Commonwealth of Pennsylvania
Environmental Resources
October 4, 1990

Subject: Source Test Review

To: Data File
CNG Transmission Corporation
Genesee Township, Potter County

From: Scott M. Darling
Air Pollution Control Engineer
Continuous Emission Monitoring Unit
Division of Technical Services and Monitoring
Bureau of Air Quality Control

Through: Chief, Continuous Emission Monitoring Unit

Chief, Source Testing and Monitoring Section

CNG Transmission Corporation operates two Model KVG-104 1,100 horsepower natural gas-fired reciprocating engines manufactured by Ingersoll-Rand at their compressor station located in Genesee Township. The engines drive compressors which are used to boost natural gas pressures in the pipeline. The exhaust gases exit the engine and enter the atmosphere approximately 20 feet above grade.

On June 13, 1990, personnel from Emission Testing Services, Inc., conducted NO_X, CO and Total Gaseous Non-Methane Organics (TGNMO) testing on the engine designated No. 1. The tests were performed in accordance with a pre-approved test protocol and are acceptable to the Department.

The following data was extracted from the test report:

Run No.	Pollutant	Emission Rate (grams/HP-hr)	Horsepower
1	NO_X	2.112	1046.8
	CO	0.872	
	TGNMO	0.147	
2	NO_X	1.917	1042.0
	CO	0.853	
	TGNMO	0.117	
3	NO_X	1.736	1045.5
	CO	0.856	
	TGNMO	0.162	

Allowable Emission Limitation For all Pollutants: 3.0 grams/HP-hr.

cc: File No. 53-399-004
Doug Lesher, Abatement and Compliance
RSL/EPA
Regional Air Quality Program Manager, Williamsport
Reading File

SMD:taw

H6a

COMMONWEALTH OF PENNSYLVANIA

September 7, 1990

SUBJECT: Stack Test Report Evaluation
CNG Transmission Corporation
State Line Station
Genesee Township, Potter County
Plan Approval No. 53-399-004

12 point traverse!

TO: Rick St. Louis, Chief
Source Testing Unit

FROM: Richard L. Maxwell, Jr.
Chief, Engineering Services
Bureau of Air Quality Control
Williamsport Regional Office

Attached is a copy of a test report submitted for NOx, CO, THC and methane stack tests performed on an 1100 HP natural gas-fired compressor station engine by ETS on June 13, 1990. Would you please have someone on your staff review this report for Chapter 139 conformance, etc.

Also enclosed is a copy of my test observation memo.

The applicable standards for this engine were established pursuant to the Chapter 127 best available technology requirements and are 3.0 grams/HP hour for NOx, 3.0 grams/HP hour for CO, and 3.0 grams/HP hour for non-methane hydrocarbons.

Scott Darling reviewed the pretest plan.

RLM/bls

Enclosures

cc: File
Hawk Run

SD
9/25

COMMONWEALTH OF PENNSYLVANIA

June 19, 1990

SUBJECT: CNG Transmission Corporation
Genesee Township, Potter County
Plan Approval No. 53-399-004

TO: Files

FROM: Richard L. Maxwell, Jr.
Chief, Engineering Services
Bureau of Air Quality Control
Williamsport Regional Office

On June 13, 1990 I observed the performance of three NOx, CO, THC and methane source tests performed on an 1100 HP Ingersoll Rand KVG-104 natural gas-fired engine at CNG's State Line Station. The testing was performed by Emission Testing Services, Inc. John Kinney from CNG's Clarksburg office was present for the first two tests while Charlie Alfred from the station was present for all three. Dave Curtin of Dresser Rand was also on-site during the testing.

The test runs were all one hour in duration. Moisture and velocity tests were being conducted simultaneously with the sampling (in the opposite port from the sampling). The first test started at approximately 11:38 a.m. and ended at approximately 12:44. The second test started at approximately 1:14 and ended at approximately 2:17. The third test started at approximately 2:49 and ended at approximately 3:53.

The ports were located 23.5 inches prior to the stack exit, and 45.5 inches downstream of the nearest upstream obstruction. The stack diameter was 15.75 inches.

The analyzers in use were a Thermo Electron model 10 chemiluminescent analyzer for NOx, a Thermo Electron model 48 analyzer for CO, and a Meloy Labs hydrocarbon gas analyzer for both methane and THCs. Instrument calibration took place prior to the commencement of testing and at the conclusion of each test run. The span gases used were 207.1 and 461.2 ppm for NOx; 60.55, 90.8 and 401.6 ppm for CO; and 89.83, 200 and 501 ppm methane for THC and methane.

CNG personnel were monitoring various engine operating parameters (RPM, HP, etc.) throughout the tests and were additionally determining engine HP independently of the regular monitoring system. I also monitored various operating parameters (data attached).

During the first test, the NOx concentration was 260-300 ppm, the CO concentration was approximately 190 ppm, the THC concentration was approximately 200 ppm, and the methane concentration was 140-145 ppm. As the day went on, the NOx concentration dropped a little, the THC went up a little and the CO stayed relatively constant.

RLM/bls

CNG - STATE LINE

6/17/90

TIME		HP ("FUEL HP")	ENGINE RPM	TURBINE RPM	FUEL MANIFOLD PRESSURE	% TORQUE	AIR MANIFOLD PRESSURE	INTAKE MANIFOLD PRESSURE	SUCTION PRESSURE	DISCHARGE PRESSURE			
11:38		1ST	TEST	STARTS									
11:43		1021	325	21,255	5.9 psig		39.6" Hg	32.4" Hg	504 psi	744 psi			
12:02		1033	329	20,889	6.5				502	734			
12:08			327	21,300	6.14	91	40.3	31.7					
12:26		1024	326	20,950	6.3	92	39.8	31.8	500	726			
12:44		1ST	TEST	OVER									
1:13		1000	329	20,869	6.1				499	720			
1:14		2ND	TEST	STARTS									
1:17			331		6.15	91	39.6	31.2					
1:32		996	329	20,991	6.1	92	39.6	31.6	499	719			
2:11		1009	329		6.1				498	720			
2:12			327		6.14	95	39.4	31.5					
2:17		2ND	TEST	OVER									
2:49		3RD	TEST	STARTS									
2:49			332		6.25	91		32.4					
2:54		1001	326		6.0				499	720			
3:09		995	330	21,245	6.1				498	720			

CNG - STATE LINE

6/13/90

TIME		HP (FUEL HP)	ENGINE RPM	TURBINE RPM	FUEL MANIFOLD PRESSURE	% TORQUE	AIR MANIFOLD PRESSURE	INTAKE MANIFOLD PRESSURE	SUCTION PRESSURE	DISCHARGE PRESSURE			
3:10			329		6.42 psi	93		32" Hg					
3:26		1000	330	21,062	6.2				498 psi	720 psi			
3:27			327		6.41	92		31.9					
3:42		1033	327		6.3				498	720			
3:48			331		6.17	94		31.7					
3:53		1021	328		6.4				499	721			
3:53		TEST	3	OVER									

AUG 24 1990

DER-AIR QUALITY CONTROL
WILLIAMSPORT REGION

Measurement of Air-to-Fuel Ration
On the Prestratified Charge Engine
State Line Station

The engine at State Line Station is naturally aspirated much like an automobile engine. This means that the relatively lower pressure in the power pistons chambers during intake of air and fuel allows the engine to "pull" or naturally aspirate the air and fuel mixture into the power pistons chambers prior to combustion.

However, before entering the power pistons chambers, the air and fuel are mixed to a specified ratio. Separate piping leads the air and fuel to a carburetor similar in principle to that of an automobile. The air and fuel are continuously mixed in the carburetor. Finally, the air and fuel mixture exit the carburetor through a common line and are "pulled" into the power pistons prior to combustion.

The air to fuel ratio is the differential pressure between the air stream entering the carburetor and the air and fuel mixture exiting the carburetor. Near the engine control panel, a gauge shows the differential pressure. The set point of the air and fuel ratio is 7.5%.

Submitted with test report

CNG TRANSMISSION CORPORATION

445 W. MAIN St.

CLARKSBURG, WEST VIRGINIA, 26302

RECEIVED

AUG 24 1990

DER-AIR QUALITY CONTROL
WILLIAMSPORT REGION

OXIDES OF NITROGEN, CARBON MONOXIDE, TOTAL HYDROCARBON, and NON-METHANE HYDROCARBON EMISSION TESTING

on

ENGINE #1
STATE LINE STATION

JUNE 13, 1990

Submitted By :

EMISSION TESTING SERVICES, INC.

POST OFFICE BOX 15075

BATON ROUGE, LOUISIANA 70895

90025D

EMISSION TESTING SERVICES, INC.

POST OFFICE BOX 15075

BATON ROUGE, LOUISIANA 70895

CONFIRMATION OF INFORMATION

EMISSION TEST REPORT

FOR

CNG TRANSMISSION CORPORATION

445 W. MAIN St.

CLARKSBURG, WEST VIRGINIA, 26302

OXIDES OF NITROGEN, CARBON MONOXIDE,
TOTAL HYDROCARBON, and NON-METHANE HYDROCARBON
EMISSION TESTING
on

ENGINE #1
STATE LINE STATION

JUNE 13, 1990

I certify that I have personally examined and am familiar with the information submitted herein, and based on my inquiries of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate, and complete.

Jon Kinney
CNG Transmission Corp.
Environmental Manager

John Angellez
Emission Testing Services
Project Leader

Barry Gipson
Emission Testing Services
Manager

OXIDES OF NITROGEN, CARBON MONOXIDE,
TOTAL HYDROCARBON, and NON-METHANE HYDROCARBON
EMISSION TESTING
on

ENGINE #1
STATE LINE STATION

JUNE 13, 1990

for

CNG TRANSMISSION CORPORATION

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I. INTRODUCTION

Emission Testing Services, Inc. was contracted by CNG Transmission Corporation to conduct emission testing on Engine #1, located at the State Line Station near Genesee, Pennsylvania. Emissions of carbon monoxide, oxides of nitrogen, total and non-methane hydrocarbons were determined in order to demonstrate compliance within permit limits. Limits were set forth by permit number 53-399-004 issued by the Commonwealth of Pennsylvania, Department of Environmental Resource, Bureau of Air Quality Control.

Engine # 1 is a 1,100 horsepower natural gas fired reciprocating engine manufactured by Ingersoll-Rand, model KVG-104. The engine drives a compressor used to boost natural gas pressures in the pipeline.

Emissions were determined using EPA Method 7E for oxides of nitrogen, EPA Method 10 for carbon monoxide, and EPA Method 25A for total and non-methane hydrocarbons. EPA Methods 1-4 were used to determine the number and location of traverse points and the stack gas moisture, velocity, and dry molecular weight.

Testing was conducted by the testing team consisting of John Angelloz, Chuck Dowling, and Kevin Thibodeaux. Jon Kinney represented CNG Transmission Corp. and coordinated testing with facility operations. Richard Maxwell represented the Pennsylvania Bureau of Air Quality Control during the test.

Emissions were determined on June 13, 1990 during three test runs while the engine was operating at maximum load conditions. During testing, CNG personnel recorded engine operating data and collected fuel gas samples for analysis of sulfur content.

II. SUMMARY

Data collected on engine #1 emissions on June 13, 1990 are presented on the following page. All data have been reported as measured.

CNG TRANSMISSION CORPORATION
STATE LINE STATION
ENGINE #1

PARAMETER	PERMIT LIMIT	RUN 1	RUN 2	RUN 3	AVG.
DATE		6-13-90	6-13-90	6-13-90	
TIME		1138-1244	1314-1417	1449-1553	
CARBON MONOXIDE					
PPM		191.58	192.98	195.23	193.26
lb/hr		2.012	1.959	1.973	1.981
g/hr		912.6	888.6	895.0	898.6
g/hp-hr	3.00	0.872	0.853	0.856	0.860
OXIDES OF NITROGEN					
PPM		282.57	264.10	241.01	262.56
lb/hr		4.875	4.403	4.001	4.426
g/hr		2211.3	1997.2	1814.9	2007.6
g/hp-hr	3.00	2.112	1.917	1.736	1.922
TOTAL HYDROCARBONS					
PPM		196.26	196.24	215.92	202.81
lb/hr		1.181	1.141	1.250	1.191
g/hr		535.7	517.6	567.0	540.2
g/hp-hr		0.512	0.497	0.542	0.517
NON-METHANE HYDROCARBONS					
PPM		56.36	46.11	64.66	55.71
lb/hr		0.339	0.268	0.374	0.327
g/hr		153.8	121.6	169.6	148.3
g/hp-hr	3.00	0.147	0.117	0.162	0.142
OXYGEN, test monitor, %		6.47	6.42	6.36	6.42
ENGINE					
Horsepower		1046.8	1042.0	1045.5	1044.8
Speed, rpm		328	328	329	328
STACK GAS DATA					
TEMPERATURE, F		914	910	912	912
MOISTURE, %		11.53	12.00	12.51	12.01
VELOCITY, ft/ sec		94.18	91.33	91.64	92.38
FLOW RATE, ACFM		9645.7	7414.2	7439.2	8166.4
, DSCFM		2406.6	2325.8	2315.7	2349.4

III. PROCEDURE

Emissions were determined using EPA Methods found in Appendix A, Part 60, Title 40 of the Code of Federal Regulations. A brief description of each method used follows.

METHOD 1: SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

Engine #1 had a stack diameter of 15.75 in. Samples and measurements were collected at a point 1.49 stack diameters upstream and 2.89 stack diameters downstream from the nearest flow disturbances. Under these conditions the method required 12 traverse points. During sampling the stack cross-section at the sampling point was divided into 12 equal areas with the sampling point located in the centroid of each area.

METHOD 2: DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

The average gas velocity in the stack was determined from the gas molecular weight, moisture content and the average velocity head measured using a type "S" pitot tube. Dry volumetric flow rate was determined from the velocity and stack diameter.

METHOD 3: GAS ANALYSIS FOR CARBON DIOXIDE, OXYGEN, EXCESS AIR, AND DRY MOLECULAR WEIGHT

The dry molecular weight of the stack gas was determined using an Orsat analyzer. The Orsat measured the concentration of oxygen, carbon monoxide and carbon dioxide. The remaining gas components were assumed to be nitrogen. A gas sample was extracted from the centroid of the stack using a stainless steel probe fitted with a particulate filter. The probe, sample lines, and orsat were purged sufficiently to obtain a representative grab sample for analysis.

METHOD 3A: DETERMINATION OF OXYGEN CONCENTRATIONS IN EMISSIONS FROM STATIONARY SOURCES. (INSTRUMENTAL ANALYZER PROCEDURE)

A gas sample was continuously extracted from the stack using a heated probe and sample line. The sample was transferred to a oxygen analyzer for analysis of oxygen concentration. Analyzer output was continuously recorded by a computer data acquisition system. Results from the oxygen monitor were used for reference purposes only and were not used to determine stack gas molecular weight.

METHOD 4: DETERMINATION OF MOISTURE CONTENT IN STACK GASES

A gas sample was extracted from the stack using a heated glass probe fitted with a particulate filter. The sample gas passed from the probe, through a series of four impingers immersed in an ice bath. The first two impingers contained measured volumes of water, the third was empty, and the fourth contained a known weight of silica gel. Any water vapor in the gas stream was condensed and trapped in the impingers. Moisture was determined gravimetrically.

METHOD 7E: DETERMINATION OF NITROGEN OXIDES EMISSIONS FROM STATIONARY SOURCES

A gas sample was continuously extracted from the stack at a centroidal sampling point. The sample was transferred through a heated sample line to continuous chemiluminescence analyzer for the determination of oxides of nitrogen concentration.

METHOD 10: DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

A gas sample was continuously extracted from the stack at a centroidal sampling point. The sample was transferred through a heated sample line to a continuous nondispersive infrared analyzer for the determination of carbon monoxide concentration

METHOD 25A: DETERMINATION OF TOTAL GASEOUS ORGANIC CONCENTRATION USING A FLAME IONIZATION ANALYZER.

A gas sample was continuously extracted from the stack at a centroidal sampling point. The sample was transferred through a heated sample line to a continuous analyzer equipped with a flame ionization detector for the analysis of total hydrocarbon concentration. Methane concentration was determined by removing all hydrocarbons from the sample with the exception of methane.

IV. ANALYTICAL TECHNIQUE

All sample analysis were conducted following EPA methodology. A brief description follows for each method employed.

