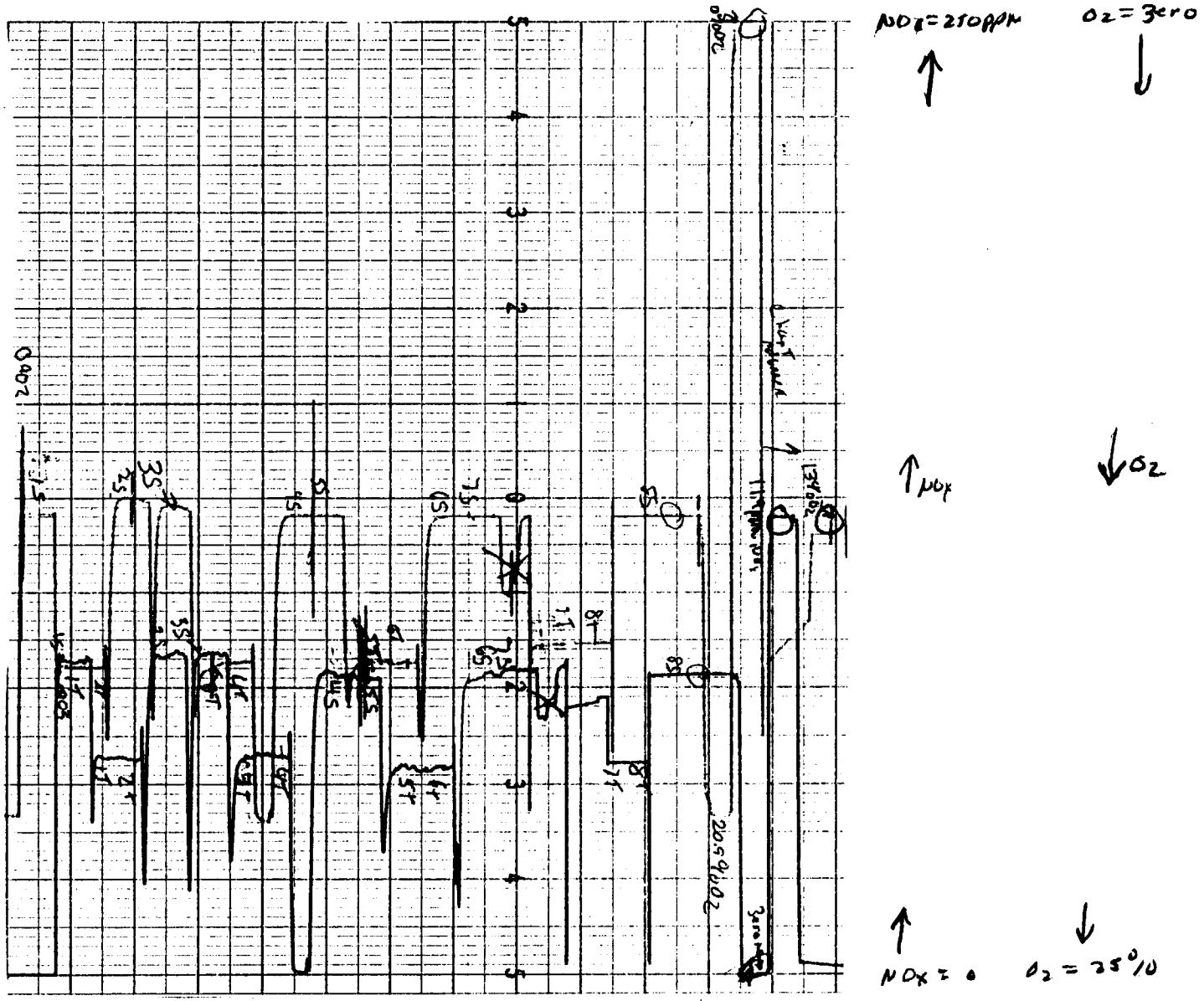


FINA GE GAS TURBINE
75% LOAD NATURAL GAS
100% LOAD NATURAL GAS
Carbon Monoxide RUNS 1-3
AND CALIBRATION DATA

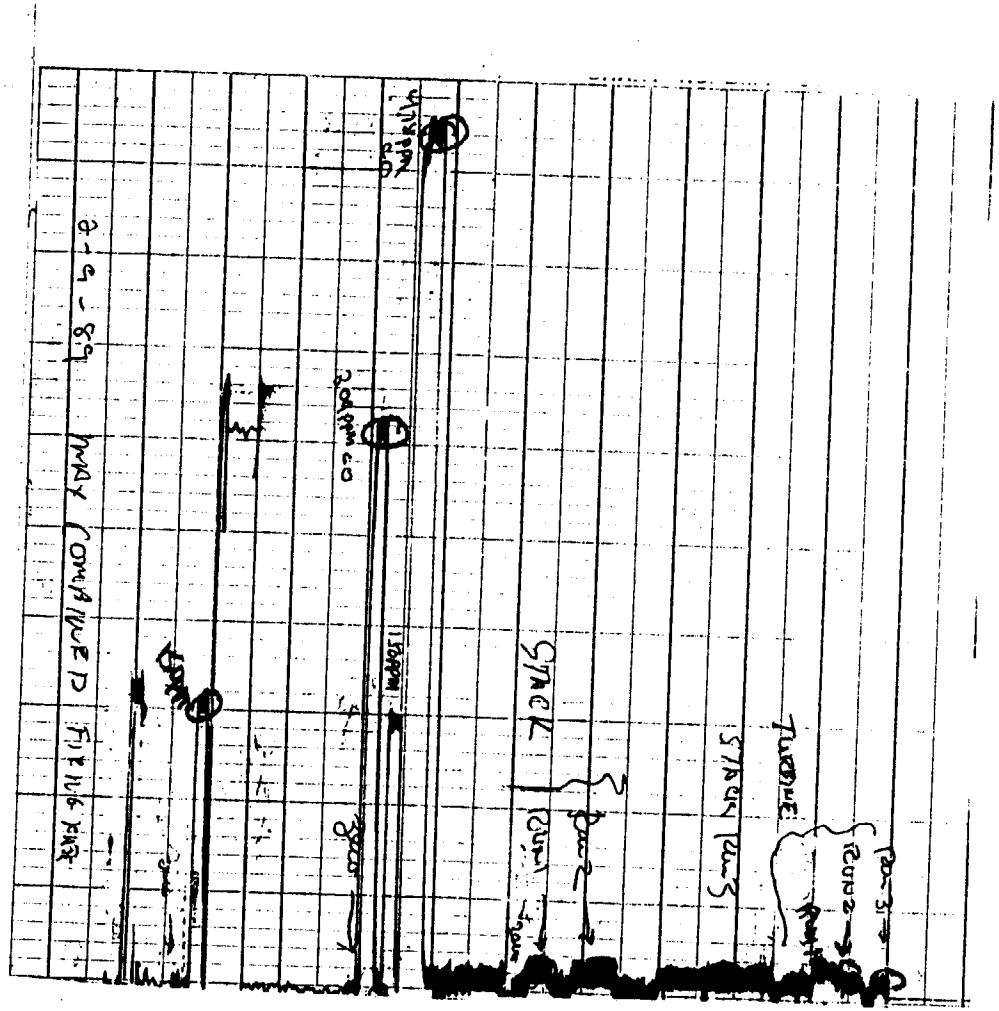


FINA GE GAS TURBINE
100% LOAD NATURAL GAS
THC RUNS 1-3

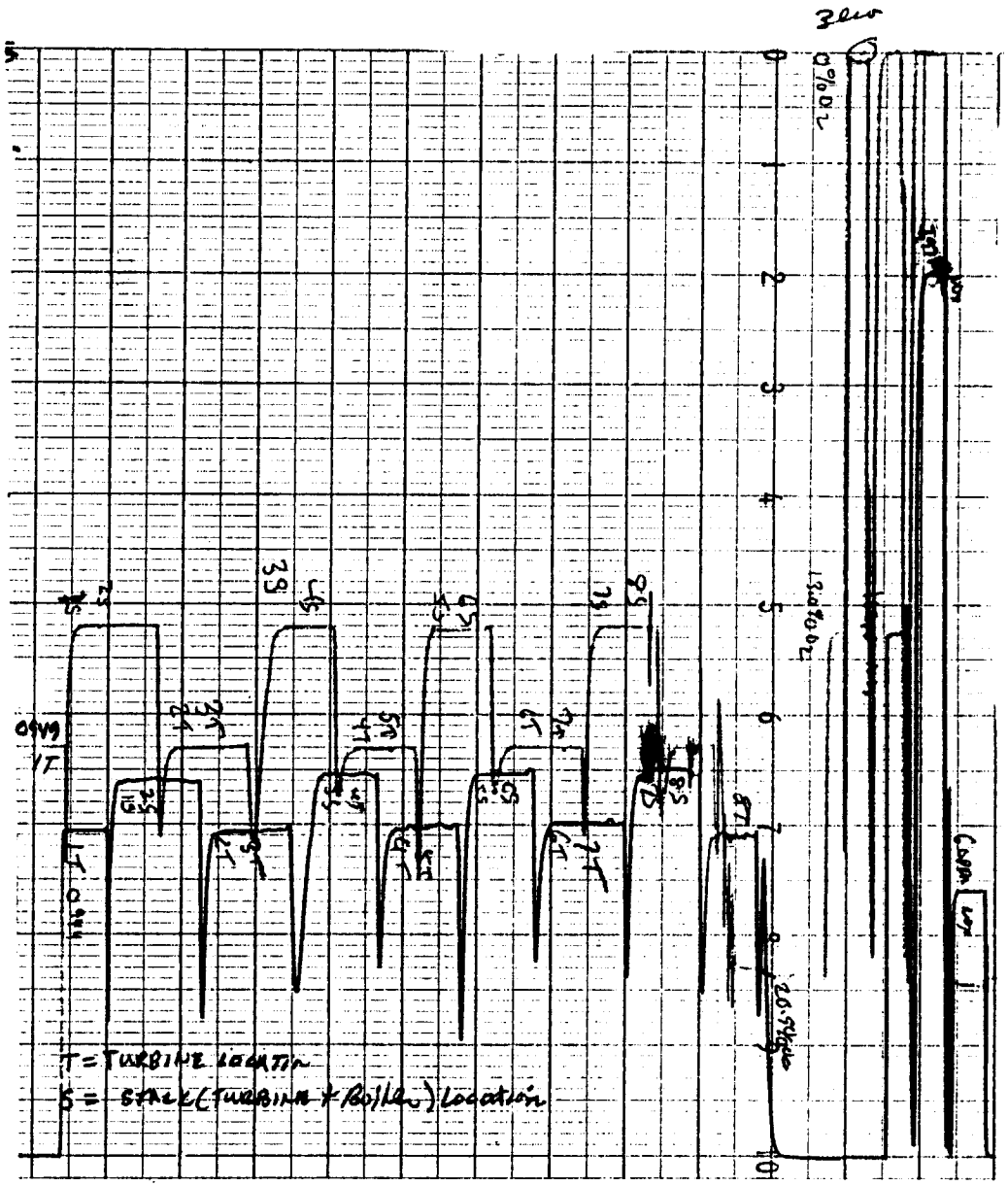

FINA GE GAS TURBINE
PRE-CAL AND MAX COMBINED FIRING RATE TESTS
S = STACK (BOILER + TURBINE) T = TURBINE LOCATION
NOx AND O2
RUN #1
2-9-89
Pre Cal
2-9-89 MAX COMBINED FIRING RATE TEST
FINA COGEN