METHOD 7E: DETERMINATION OF NITROGEN OXIDES EMISSIONS FROM STATIONARY SOURCES

All samples collected were analyzed using a continuous chemiluminescence analyzer. The analyzer was calibrated using gas standards prepared by EPA protocol number 1, traceable to NBS standards.

METHOD 10: DETERMINATION OF CARBON MONOXIDE EMISSIONS FROM STATIONARY SOURCES

All samples collected were analyzed using a continuous nondispersive infrared analyzer. The analyzer was calibrated using gas standards prepared by EPA protocol number 1, traceable to NBS standards.

METHOD 25A: DETERMINATION OF TOTAL GASEOUS ORGANIC CONCENTRATION USING A FLAME IONIZATION ANALYZER.

Total hydrocarbons were determined using a flame ionization analyzer. The analyzer was calibrated using methane standards prepared by EPA protocol number 1, traceable to NBS standards. Non-methane hydrocarbon results were obtained by subtraction of the methane concentration from the total hydrocarbon concentration.

V. CHAIN of CUSTODY

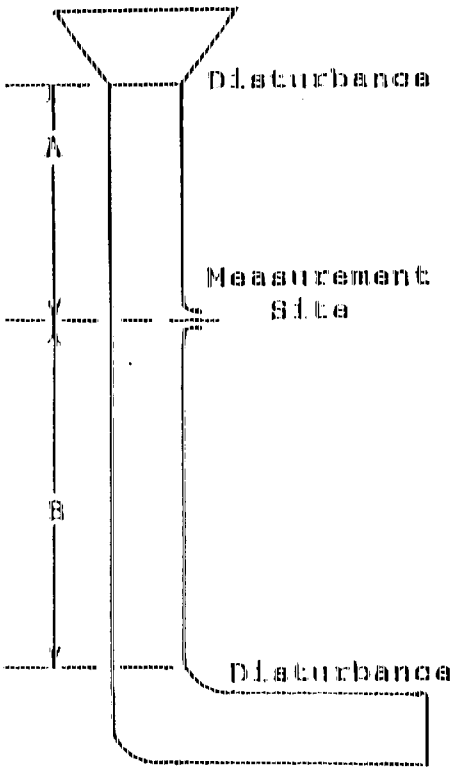
Chain of custody procedures are initiated for all samples transported to the laboratory for analysis. Since all emissions analysis were conducted in the field using continuous monitors, no chain of custody was necessary.

VI. TEST DATA & CALCULATIONS

All emission test field data, unit operations data, and laboratory analytical data are contained in this section along with the associated data reduction calculations.

Data from the field data sheets were manually input into a computer for data processing and calculations. Integrity of data input is maintained by using a double entry system. The computer performed all calculations and produced the calculations and results summary pages. Input data accuracy were further verified by comparison of raw field data to the computer data printed on the summary pages. Computer program integrity and calculations verification are validated by processing a known set of data. Further controls on the computer program are conducted by comparison of manual spot calculations of the raw data input to computer calculations results.

Traverse Point Layout



Client CNG - STATE LINE

Date 061290

Unit Tested ENGINE #1

Location GENESEE, PA

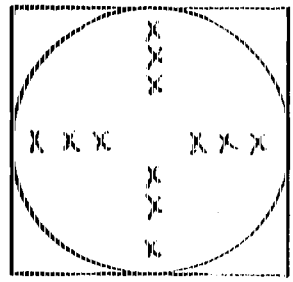
Upstream Distance (A) 23.5"

Downstream Distance (B) 45.5"

Inside Diameter 15.75"

Coupling Length 19.25"

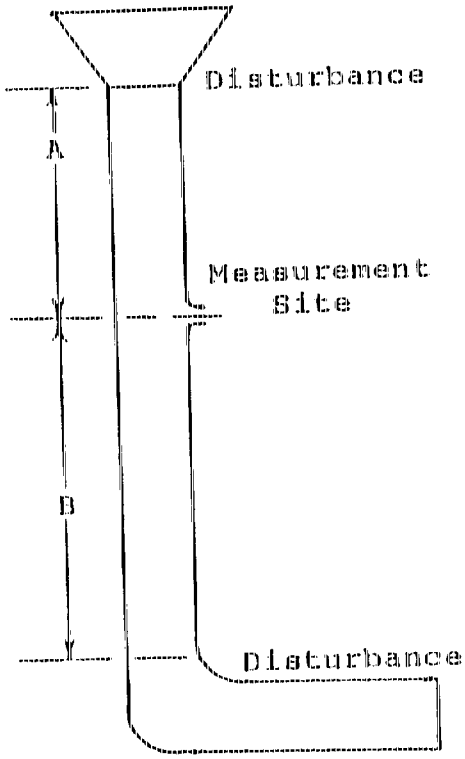
Coupling Type 2" FEMALE SCREW-ON



Cross Section Schematic of Stack

Traverse Point	Distance % of Diameter		Stack Diameter		Coupling Length		Traverse Points
1	0.044	x	15.75	+	19.25	=	19.943
2	0.146						21.549
3	0.296						23.912
4	0.704						30.338
5	0.854						32.700
6	0.956		15.75		19.25		34.307
7							
8							
9							
10							
11							

Traverse Point Layout



Client CNG - STATE LINE

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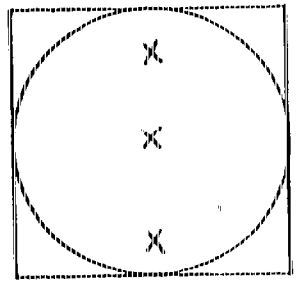
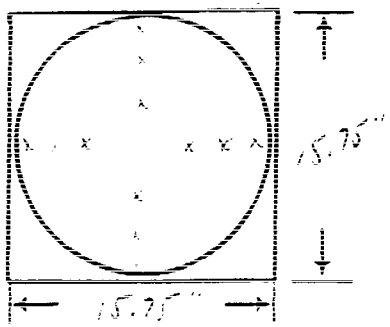


Cross Section Schematic of Stack

Traverse Point	Distance % of Diameter		Stack Diameter		Coupling Length		Traverse Points
1	.167	x	15.75	+	19.25	=	21.880
2	.500		15.75		19.25		27.125
3	.833		15.75		19.25		32.369
4							
5							
6							
7							
8							
9							
10							
11							
12	* - TRAVERSE LAYOUT FOR MONITOR PROBE						

CROSS SECTIONAL SCHEMATIC OF STACK TRAVERSE POINT LAYOUT



E T S FIELD DATA, METHOD(S) 1-5

PLANT C&G - Stackline
DATE 06/3/90
LOCATION Conshohocken PA
OPERATOR K. Tibb / Leavel
STACK NO. 1 - Engine
RUN NO. 1

SAMPLE BOX NO. KA
METER BOX NO. 981
AMBIENT TEMPERATURE n/a
BAROMETRIC PRESSURE 27.74
FILTER TARE wt mg n/a
NOZZLE DIAMETER, in. n/a

STACK DIAMETER, in. 15.75"
PITOT TUBE NO. P-6-0
PITOT FACTOR 0.840
METER Δ Hg 1.916
D.G.M.C. FACTOR 0.9815
K FACTOR n/a

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in.H2O)	STACK TEMP (Ts), °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD (√ΔPs)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H2O ACTUAL	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in. H2O DESIRED	GAS SAMPLE VOLUME (Vm), ft3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tmin), °F	GAS SAMPLE TEMPERATURE AT DRY GAS METER OUTLET (Tmout), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F	PUMP VACUUM in. Hg gauge
1	1139	-0.515	899	.755	.869	1.3	1.5	990.600	82	81	271	67	19.1
2			889	.925	.962								
3	1209	~~Ho~~	915	.950	.975	1.2	1.5	009.421	89	85	273	68	19.1
4			923	1.050	1.025								
5	1211	~~Ho~~	924	1.100	1.049	1.4	1.5	009.421	85	85	270	65	19.0
6			924	1.150	1.072								
7	1241	~~Ho~~	900	.870	.933	1.3	1.5	029.027	94	91	269	65	19.9
8			910	.895	.946								
9			918	.910	.954								
10			921	1.050	1.025								
11			922	1.050	1.025								
12			923	1.050	1.025								
AVERAGE	60 min	-0.515	914.0		.9883	1.300		38.427		86.5			

VOLUME OF LIQUID WATER COLLECTED		IMPINGER WEIGHTS			
K.T.	FINAL	635.6	533.4	451.9	616.4
C.D.	INITIAL	573.4	518.2	447.8	604.9
WEIGHT COLLECTED		62.2	15.2	4.1	24.5
TOTAL WEIGHT					

ORSAT MEASUREMENT

	CO_2	O_2	CO	N_2
1	7.5	7.0	0.0	85.5
2				
3				
4				

COMMENTS: No Cyclonic Flow Present.

PRE-LEAK CHECK GOOD @ 15.0" Hg = 0.005 CFM

POST-LEAK CHECK GOOD @ Leak check

WET = 78.0 °F

DRY = 82.0 °F

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1

DETERMINATION OF STACK GAS MOISTURE CONTENT

Bws - Moisture fraction content
dH - Pressure differential across meter orifice, in H2O
Mw - Molecular weight of water, 18.0 lb/ lb mole
Pb - Barometric pressure at meter, in-Hg
Pst - Standard absolute pressure, 29.92 in-Hg
R - Ideal gas constant, 21.85 in-Hg ft3/ lb-mole deg R
Tm - Absolute temperature at meter, deg R
Tst - Standard absolute temperature, 528 deg R
Vm - Dry gas volume measured by meter, DCF
Vmstd- Dry gas volume at standard conditions, DSCF
Vw - Volume of water vapor collected, SCF
Wwc - Weight of water vapor collected, lb
I1w, I2w, I3w, weight of water condensed by impingers, g
SGw, weight of water collected by silica gel, g
Y - Dry gas meter calibration factor

$$Wwc = (I1w + I2w + I3w + SGw) / (453.6\ g/lb)$$

$$= (62.2 + 15.2 + 4.1 + 12.1) / (453.6) = .20635$$

$$Vw = \frac{Wwc\ R\ Tst}{Pst\ Mw} = \frac{(.20635)(21.85)(528)}{(29.92)(18.0)} = 4.42032$$

$$Vmstd = Vm\ Y \frac{(Pb + dH/13.6)}{Pst} \frac{Tst}{Tm}$$

$$= (38.427)(.9818) \frac{(27.740 + 1.3000/13.6)}{(29.92)} \frac{(528)}{(547.)}$$

$$= 33.91112$$

$$Bws = \frac{Vw}{Vw + Vmstd} = \frac{(4.42032)}{(4.42032 + 33.91112)} = .1153$$

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1

DETERMINATION OF DRY MOLECULAR WEIGHT

Md - Dry molecular weight, lb/ lb-mole
%CO2 - Percent CO2 by volume (dry basis)
%O2 - Percent O2 by volume (dry basis)
%CO - Percent CO by volume (dry basis)
%N2 - Percent N2 by volume (dry basis)
0.280 - Molecular weight of N2 or CO, divided by 100
0.320 - Molecular weight of O2, divided by 100
0.440 - Molecular weight of CO2, divided by 100

Md = 0.440(%CO2) + 0.320(%O2) + 0.280(%N2 + %CO)

Md = 0.440(7.5) + 0.320(7.0) + 0.280(85.5 + .0)

= 29.480

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1

DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

A - Cross-sectional area of stack, ft2
Bws - Moisture fraction of stack gas
Cp - Pitot tube coefficient
dP - Avg., square root of velocity head, (in-H2O)**0.5
Kp - Pitot tube constant,
ft/sec (lb in-Hg/ lb-mole deg R in H20)**0.5
Md - Molecular weight of stack gas, dry basis, lb/ lb-mole
Ms - Molecular weight of stack gas, wet basis, lb/ lb-mole
Pbar - Barometric pressure at measurement site, in-Hg
Pg - Static pressure of the stack gas, in H2O
Ps - Absolute stack gas pressure, in-Hg
Pstd - Standard absolute pressure, 29.92 in-Hg
Acf - Actual stack gas flow rate, ACF/min
Qsd - Dry volumetric stack gas flow rate
standard conditions, DSCF/Hr
Ts - Average stack gas temperature, deg R
Tstd - Standard absolute temperature, 528 deg R
Vs - Average stack gas velocity, ft/sec
3600 - Conversion factor, sec to Hr
18.0 - Molecular weight of water, lb/lb-mole

$$Ms = Md\ (1 - Bws) + 18.0\ (Bws) =$$

$$= (29.480)(1 - .1153) + (18.0)(.1153) = 28.156$$

$$Vs = Kp\ Cp\ dP \left(\frac{Ts}{Ps\ Ms}\right)^{0.5} =$$

$$= (85.49)(.8400)(.9882)\left(\frac{1374.}{[27.702][28.156]}\right)^{0.5} = 94.1839$$

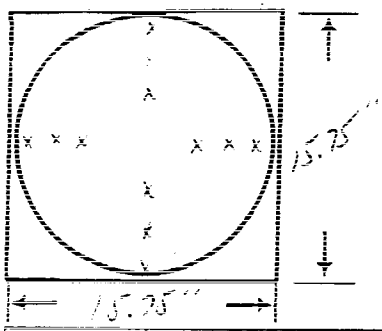
$$Acf = (60)(Vs)(A) = (60)(94.1839)(1.3530) = 7645.7$$

$$Qsd = 3600\ (1 - Bws)\ Vs\ A\ \frac{Tstd}{Ts}\ \frac{Ps}{Pstd} =$$

$$Qsd = 3600(1 - .1153)(94.1839)(1.3530)\frac{(528)(27.702)}{(1374.)(29.92)}$$

= 144395.3 DSCFH
= 2406.6 DSCFM

CROSS SECTIONAL SCHEMATIC OF STACK
TRAVERSE POINT LAYOUT



E T S FIELD DATA, METHOD(S) 1-4

PLANT CWC - State College
DATE 06 13 90
LOCATION Gene Sep PA.
OPERATOR K. Th. Leave
STACK NO. 1 - Engine
RUN NO. 2

SAMPLE BOX NO. BL
METER BOX NO. 481
AMBIENT TEMPERATURE n/a
BAROMETRIC PRESSURE 27.72
FILTER TARE wt mg n/a
NOZZLE DIAMETER, in. n/a

STACK DIAMETER, in. 15.75"
PITOT TUBE NO. P-6-0
PITOT FACTOR 0.840
METER Δ Hø 1.916
D.G.M.C. FACTOR 0.9818
K FACTOR n/a

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in.H₂O)	STACK TEMP (Ts), °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD (√ΔPs)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in.. H₂O ACTUAL	DESIRED	GAS SAMPLE VOLUME (Vm), ft³	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tmin), °F	OUTLET (Tmout), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F	PUMP VACUUM in. Hg gauge
1	1315	-0.630	896	.935	.914	1.25	1.50	029.200	96	97	240	61	19.2
2			900	.885	.941								
3	1345	off	915	.885	.941	1.20	1.50	048.336	95	93	271	60	19.1
4			919	.955	.972								
5	1347	on	922	.965	.982	1.25	1.50	048.336	94	92	269	62	19.2
6			919	.980	.990								
7	1417	off	867	.800	.894	1.20	1.50	066.145	96	94	294	58	19.2
8			899	.875	.935								
9			912	.940	.969								
10			919	.930	.964								
11			920	.960	.980								
12			921	1.000	1.000								
					.9574								
AVERAGE	60 min	-0.630	909.92		.9568	1.225		36.945	94.62				

VOLUME OF LIQUID WATER COLLECTED		IMPINGER WEIGHTS			
K. T.	FINAL	626.4	536.0	441.5	575.5
C.D.	INITIAL	620.2	528.4	437.0	561.4
WEIGHT COLLECTED		6.2	7.6	4.5	14.1
TOTAL WEIGHT					

92.7

ORSAT MEASUREMENT

	CO_2	O_2	CO	N_2
1	7.2	6.7	0.0	86.1
2				
3				
4				

COMMENTS:

PRE-LEAK CHECK GOOD @ 15.0" Hg. - .006 CFM
POST-LEAK CHECK GOOD @ 20.0" Hg - .003 CFM

WET = 70°F
DRY = 82°F

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 2

DETERMINATION OF STACK GAS MOISTURE CONTENT

Bws - Moisture fraction content
dH - Pressure differential across meter orifice, in H2O
Mw - Molecular weight of water, 18.0 lb/ lb mole
Pb - Barometric pressure at meter, in-Hg
Pst - Standard absolute pressure, 29.92 in-Hg
R - Ideal gas constant, 21.85 in-Hg ft3/ lb-mole deg R
Tm - Absolute temperature at meter, deg R
Tst - Standard absolute temperature, 528 deg R
Vm - Dry gas volume measured by meter, DCF
Vmstd- Dry gas volume at standard conditions, DSCF
Vw - Volume of water vapor collected, SCF
Wwc - Weight of water vapor collected, lb
I1w, I2w, I3w, weight of water condensed by impingers, g
SGw, weight of water collected by silica gel, g
Y - Dry gas meter calibration factor

$$Wwc = (I1w + I2w + I3w + SGw) / (453.6\ g/lb)$$

$$= (66.2 + 7.9 + 4.5 + 14.1) / (453.6) = .20436$$

$$Vw = \frac{Wwc\ R\ Tst}{Pst\ Mw} = \frac{(.20436)(21.85)(528)}{(29.92)(18.0)} = 4.37782$$

$$Vmstd = Vm\ Y \frac{(Pb + dH/13.6)}{Pst} \frac{Tst}{Tm}$$

$$= (36.945)(.9818) \frac{(27.720 + 1.2250/13.6)}{(29.92)} \frac{(528)}{(555.)}$$

$$= 32.09621$$

$$Bws = \frac{Vw}{Vw + Vmstd} = \frac{(4.37782)}{(4.37782 + 32.09621)} = .1200$$

Emission Testing Services, Inc.
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504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 2

DETERMINATION OF DRY MOLECULAR WEIGHT

Md - Dry molecular weight, lb/ lb-mole
%CO2 - Percent CO2 by volume (dry basis)
%O2 - Percent O2 by volume (dry basis)
%CO - Percent CO by volume (dry basis)
%N2 - Percent N2 by volume (dry basis)
0.280 - Molecular weight of N2 or CO, divided by 100
0.320 - Molecular weight of O2, divided by 100
0.440 - Molecular weight of CO2, divided by 100

$$Md = 0.440(\%CO2) + 0.320(\%O2) + 0.280(\%N2 + \%CO)$$

$$Md = 0.440(7.2) + 0.320(6.7) + 0.280(86.1 + .0)$$

$$= 29.420$$

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 2

DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

A - Cross-sectional area of stack, ft2
Bws - Moisture fraction of stack gas
Cp - Pitot tube coefficient
dP - Avg., square root of velocity head, (in-H2O)**0.5
Kp - Pitot tube constant,
ft/sec (lb in-Hg/ lb-mole deg R in H2O)**0.5
Md - Molecular weight of stack gas, dry basis, lb/ lb-mole
Ms - Molecular weight of stack gas, wet basis, lb/ lb-mole
Pbar - Barometric pressure at measurement site, in-Hg
Pg - Static pressure of the stack gas, in H2O
Ps - Absolute stack gas pressure, in-Hg
Pstd - Standard absolute pressure, 29.92 in-Hg
Acf - Actual stack gas flow rate, ACF/min
Qsd - Dry volumetric stack gas flow rate
standard conditions, DSCF/Hr
Ts - Average stack gas temperature, deg R
Tstd - Standard absolute temperature, 528 deg R
Vs - Average stack gas velocity, ft/sec
3600 - Conversion factor, sec to Hr
18.0 - Molecular weight of water, lb/lb-mole

$$Ms = Md\ (1 - Bws) + 18.0\ (Bws) =$$

$$= (29.420)(1 - .1200) + (18.0)(.1200) = 28.049$$

$$Vs = Kp\ Cp\ dP \left(\frac{Ts}{Ps\ Ms}\right)^{0.5} =$$

$$= (85.49)(.8400)(.9574)\left(\frac{1370.}{[27.674][28.049]}\right)^{0.5} = 91.3321$$

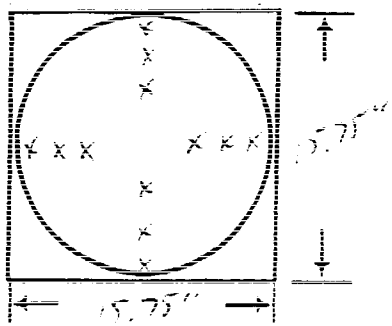
$$Acf = (60)(Vs)(A) = (60)(91.3321)(1.3530) = 7414.2$$

$$Qsd = 3600\ (1 - Bws)\ Vs\ A\ \frac{Tstd}{Ts}\ \frac{Ps}{Pstd} =$$

$$Qsd = 3600(1 - .1200)(91.3321)(1.3530)\frac{(528)(27.674)}{(1370.)(29.92)}$$

= 139549.8 DSCFH
= 2325.8 DSCFM

CROSS SECTIONAL SCHEMATIC OF STACK TRAVERSE POINT LAYOUT



E T S FIELD DATA, METHOD(S) 1-4

PLANT CWG - Stablinc
DATE 061390
LOCATION Genesee, PA
OPERATOR K. Thibodeaux
STACK NO. 1 - Engine
RUN NO. 3

SAMPLE BOX NO. KA
METER BOX NO. 981
AMBIENT TEMPERATURE 4/a
BAROMETRIC PRESSURE 27.68
FILTER TARE wt mg 4/a
NOZZLE DIAMETER, in. 4/a

STACK DIAMETER, in. 15.75"
PITOT TUBE NO. P-6-2
PITOT FACTOR 0.840
METER Δ He 1.916
D.G.M.C. FACTOR 0.9818
K FACTOR 4/a

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (in.H2O)	STACK TEMP (Ts), °F	VELOCITY HEAD (ΔPs)	VELOCITY HEAD (√ΔPs)	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H2O ACTUAL	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH) in., H2O DESIRED	GAS SAMPLE VOLUME (Vm), ft3	GAS SAMPLE TEMPERATURE AT DRY GAS METER INLET (Tmin), °F	GAS SAMPLE TEMPERATURE AT DRY GAS METER OUTLET (Tmout), °F	SAMPLE BOX TEMPERATURE °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER F	PUMP VACUUM in. Hg gauge
1	1447	-0.350	890	.810	.900	1.30	1.50	066.400	97	97	254	65	18.9
2			893	.875	.935								
3	1517	dito	912	.920	.959	1.25	1.50	085.913	97	94	264	60	19.0
4		"	922	.930	.964								
5	1520	dito	920	1.000	1.000	1.40	1.50	085.913	93	94	248	59	18.8
6			921	1.050	1.025								
7	1550	dito	893	.940	.970	1.35	1.50	106.214	98	96	272	68	18.9
8			915	1.855	.925								
9			918	.905	.951								
10			918	.930	.964								
11			913	.965	.982								
12			919	.960	.980								
AVERAGE	60 min	-0.350	911.58		.9584	1.325		39.814	95.75				

VOLUME OF LIQUID WATER COLLECTED	IMPINGER WEIGHTS			
FINAL	712.6	543.5	456.3	610.9
INITIAL	635.6	533.4	451.9	597.0
WEIGHT COLLECTED	77.0	10.1	3.4	13.9
TOTAL WEIGHT				

104.4

ORSAT MEASUREMENT

	CO2	O2	CO	N2
1	7.1	6.9	0.0	86.0
2				
3				
4				

COMMENTS:

PRE-LEAK CHECK GOOD @ 15" Hg - .002 CFM
POST-LEAK CHECK GOOD @ 20.5" Hg - .005 CFM

wet = 74°F
Dry = 83°F

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 3

DETERMINATION OF STACK GAS MOISTURE CONTENT

Bws - Moisture fraction content
dH - Pressure differential across meter orifice, in H2O
Mw - Molecular weight of water, 18.0 lb/ lb mole
Pb - Barometric pressure at meter, in-Hg
Pst - Standard absolute pressure, 29.92 in-Hg
R - Ideal gas constant, 21.85 in-Hg ft3/ lb-mole deg R
Tm - Absolute temperature at meter, deg R
Tst - Standard absolute temperature, 528 deg R
Vm - Dry gas volume measured by meter, DCF
Vmstd- Dry gas volume at standard conditions, DSCF
Vw - Volume of water vapor collected, SCF
Wwc - Weight of water vapor collected, lb
I1w, I2w, I3w, weight of water condensed by impingers, g
SGw, weight of water collected by silica gel, g
Y - Dry gas meter calibration factor

$$Wwc = (I1w + I2w + I3w + SGw) / (453.6\ g/lb)$$

$$= (77.0 + 10.1 + 3.4 + 13.9) / (453.6) = .23016$$

$$Vw = \frac{Wwc\ R\ Tst}{Pst\ Mw} = \frac{(.23016)(21.85)(528)}{(29.92)(18.0)} = 4.93036$$

$$Vmstd = Vm\ Y \frac{(Pb + dH/13.6)}{Pst} \frac{Tst}{Tm}$$

$$= (39.814)(.9818) \frac{(27.680 + 1.3250/13.6)}{(29.92)} \frac{(528)}{(556.)}$$

$$= 34.47813$$

$$Bws = \frac{Vw}{Vw + Vmstd} = \frac{(4.93036)}{(4.93036 + 34.47813)} = .1251$$

Emission Testing Services, Inc.
P.O. Box 15075
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504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 3

DETERMINATION OF DRY MOLECULAR WEIGHT

Md	- Dry molecular weight, lb/ lb-mole
%CO2	- Percent CO2 by volume (dry basis)
%O2	- Percent O2 by volume (dry basis)
%CO	- Percent CO by volume (dry basis)
%N2	- Percent N2 by volume (dry basis)
0.280	- Molecular weight of N2 or CO, divided by 100
0.320	- Molecular weight of O2, divided by 100
0.440	- Molecular weight of CO2, divided by 100

Md = 0.440(%CO2) + 0.320(%O2) + 0.280(%N2 + %CO)

Md = 0.440(7.1) + 0.320(6.9) + 0.280(86.0 + .0)

= 29.412

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 3

DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

A - Cross-sectional area of stack, ft2
Bws - Moisture fraction of stack gas
Cp - Pitot tube coefficient
dP - Avg., square root of velocity head, (in-H2O)**0.5
Kp - Pitot tube constant,
ft/sec (lb in-Hg/ lb-mole deg R in H2O)**0.5
Md - Molecular weight of stack gas, dry basis, lb/ lb-mole
Ms - Molecular weight of stack gas, wet basis, lb/ lb-mole
Pbar - Barometric pressure at measurement site, in-Hg
Pg - Static pressure of the stack gas, in H2O
Ps - Absolute stack gas pressure, in-Hg
Pstd - Standard absolute pressure, 29.92 in-Hg
Acf - Actual stack gas flow rate, ACF/min
Qsd - Dry volumetric stack gas flow rate
standard conditions, DSCF/Hr
Ts - Average stack gas temperature, deg R
Tstd - Standard absolute temperature, 528 deg R
Vs - Average stack gas velocity, ft/sec
3600 - Conversion factor, sec to Hr
18.0 - Molecular weight of water, lb/lb-mole

$$Ms = Md\ (1 - Bws) + 18.0\ (Bws) =$$

$$= (29.412)(1 - .1251) + (18.0)(.1251) = 27.984$$

$$Vs = Kp\ Cp\ dP \left(\frac{Ts}{Ps\ Ms}\right)^{0.5} =$$

$$= (85.49)(.8400)(.9586)\left(\frac{1372.}{[27.654][27.984]}\right)^{0.5} = 91.6398$$

$$Acf = (60)(Vs)(A) = (60)(91.6398)(1.3530) = 7439.2$$

$$Qsd = 3600\ (1 - Bws)\ Vs\ A\ \frac{Tstd}{Ts}\ \frac{Ps}{Pstd} =$$

$$Qsd = 3600(1 - .1251)(91.6398)(1.3530)\frac{(528)(27.654)}{(1372.)(29.92)}$$

= 138944.3 DSCFH
= 2315.7 DSCFM

Emission Testing Services, Inc.
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Baton Rouge, LA 70895
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Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1 - 3

OXIDES OF NITROGEN EMISSION RATE

ENOX - Oxides of nitrogen emission rate as NO2, lb/hr
F - NO2 conv. factor, 1.1948 X 10-7 (lb/ft3)/(PPM)
NOXmsc - NOX concentration as measured, PPM
Qsd - Dry volumetric stack gas flow rate, DSCF/hr

ENOX = (NOXmsc)(F)(Qsd)

---------- RUN 1 ----------

ENOX = (282.57)(1.1948 X 10-7)(144395.3) = 4.875

---------- RUN 2 ----------

ENOX = (264.10)(1.1948 X 10-7)(139549.8) = 4.403

---------- RUN 3 ----------

ENOX = (241.01)(1.1948 X 10-7)(138944.3) = 4.001

Emission Testing Services, Inc.
P.O. Box 15075
Baton Rouge, LA 70895
504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1 - 3

CARBON MONOXIDE EMISSION RATE

ECO - Carbon Monoxide Emission Rate - Lb/Hr
F - CO conv. factor, 7.2727 X 10-8 (lb/ft3)/(PPM)
COms - Concentration of carbon monoxide - PPM
Qsd - Dry volumetric stack gas flow rate, DSCF/Hr

ECO = (COms)(F)(Qsd)

RUN 1

ECO = (191.58)(7.2727 X 10-8)(144395.3) = 2.012

RUN 2

ECO = (192.98)(7.2727 X 10-8)(139549.8) = 1.959

RUN 3

ECO = (195.23)(7.2727 X 10-8)(138944.3) = 1.973

Emission Testing Services, Inc.
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504-925-8405

Client : CNG TRANS.
Source : STATE LINE ENG. 1
Testing Date : 6-13-90
Run : 1 - 3

TOTAL HYDROCARBONS EMISSION RATE and NON-METHANE HYDROCARBON EMISSION RATE

ETHC - Total hydrocarbons emission rate as CH4, lb/hr
ENMHC - Non-methane hydrocarbon emission rate as CH4, lb/hr
F - CH4 conv. factor, 4.1670 X 10-8 lb/ft3 / PPM
CH4ms - CH4 concentration as measured, PPM
NMHCc - NMHC concentration, by subtraction, PPM
THCms - THC concentration as measured, PPM
Qsd - Dry volumetric stack gas flow rate, DSCF/hr

NMHCc = (THCms) - (CH4ms)

ETHC = (THCms)(F)(Qsd)

ENMHC = (NMHCc)(F)(Qsd)

RUN 1

NMHCc = (196.26) - (139.89) = 56.36

ETHC = (196.26)(4.1670 X 10-8)(144395.3) = 1.181

ENMHC = (56.36)(4.1670 X 10-8)(144395.3) = .339

RUN 2

NMHCc = (196.24) - (150.13) = 46.11

ETHC = (196.24)(4.1670 X 10-8)(139549.8) = 1.141

ENMHC = (46.11)(4.1670 X 10-8)(139549.8) = .268

RUN 3

NMHCc = (215.92) - (151.26) = 64.66

ETHC = (215.92)(4.1670 X 10-8)(138944.3) = 1.250

ENMHC = (64.66)(4.1670 X 10-8)(138944.3) = .374

Test analyzer response, Method 3A, 7E, 10, and 25A was recorded by a computer data acquisition system. One minute average data were printed as recorded and served as a hardcopy record of the test data. Presented on the following pages are the computer print outs of the test data.

Each test analyzer is calibrated before and after each test run by challenging the analyzer with a set of certified calibration gases. Analyzer response is recorded by a computer data acquisition system. Calibration data sheets are manually completed as the calibrations are performed serving as hardcopy records of the calibration. Calibration results are taken from the computer system to avoid any data acquisition bias. Analyzer calibration data sheets are presented following the test data.