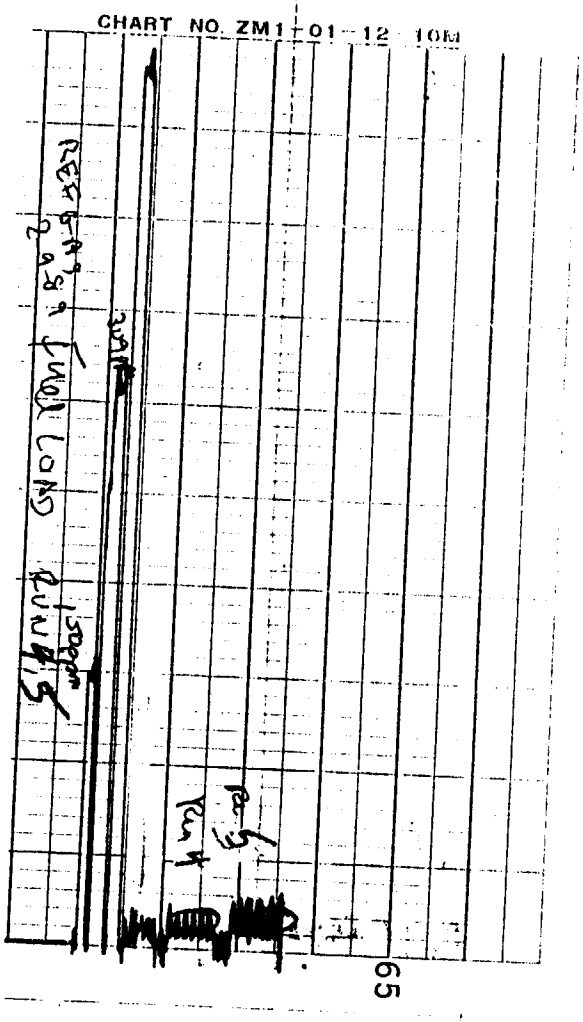
FINA GE GAS TURBINE
MAX COMBINED FIRING RATE
RUN 2
NOx AND O2 2-9-89



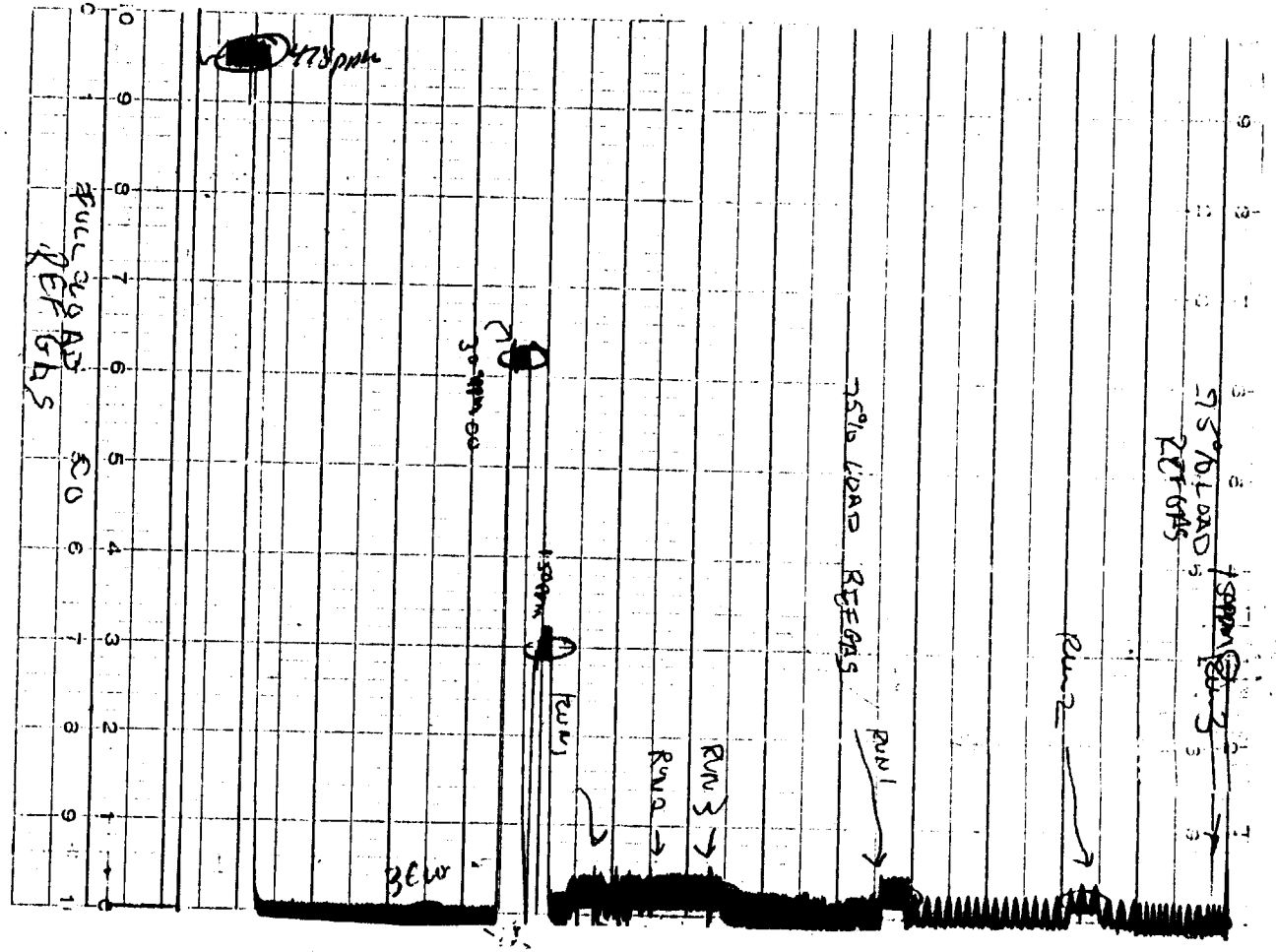
FINA GE GAS TURBINE
MAX COMBINED FIRING RATE
RUNS 1-3 STACK (TURBINE + Boiler)
RUNS 1-3 Turbine



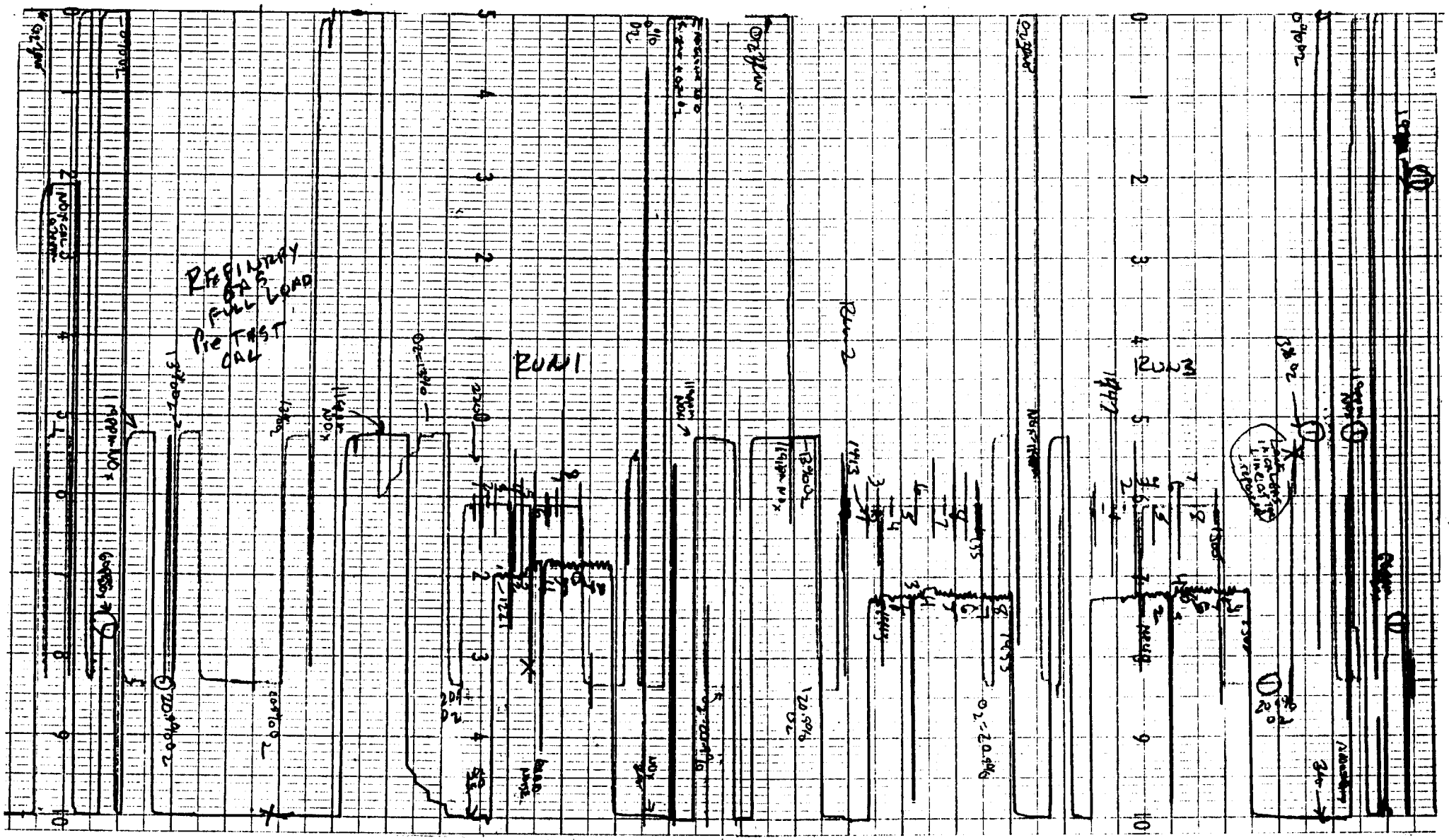
FINA GE GAS TURBINE
MAX COMBINED FIRING RATE
RUN 3 + POST TEST CALIBRATION
NOx + O2 2-9-89