Run Title: CUG STATE LINE RUN 1
Date: 6/13/1990

Time	CO-VTS	NOX-VTS	HC-VTS	CO-PPM	NOX-PPM	O2-%	HC-PPM
11:38:19	3.946	2.769	2.193	194.362	275.120	6.4945	208.678
11:39:19	3.951	3.057	2.164	194.598	303.824	6.4945	205.767
11:40:19	3.897	2.872	2.139	192.002	285.336	6.5071	203.340
11:41:19	3.897	2.774	2.134	192.002	275.606	6.4062	202.855
11:42:19	3.883	3.223	2.002	191.294	320.366	6.3810	189.753
11:43:19	3.946	3.145	2.032	194.362	312.582	6.3936	192.665
11:44:19	3.951	2.930	2.154	194.598	291.175	6.4693	204.796
11:45:19	3.937	3.057	2.051	193.890	303.824	6.3431	194.606
11:46:19	3.946	3.023	2.188	194.362	300.419	6.4188	208.193
11:47:19	3.897	2.930	2.115	192.002	291.175	6.4945	200.914
11:48:19	3.907	2.784	2.056	192.474	276.579	6.4693	195.091
11:49:19	3.902	2.994	2.022	192.238	297.500	6.3936	191.694
11:50:19	3.951	2.799	2.100	194.598	278.039	6.4440	199.458
11:51:20	3.883	2.799	2.027	191.294	278.039	6.4693	192.179
11:52:20	3.917	3.023	2.071	192.946	300.419	6.5323	196.547
11:53:20	3.888	2.901	2.139	191.530	288.256	6.4566	203.340
THC 11:54:20	3.873	3.228	2.168	190.822	320.853	6.5702	206.252
11:55:20	3.853	3.204	2.051	189.878	318.420	6.4566	194.606
11:56:20	3.868	3.043	2.056	190.586	302.365	6.4693	195.091
11:57:20	3.907	2.774	2.110	192.474	275.606	6.5197	200.429
11:58:20	3.902	2.589	2.188	192.238	257.118	6.5576	208.193
11:59:20	3.907	2.769	2.105	192.474	275.120	6.5071	199.944
12:00:20	3.873	2.965	2.042	190.822	294.580	6.5323	193.635
12:01:20	3.873	2.872	2.032	190.822	285.336	6.5197	192.665
12:02:20	3.844	2.926	2.061	189.405	290.688	6.4440	195.376
12:03:20	3.844	3.067	2.002	189.405	304.757	6.4314	189.753
12:04:20	3.844	3.033	2.100	189.405	301.392	6.6711	199.458
12:05:20	3.883	2.965	2.071	191.294	294.580	6.5702	196.547
12:06:20	3.863	2.799	2.076	190.350	278.039	6.5197	197.032
12:07:20	3.873	2.701	2.022	190.822	268.308	6.4566	191.694

Run Title: CUG STATE LINE RUN 1
Date: 6/13/1990

Time	CO-VTS	NOX-VTS	HC-VTS	CO-PPM	NOX-PPM	O2-%	HC-PPM
12:11:19	3.897	2.818	1.949	192.002	279.985	6.4062	184.415
12:12:20	3.834	2.926	1.988	188.933	290.688	6.4314	188.297
12:13:20	3.834	2.882	2.022	188.933	286.310	6.4945	191.694
THC 12:14:20	3.873	2.813	2.071	190.822	279.498	6.4819	196.547
12:15:20	3.814	3.038	2.090	187.989	301.878	6.4566	198.488
12:16:20	3.912	2.823	2.042	192.710	280.471	6.4693	193.635
12:17:20	3.824	2.999	1.915	188.461	297.986	6.4188	181.018
12:18:20	3.922	2.618	2.022	193.182	260.037	6.4188	191.694
12:19:20	3.897	2.764	1.983	192.002	274.633	6.4188	187.812
12:20:20	3.824	2.598	1.963	188.461	258.091	6.4693	185.871
12:21:20	3.946	2.598	-0.020	194.362	258.091	6.4440	-11.145L
12:22:20	3.897	2.652	-0.024	192.002	263.443	6.4314	-11.630L
12:23:20	3.873	2.447	-0.020	190.822	243.009	6.4819	-11.145L
12:24:20	3.863	2.637	-0.020	190.350	261.983	6.4693	-11.145L
12:25:20	3.814	2.681	1.568	187.989	266.362	6.4945	146.565
12:26:20	3.853	2.774	1.490	189.878	275.606	6.4440	138.801
12:27:20	3.844	2.755	1.543	189.405	273.660	6.4693	144.139
12:28:20	3.912	2.667	1.509	192.710	264.903	6.4693	140.742
CH_4 12:29:20	3.927	2.637	1.485	193.418	261.983	6.3936	138.316
12:30:20	3.912	2.823	1.446	192.710	280.471	6.5323	134.433
12:31:20	3.897	2.940	1.480	192.002	292.148	6.3936	137.830
12:32:20	3.844	2.422	1.421	189.405	240.576	6.5071	132.007
12:33:20	3.897	2.755	1.582	192.002	273.660	6.5323	148.021
12:34:20	3.932	2.989	1.578	193.654	297.013	6.5449	147.535
12:35:20	3.985	2.911	1.568	196.251	289.229	6.4945	146.565
12:36:20	3.951	2.711	1.538	194.598	269.281	6.4693	143.653
12:37:20	3.912	2.818	1.495	192.710	279.985	6.4314	139.286
12:38:20	3.819	2.647	1.397	188.225	262.956	6.4945	129.581
12:39:20	3.878	2.838	1.480	191.058	281.931	6.4566	137.830
12:40:21	3.858	2.794	1.465	190.114	277.552	6.4566	136.374
12:41:21	3.878	2.833	1.509	191.058	281.444	6.4314	140.742
12:42:21	3.966	2.872	1.543	195.307	285.336	6.4693	144.139
12:43:21	3.805	2.672	1.397	187.517	265.389	6.3936	129.581
12:44:21	3.868	2.852	1.519	190.586	283.390	6.4819	141.712

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191.56

Run Title: CNG STATE LINE RUN 2
Date: 6/13/1990

Time	CO-VTS	NOx-VTS	HC-VTS	CO-PPM	NOx-PPM	O2-%	HC-PPM
13:14:49	3.868	2.667	2.095	190.875	257.752	6.5017	199.970
13:15:49	3.917	2.833	2.183	193.243	273.909	6.5651	208.719
13:16:49	3.883	2.872	2.085	191.586	277.711	6.4130	198.998
13:17:49	3.995	2.740	2.193	197.032	264.880	6.5144	209.691
13:18:49	3.995	2.842	2.144	197.032	274.859	6.4130	204.831
13:19:49	3.814	2.891	1.978	188.270	279.611	6.5144	188.305
13:20:49	3.878	2.911	2.012	191.349	281.512	6.3496	191.708
13:21:49	3.844	2.867	2.017	189.691	277.235	6.3876	192.194
13:22:49	3.883	3.048	1.988	191.586	294.818	6.3876	189.277
13:23:49	3.941	2.774	2.032	194.427	268.206	6.3876	193.652
13:24:49	3.922	2.589	2.076	193.480	250.148	6.4510	198.026
13:25:49	3.966	2.779	2.173	195.611	268.682	6.5397	207.747
13:26:49	3.922	2.862	2.090	193.480	276.760	6.4890	199.484
13:27:49	3.971	2.847	2.027	195.848	275.334	6.4256	193.166
13:28:49	3.932	2.808	2.017	193.954	271.533	6.5397	192.194
13:29:49	3.907	2.901	2.139	192.770	280.562	6.4383	204.345
TMC 13:30:49	4.034	2.911	2.139	198.926	281.512	6.4637	204.345
13:31:49	3.980	2.813	2.076	196.322	272.008	6.5749	198.026
13:32:49	3.976	2.755	2.032	196.085	266.306	6.4510	193.652
13:33:49	3.863	2.686	1.973	190.638	259.653	6.4256	187.819
13:34:49	3.824	3.116	2.017	188.744	301.471	6.4510	192.194
13:35:49	3.883	2.852	1.973	191.586	275.810	6.4003	187.819
13:36:49	3.805	2.711	2.081	187.797	262.029	6.5397	198.512
13:37:49	3.946	2.901	1.924	194.664	280.562	6.2862	182.959
13:38:49	3.844	2.930	1.958	189.691	283.413	6.4763	186.361
13:39:49	3.873	2.896	2.017	191.112	280.087	6.4130	192.194
13:40:49	3.795	2.808	2.017	187.323	271.533	6.4763	192.194
13:41:49	3.819	2.647	2.051	188.507	255.851	6.5270	195.596
13:42:49	3.922	2.750	2.149	193.480	263.929	6.5397	205.317
13:43:49	3.995	2.769	2.076	197.032	267.751	6.4130	198.026

Run Title: CNG STATE LINE RUN 2
Date: 6/13/1990

Time	CO-VTS	NOx-VTS	HC-VTS	CO-PPM	NOx-PPM	O2-%	HC-PPM
13:48:25	3.907	2.696	1.485	192.770	260.803	6.4510	139.215
13:49:25	3.912	2.559	1.597	193.006	247.257	6.5270	150.394
13:50:25	3.883	2.730	1.553	191.586	263.929	6.4890	146.019
13:51:25	3.897	2.608	1.582	192.296	252.049	6.5777	148.936
13:52:25	3.897	2.632	1.485	192.296	254.425	6.4637	139.215
13:53:25	3.883	2.598	1.592	191.586	251.099	6.5144	149.908
13:54:25	3.907	2.598	1.568	192.770	251.099	6.5904	147.478
13:55:25	3.961	2.603	1.582	195.374	251.574	6.5144	148.936
13:56:25	3.917	2.687	2.100	193.243	286.801	6.5144	200.457
13:57:25	3.907	2.638	1.519	192.770	253.950	6.4890	142.617
13:58:25	3.985	2.408	1.680	196.558	232.566	6.5397	158.657
13:59:25	3.976	2.491	1.636	196.085	240.644	6.5270	154.282
14:00:25	4.015	2.476	1.709	197.979	239.219	6.6031	161.573
14:01:25	3.907	2.711	1.621	192.770	262.029	6.5270	152.824
CH4 14:02:25	3.966	2.575	1.543	195.611	249.198	6.4637	145.047
14:03:25	3.927	2.833	1.573	193.717	273.909	6.5270	147.964
14:04:25	3.907	2.637	1.573	192.770	254.901	6.5397	147.964
14:05:25	3.873	2.706	1.548	191.112	261.553	6.5144	145.533
14:06:25	3.863	2.735	1.612	190.638	263.888	6.5017	151.852
14:07:25	3.917	2.652	1.612	193.243	256.526	6.5144	151.852
14:08:25	3.888	2.574	1.612	191.822	248.723	6.5777	151.852
14:09:25	3.844	2.540	1.538	189.691	245.596	6.4510	144.561
14:10:25	3.932	2.628	1.626	193.954	253.950	6.5017	153.310
14:11:25	3.912	2.662	1.631	193.006	257.277	6.5017	153.796
14:12:25	3.897	2.530	1.582	192.296	244.446	6.4890	148.936
14:13:25	3.873	2.564	1.524	191.112	247.772	6.6031	143.103
14:14:25	3.946	2.462	1.475	194.664	237.793	6.5017	138.243
14:15:25	3.946	2.842	1.602	194.664	274.859	6.5017	150.880
14:16:25	3.917	2.926	1.524	193.243	282.936	6.4637	143.103
14:17:26	3.932	2.671	1.548	193.954	260.128	6.4763	145.533

192.98 264.16 6.42

Run Title: CNG STATE LINE RUN 3
Date: 6/13/1990

Time	CO-VTS	NOX-VTS	HC-VTS	CO-PPM	NOX-PPM	O2-%	HC-PPM
14:49:30	3.906	2.608	2.330	195.228	254.129	0.6428	225.333
14:50:30	3.946	2.413	2.208	194.754	235.040	0.5000	213.052
14:51:30	3.951	2.374	2.305	194.991	231.223	0.5920	222.877
14:52:30	3.912	2.584	2.203	193.094	251.743	0.5539	212.561
14:53:30	3.873	2.598	2.232	191.190	253.175	0.5920	215.508
14:54:30	3.976	2.408	2.349	196.177	234.503	0.6555	227.298
14:55:30	3.907	2.535	2.178	192.856	246.971	0.5412	210.105
14:56:30	3.937	2.437	2.208	194.279	237.427	0.5285	213.052
14:57:30	3.932	2.462	2.252	194.042	239.813	0.5666	217.473
14:58:30	3.897	2.369	2.168	192.382	230.745	0.5285	209.123
14:59:30	3.907	2.305	2.266	192.856	224.542	0.5412	218.947
15:00:30	3.912	2.554	2.212	193.094	248.880	0.5412	213.544
15:01:30	3.912	2.291	2.315	193.094	223.110	0.6301	223.859
15:02:30	3.951	2.305	2.237	194.991	224.542	0.6047	216.000
15:03:31	3.951	2.525	2.256	194.991	246.017	0.5666	217.965
THC 15:04:31	4.044	2.247	2.413	199.497	218.815	0.5285	233.683
15:05:31	4.073	2.330	2.237	200.921	226.928	0.5793	216.000
15:06:31	4.024	2.422	2.232	198.549	235.995	0.5539	215.508
15:07:31	3.976	2.413	2.139	196.177	235.040	0.5158	206.175
15:08:31	3.951	2.325	2.237	194.991	226.450	0.5920	216.000
15:09:31	3.932	2.369	2.222	194.042	230.745	0.5539	214.526
15:10:31	3.946	2.242	2.261	194.754	218.338	0.5539	218.456
15:11:31	3.976	2.618	2.291	196.177	255.084	0.6174	221.403
15:12:31	3.976	2.335	2.198	196.177	227.405	0.6428	212.070
15:13:31	4.005	2.261	2.212	197.600	220.247	0.6301	213.544
15:14:31	4.024	2.545	2.178	198.549	247.928	0.5539	210.105
15:15:31	4.044	2.393	2.256	199.497	233.132	0.5793	217.965
15:16:31	4.044	2.374	2.208	199.497	231.223	0.6428	213.052
15:17:31	3.956	2.447	2.100	195.228	238.381	0.5920	202.246
15:18:31	3.951	2.574	2.178	194.991	250.789	0.6047	210.105

Run Title: CNG STATE LINE RUN 3
Date: 6/13/1990

Time	CO-VTS	NOX-VTS	HC-VTS	CO-PPM	NOX-PPM	O2-%	HC-PPM
15:24:11	3.917	2.398	1.587	193.331	233.609	0.5793	150.669
15:25:11	3.956	2.647	1.602	195.228	257.947	0.5285	152.142
15:26:12	4.024	2.374	1.661	198.549	231.223	0.5920	158.037
15:27:12	4.034	2.491	1.636	199.023	242.676	0.6428	155.581
15:28:12	3.976	2.374	1.568	196.177	231.223	0.5285	148.704
15:29:12	3.937	2.403	1.592	194.279	234.086	0.5031	151.160
15:30:12	3.902	2.422	1.558	192.619	235.995	0.6683	147.721
15:31:12	3.922	2.349	1.592	193.568	228.837	0.6301	151.160
15:32:12	3.927	2.466	1.621	193.805	240.290	0.6301	154.107
15:33:12	3.951	2.403	1.578	194.991	234.086	0.6555	149.686
15:34:12	3.971	2.300	1.529	195.940	224.064	0.4650	144.774
15:35:12	4.029	2.471	1.646	198.786	240.767	0.5793	156.563
15:36:12	3.951	2.491	1.636	194.991	242.676	0.5158	155.581
CH4 15:37:12	4.015	2.447	1.719	198.074	238.381	0.5666	163.931
15:38:12	3.961	2.515	1.582	195.465	245.062	0.6174	150.178
15:39:12	3.951	2.589	1.582	194.991	252.220	0.6047	150.178
15:40:12	3.961	2.779	1.568	195.465	270.832	0.5666	148.704
15:41:12	3.917	2.510	1.621	193.331	244.585	0.6301	154.107
15:42:12	3.957	2.525	1.621	194.279	246.017	0.6174	154.107
15:43:12	3.976	2.530	1.548	196.177	246.494	0.5666	146.739
15:44:12	3.878	2.672	1.573	191.433	260.333	0.5793	149.195
15:45:12	3.922	2.711	1.621	194.042	264.151	0.5920	154.107
15:46:12	3.932	2.613	1.548	194.042	254.606	0.5412	146.739
15:47:12	3.976	2.652	1.563	196.177	258.424	0.5539	148.213
15:48:12	3.951	2.540	1.631	194.991	247.448	0.5412	155.090
15:49:12	3.961	2.603	1.563	195.465	253.652	0.6047	148.213
15:50:12	3.907	2.711	1.529	192.856	264.151	0.5285	144.774
15:51:12	3.927	2.525	1.612	193.805	246.017	0.6428	153.125
15:52:12	3.927	2.745	1.548	193.805	267.491	0.6555	146.739
15:53:12	3.917	2.510	1.558	193.331	244.585	0.5666	147.721

Run Title: CNG STATE LINE OE TEST
Date: 6/12/1990

Time	NOX-VTS	NOX-PPM
17:08:25	2.125	47.35
17:09:25	2.129	47.47
17:10:25	2.115	47.12
17:11:25	2.120	47.24
17:12:25	2.120	47.24
17:13:25	2.120	47.24
17:14:25	2.115	47.12
17:15:25	2.110	47.01
17:16:25	2.120	47.24
17:17:25	2.120	47.24
17:18:25	2.115	47.12
17:19:25	2.115	47.12
17:20:25	2.110	47.01
17:21:25	2.110	47.01
17:22:25	2.110	47.01
17:23:25	2.110	47.01
17:24:26	2.100	46.78
17:25:26	2.105	46.89
17:26:26	2.095	46.67
17:27:26	2.095	46.67
17:28:26	2.100	46.78
17:29:26	2.100	46.78
17:30:26	2.090	46.55
17:31:26	2.090	46.55
17:32:26	2.085	46.44
17:33:26	2.095	46.67
17:34:26	2.090	46.55
17:35:26	2.090	46.55
17:36:26	2.085	46.44
17:37:26	2.090	46.55

METHOD 7E DATA SHEET

COMPANY CNG-STATE COLLEGE SOURCE # ENGINE 1 DATE 06/3/90

PARAMETER NOx LOAD% 95 RUN NUMBER 1

CALIBRATION STATISTICS

Cylinder Value		Analyzer Response mv	Analyzer Response ppm	Absolute Difference mv	Absolute Difference ppm	% Drift ±3%
Zero	N_2	0.00	-0.74	0.01	0.26	0.10
Mid	207.10	2.10	208.45	2.16	214.43	0.60
High	460.10	4.62	459.48	4.74	471.44	1.20

Calibration curve: ppm = (response mv)(slope) + Intercept

Slope 99.6454 Intercept -0.7385 Span Range 995.42

Analyzer Cal	Init. mv	Analyzer Resp. ppm	Bias ±5	Final mv	Analyzer Resp. ppm	Bias ±5	Drift ±3
Conc.	-0.74	0.08	1.23	0.80	0.04	3.25	+0.40	-0.40

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 1.0000

BIAS MID GAS START = 2.04 VTS

BIAS MID GAS END = 2.11 VTS

ETS

METHOD 10 DATA SHEET

COMPANY CNG - STATE COVE SOURCE #ENGINE 1 DATE 061390

PARAMETER CO LOAD% 95 RUN NUMBER 1

CALIBRATION STATISTICS

	Cylinder Value	Initial Analyzer Response mv	Initial Analyzer Response ppm	Final Analyzer Response mv	Final Analyzer Response ppm	%Drift
Zero	N_2	0.00	3.64	0.00	3.64	0.00
Low	60.55	1.16	59.70	1.15	59.21	-0.10
Mid	90.80	1.74	88.70	1.75	88.22	-0.10
High	401.60	8.25	402.36	8.23	401.40	-0.20

Calibration curve: ppm = (response mv)(slope) + intercept

Slope 48.3304 Intercept 3.6373 Span Range 486.94 ,

$$\%Drift = \frac{\text{Final response (ppm)} - \text{Initial response (ppm)}}{\text{Span (ppm)}} \times 100$$

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____ ,

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 0.9999

ETS
EMISSION TESTING SERVICES, INC.

METHOD 25A DATA SHEET

COMPANY CMG-STATE CLAVE SOURCE #ENGINE 1 DATE 061390

PARAMETER THC LOAD% 95 RUN NUMBER 1

CALIBRATION STATISTICS

	Cylinder Value	Analyzer Response mv	Analyzer Response ppm	Absolute Difference mv	Absolute Difference ppm	% Span ±3%
Zero	N/A	0.00	-9.20	0.00	-9.20	0.00
Low	89.83	1.06	96.11	1.05	95.12	-0.10
Mid	200	2.18	207.39	2.16	205.41	-0.20
High	501	5.09	496.52	5.08	495.53	-0.10

Calibration curve: ppm = (response mv)(slope) + intercept
Slope 99.3571 Intercept -9.2037 Span Range 984.37

Analyzer Cal		Init. Analyzer Resp. mv	Init. Analyzer Resp. ppm	Bias ±5	Final Analyzer Resp. mv	Final Analyzer Resp. ppm	Bias ±5	Span Drift ±3
Low	96.11	1.04	94.13	-0.20	96.11	1.06	0.00	0.20
Mid	207.39	2.12	201.43	-0.61	208.65	2.10	0.13	0.73

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal.}}{\text{Span (ppm)}}$ (ppm) X 100

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}}$ X 100

Response Time Test--Stabilize with zero gas and swith to high concentration. Record time for 95% change.

Time: 1)_____ 2)_____ 3)_____ Average _____

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 0.9993

M E T H O D 3 A D A T A S H E E T

COMPANY CNG-STATE LINE SOURCE # EMBOUE 1 DATE 06/3/90

PARAMETER O_2 LOAD% 95 RUN NUMBER 1

C A L I B R A T I O N S T A T I S T I C S

Cylinder Value		Analyzer Response v	Analyzer Response %	Absolute Difference v	Absolute Difference %	% Span ±2%
Zero	N_2	0.07	0.20	0.07	0.20	0.00
Mid	13.21	4.91	11.70	4.90	12.68	-0.08
High	20.9	8.10	21.10	8.16	21.10	-0.40

Calibration curve: ppm = (response v)(slope) + intercept

Slope 2.5926 Intercept 0.0238 Span Range 25.85

Analyzer Cal	Init. Analyzer Resp. v	ppm	Bias ±5	Final Analyzer Resp. v	ppm	Bias ±5	Span ±3	Drift
Conc. 0.20	0.07	0.20	0.00	0.06	0.18	-0.08	-0.08	

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{Span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

T E S T D A T A

Start time _____ Finish time _____ Minutes per point _____

Test Point v Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. v _____

Ave. conc. _____ %

COMMENTS:

R = 0.9991

BIAS MID GAS START = 4.88 VTS

BIAS MID GAS END = 4.93 VTS

M E T H O D 7 E D A T A S H E E T

COMPANY CNG - STATE LINE SOURCE # ENGINE 1 DATE 061390

PARAMETER NOx LOAD% 95 RUN NUMBER 2

C A L I B R A T I O N S T A T I S T I C S

Cylinder Value		Analyzer Response mv	Analyzer Response ppm	Absolute mv	Difference ppm	% Drift ±2%
Zero	N2	0.04	-0.74	0.00	-1.71	-0.10
Mid	201.10	2.16	208.45	2.14	206.51	-0.20
High	460.10	4.74	459.48	4.71	456.57	-0.30

Calibration curve: ppm = (response mv)(slope) + intercept

Slope 97.2967 Intercept -1.7114 Span Range 97.28

Analyzer Cal	Init. mv	Analyzer Resp. ppm	Bias ±5	Final mv	Analyzer Resp. ppm	Bias ±5	Drift ±3
Conc.	-0.74	0.04	2.18	0.30	0.02	0.23	0.10	-0.20

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

T E S T D A T A

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 1.0000

BIAS MID GAS START = 2.10 VTS

BIAS MID GAS END = 2.10 VTS

ETS

METHOD 10 DATA SHEET

COMPANY CNG - STATE CLOSE SOURCE # ENGINE 1 DATE 06/13/90

PARAMETER CO LOAD# 95 RUN NUMBER 2

CALIBRATION STATISTICS

	Cylinder Value	Initial Analyzer Response mv	Initial Analyzer Response ppm	Final Analyzer Response mv	Final Analyzer Response ppm	%Drift
Zero	N2	0.00	3.33	0.00	3.33	0.00
Low	60.55	1.15	59.08	1.15	59.08	0.00
Mid	90.80	1.75	88.18	1.76	88.66	0.10
High	401.60	8.23	402.36	8.22	401.88	-0.16

Calibration curve: ppm = (response mv)(slope) + intercept

Slope 48.4856 Intercept 3.3264 Span Range 488.18

$$\%Drift = \frac{\text{Final response (ppm)} - \text{Initial response (ppm)}}{\text{Span (ppm)}} \times 100$$

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Sample port _____

Test Point	mv				
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS: r = 0.9999

ETS
EMISSION TESTING SERVICES, INC.

METHOD 25A DATA SHEET

COMPANY CNG- STATE LINE SOURCE # ENGINE 1 DATE 061390

PARAMETER THC LOAD% 95 RUN NUMBER 2

CALIBRATION STATISTICS

	Cylinder Value	Analyzer Response µv	Analyzer Response ppm	Absolute Difference µv	Absolute Difference ppm	% Span ±3%
Zero	N.A.	0.00	-8.54	0.00	-8.54	0.00
Low	89.83	1.05	95.95	1.05	95.95	0.00
Mid	200	2.16	206.42	2.14	204.43	-0.10
High	501	5.08	497.01	5.03	492.03	-0.50

Calibration curve: ppm = (response µv)(slope) + intercept
Slope 99.5178 Intercept -8.5430 Span Range 986.64

Analyzer Cal		Init. Analyzer Resp. µv	Init. Analyzer Resp. ppm	Bias ±5	Final Analyzer Resp. µv	Final Analyzer Resp. ppm	Bias ±5	Span Drift ±3
Low	95.95	1.06	96.95	0.10	1.10	100.93	0.50	0.40
Mid	206.42	2.10	200.44	-0.61	2.07	197.96	-0.91	-0.30

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{Span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

Response Time Test---Stabilize with zero gas and swith to high concentration. Record time for 95% change.

Time: 1)_____ 2)_____ 3)_____ Average _____

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Sample port _____

Test Point	mv				
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 0.9994

M E T H O D 3 A D A T A S H E E T

COMPANY ENG - STATE LINE SOURCE # ENGINE 1 DATE 06/30/90

PARAMETER O_2 LOAD% 95 RUN NUMBER 2

C A L I B R A T I O N S T A T I S T I C S

Cylinder Value		Analyzer Response v	Analyzer Response %	Absolute Difference v	Absolute Difference %	% Span ±2%
Zero	N_2	0.07	0.19	0.07	0.19	0.00
Mid	13.21	4.90	12.73	4.89	12.70	-0.11
High	20.9	8.16	21.19	8.14	21.14	-0.21

Calibration curve: ppm = (response v)(slope) + intercept

Slope 2.5950 Intercept 0.0126 Span Range 25.96

Analyzer Cal	Init. Analyzer Resp. v	ppm	Bias ±5	Final Analyzer Resp. v	ppm	Bias ±5	Span Drift ±3
Conc. 0.19	0.06	0.17	-0.08	0.07	0.19	0.00	0.08

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{Span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

T E S T D A T A

Start time _____ Finish time _____ Minutes per point _____

Test Point v Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. v _____

Ave. conc. _____ %

COMMENTS:

R = 0.9992

BIAS MID GAS START = 4.93 VTS

BIAS MID GAS END = 4.87 VTS

METHOD 7E DATA SHEET

COMPANY CNG - STATE LINE SOURCE # Engine 1 DATE 061390

PARAMETER NO_x LOAD% 95 RUN NUMBER 3

CALIBRATION STATISTICS

Cylinder Value		Analyzer Response mv	Analyzer Response ppm	Absolute Difference mv	Absolute Difference ppm	% Drift ±20
Zero	N2	0.00	-0.71	0.00	-0.71	0.00
Mid	207.10	2.14	204.39	2.16	205.35	0.20
High	460.10	4.77	459.51	4.78	466.35	0.70

Calibration curve: ppm = (response mv)(slope) + Intercept

Slope 97.7069 Intercept -0.7065 Span Range 976.40

Analyzer Cal	Init. mv	Analyzer Resp. ppm	Bias ±5	Final mv	Analyzer Resp. ppm	Bias ±5	Drift ±3
Conc. -0.71	0.02	1.25	0.20	0.04	3.20	0.40	0.20

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{span (ppm)}} \times 100$

Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 1.0000

BIAS MID GAS START = 2.10 VTS

BIAS MID GAS END = 2.22 VTS

ETS

METHOD 10 DATA SHEET

COMPANY CMG - STATE LINE SOURCE # ENGINE 1 DATE 061390

PARAMETER CO LOAD% 95 RUN NUMBER 3

CALIBRATION STATISTICS

	Cylinder Value	Initial Analyzer Response mv	Initial Analyzer Response ppm	Final Analyzer Response mv	Final Analyzer Response ppm	%Drift
Zero	N_2	0.00	3.11	0.00	3.11	0.00
Low	60.55	1.15	58.94	1.16	59.44	0.10
Mid	90.80	1.76	88.58	1.75	88.10	-0.10
High	401.60	8.22	401.30	8.20	401.33	-0.20

Calibration curve: ppm = (response mv)(slope) + intercept

Slope 48.5628 Intercept 3.1116 Span Range 488.74

$$\%Drift = \frac{\text{Final response (ppm)} - \text{Initial response (ppm)}}{\text{Span (ppm)}} \times 100$$

TEST DATA

Start time _____ Finish time _____ Minutes per point _____

Test Point mv Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv _____

Ave. conc. _____ ppm

COMMENTS:

R = 0.9999

ETS
EMISSION TESTING SERVICES, INC.

METHOD 25A DATA SHEET

COMPANY CNG - STATE LINE SOURCE # ENGINE 1 DATE 061390

PARAMETER THC LOAD% 95 RUN NUMBER 3

CALIBRATION STATISTICS

Cylinder Value		Analyzer Response mv	Analyzer Response ppm	Absolute Difference mv	Absolute Difference ppm	% Span ±3%
Zero	N2	0.00	-0.97	0.00	-0.97	0.00
Low	89.93	1.05	96.63	1.06	97.63	0.10
Mid	200	2.14	206.26	2.16	208.27	0.20
High	501	5.03	496.92	5.05	498.93	0.20

Calibration curve: ppm = (response mv)(slope) + intercept
Slope 100.5753 Intercept -0.9746 Span Range 496.78

Analyzer Cal		Init. Analyzer Resp. mv	Init. Analyzer Resp. ppm	Bias ±5	Final Analyzer Resp. mv	Final Analyzer Resp. ppm	Bias ±5	Span Drift ±3
Low	96.03	1.10	100.66	0.50	1.07	98.64	0.20	-0.30
Mid	206.26	2.01	199.22	-0.71	2.11	203.24	-0.30	0.40

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{Span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

Response Time Test---Stabilize with zero gas and swith to high concentration. Record time for 95% change.

Time: 1)____ 2)____ 3)____ Average ____

TEST DATA

Start time ____ Finish time ____ Minutes per point ____

Test Point mv Sample port ____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. mv ____

Ave. conc. ____ ppm

COMMENTS:

R = 0.9994

M E T H O D 3 A D A T A S H E E T

COMPANY CNG- STATE LINE SOURCE # EMPPEL DATE 06 13 90

PARAMETER O_2 LOAD% 95 RUN NUMBER 3

C A L I B R A T I O N S T A T I S T I C S

Cylinder Value		Analyzer Response v	Analyzer Response %	Absolute Difference v	Absolute Difference %	% Span ±2%
Zero	N_2	0.07	0.19	0.07	0.19	0.00
Mid	13.21	4.89	12.73	4.87	12.68	-0.19
High	20.9	8.14	21.19	8.10	21.08	-0.41

Calibration curve: ppm = (response v)(slope) + intercept

Slope 2.6014 Intercept 0.0107 Span Range 26.02

Analyzer Cal		Init. Analyzer Resp. v	ppm	Bias ±5	Final Analyzer Resp. v	ppm	Bias ±5	Span Drift ±3
Conc.	0.19	0.07	0.19	0.00	0.06	0.17	-0.09	-0.09

Sys. Cal. Bias = $\frac{\text{Sys. cal. (ppm)} - \text{analyzer cal. (ppm)}}{\text{Span (ppm)}} \times 100$

%Drift = $\frac{\text{Final sys. resp. (ppm)} - \text{Initial sys. resp. (ppm)}}{\text{span (ppm)}} \times 100$

T E S T D A T A

Start time _____ Finish time _____ Minutes per point _____

Test Point v Sample port _____

1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Ave. v _____

Ave. conc. _____ %

COMMENTS:

R = 0.9992

BIAS MID GAS START = 4.87 VTS

BIAS MID GAS END = 4.84 VTS

Presented on the following pages are engine operating data collected by the control room computer during emission testing on June 13, 1990. Following these data are fuel gas analysis on the fuel gas samples collected during the emission tests.

EMISSION TESTING SERVICES, INC.

INTERNAL COMBUSTION ENGINE
OPERATIONAL RECORD

Company Name Consolidated Natural Gas Transmission Corporation (CNGT)

Company Location State Line Station

Engine Name KVG-104 Ingersoll-Rand

Engine Source I. D. No. Engine # 1

Design Specifications

Manufacturer's Name Ingersoll-Rand

Model No. KVG-104 Serial No.