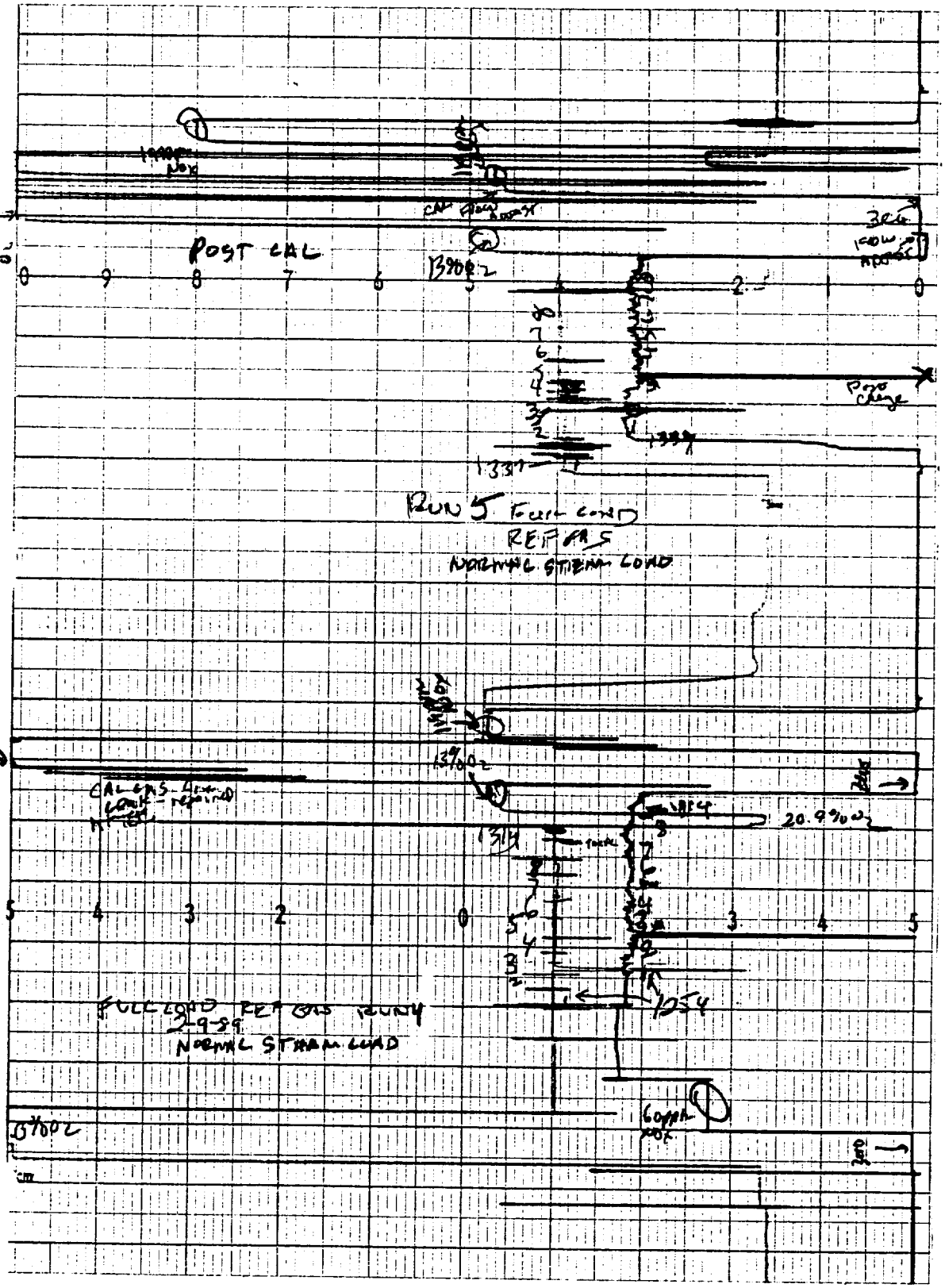
FINA GE GAS TURBINE
100% LOAD REFINERY GAS
RUNS 4 AND 5
NORMAL STEAM INJECTION RATE
2-9-69



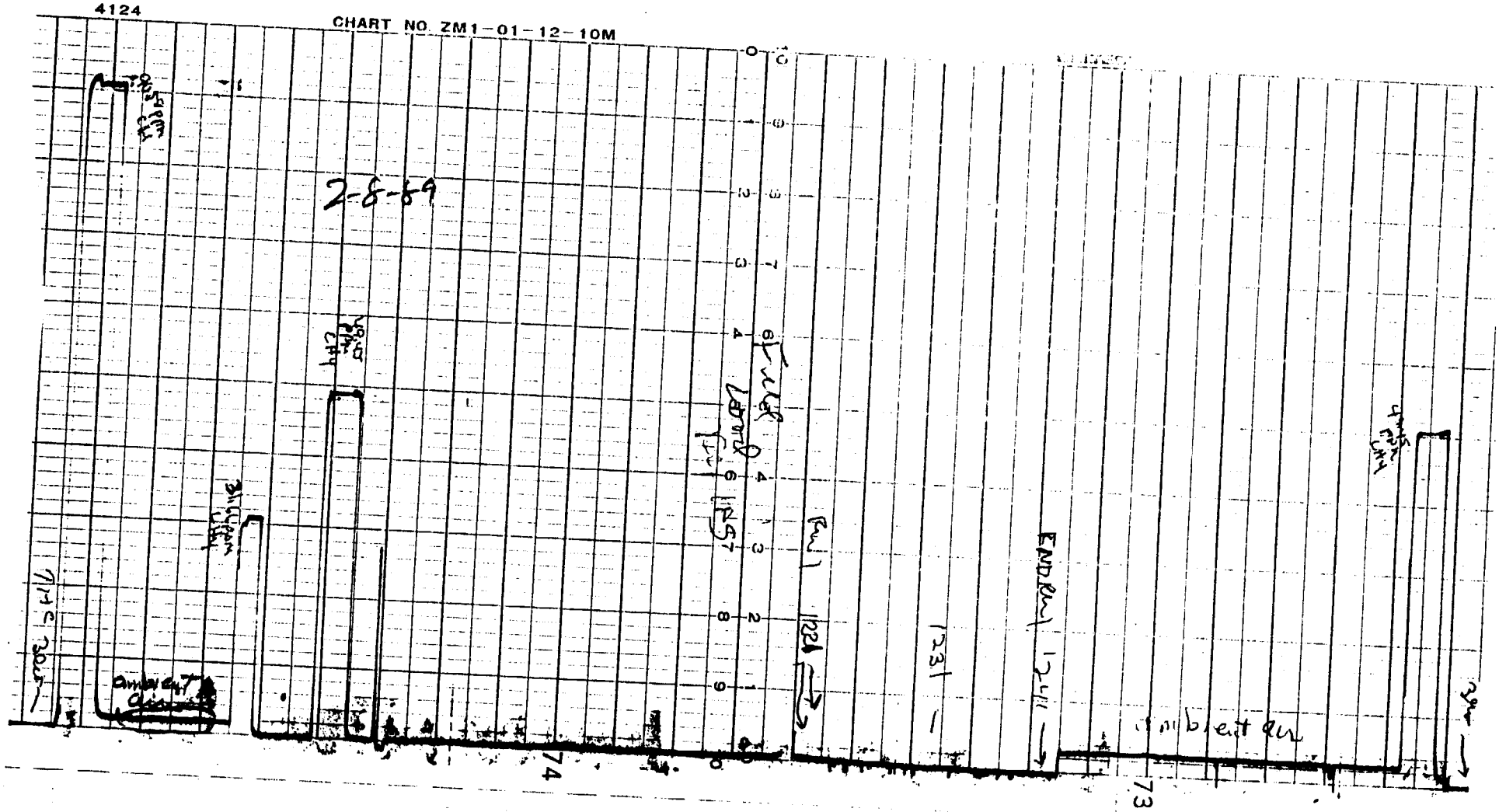
FINA GE GAS TURBINE
100% LOAD REFINERY GAS RUNS 1-3
75% LOAD REFINERY GAS RUNS 1-5



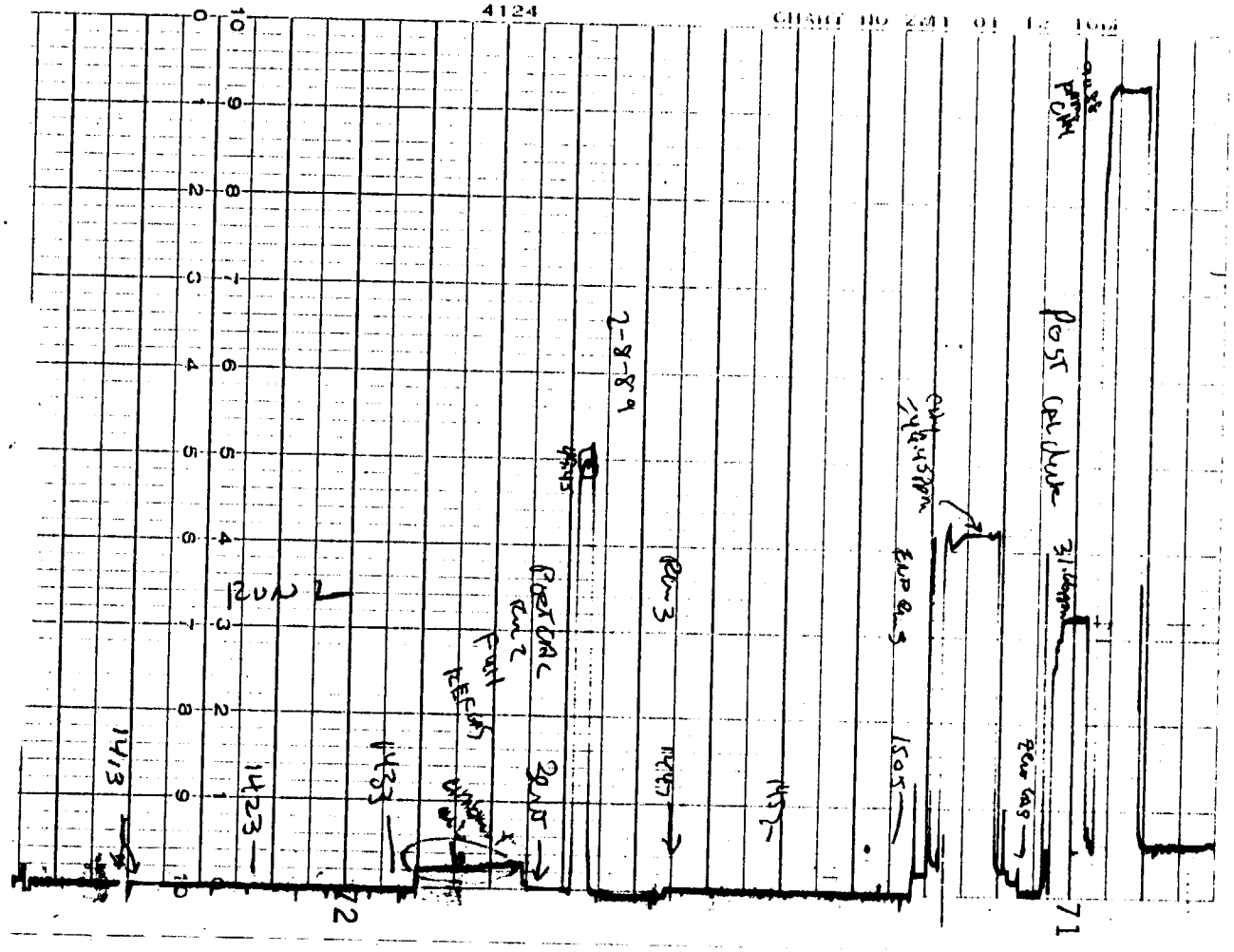
FINA GE GAS TURBINE
100% LOAD REFINERY GAS
RUN 1, NORMAL STEAM INJECTION RATE
RUNS 2,3 INCREASED STEAM INJECTION RATE
NOx AND O2 2-8-89