Parameter Specifications

A. Fuel Type Natural Gas B. Fuel Supplier CNGT

C. Fuel Flow Units MCFH Meas. Method orifice

D. Is unit equipped for waste heat recovery? NO

Describe

E. Does unit use water or steam injection? NO

If so, describe measurement method (continuous flow, start-finish volumes, etc)

F. Manifold Pressure units (psia, kpa, etc.) Air - "H2O; Fuel - PSI

G. Manifold Temp. (°F, °C, etc.)

Ultimate Fuel Analysis

C S H Ash

O H_2O N

Trace Metals: Na Va K

Fuel elements added

Fuel elements added for smoke suppression

June 13, 1990

STATE LINE STATION

First Test

/T Engine

I gine RPM 330 Engine Oil Temperature In 172°

Turbo RPM 21,195 Engine Oil Temperature Out 178°

	1st Run	2nd Run	3rd Run	4th Run	5th Run	6th Run	7th Run	8th Run	9th Ru
/ Comp.									
End	141.1	140.1	137.8	137.8	136.2	134.5	133.7	133.2	134.3
C End	115.8	115.7	112.9	114.3	112.2	113.2	112.3	111.9	111.3
Comp.									
H End	140.5	137.7	139.0	135.6	133.6	133.1	131.7	131.7	132.1
End	117.8	117.5	116.2	115.3	112.9	112.4	111.3	112.4	111.2
C Comp.									
I End	141.0	139.6	137.8	136.4	149.4	133.8	132.5	132.4	131.6
End	116.9	115.7	115.1	113.9	125.4	111.1	110.5	111.2	109.5
Comp									
I End	140.2	137.8	135.0	134.6	134.8	132.0	131.7	131.1	131.
C End	118.2	117.9	116.7	115.4	114.2	113.9	112.1	112.7	113.
TOTAL	**1031.5**	**1013.2**	**1010.5**	**1003.3**	**1016.7**	**984.0**	**975.8**	**976.6**	**974.8**
ech HP + .95	1085.7	1066.5	1063.6	1056.1	1070.2	1035	1025	1028	1026.
Water Pump HP + 17.5 = Total HP	**1103.2**	**1084.0**	**1081.1**	**1073.6**	**1087.7**	**1053.2**	**1044.6**	**1045.5**	**1043.6**

June 13, 1990

STATE LINE STATION

Second Test

#1 Engine

Engine RPM 330 Engine Oil Temperature In 172°

Turbo RPM 21,190 Engine Oil Temperature Out 178°

	1st Run	2nd Run	3rd Run	4th Run	5th Run	6th Run
A Comp.						
H End	132.4	134.5	133.0	133.0	133.5	134.1
C End	111.0	111.1	111.1	111.8	111.6	111.5
B Comp.						
H End	130.6	132.1	132.3	132.7	132.8	132.3
C End	112.3	110.4	112.1	112.2	111.7	112.2
C Comp.						
H End	132.4	132.5	132.6	131.4	130.4	131.9
C End	109.2	110.7	110.3	110.7	110.2	110.2
D Comp						
H End	131.2	130.9	130.6	131.0	130.0	132.3
C End	112.9	111.3	111.4	112.2	112.1	112.6
Total	972	973	972.7	975	972.3	977.1
Mech HP ÷ .95	102.31	1024.7	1023	1026.3	1023.4	1028.5
Water Pump HP + 17.5 = Total HP	1040.6	1042.2	1041.3	1043.8	1040.9	1046.0

June 13, 1990

STATE LINE STATION

Third Test

#1 Engine

Engine RPM 330 Engine Oil Temperature In 172°

Turbo RPM 21,190 Engine Oil Temperature Out 178°

	1st Run	2nd Run	3rd Run	4th Run	5th Run	6th Run
A Comp.						
H End	134.2	134.6	133.0	133.7	134.1	134.1
C End	109.7	111.3	111.7	112.7	111.3	112.7
B Comp						
H End	131.9	132.1	131.7	133.8	133.1	134.1
C End	111.9	112.3	114.0	114.4	112.7	113.4
C Comp						
H End	132.6	131.0	132.4	132.4	134.6	133.4
C End	109.7	109.9	110.4	111.1	110.6	111.8
D Comp						
H End	131.8	130.3	130.2	130.9	131.7	131.3
C End	112.8	113.0	112.4	112.8	113.8	112.9
Total	**974.6**	**974.5**	**975.8**	**981.8**	**981.8**	**983.8**
Mech HP ÷ .95 =	1025.8	1025.7	1027.1	1033.4	1033.4	1035.5
Water Pump HP + 17.5 =						
Total HP	**1043.3**	**1043.2**	**1044.6**	**1050.9**	**1050.9**	**1053.0**

Test 1

EMISSION TESTING SERVICES, INC.

INTERNAL COMBUSTION ENGINE

TEST RUN LOG

(GAS ENGINES)

Company Consolidated Natural Gas Transmission Corporation (CNG)

Engine State Line Station Engine # 1

Operator

Date: 6/13/90 Test Time: Start 11:33 End 12:24

Ambient Temperature, at time of test 74°F

Engine Load Condition %

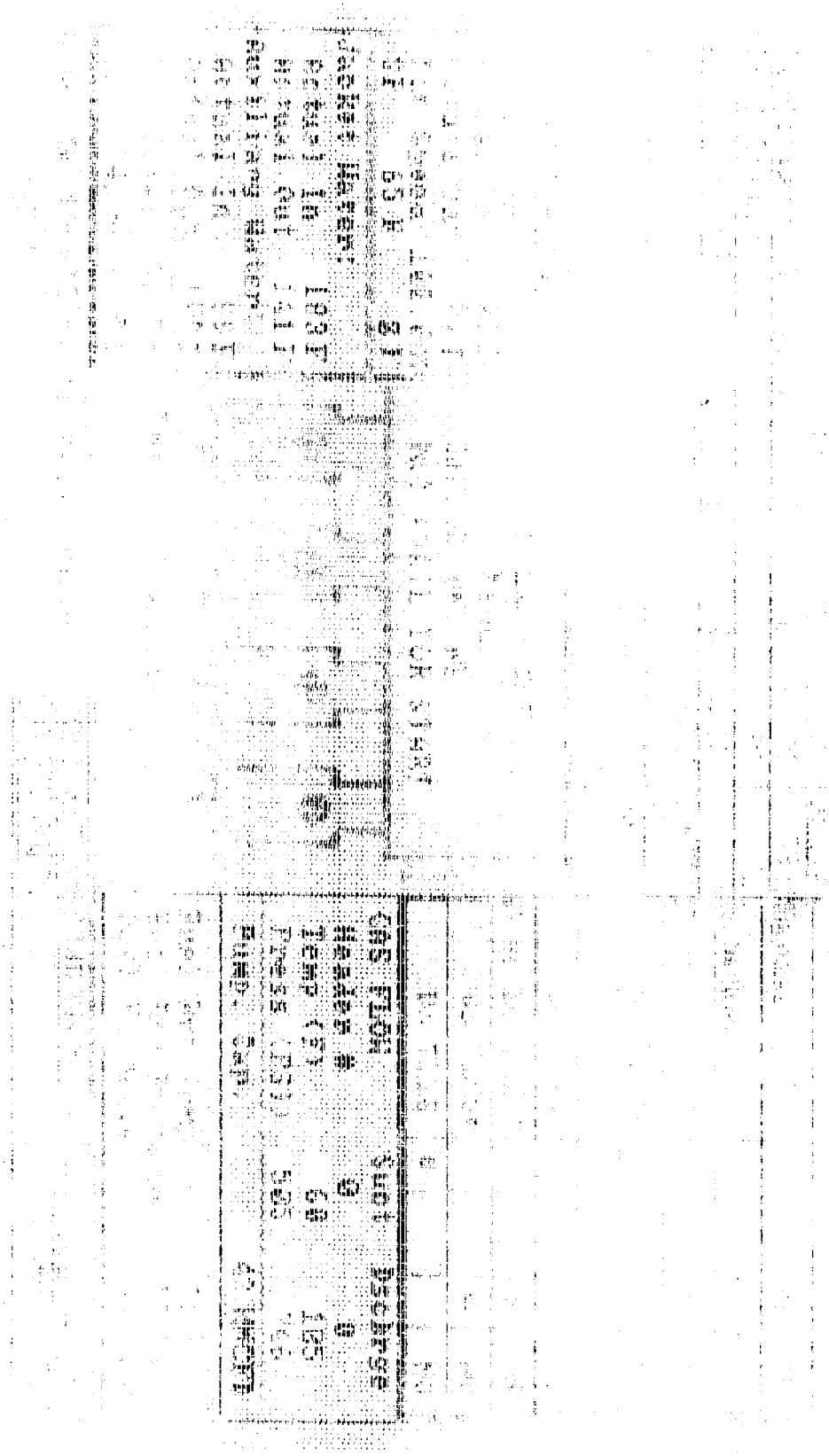
DATA LOG TIME (15 minute intervals)	11:33	11:52	12:09	12:24
Fuel Feed (flow) (MCFH)	10	10	10	10
Intake Manifold Temp.				
Intake Manifold Pressure				
Fuel Header Pressure	6.0	6.5	6.5	6.3
Engine Speed (rpm)	329	326	328	329
Spark Ignition Timing	16°	16°	16°	16°
Horse Power	1053.2	1044.6	1045.6	1043.6

Run Conditions:

Remarks:

Test #1
11:37 AM
Engine #1
State Line
Station

2% DIE on AIR/FUEL



RWater OUT OF Engine	96	F
JWater INTO Engine	167	F
JWater OUT OF Engine	184	F

	104	106	105	106	105
					Left Avg
					Comp Press

60°

60°

11:50:36	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
11:50:39	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
11:50:42	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
11:50:45	LOW	ENG 1 OP TURBOIL.PRESS.	20.1	PSIG
11:50:57	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG

AWater INTO Engine	169 F
AWater OUT OF Engine	99 F
JWater INTO Engine	164 F
JWater OUT OF Engine	182 F

MISC. TEMPS & PRESS	TEMP	PRESS
Engine Oil Tm	172 F	------
Engine Oil Out	170 F	44 PSI
[illegible]		[illegible]
[illegible]		[illegible]
Inlet Air	76 F	
Ambient Temp	[illegible] F	

103	105	105	106	105	Chmr

ENGINE OFF ME

NOT READY FOR START

Jacket Water:

Actual In 181 F

Actual Out 138 F

Conditioned Water:

Actual In 160 F

GAS FLOW	Suct	Discharge
Header #	9	0
Temp (F)	60	104
Press (PSI)	54	733
Pump. Cap.		42 MMCFD

AWater INTO Engine	99	F
AWater OUT OF Engine	99	F
JWater INTO Engine	163	F
JWater OUT OF Engine	181	F

	TEMP	PRESS
Engine Oil IN	172 F	------
Engine Oil OUT	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
Inlet Air	[illegible]	
Exhaust Stack	[illegible]	

					Left
					Avg
103	181	104	185		184
					Comp

12:25:00	LOW	ENG 1 OP TURBOIL PRESS.	20.0	PSIG
12:25:03	LOW	ENG 1 OP TURBOIL PRESS.	20.1	PSIG

Actual Out	80	ENGINE ON LINE	
Des Speed	100.0%	NOT AVAIL FOR START	
SP	65 A	80	
Jacket Water:			
Actual In	180F		
Actual Out	136F		
Auxiliary Water:			
Actual In	99F		

Bearings		0	NO
Vibration		0	
[illegible]			
[illegible]			
[illegible]			
[illegible]			
Disc D1 TI557		0	NO
D2 TI554		0	NO
D3 TI12	0		NO

GAS FLOW	Suct	Dschrge
Header #	0	0
Temp (F)	60	103
Press (PSI)	501	727
Pump. Cap.		42 MMCFD

Fuel Run Temp		
Fuel Run Pressure		
Fuel Flowrate		

Test 2

EMISSION TESTING SERVICES, INC.

INTERNAL COMBUSTION ENGINE

TEST RUN LOG

(GAS ENGINES)

Company Consolidated Natural Gas Transmission Corporation (CNGT)

Engine State Line Station Engine #1

Operator

Date: 6/13/90 Test Time: Start 1:15 End 1:56

Ambient Temperature, at time of test 77°F

Engine Load Condition %

DATA LOG TIME (15 minute intervals)	13:15	13:29	1:45	1:57
Fuel Feed (flow)	10	10	10	10
Intake Manifold Temp.				
Intake Manifold Pressure				
Fuel Header Pressure	6.1	6.1	6.0	6.2
Engine Speed (rpm)	329	329	327	327
Spark Ignition Timing	16°	16°	16°	16°
Horse Power	1040.6	1042.2	1041.3	1043.8

Run Conditions:

Remarks:

ENGINE COOLED LIGHT		
AWater INTO Engine	139	F
AWater OUT OF Engine	99	F
JWater INTO Engine	165	F
JWater OUT OF Engine	181	F

MISC. TEMPS & PRESS	TEMP	PRESS
Engine Oil TK	173 F	------
Engine Oil Out	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]	61	[illegible]
Water Out	[illegible]	
Exhaust After	[illegible]	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Avg
99	181	140	181	100	Comp Press

Test #2
Slate Run Station

	ACTUAL	OPTI SP	
Performance Torque %	77		
Peak Torque	95		
Horsepower	[illegible]		

Actual In	188 F
Actual Out	87 F
Fan Speed	100.0%
SP	65 F

Jacket Water:

Actual In	184 F
Actual Out	142 F

Auxiliary Water:

Actual In	99 F
Actual Out	109 F
Fan Speed	69.9 %
SP	140 F

ENGINE TRACE
Manual
ENGINE ONLINE
NOT AVAIL FOR START

Present Load Step

GAS FLOW	Suct	Dscharge
Header #	9	8
Temp (F)	60	180
Press (PSI)	499	726
Pump. Cap.		42 MMCFD

Fuel Run Tank
Fuel Run Pressure
Fuel Pressure

13:30:45	LOW	ENG 1 OF TURBOIL.PRESS.	20.0	PSIG
13:30:48	LOW	ENG 1 OF TURBOIL.PRESS.	20.1	PSIG

Bypass				No
Disc D1 TL255				No
D2 TL554				No
D3 TL12				No

ENGINE ONLINE

NO1 AVAIL FOR START

Actual Out

Fan Speed 101.3

SP 65 B

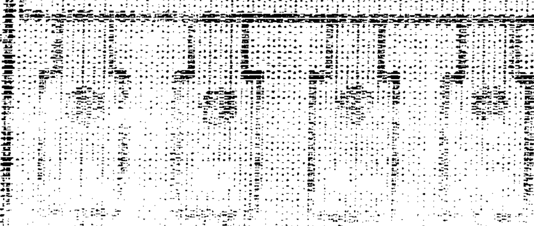
Jacket Water:

Actual In 181 F

Actual Out 137 F

Auxiliary Water:

Actual In 99 F



GAS FLOW	Suct	Dschrge
Header #	0	0
Temp (F)	60	180
Press (PSI)	499	719
Pump. Cap.		43 MMCFD