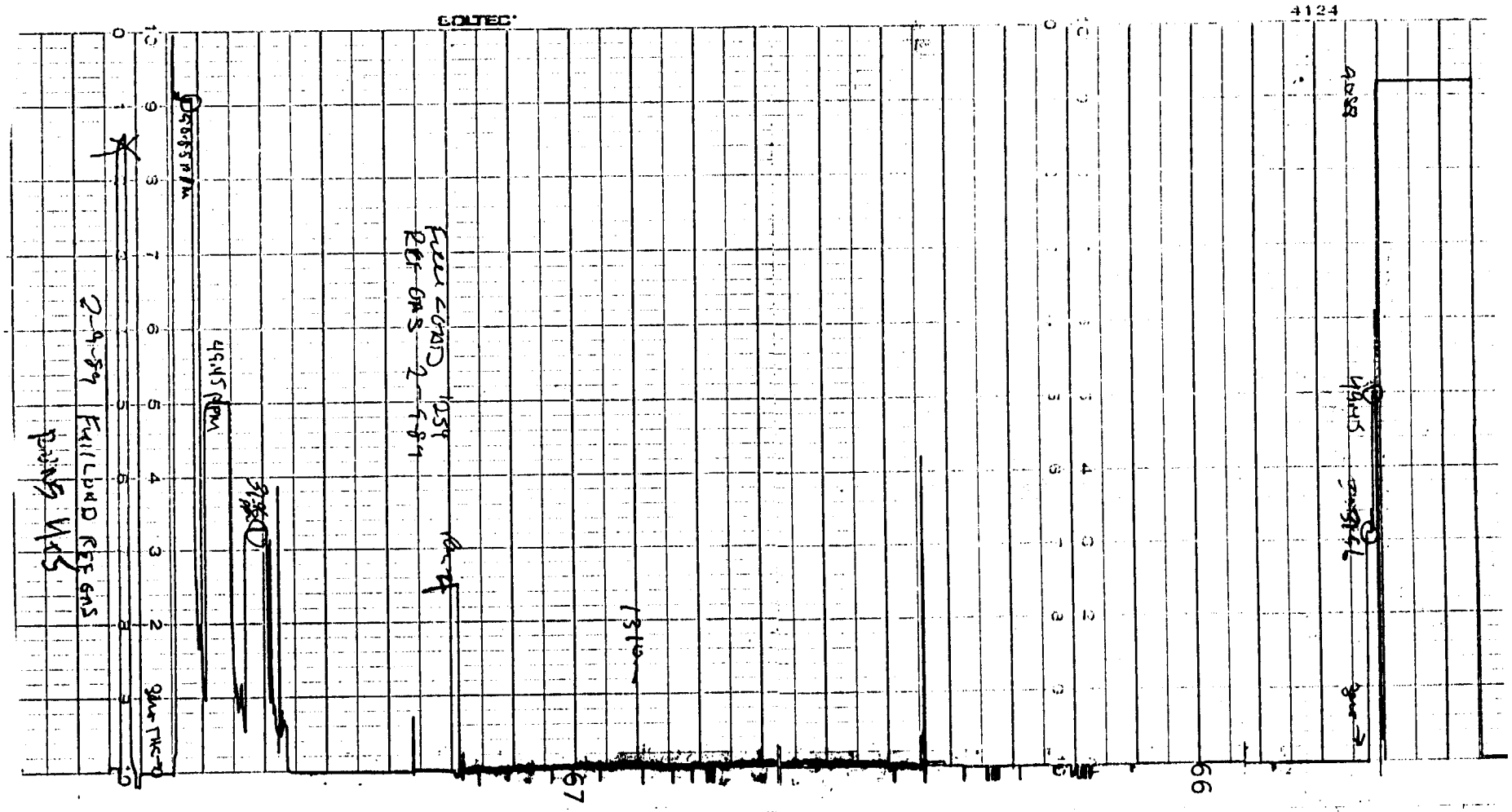
FINA GE GAS TURBINE
100% LOAD REFINERY GAS
RUNS 4 AND 5 NORMAL STEAM INJECTION RATE
NOx AND O2
2-9-89



FINA GE GAS TURBINE
100% LOAD REFINERY GAS
RUN 1 2-8-89

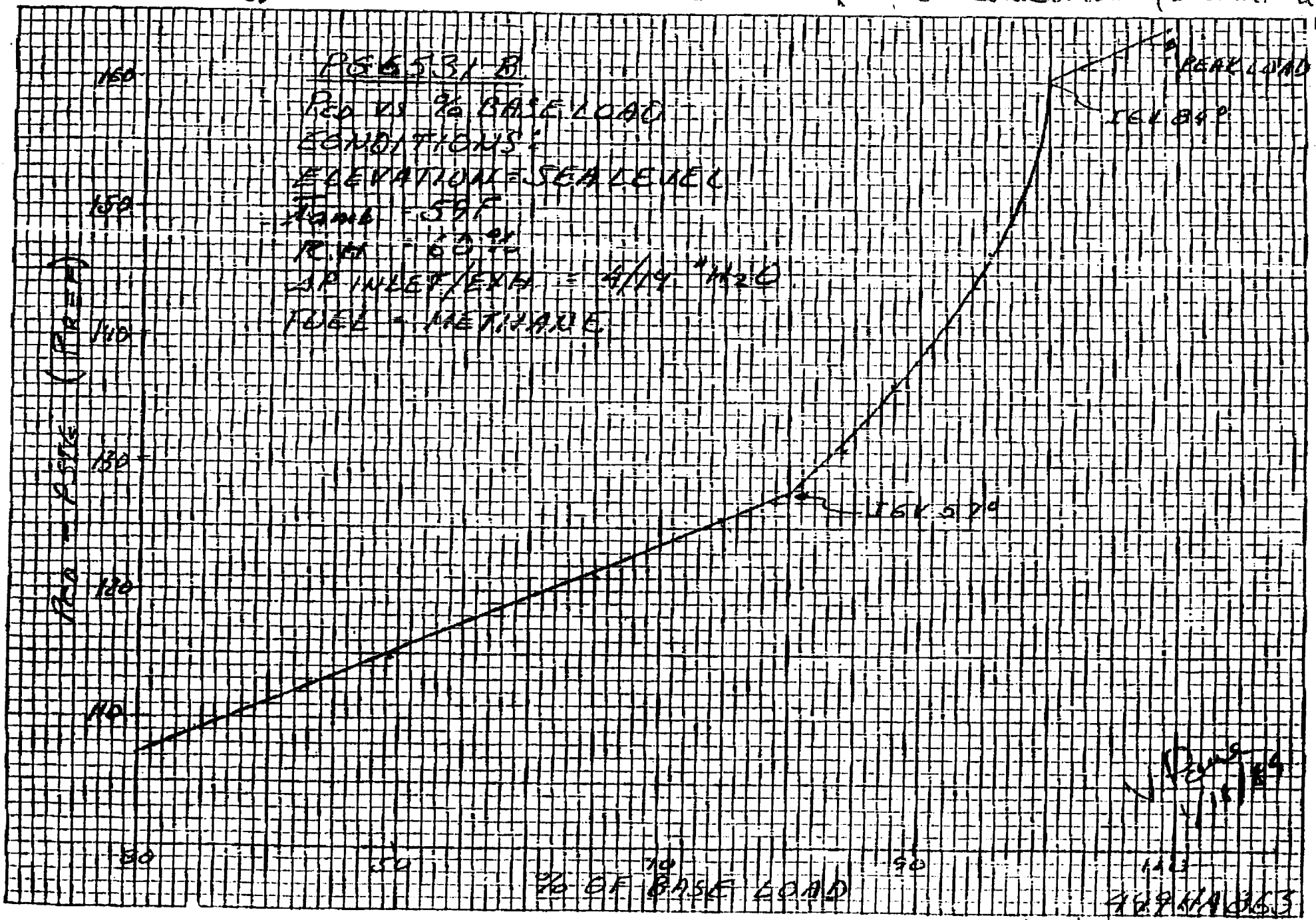


FINA GE GAS TURBINE
100% LOAD REFINERY GAS
RUNS 2 AND 3
2-8-89



FINA GE GAS TURBINE
100% REFINERY GAS
RUNS 4 AND 5
NORMAL STEAM LOAD
Total HYDROCARBONS
2-9-89

PREF VALUES TO BE USED FOR NOX ISO CORRECTION (SUBPART GG



GE GAS TURBINE COGENERATION FACILITY
EMISSION COMPLIANCE TEST PROGRAM
FINA OIL AND CHEMICAL COMPANY: PORT ARTHUR, TEXAS

APPENDIX C

Test Equipment Calibration Data and Calibration Gas Certification Sheets

Date of test 2-7-89

Analyzer type RATFISCH MODEL 55 THC SN _____

Span gas concentration 90.88 PPM (indicate units)

Analyzer span setting 100 PPM (indicate units)

Upscale	1	30	seconds
	2	31	seconds
	3	32	seconds
Average upscale response		31	seconds
Downscale	1	29	seconds
	2	30	seconds
	3	29	seconds
Average downscale response		29.5	seconds

System response time = slower average time = 31 seconds

Figure 6C-5. Response time.

Source identification: FINA

Test personnel: LG/HT/BP

Date: 2-7-89 Run number: _____

Span: _____

	Analyzer calibration response	Initial Values: System calibration response	Initial Values: System cal. bias (% of span)	Final Values: System calibration response	Final Values: System cal. bias (% of span)	Drift
Zero gas						
Mid-range						

System Calibration Bias = $\frac{\text{System Cal. Response} - \text{Analyzer Cal. Response}}{\text{Span}} \times 100$

Drift = $\frac{\text{Final System Cal. Response} - \text{Initial System Cal. Response}}{\text{Span}} \times 100$

Figure 6C-6. System calibration bias and drift data.

Date of test 2-7-89

Analyzer type TECO model 10 NOx/NOSN

Span gas concentration 197PPM (indicate units)

Analyzer span setting 250 PPM (indicate units)

Upscale
1 30 seconds
2 30 seconds
3 28 seconds

Average upscale response 29.3 seconds

Downscale
1 28 seconds
2 25 seconds
3 30 seconds

Average downscale response 27.7 seconds

System response time = slower average time = 29.3 seconds

Figure 6C-5. Response time.

Source identification: _____

Test personnel: _____

Date: _____ Run number: _____

Span: _____

	Analyzer calibration response	Initial Values: System calibration response	Initial Values: System cal. bias (% of span)	Final Values: System calibration response	Final Values: System cal. bias (% of span)	Drift
Zero gas						
Mid-range						

$$\text{System Calibration Bias} = \frac{\text{System Cal. Response} - \text{Analyzer Cal. Response}}{\text{Span}} \times 100$$

$$\text{Drift} = \frac{\text{Final System Cal. Response} - \text{Initial System Cal. Response}}{\text{Span}} \times 100$$

Figure 6C-6. System calibration bias and drift data.

Date of test 2-7-89

Analyzer type TELEDYNE O_2 SN _____

Span gas concentration 20.99% (indicate units)

Analyzer span setting 25.0% (indicate units)

Upscale
1 35 seconds
2 34 seconds
3 36 seconds

Average upscale response 35.0 seconds

Downscale
1 38 seconds
2 35 seconds
3 37 seconds

Average downscale response 36.7 seconds

System response time = slower average time = 36.7 seconds

Figure 6C-5. Response time.