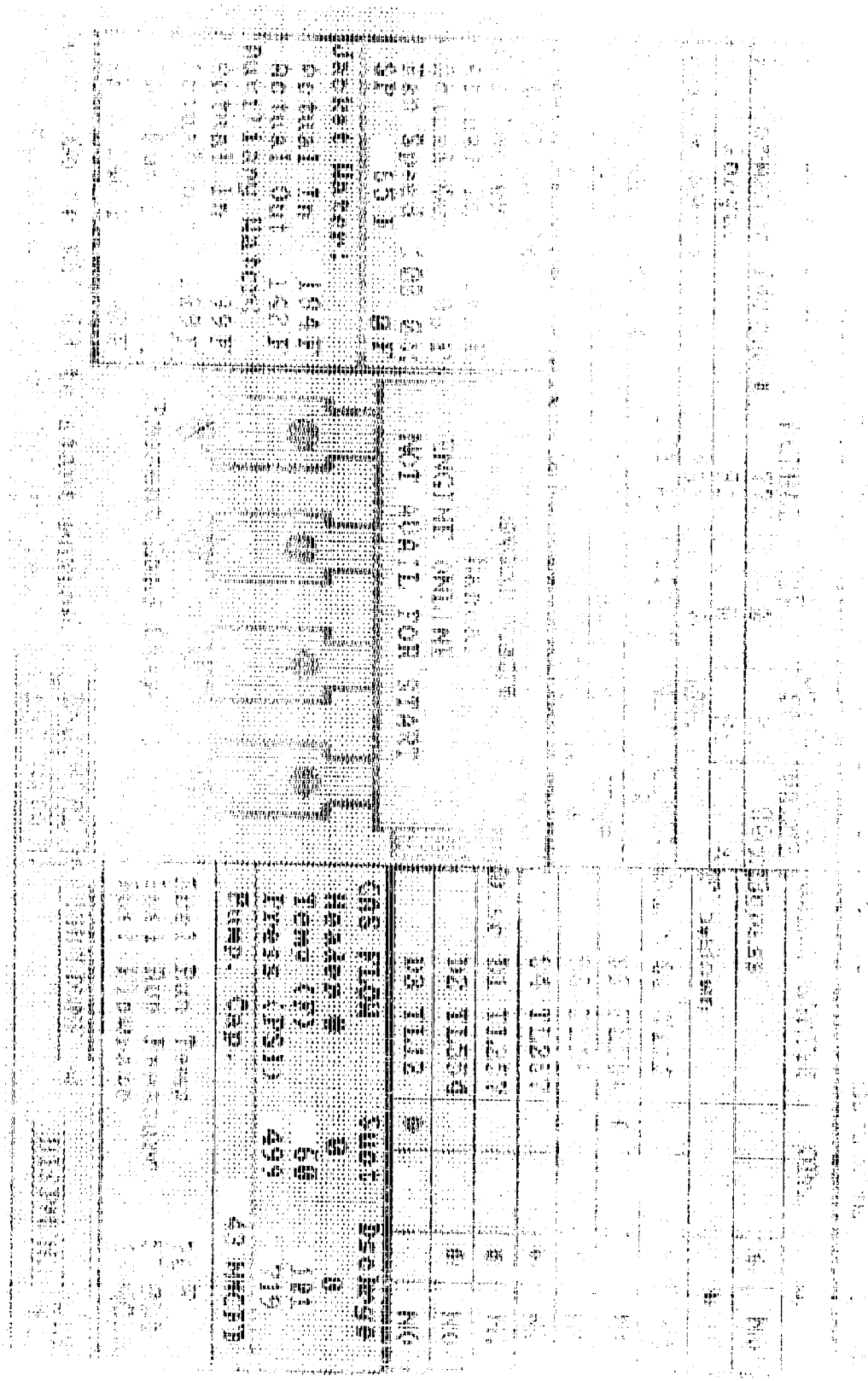
Fuel Run Temp

Fuel Run Pressure

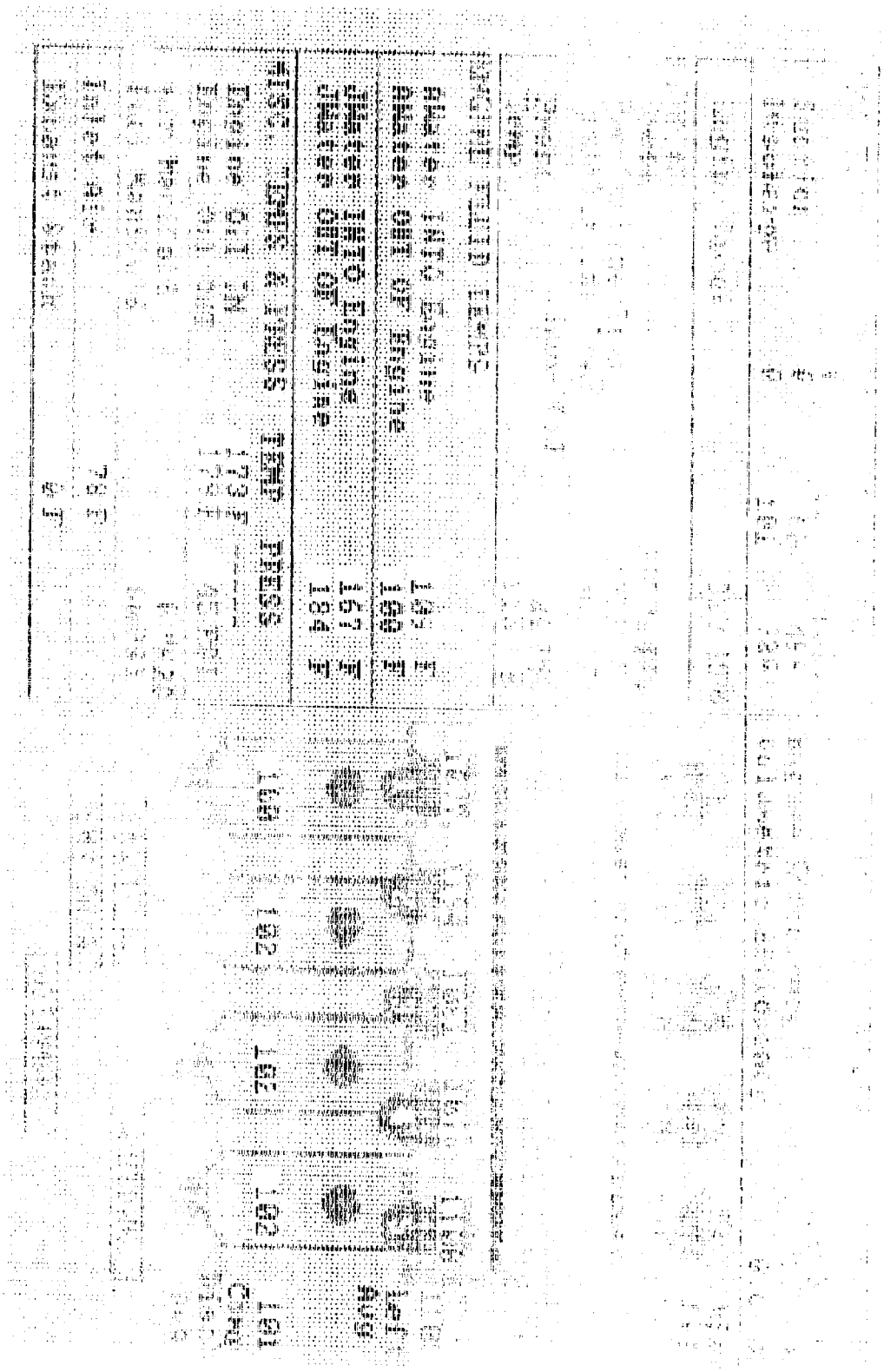
Fuel Flowrate

to start engine

13:43:39	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
13:43:42	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG

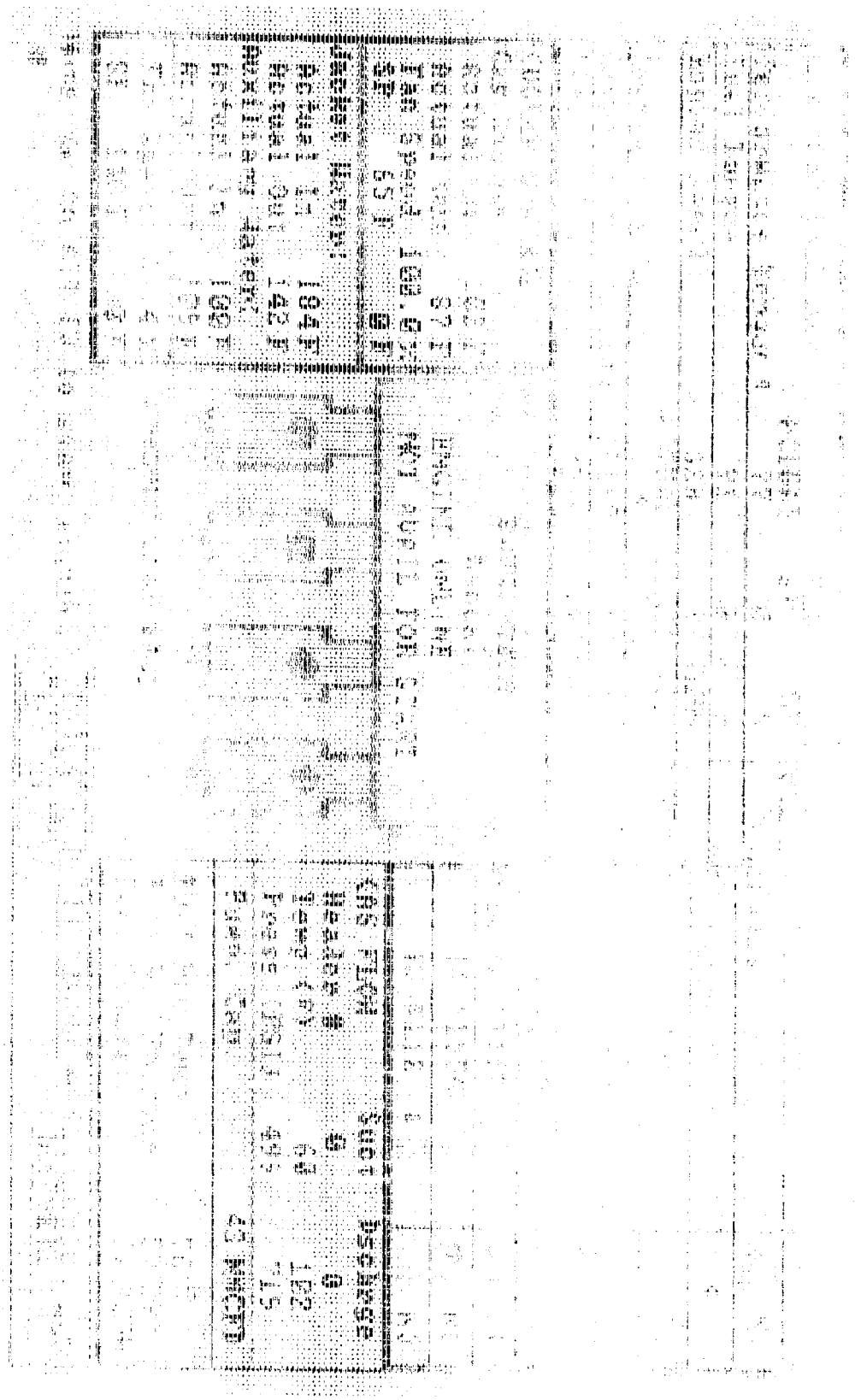


13:46:09 LOW ENG 1 OP TURBOIL.PRESS. 20.0 PSIG



AWater INTO Engine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AWater OUT OF Engine	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JWater INTO Engine	102	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JWater OUT OF Engine	101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MISC. TEMPS & PRESS	TEMP	PRESS	100	102	102	103	102 Comp Press
Engine Oil IN	[illegible]	[illegible]					
Engine Oil OUT	[illegible]	[illegible]					
[illegible]	[illegible]						
[illegible]	[illegible]						
[illegible]	[illegible]						
[illegible]	[illegible]						

14:12:15	LOW	ENG 1 OP TURBOIL.PRESS.	19.9	PSIG
14:12:21	LOW	ENG 1 OP TURBOIL.PRESS.	20.2	PSIG



14:15:33 LOW ENG 1 OP TURBOIL.PRESS. 20.0 PSIG
14:15:36 LOW ENG 1 OP TURBOIL.PRESS. 20.1 PSIG

13:54:39	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
13:54:42	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
13:54:48	LOW	ENG 1 OP TURBOIL.PRESS.	20.0	PSIG
13:54:51	LOW	ENG 1 OP TURBOIL.PRESS.	20.1	PSIG

Test 3

EMISSION TESTING SERVICES, INC.

INTERNAL COMBUSTION ENGINE

TEST RUN LOG

(GAS ENGINES)

Company Consolidated Natural Gas Transmission Corporation (CNG)

Engine State Line Station Engine #1

Operator

Date: 6/13/90 Test Time: Start 2:48 End 3:45

Ambient Temperature, at time of test 76°F

Engine Load Condition %

DATA LOG TIME (15 minute intervals)	2:56	3:03	3:26	3:47
Fuel Feed (flow)	10	10	10	10
Intake Manifold Temp.				
Intake Manifold Pressure				
Fuel Header Pressure	6.2	6.1	6.2	6.2
Engine Speed (rpm)	326	330	330	328
Spark Ignition Timing	16°	16°	16°	16°
Horse Power	1049.2	1048.2	1044.6	1050.9

Run Conditions:

Remarks:

	F	98	498
	F	103	719

	136 RPM
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	28 PSI
	[illegible] F

ENGINE FLUID TEMPS		
AWater INTO Engine	110	F
AWater OUT OF Engine	100	F
JWater INTO Engine	164	F
JWater OUT OF Engine	182	F

MISC. TEMPS & PRESS	TEMP	PRESS
Engine OIL IN	172 F	-----
Engine OIL OUT	178 F	46 PSI
[illegible]		8 MMHG
Fuel Pump Oil		4 PSI
Inlet Air	76 F	
Exhaust Gas	8 F	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Left Avg
101	103	103	104	103	Comp Avg

Test #3

Stateline Station

14:47:03 LOW ENG 1 OP TURBOIL.PRESS. 20.0 PSIG
14:47:06 LOW ENG 1 OP TURBOIL.PRESS. 20.2 PSIG

15:07:57	LOW	ENG 1 OP TURBOIL PRESS.	20.0 PSIG
15:08:40	LOW	ENG 1 OP TURBOIL PRESS.	20.2 PSIG

ENGINE BLOCK TEMPS		
aWater INTO Engine	155	F
aWater OUT OF Engine	99	F
dWater INTO Engine	165	F
dWater OUT OF Engine	181	F

MISC. TEMPS & PRESS	TEMP	PRESS
Engine Oil IN	178 F	[illegible]
Engine Oil OUT	177 F	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
Inlet Air	78 F	
Exhaust Stack	47 F	

101	103	103	104	103	161 F
					99
					Comp Stop

TEST # 3

STATELINE STATION

Actual Out 88 F
Fan Speed 101.9%
SP 65 F 0 F

Jacket Water:
Actual In 102 F
Actual Out 199 F

Auxiliary Water:
Actual In 189 F
Actual Out 185 F
Fan Speed
SP

ENGINE STATUS
Manual
ENGINE ONLINE
NOT AVAIL FOR START

GAS FLOW	Suct	Dscrge
Header #	9	0
Temp (F)	60	183
Press (PSIG)	499	706
Pump Cap.		40 MMCFD

Water Into Engine	163 F
Water OUT OF Engine	181 F

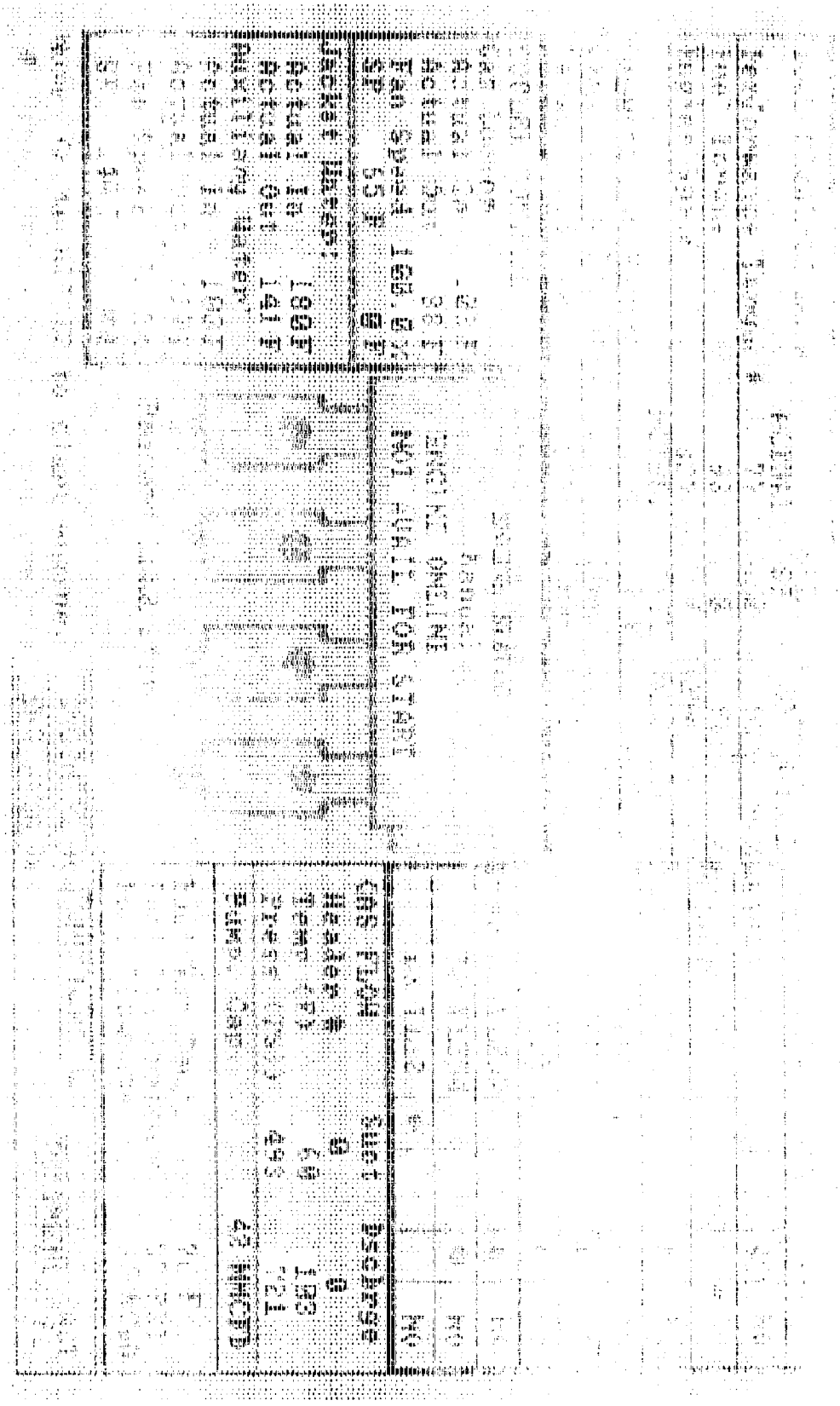
MISC. TEMPS & PRESS	TEMP	PRESS
Engine Oil IN	172 F	------
Engine Oil OUT	[illegible] F	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
Ambient Temp	78 F	
Lowest Stack	[illegible] F	