Source identification: _____

Test personnel: _____

Date: _____ Run number: _____

Span: _____

	Analyzer calibration response	Initial Values: System calibration response	Initial Values: System cal. bias (% of span)	Final Values: System calibration response	Final Values: System cal. bias (% of span)	Drift
Zero gas						
Mid-range						

$$\text{System Calibration Bias} = \frac{\text{System Cal. Response} - \text{Analyzer Cal. Response}}{\text{Span}} \times 100$$

$$\text{Drift} = \frac{\text{Final System Cal. Response} - \text{Initial System Cal. Response}}{\text{Span}} \times 100$$

Figure 6C-6. System calibration bias and drift data.

ZERO AND CALIBRATION DATA

COMPANY: FINA
SOURCE: GAS TURBINE 100% LOAD NATURAL GAS
ANALYZER: TECO Model 10 1
TEST DATE: 2-7-89

	Cylinder Value PPM	Pre-Cal Analyzer Response % of Scale	Pre-Cal Analyzer Response PPM	Post-Cal Analyzer Response % of Scale	Post-Cal Analyzer Response PPM	Absolute Difference: Cylinder Value - Pre Cal Response PPM	Absolute Difference: Cylinder Value - Post Cal Response PPM	Absolute Difference: Pre Cal-Post Cal Analyzer Response PPM	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas	60	23.3	58.3	23.3	58.3	1.7	1.7	0.0	0.7	0.7	0.0
Mid level gas	119	47.0	117.5	47.0	117.5	1.5	1.5	0.0	0.6	0.6	0.0
High level gas	197	78	195	79.2	198	2.0	1.0	1.0	0.8	0.4	0.2

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 100% LOAD NATURAL GAS

ANALYZER: TELEDYNE O_2

TEST DATE: 2-7-89

	Cylinder Value	Pre-Cal Analyzer Response % of SCALE	Pre-Cal Analyzer Response PPM	Post-Cal Analyzer Response % of SCALE	Post-Cal Analyzer Response PPM	Absolute Difference: Cylinder Value - Pre Cal Response PPM	Absolute Difference: Cylinder Value - Post Cal Response PPM	Absolute Difference: Pre Cal-Post Cal Analyzer Response PPM	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas											
Mid level gas	13.0	52.0	13.0	53.0	13.3	0.0	0.3	0.3	0.0	1.2	1.2
High level gas	20.9	82.9	20.7	84.8	21.2	0.2	0.3	0.1	0.8	1.2	1.6

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 75% LOAD NATURAL GAS

ANALYZER: TELCO MODEL 10 NOx

TEST DATE: 2-7-89

	Cylinder Value	Pre-Cal Analyzer Response		Post-Cal Analyzer Response		Absolute Difference			Linearity Response (%)		Cal Drift %
		% of scale	ppm	% of scale	ppm	Cylinder Value - Pre Cal Response ppm	Cylinder Value - Post Cal Response ppm	Pre Cal-Post Cal Analyzer Response ppm	Pre Cal	Post Cal	
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas	60.0	23.3	58.3	23.3	58.3	1.7	1.7	0.0	0.7	0.7	0.0
Mid level gas	119.0	47.0	117.5	47.0	117.5	1.5	1.5	0.0	0.6	0.6	0.0
High level gas	197.0	78.0	195.0	78.0	195.0	2.0	2.0	0.0	0.8	0.8	0.0

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 75% LOAD NATURAL GAS

ANALYZER: TELEDYNE O2 MONITOR

TEST DATE: 2-7-89

	Cylinder Value	Pre-Cal Analyzer Response		Post Cal Analyzer Response		Absolute Difference			Linearity Response (%)		Cal Drift %
		% of Scale	% O_2	% of Scale	% O_2	Cylinder Value - Pre Cal Response % O_2	Cylinder Value - Post Cal Response % O_2	Pre Cal-Post Cal Analyzer Response % O_2	Pre Cal	Post Cal	
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas											
Mid level gas	13.0	53.0	13.3	52.0	13.0	0.3	0.0	0.3	1.2	0.0	1.2
High level gas	20.9	84.8	21.2	83.0	20.8	0.3	0.1	0.2	1.2	0.4	0.8

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 100% LOAD REFINERY GAS

ANALYZER: Teledyne O_2 MONITOR

TEST DATE: 2-8-89

	Cylinder Value % O_2	Pre Cal Analyzer Response % of Scale	Pre Cal Analyzer Response % O_2	Post Cal Analyzer Response % of Scale	Post Cal Analyzer Response % O_2	Absolute Difference: Cylinder Value - Pre Cal Response % O_2	Absolute Difference: Cylinder Value - Post Cal Response % O_2	Absolute Difference: Pre Cal-Post Cal Analyzer Response % O_2	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas											
Mid level gas	13.0	52.1	13.0	52.0	13.0	0.0	0.0	0.0	0.0	0.0	-0.0
High level gas	20.9	83.6	20.9	83.5	20.9	0.0	0.0	0.0	0.0	0.0	0.0

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 100% LOAD REFINERY GAS

ANALYZER: TECO model 10 NOx

TEST DATE: 2-8-89

	Cylinder Value PPM	Pre-Cal Analyzer Response % of Scale	Pre-Cal Analyzer Response PPM	Post-Cal Analyzer Response % of Scale	Post-Cal Analyzer Response PPM	Absolute Difference: Cylinder Value - Pre Cal Response PPM	Absolute Difference: Cylinder Value - Post Cal Response PPM	Absolute Difference: Pre Cal-Post Cal Analyzer Response PPM	Linearity Response (%): Pre Cal	Linearity Response (%): Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	-0.1	0.25	0.0	0.25	0.25	0.0	0.1	0.1
Low level gas	60.0	23.8	59.5	24.0	60.0	0.5	0.0	0.5	0.2	0.0	0.2
Mid level gas	119.0	47.8	119.5	48.0	120.0	0.5	1.0	0.5	0.2	0.4	0.2
High level gas	197.0	78.8	197.0	79.1	197.8	0.0	0.8	0.8	0.0	0.3	0.3

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 100% LOAD REFINERY GAS

ANALYZER: RATFISCH MODEL 55 THC

TEST DATE: 2-8-89

	Cylinder Value	Pre-Cal Analyzer Response		Post-Cal Analyzer Response		Absolute Difference			Linearity Response (%)		Cal Drift %
		% of Scale	PPM	% of Scale	PPM	Cylinder Value - Pre Cal Response PPM	Cylinder Value - Post Cal Response PPM	Pre Cal-Post Cal Analyzer Response PPM	Pre Cal	Post Cal	
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas	31.96	31.0	31.0	32.1	32.1	0.96	0.14	0.82	0.96	0.14	0.82
Mid level gas	49.45	49.5	49.5	52.0	52.0	0.05	2.55	2.5	0.05	2.55	2.5
High level gas	90.88	91.0	91.0	93.7	93.7	0.12	2.82	2.7	0.12	2.82	2.7

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: GAS TURBINE 75% LOAD REFINERY GAS

ANALYZER: TECO MODEL 10 NOx

TEST DATE: 2-8-89

	Cylinder Value PPM	Pre Cal Analyzer Response % of Scale	Pre Cal Analyzer Response PPM	Post Cal Analyzer Response % of Scale	Post Cal Analyzer Response PPM	Absolute Difference: Cylinder Value - Pre Cal Response PPM	Absolute Difference: Cylinder Value - Post Cal Response PPM	Absolute Difference: Pre Cal-Post Cal Analyzer Response PPM	Linearity Response (%): Pre Cal	Linearity Response (%): Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas	60.0	23.0	57.5	23.5	58.8	2.5	2.2	0.3	1.0	0.9	0.1
Mid level gas	119.0	47.0	117.5	47.3	118.3	1.5	1.7	0.2	0.6	0.7	0.1
High level gas	197.0	78.3	195.8	80.0	200.0	1.2	3.0	1.8	0.5	1.2	0.7

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FIM

SOURCE: GAS TURBINE 75% LOAD REFINERY GAS

ANALYZER: Teledyne O_2

TEST DATE: 2-8-89

	Cylinder Value % O_2	Pre Cal Analyzer Response % of Scale	Pre Cal Analyzer Response % O_2	Post Cal Analyzer Response % of Scale	Post Cal Analyzer Response % O_2	Absolute Difference: Cylinder Value - Pre Cal Response % O_2	Absolute Difference: Cylinder Value - Post Cal Response % O_2	Absolute Difference: Pre Cal-Post Cal Analyzer Response % O_2	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas											
Mid level gas	13.0	52.1	13.0	52.2	13.0	0.0	0.0	0.0	0.0	0.0	0.0
High level gas	20.9	83.5	20.9	83.5	20.9	0.0	0.0	0.0	0.0	0.0	0.0

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: MAX COMBINED FIRING RATE

ANALYZER: TECO Model 10 NO_x

TEST DATE: 2-9-89

	Cylinder Value PPM	Pre-Cal Analyzer Response % of Scale	Pre-Cal Analyzer Response PPM	Post-Cal Analyzer Response % of Scale	Post-Cal Analyzer Response PPM	Absolute Difference: Cylinder Value - Pre Cal Response PPM	Absolute Difference: Cylinder Value - Post Cal Response PPM	Absolute Difference: Pre Cal-Post Cal Analyzer Response PPM	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low level gas	60.0	23.2	58.0	24.0	60	2.0	0.0	2.0	0.8	0.0	0.8
Mid level gas	119.0	47.2	118.0	47.5	118.8	1.0	0.2	0.8	0.4	0.1	0.3
High level gas	197.0	78.8	197.0	80.1	200.3	0.0	3.0	3.0	0.0	1.2	1.2

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

ZERO AND CALIBRATION DATA

COMPANY: FINA

SOURCE: MAX COMBINED FIRING RATE

ANALYZER: TELEDYNE O2 MONITOR

TEST DATE: 2-9-89

	Cylinder Value %O2	Pre Cal Analyzer Response % of Scale	Pre Cal Analyzer Response %O2	Post Cal Analyzer Response % of Scale	Post Cal Analyzer Response %O2	Absolute Difference: Cylinder Value - Pre Cal Response % O2	Absolute Difference: Cylinder Value - Post Cal Response % O2	Absolute Difference: Pre Cal-Post Cal Analyzer Response % O2	Linearity Response (%) Pre Cal	Linearity Response (%) Post Cal	Cal Drift %
Zero gas	0.0	0.0	0.0	+0.2	0.05	0.0	0.05	0.05	0.0	0.2	0.2
Low level gas											
Mid level gas	13.0	52.1	13.0	52.5	13.1	0.0	0.1	0.1	0.0	0.4	0.4
High level gas	20.9	83.6	20.9	83.7	20.9	0.0	0.0	0.0	0.0	0.0	0.0

[1] Linearity response $= \frac{|\text{cylinder value} - \text{pre or post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

[2] Calibration drift $= \frac{|\text{pre cal} - \text{post cal}|}{\text{span value}} \times 100$ should be $\leq 2\%$

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 1-4-89 Meter box number 597

Barometric pressure, P_b = 29.67 in. Hg Calibrated by LG

Orifice manometer setting (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperatures: Wet test meter (t_w), °F	Temperatures: Dry gas meter: Inlet (t_{d_i}), °F	Temperatures: Dry gas meter: Outlet (t_{d_o}), °F	Temperatures: Dry gas meter: Avg[a] (t_d), °F	Time (θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5	4.987	70	81	72	76.5	16.0	1.014	
1.0	5	5.026	70	84	75	79.5	10.3	1.010	
1.5	10	10.126	70	88	77	82.5	16.6	1.007	
2.0	10	10.164	71	93	78	85.5	13.3	1.006	
3.0	10	10.172	71	96	78	87.0	11.5	1.005	
4.0	10	10.128	71	98	79	88.5	9.7	1.010	
							Avg	1.009	

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$	$\Delta H@_i = \frac{0.0317\ \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\ \theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
1.5	0.110		
2.0	0.147		
3.0	0.221		
4.0	0.294		

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.

POSTTEST DRY GAS METER CALIBRATION DATA FORM (English units)

Test numbers 75, 100% LOADS MAX COMB TEST STACK Date 2-7 → 2-9 Meter box number _____ Plant FINA

Barometric pressure, P_b = 29.65 in. Hg Dry gas meter number 597 Pretest Y 1.009

Orifice manometer setting, (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperature: Wet test meter (t_w), °F	Temperature: Dry gas meter: Inlet (t_{d_i}), °F	Temperature: Dry gas meter: Outlet (t_{d_o}), °F	Temperature: Dry gas meter: Average[a] (t_d), °F	Time (θ), min	Vacuum setting, in. Hg	Y_i	Y_i $\frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$
5.5	10.000	9.901	71	77	72	74.5		5		1.003
5.5	10.000	9.915	71	81	73	77.0		5		1.006
5.5	10.000	9.947	71	83	73	78.0		5		1.005
									Y =	1.005

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.

V_w = Gas volume passing through the wet test meter, ft^3.

V_d = Gas volume passing through the dry gas meter, ft^3.

t_w = Temperature of the gas in the wet test meter, °F.

t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F.

t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F.

t_d = Average temperature of the gas in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o}, °F.

ΔH = Pressure differential across orifice, in H_2O.

Y_i = Ratio of accuracy of wet test meter to dry gas meter for each run.

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y $\pm 0.05Y$

P_b = Barometric pressure, in. Hg.

θ = Time of calibration run, min.

METER
~~STACK~~ TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-19-89 Thermocouple number 597

Ambient temperature 71 °F Barometric pressure _____ in. Hg

Calibrator LB Reference: mercury-in-glass ✓

other _____

Reference point number	Source[a] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[b] %
1	ICE WATER	33	35	0.41
2	Boiling water	210	215	0.75

[a]Type of calibration system used.

[b] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 10-6-88 Meter box number 2390

Barometric pressure, P_b = 29.85 in. Hg Calibrated by HMT

Orifice manometer setting (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperatures: Wet test meter (t_w), °F	Temperatures: Dry gas meter: Inlet (t_{d_i}), °F	Temperatures: Dry gas meter: Outlet (t_{d_o}), °F	Temperatures: Dry gas meter: Avg[a] (t_d), °F	Time (Θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5.000	5.022	68.8	76.3	70.1	73.2		1.0026	
1.0	5.000	5.033	68.8	78.5	71.9	75.2		1.0030	
1.5	10.000	10.115	68.8	84.5	73.5	79.0		1.0040	
2.0	10.000	10.146	68.8	87.6	75.5	81.6		1.0045	
3.0	10.000	10.153	68.8	90.0	77.0	83.5		1.0049	
4.0	10.000	10.065	68.8	94.4	80.1	87.3		1.0049	
							Avg	1.0040	

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6})(t_w + 460)}$	$\Delta H@_i = \frac{0.0317\ \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460)\ \Theta}{V_w}\right]^2$
0.5	0.0368		
1.0	0.0737		
1.5	0.110		
2.0	0.147		
3.0	0.221		
4.0	0.294		

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.

POSTTEST DRY GAS METER CALIBRATION DATA FORM (English units) 2-15-89

Test numbers 1-3 Date 2/9/89 Meter box number 2390 Plant FINA

Barometric pressure, P_b = 29.65 in. Hg Dry gas meter number _____ Pretest Y 1.004

Orifice manometer setting, (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperature: Wet test meter (t_w), °F	Temperature: Dry gas meter: Inlet (t_{d_i}), °F	Temperature: Dry gas meter: Outlet (t_{d_o}), °F	Temperature: Dry gas meter: Average[a] (t_d), °F	Time (θ), min	Vacuum setting, in. Hg	Y_i	Y_i $\frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$
2.0	10.000	10.043	71	82	72	77.0		4		1.002
2.0	10.000	10.147	71	87	75	81.0		4		0.999
2.0	10.000	10.245	71	92	77	84.5		4		0.996
									Y =	0.999

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.

V_w = Gas volume passing through the wet test meter, ft^3.

V_d = Gas volume passing through the dry gas meter, ft^3.

t_w = Temperature of the gas in the wet test meter, °F.

t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F.

t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F.

t_d = Average temperature of the gas in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o}, °F.

ΔH = Pressure differential across orifice, in H_2O.

Y_i = Ratio of accuracy of wet test meter to dry gas meter for each run.

Y = Average ratio of accuracy of wet test meter to dry gas meter for all three runs; tolerance = pretest Y $\pm 0.05Y$

P_b = Barometric pressure, in. Hg.

θ = Time of calibration run, min.

METER ~~STACK~~ TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-19-89 Thermocouple number 2390

Ambient temperature 71 °F Barometric pressure _____ in. Hg

Calibrator LG Reference: mercury-in-glass ✓

other _____

Reference point number	Source[a] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[b] %
1	ICE WATER	33	36	0.61
2	Boiling WATER	210	214	0.60

[a]Type of calibration system used.

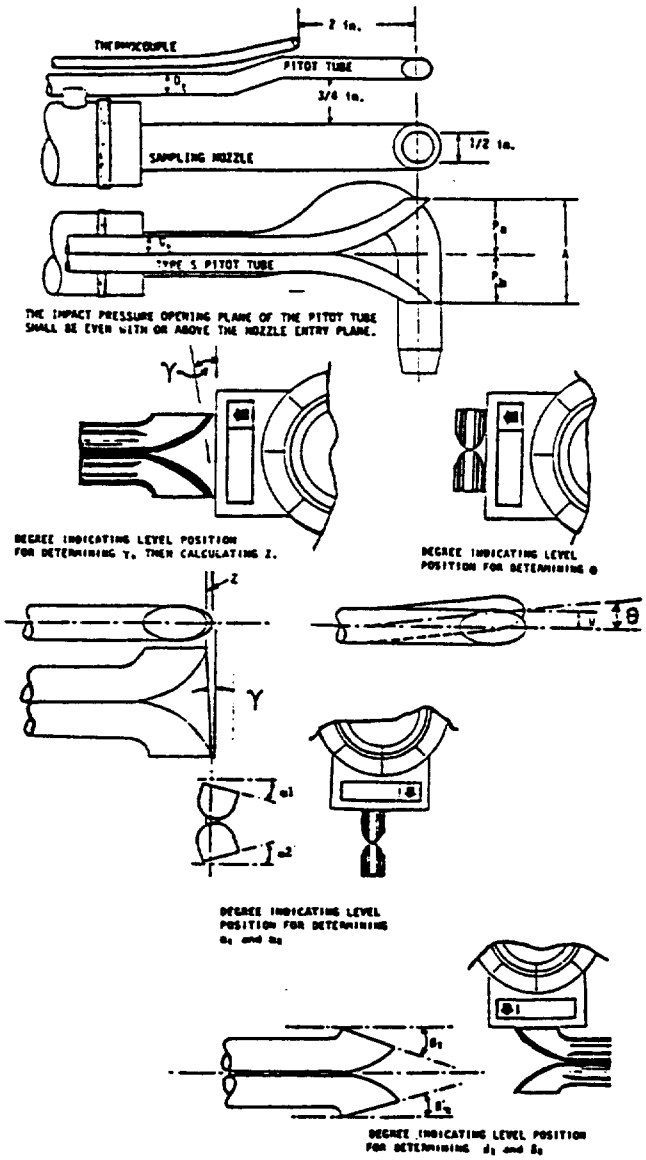
[b] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

PITOT TUBE INSPECTION DATA SHEET

Company Name: FINA

Pre-sample Date 2-6-89

Post Sample Date 2-9-89



Y	level?	Y
N	obstructions?	N
N	damaged?	N
0	$-10° < \alpha_1 < +10°$	0
0	$-10° < \alpha_2 < +10°$	0
2	$-5° < \beta_1 < +5°$	2
1	$-5° < \beta_2 < +5°$	1
0	γ	0
0	θ	0
1.11	A	1.11
0.55	$1.05\ D_t < P_a < 1.5\ D_t$	0.55
0.56	$1.05\ D_t < P_b < 1.5\ D_t$	0.55
3/8	$3/16" \leq D_t \leq 3/8"$	3/8
0	$A \tan \gamma < 0.125"$	0
0	$A \tan \theta < 0.03125"$	0
✓	$P_a = P_b \pm 0.063"$	✓

Comments: _____

Pitot tube/probe number P8A meets or exceeds all specifications criteria and/or applicable design features* and is hereby assigned a pitot tube calibration factor of 0.84.

Signature [signature]

Date 2-9-89

*See 40 CFR 60, Vol. 42, No. 160, Method 2. Verify the minimum 2 inch setback of the thermocouple and the minimum 3/4 inch separation between the pitot tube and the nozzle as shown at the top of this page. ✓

STACK TEMPERATURE SENSOR CALIBRATION DATA FORM

Date 1-19-89 Thermocouple number T8A

Ambient temperature 71 °F Barometric pressure 29.65 in. Hg

Calibrator LS Reference: mercury-in-glass ✓

other _____

Reference point number	Source[a] (specify)	Reference thermometer temperature, °F	Thermocouple potentiometer temperature, °F	Temperature difference,[b] %
1	ICE WATER	33	31	0.41
2	Boiling water	210	209	0.1
3	HOT OIL	388	384	0.6

[a]Type of calibration system used.

[b] $\left[\frac{(\text{ref temp, °F} + 460) - (\text{test thermom temp, °F} + 460)}{\text{ref temp, °F} + 460}\right] 100 \leq 1.5\%.$

Scott Specialty Gases a division of Scott Environmental Technology, Inc.
PLUMSTEADVILLE, PA. 18949 PHONE: (215) 766-8861 TWX: 510-665-9344

Date: 7/15/88
Our Project No.: 712982
Your P.O. No.: 540-88

ARI ENVIRONMENTAL
3407 NORTH RIDGE AVE
ARINGTON HEIGHTS, IL 60004

Gentlemen:

Thank you for choosing Scott for your Specialty Gas needs. The analyses for the gases ordered, as reported by our laboratory, are listed below. Results are in volume percent, unless otherwise indicated.

ANALYTICAL REPORT

Cyl. No. BAL4741 Analytical Accuracy ±2%

Component	Concentration
OXYGEN	13.0%
NITROGEN	BALANCE

Cyl. No. BLM141 Analytical Accuracy ±2%

Component	Concentration
NITRIC OXIDE	856 PPM
NITROGEN	BALANCE
REPORT NOx	866 PPM

Cyl. No. LL19825 Analytical Accuracy ±2%

Component	Concentration
NITRIC OXIDE	240 PPM
NITROGEN	BALANCE
REPORT NOx	246 PPM

Cyl. No. LL11943 Analytical Accuracy ±2%

Component	Concentration
NITRIC OXIDE	476 PPM
NITROGEN	BALANCE
REPORT NOx	483 PPM

Analyst

Approved By

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the Company without extra cost.

CERTIFIED REFERENCE MATERIALS EPA PROTOCOL GASES
ACUBLEND® CALIBRATION & SPECIALTY GAS MIXTURES PURE GASES
ACCESSORY PRODUCTS CUSTOM ANALYTICAL SERVICES
TROY, MICHIGAN / SAN BERNARDINO, CALIFORNIA / HOUSTON, TEXAS

Scott Specialty Gases
a division of
Scott Environmental Technology, Inc.
3714 LAPAS DRIVE, HOUSTON, TEXAS 77023, (713) 644-4820, FAX 644-0244

ARI ENVIRONMENTAL
3407 NORTH RIDGE
ARLINGTON HEIGHTS, IL 60004
LARRY GOLDFINE

Date: NOVEMBER 11, 1988
Our Project No.: 714759
Your P.O. No.: 61888

NOV 14 1988

Gentlemen:
Thank you for choosing Scott for your Specialty Gas needs. The analyses for the gases ordered, as reported by our laboratory, are listed below. Results are in volume percent, unless otherwise indicated.

ANALYTICAL REPORT

Cyl No. CAL10721 Analytical Accuracy ±2%

Component	Concentration
CARBON MONOXIDE	309 PPM
NITROGEN	BALANCE

Cyl No. 3L1737 Analytical Accuracy ±2%

Component	Concentration
CARBON MONOXIDE	309 PPM
NITROGEN	BALANCE

Cyl No. CAL7781 Analytical Accuracy ±2%

Component	Concentration
CARBON MONOXIDE	154 PPM
NITROGEN	BALANCE

Cyl No. CAL8182 Analytical Accuracy ±2%

Component	Concentration
CARBON MONOXIDE	150 PPM
NITROGEN	BALANCE

Analyst D. S. Kelly

Approved By

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the company without extra cost.

CERTIFIED REFERENCE MATERIALS EPA PROTOCOL GASES
ACUBLEND® CALIBRATION & SPECIALTY GAS MIXTURES PURE GASES
ACCESSORY PRODUCTS CUSTOM ANALYTICAL SERVICES

TROY, MICHIGAN / SAN BERNARDINO, CALIFORNIA / HOUSTON, TEXAS / BATON ROUGE, LOUISIANA / AUSTIN, TEXAS
SOUTH PLAINFIELD, NEW JERSEY / FREMONT, CALIFORNIA

Scott Specialty Gases
a division of
Scott Environmental Technology, Inc.
3714 LAPAS DRIVE, HOUSTON, TEXAS 77023, (713) 644-4820, FAX 644-0244

ARI ENVIRONMENTAL
3407 NORTH RIDGE
ARLINGTON HEIGHTS, IL 60004

Date: NOVEMBER 11, 1988
Our Project No.: 714915
Your P.O. No.: 61888

Gentlemen:
Thank you for choosing Scott for your Specialty Gas needs. The analyses for the gases ordered, as reported by our laboratory, are listed below. Results are in volume percent, unless otherwise indicated.

ANALYTICAL REPORT

Cyl No. BAL4978 Analytical Accuracy ±2%

Component	Concentration
CARBON DIOXIDE	14.4%
NITROGEN	BALANCE

Cyl No. BAL2942 Analytical Accuracy ±2%

Component	Concentration
CARBON MONOXIDE	478 PPM
NITROGEN	BALANCE

Cyl No. _____ Analytical Accuracy _____

Component	Concentration

Cyl No. _____ Analytical Accuracy _____

Component	Concentration

Analyst D. S. Kelly

Approved By

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the company without extra cost.

NOV 17 1988

CERTIFIED REFERENCE MATERIALS EPA PROTOCOL GASES
ACUBLEND® CALIBRATION & SPECIALTY GAS MIXTURES PURE GASES
ACCESSORY PRODUCTS CUSTOM ANALYTICAL SERVICES
TROY, MICHIGAN / SAN BERNARDINO, CALIFORNIA / HOUSTON, TEXAS / BATON ROUGE, LOUISIANA / AUSTIN, TEXAS
SOUTH PLAINFIELD, NEW JERSEY / FREMONT, CALIFORNIA

COMPANY _____ DATE _____

LOCATION _____ TEST TEAM HT, K.F

SOURCE CAL GAS STANDARDS

Barometric Pressure in Hg: Sample 1 30.11 /2 ____ /3 ____

EPA METHOD 7 - NO_x Sample Recovery 1 30.22 /2 ____ /3 ____

FIELD DATA									SAMPLE RECOVERY			
Sample #	Time	Flask #	Flask Vol. (ml)	Solution Vol. (ml)	Leak Rate in Hg/min	Initial Manometer Reading in Hg	T_i °F	ORSAT	Final Manometer Reading in Hg	T_f °F	Shipping Container #	COMMENTS
	60	ppm STD. AAL 16448										
1		H-4	2074	25	0	-30.1	55	CO_2 ____	+1.0	76		
2		H-15	2073	25	0	-30.0	55	O_2 ____	+0.7	76		
3		#3	2067	25	0	-30.1	55	CO ____	+0.8	76		
4								N_2 ____				
								Time: ____				
	119 ppm	STD	AAL 5417									
1		H-56	2064	25	0	-30.1	55	CO_2 ____	+0.5	76		
2		25	2073	25	0	-30.1	55	O_2 ____	+0.8	76		
3		H-2	2068	25	0	-30.1	55	CO ____	+1.0	76		
4								N_2 ____				
								Time: ____				
	197	ppm STD. IL 9326										
1		#13	2070	25	0	30.1		CO_2 ____	+1.0	76		
2		#4	2054	25	0	30.1		O_2 ____	+0.8	76		
3		#12	2071	25	0	30.0		CO ____	+1.0	76		
								N_2 ____				
								Time: ____				

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL 16948 (60 ppm)

DATE: 01-26-89

RUN NO: 1-1

Sample Volume

Vf =	2074 ml	Pi =	0.01 in. Hg
Pf =	31.22 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2104.6 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.185

F = 1

$m = 2Kc\ A\ F =$ 238.057 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) =$ 0.7062×10^{-5} lb/dscf

$lb/dscf \times 385.26\ /\ 46 \times 10^{6} =$ 59.1 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL 16948 (60 ppm)

DATE: 01-26-89

RUN NO: 1-2

Sample Volume

Vf =	2073 ml	Pi =	0.01 in. Hg
Pf =	30.29 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2040.9 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.183

F = 1

$m = 2Kc\ A\ F =$ 235.483 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) =$ 0.7203×10^{-5} lb/dscf

lb/dscf $\times$ $385.26\ /\ 46 \times 10^{6} =$ 60.3 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL 16948 (60 ppm)

DATE: 01-26-89

RUN NO: 1-3

Sample Volume

Vf =	2067 ml	Pi =	0.01 in. Hg
Pf =	31.02 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2083.9 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.185

F = 1

$m = 2Kc\ A\ F =$ 238.057 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) = 0.7132 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26\ /\ 46 \times 10^{6} =$ 59.7 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL5417 (119 ppm)

DATE: 01-26-89

RUN NO: 2-1

Sample Volume

Vf =	2064 ml	Pi =	0.01 in. Hg
Pf =	30.72 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2060.7 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.363

F = 1

$m = 2Kc\ A\ F =$ 467.106 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) =$ 1.4151×10^{-5} lb/dscf

$lb/dscf \times 385.26\ /\ 46 \times 10^{6} =$ 118.5 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL5417 (119 ppm)

DATE: 01-26-89

RUN NO: 2-2

Sample Volume

Vf =	2064 ml	Pi =	0.01 in. Hg
Pf =	31.02 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2080.9 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.363

F = 1

$m = 2Kc\ A\ F =$ 467.106 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) = 1.4014 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26\ /\ 46 \times 10^{6} =$ 117.4 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - AAL5417 (119 ppm)

DATE: 01-26-89

RUN NO: 2-3

Sample Volume

Vf = 2073 ml Pi = 0.01 in. Hg

Pf = 31.22 in. Hg Ti = 515 deg. R

Tf = 536 deg. R

Vsc = 17.64 (Vf - 25) [Pf/Tf - Pi/Ti] = 2103.5 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.368

F = 1

m = 2Kc A F = 473.540 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5} (m / Vsc) = 1.4054 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26 / 46 \times 10^{6} = 117.7$ ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - IL 9326 (197 ppm)

DATE: 01-26-89

RUN NO: 3-1

Sample Volume

Vf =	2070 ml	Pi =	0.01 in. Hg
Pf =	31.22 in. Hg	Ti =	482 deg. R
Tf =	536 deg. R		

Vsc = 17.64 (Vf - 25) [Pf/Tf - Pi/Ti] = 2100.4 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.307

F = 2

m = 2Kc A F = 790.092 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5} (m / Vsc) = 2.3484 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26 / 46 \times 10^{6} =$ 196.7 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - IL9326 (197 ppm)

DATE: 01-26-89

RUN NO: 3-3

Sample Volume

Vf =	2071 ml	Pi =	0.11 in. Hg
Pf =	31.22 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

Vsc = 17.64 (Vf - 25) [Pf/Tf - Pi/Ti] = 2094.5 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.306

F = 2

m = 2Kc A F = 787.518 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5} (m / Vsc) = 2.3473 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26 / 46 \times 10^{6} =$ 196.6 ppm

Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

NITROGEN OXIDES CALCULATION FORM
English Units

PLANT:

LOCATION:

SOURCE: NOX CAL GAS STD - IL 9326 (197 ppm)

DATE: 01-26-89

RUN NO: 3-2

Sample Volume

Vf =	2054 ml	Pi =	0.01 in. Hg
Pf =	31.02 in. Hg	Ti =	515 deg. R
Tf =	536 deg. R		

$Vsc = 17.64\ (Vf - 25)\ [\ Pf/Tf - Pi/Ti\ ] =$ 2070.7 ml

Total ug NO2 Per Sample

Kc = 643.397

A = 0.304

F = 2

$m = 2Kc\ A\ F =$ 782.371 ug of NO2

Sample Concentration

$C = 6.243 \times 10^{-5}\ (\ m\ /\ Vsc\ ) =\ 2.3588 \times 10^{-5}$ lb/dscf

$lb/dscf \times 385.26\ /\ 46 \times 10^{6} =$ 197.6 ppm

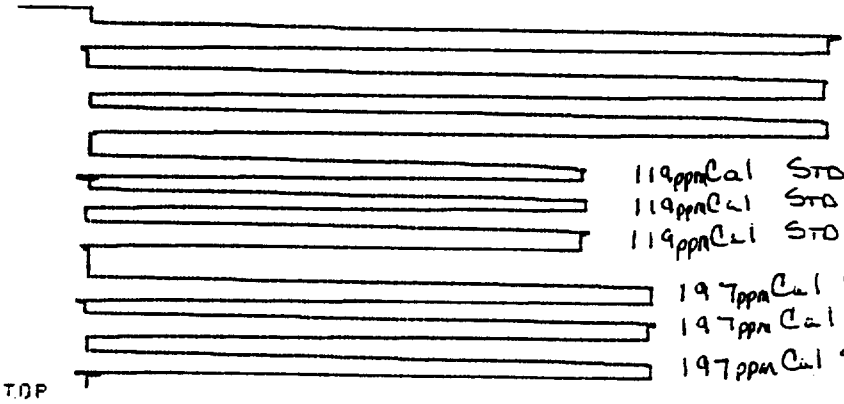
Emission Rate

Qs = 0 dscf/hr

lb/dscf x Qs = 0.00 lb/hr

CALIBRATION STANDARDS: 60 PPM 119 PPM 197 PPM

* PLOT



60ppm Cal STD 0.195
60 ppm Cal STD 0.183
60ppm Cal STD 0.195
119ppm Cal STD 0.363
119ppm Cal STD 0.363
119ppm Cal STD 0.368
197ppm Cal STD 0.307 x 2
197ppm Cal STD 0.304 x 2
197ppm Cal STD 0.306 x 2

STOP

*

Scott Specialty Gases
a division of
Scott Environmental Technology, Inc.
3714 LAPAS DRIVE, HOUSTON, TEXAS 77023, (713) 644-4820, FAX 644-0244

ARI ENVIRONMENTAL
3407 N. RIDGE AVE.
ARLINGTON HEIGHTS, IL. 60004

Date: FEBRUARY 1, 1989
Our Project No.: 715931
Your P.O. No.: 639-88

Gentlemen:
Thank you for choosing Scott for your Specialty Gas needs. The analyses for the gases ordered, as reported by our laboratory, are listed below. Results are in volume percent, unless otherwise indicated.

ANALYTICAL REPORT

Cyl No. AAL16948 Analytical Accuracy ±2%

Component	Concentration
NITRIC OXIDE	58 PPM
NITROGEN	BALANCE
NOx	60 PPM

Cyl No. AAL5417 Analytical Accuracy ±1%

Component	Concentration
NITRIC OXIDE	117 PPM
NITROGEN	BALANCE
NOx	119 PPM

Cyl No. IL9326 Analytical Accuracy ±1%

Component	Concentration
NITRIC OXIDE	194 PPM
NITROGEN	BALANCE
NOx	197 PPM

Cyl No. _____ Analytical Accuracy _____

Component	Concentration

Analyst _____ Approved By _____

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the company without extra cost.

CERTIFIED REFERENCE MATERIALS EPA PROTOCOL GASES
ACUBLEND CALIBRATION & SPECIALTY GAS MIXTURES PURE GASES
ACCESSORY PRODUCTS CUSTOM ANALYTICAL SERVICES
TROY, MICHIGAN / SAN BERNARDINO, CALIFORNIA / HOUSTON, TEXAS / BATON ROUGE, LOUISIANA / AUSTIN, TEXAS
SOUTH PLAINFIELD, NEW JERSEY / FREMONT, CALIFORNIA / WAKEFIELD, MASSACHUSETTS

Scott Specialty Gases

a division of Scott Environmental Technology, Inc.

1290 COMBERMERE STREET, TROY, MICHIGAN 48084 (313) 589-2950

Shipped From : Scott Troy
Date Shipped : ____
Our Project # : 932423
Your P.O. # : 0675
Page ____ of ____
Expiration Date : 7-18-89

Customer :
SCOTT SPECIALTY GASES
3714 LAPAS DR
HOUSTON, TEXAS 77023

**** CERTIFICATE OF ANALYSIS - EPA PROTOCOL GASES ****

Certified Per Traceability Protocol # 2

Procedure # G2

File # P0215B

Certified Accuracy 2 % NBS Traceable

Cylinder Number ALM-2946

Cylinder Pressure 2000 psig

COMPONENT	CERTIFIED CONC.	REFERENCE STD: SRM # (CRM #)	REFERENCE STD: CYLINDER NUMBER	REFERENCE STD: CONC.	GAS ANALYZER: MAKE/MODEL/SERIAL #	GAS ANALYZER: LAST CALIBRATION DATE	ANALYTICAL PRINCIPLE
METHANE	31.96 PPM	1695	CAL-8215	9.840 PPM	BECKMAN	1-18-89	FLAME IONIZATION DETECTOR
GAS SPLITTER USED AT 30% OF TEST GAS CONCENTRATION.		GMIS*	A-3528	99.93 PPM			

BALANCE GAS : AIR

CERTIFIED EPA PROTOCOL

ORIGINAL CERTIFICATION SHEETS IN MAIL

ANALYSIS DATE : 1-18-89

ZERO GAS (mV)	TEST GAS (mV)	RESULTS PPM	REFERENCE GAS CONC.	REFERENCE GAS (mV)	RESULTS PPM
0.00	9.60	9.565	9.840 PPM	9.85	9.815
0.00	9.60	9.565		9.85	9.815
0.00	9.60	9.565		9.85	9.815

CALCULATED RESULTS 9.589
9.589
9.589

AVERAGE : 9.589 PPM

CALIBRATION CURVE 1 st DEGREE

SRM # (CRM #)	CONC. PPM	SPLIT PT (%)	DVM (mV)	FITTED VALUE	PERCENT ERROR
	99.93	100	100.00	99.93	.00
	49.10	49	49.30	49.25	0.31
	25.25	25	25.30	25.26	0.04
1695A	9.840	10	9.85	9.815	-0.25
	0.0000	0	0.00	0.0000	0.00
		0		0.00	0.00
		0		0.00	0.00
1695	9.840	LOW	9.85	9.815	-0.25
N/A	99.93	GMIS*	100.00	99.93	.00

* GMIS - GAS MANUFACTURER'S INTERNAL STANDARD

Analyst : [signature]

Approved By : J. Shapiro

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the Company without extra cost.

Scott Specialty Gases

a division of
Scott Environmental Technology, Inc.

1290 COMBERMERE STREET, TROY, MICHIGAN 48084 (313) 589-2950

Ship from Scott
Date Shipped : ----------
Our Project # : 932423
Your P.O. # : 0675
Page ____ of ____
Expiration Date : 7-18-89

Customer :
SCOTT SPECIALTY GASES
3714 LAPAS DR
HOUSTON, TEXAS 77023

**** CERTIFICATE OF ANALYSIS - EPA PROTOCOL GASES ****

Certified Per Traceability Protocol # 2

Procedure # B2

File # P02157

Certified Accuracy 2 % NBS Traceable

Cylinder Number ALM-2891

Cylinder Pressure 2000 psig

COMPONENT	CERTIFIED CONC.	REFERENCE STD: SRM # (CRM #)	REFERENCE STD: CYLINDER NUMBER	REFERENCE STD: CONC.	GAS ANALYZER: MAKE/MODEL/SERIAL #	GAS ANALYZER: LAST CALIBRATION DATE	GAS ANALYZER: ANALYTICAL PRINCIPLE
METHANE	49.45 PPM	1695	CAL-8215	9.840 PPM	BECKMAN	1-18-89	FLAME IONIZATION DETECTOR
GAS SPLITTER USED AT 20% OF TEST GAS CONCENTRATION.		GMIS†	A-3528	99.93 PPM			

BALANCE GAS : AIR

CERTIFIED EPA PROTOCOL

ORIGINAL CERTIFICATION SHEETS IN MAIL

ANALYSIS DATE : 1-18-89

ZERO GAS (mV)	TEST GAS (mV)	RESULTS PPM	REFERENCE GAS CONC.	REFERENCE GAS (mV)	RESULTS PPM
0.00	9.90	9.865	9.840 PPM	9.85	9.815
0.00	9.90	9.865		9.85	9.815
0.00	9.90	9.865		9.85	9.815

CALCULATED RESULTS 9.890
9.890
9.890

AVERAGE : 9.890 PPM

CALIBRATION CURVE 1 st DEGREE

SRM # (CRM #)	CONC. PPM	SPLIT PT (%)	DVM (mV)	FITTED VALUE	PERCENT ERROR
	99.93	100	100.00	99.93	.00
	49.10	49	49.30	49.25	0.31
	25.25	25	25.30	25.26	0.04
1695A	9.840	10	9.85	9.815	-0.25
	0.0000	0	0.00	0.0000	0.00
		0		0.00	0.00
		0		0.00	0.00
1695	9.840	LOW	9.85	9.815	-0.25
N/A	99.93	GMIS†	100.00	99.93	.00

† GMIS - GAS MANUFACTURER'S INTERNAL STANDARD

Analyst : [signature]

Approved By : J. Shapiro

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the Company without extra cost.

Scott Specialty Gases

a division of
Scott Environmental Technology, Inc.

1290 COMBERMERE STREET, TROY, MICHIGAN 48084 (313) 589-2950

Shipped From : Scott Troy
Date Shipped : ----------
Our Project # : 932423
Your P.O. # : 0675
Page ____ of ____
Expiration Date : 7-18-89

Customer :
SCOTT SPECIALTY GASES
3714 LAPAS DR
HOUSTON, TEXAS 77023

**** CERTIFICATE OF ANALYSIS - EPA PROTOCOL GASES ****

Certified Per Traceability Protocol # 2

Procedure # 82

File # P02156

Certified Accuracy 2 % NBS Traceable

Cylinder Number ALM-2880

Cylinder Pressure 2000 psig

COMPONENT	CERTIFIED CONC.	REFERENCE STD: SRM # (CRM #)	REFERENCE STD: CYLINDER NUMBER	REFERENCE STD: CONC.	GAS ANALYZER: MAKE/MODEL/SERIAL #	GAS ANALYZER: LAST CALIBRATION DATE	ANALYTICAL PRINCIPLE
METHANE	90.88 PPM	1695	CAL-8215	9.840 PPM	BECKMAN	1-18-89	FLAME IONIZATION DETECTOR
GAS SPLITTER USED AT 10% OF TEST GAS CONCENTRATION.		GMIS*	A-3528	99.93 PPM			

BALANCE GAS : AIR

CERTIFIED EPA PROTOCOL

ORIGINAL CERTIFICATION SHEETS IN MAIL

ANALYSIS DATE: 1-18-89

ZERO GAS (mV)	TEST GAS (mV)	RESULTS PPM	REFERENCE GAS CONC.	REFERENCE GAS (mV)	REFERENCE RESULTS PPM
0.00	9.10	9.065	9.840 PPM	9.85	9.815
0.00	9.10	9.065		9.85	9.815
0.00	9.10	9.065		9.85	9.815

CALCULATED RESULTS 9.088
9.088
9.088

AVERAGE : 9.088 PPM

CALIBRATION CURVE 1 st DEGREE

GRM # (CRM #)	CONC. PPM	SPLIT PT (%)	DVM (mV)	FITTED VALUE	PERCENT ERROR
	99.93	100	100.00	99.93	.00
	49.10	49	49.30	49.25	0.31
	25.25	25	25.30	25.26	0.04
1695A	9.840	10	9.85	9.815	-0.25
	0.0000	0	0.00	0.0000	0.00
		0		0.00	0.00
		0		0.00	0.00
1695	9.840	LOW	9.85	9.815	-0.25
N/A	99.93	GMIS*	100.00	99.93	.00

* GMIS - GAS MANUFACTURER'S INTERNAL STANDARD

Analyst : [signature]

Approved By : J. Shapiro

The only liability of this Company for gas which fails to comply with this analysis shall be replacement thereof by the Company without extra cost.