1026	1174	1075	1070	1096	1184
					Left Avg
101	103	103	104	103	Comp Block

TEST # 3

STATE LINE STATION

	LOW	ENG 1 OP TURBOIL.PRESS.	20.1	PSIG
15:29:40	LOW	ENG 1 OP TURBOIL.PRESS.	20.2	PSIG



15:45:40 LOW ENG 1 OF TURBOCH. PRESS. 20.1 PSIG

Engine	0	68	[illegible]
Lubricate	0	103	720

Engine [illegible]
Volumetric Efficiency

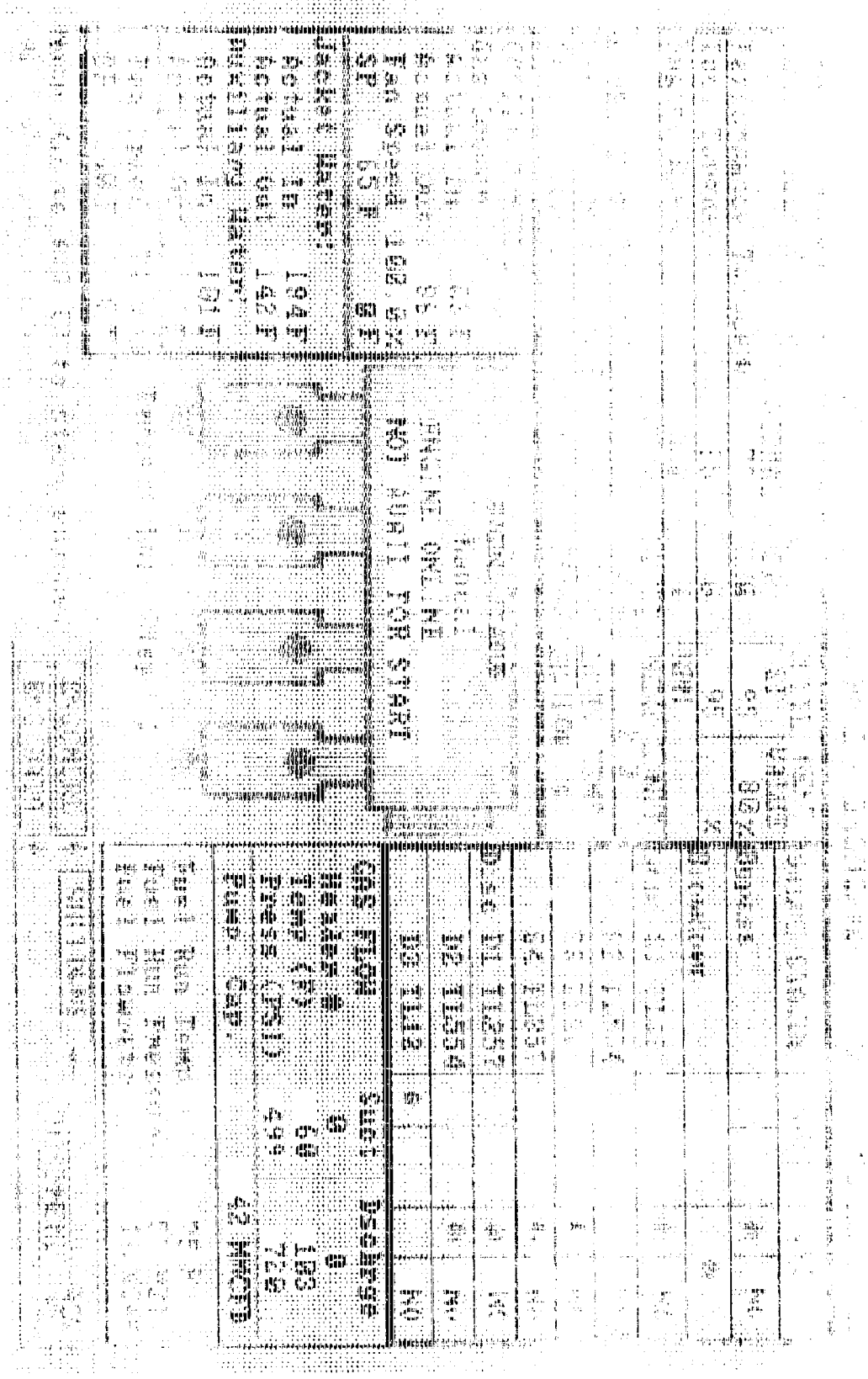
1075	1169	1188	1079	[illegible]	[illegible]
					Avg
101	103	103	184	183	

AWater IN TO Engine	111	F
AWater OUT OF Engine	180	F
JWater IN TO Engine	165	F
JWater OUT OF Engine	183	F

MISC. TEMPS & PRESS	TEMP	PRESS
Engine Oil IN	173 F	------
Engine Oil OUT	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
Inlet Air	79 F	
Exhaust Stack	0 F	

Test #3
Stateline Station

15:43:34 EOW ENG 1 OP TURBOJ1.PRESS. 20.1 PSIG



VII. APPENDIX

Contained in this section is a copy of the dry gas meter calibration, pitot tube calibration, gas standard certifications and resumes of Emission Testing Services, Inc. personnel who performed the testing. Also contained at the end of this section are excerpts from the operating manuals for each of the continuous analyzers used. The excerpts describe the principle operation of the instrument, analytical technique, performance characteristics, etc..

John R. Angelloz, Jr.
Project Engineer
Emission Testing Services, Incorporated
Baton Rouge, Louisiana

EDUCATION

B.S., Engineering Technology
Louisiana State University

Engineer Officer Advanced Course, 1988
Fort Belvoir, Virginia

Engineer Officer Basic Course, 1983
Fort Belvoir, Virginia

Participates in Air-Pollution Training
Institute Courses (APTI)

SOCIETIES

Source Evaluation Society (SES)

Society of American Military Engineers (SAME)

LSU Alumini Association

The National Guard Association of the United States

EXPERIENCE

1990 to Present - Emission Testing Services - Project Engineer responsible for performing continuous emission monitoring for THC, SO_2, NO_x, CO, O_2 and CO_2, logistics for sampling and testing projects, feasibility studies for process operation modifications, coordinating plant start-up operations, equipment and crew preparation, and crew development. Mr. Angelloz has been observed in 8 states coordinating various engineer projects.

1986 to 1990 - Emission Testing Services - Testing Team Leader experienced in emission testing, fugitive emissions and ambient air monitoring. Familiar with all routine US EPA New Source Performance Test procedures. Routinely performed actual source sampling and testing using Reference Method test as well as non-standard testing procedures. Proficient in data reduction and report preparation.

1985 to 1986 - Kemron Environmental Services - Sampling Specialist experienced in emission testing, monitor certifications, calibration and repair of source sampling and continuous monitoring equipment. Cross-trained as a laboratory testing assistant responsible for standard solution preparation, water sampling analysis, total organic carbon analysis, total solids and suspended solids analysis and GC/MS sample preparation.

MILITARY

Louisiana National Guard - CPT. - Active duty includes tours of Ft. Riley, Kansas; Ft. Belvoir, Virginia, the Republic of Panama, and the United Kingdom.

Kevin Thibodeaux
Sampling Specialist
Emission Testing Services, Incorporated
Baton Rouge, Louisiana

EDUCATION

High School Graduate

U.S. EPA Round Robin sample integrity audits

Completed Emission Testing Services Air Sampling Techniques Seminar

Participates in on going Air-Pollution Training Institute Courses (APTI)

EPA certified opacity reader (Method 9)

EXPERIENCE

1987 to Present - Emission Testing Services, Inc. - Sampling Specialist in emission testing. Performing EPA Reference Methods and non routine source evaluations. Crew leader for monitor certifications and various other source evaluations.

Responsible for the calibration of pitot tubes, control consoles, and thermocouples.

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English Units)

Leak Check Good @ 0.00562

T.D.G.M.R. 569.900

Date 05 30 90

Meter box number 481

Barometric pressure, P_b 29.90 in. Hg

Calibrated by K. Thibodeaux

Orifice manometer setting (ΔH), in. H_2O	Wet test meter (V_w), ft^3	Dry gas meter (V_d), ft^3	Wet test meter (t_w), °F	Dry gas meter Inlet (t_{d_i}), °F	Dry gas meter Outlet (t_{d_o}), °F	Dry gas meter Avg[a] (t_d), °F	Time (θ), min.
0.5	5	569.636	80.5	95 / 105	92 / 95	96.75	12.97
1.0	5	574.901	81.5	96 / 110	95 / 97	99.50	9.28
1.5	10	585.419	82.2	101 / 115	97 / 100	103.25	15.17
2.0	10	595.964	83.4	104 / 119	99 / 102	106.0	13.20
3.0	10	606.529	84.2	106 / 122	101 / 103	108.0	10.87
4.0	10						

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$	$\Delta H@_i = \frac{0.0317 \; H}{P_b \; (t_d + 460)} \left[\frac{(t_w + 460) \; \theta}{V_w}\right]^2$
0.5	0.0368	0.9824	1.872
1.0	0.0737	0.9788	1.912
1.5	0.110	0.9840	1.910
2.0	0.147	0.9829	1.927
3.0	0.221	0.9807	1.959
4.0	0.294		
Average		0.9818	1.916

Y = Ratio of reading of wet test meter to dry test meter; tolerance for individual values ± 0.02 from average.

$H_@$ = Orifice pressure differential that equates to 0.75 cfm of air @ 68 F and 29.92 inches of mercury, in. H_2O; tolerance for individual values ± 0.20 from average.

Calibrated by [signature]

ETS

PITOT TUBE CALIBRATION

Pitot Tube Number P.6-0 Cp (std) 0.99

Calibrated By T. L. Sage Date 062690

Point Number		Standard Pitot Δ p (in. H_2O)	"S" Type Pitot Δ p (in. H_2O) "A" Side	"B" Side
1	H	1.500	2.100	2.00
2	M	0.625	0.930	0.930
3	L	0.105	0.155	0.150

Calculations:

$$Cp_{(s)} = Cp_{(std)} \times \sqrt{\frac{\Delta p\ (std)}{\Delta p\ (s)}}$$

Deviation $= Cp_{(s)} - \overline{Cp}$ (Side A or B)

Avg. Dev. $= \dfrac{\sum_{1}^{3} \left| Cp_{(s)} - \overline{Cp} \right|}{3}$ (Side A or B)

"A" Side $Cp_{(s)}$	Deviation	"B" Side $Cp_{(s)}$	Deviation
0.837	0.005	0.857	0.014
0.843	0.011	0.843	0.843
0.815	0.017	0.828	0.015

$\overline{Cp}$ = 0.832 = 0.843

$\left| \overline{Cp}\ (\text{Side A}) - \overline{Cp}\ (\text{Side B}) \right|$ = 0.011 (must be $\leq$ 0.01)

Avg. Dev. (Side A) = 0.011 (must be $\leq$ 0.01)

(Side B) = 0.009 (must be $\leq$ 0.01)

$Cp = \dfrac{\overline{Cp}\ (\text{Side A}) + \overline{Cp}\ (\text{Side B})}{2}$ (should be $0.80 \leq Cp \leq 0.85$) = 0.838

Scott Specialty Gases, Inc.

Rec'd 10-10-89

TROY, MI 48083 PHONE: 313-589-2950 FAX NO: 313-589-2134

EMISSION TESTING SERVICES
10389 MAMMOTH DR
BATON ROUGE , LA 70895

Date: 8/31/89
Our Project No.: 4778
Your P.O. No.: FD082989

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. AAL 5461 — Analytical Accuracy ±1%

Component	Concentration
METHANE	89.83ppm
AIR	BALANCE
ACUBLEND MASTER GAS	

Cyl. No. ALM002902 — Analytical Accuracy ±1%

Component	Concentration
METHANE	60.56ppm
AIR	BALANCE
ACUBLEND MASTER GAS	

Cyl. No. AAL 6917 — Analytical Accuracy ±1%

Component	Concentration
METHANE	30.17ppm
AIR	BALANCE
ACUBLEND MASTER GAS	

Cyl. No. — Analytical Accuracy

Component	Concentration

Analyst [signature]

Approved By [signature]

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 GAS
ACCESSORY PRODUCTS CUSTOM ANALYTICAL SERVICES

PHILADELPHIA, PENNSYLVANIA / TROY, MICHIGAN / HOUSTON, TEXAS / WHEELING, ILLINOIS

TELEX: 510-100-8831 (ScotGas)
FAX: 714-887-0549
PHONE: 714-887-2571

Scott Specialty Gases a division of

Scott Environmental Technology Inc. 2600 CAJON BLVD., SAN BERNARDINO, CA 92405

Shipped From: Scott SAN BERNARDINO
Date Shipped 2-16-89
Our Project No: 416096
Your P.O. No: 89-0120
Page 1 of 1
Expiration Date: 8-27-90

EMISSION TESTING SERVICES
ATTN: FRED DOROLING

CERTIFICATE OF ANALYSIS—EPA PROTOCOL GASES*

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. AAL-13646 Cylinder Pressure 1900 psig Certified Accuracy ±1 % NBS Traceable

REFERENCE STD					GAS ANALYZER		
COMPONENTS	CERTIFIED CONC	SRM/CRM NO.	CYL NO.	CONC.	MAKE/MODEL/SERIAL NO.	LAST CAL DATE	ANALYTICAL PRINCIPLE
Carbon Monoxide	60.55 PPM	SRM 2636	AAL-6965	244 PPM	Horiba AIA 24 S/N 4564403	12-7-88	Infra-red

BALANCE GAS Nitrogen

ANALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

Component Carbon Monoxide
First Analysis Date 1-31-89 Units PPM

Z 00.0	R 92.8	T 25.6
R 92.8	Z 00.0	T 25.6
Z 00.0	T 25.6	R 92.8

Mean Test Assay 60.47

Second Analysis Date 2-7-89 Units PPM

Z 00.0	R 92.8	T 25.7
R 92.8	Z 00.0	T 25.6
Z 00.0	T 25.6	R 92.8

Mean Test Assay 60.55

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Chronology: Date _____
Assay _____

Analyst MAYNARD JOHNSON

Approved By: [signature]

TELEX: 510-100-8831 (ScotGas)
FAX: 714-887-0549
PHONE: 714-887-2571

Scott Specialty Gases a division of

Scott Environmental Technology Inc. 2600 CAJON BLVD., SAN BERNARDINO, CA 92405

EMISSION TESTING SERVICES
ATTN: FRED DOWLING

Shipped From: Scott SAN BERNARDINO
Date Shipped 6-1-89
Our Project No: 00584
Your P.O. No: PD050389
Page 1 of 1
Expiration Date: 12-1-90

CERTIFICATE OF ANALYSIS—EPA PROTOCOL GASES*

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. AAL-8742 Cylinder Pressure 1900 psig Certified Accuracy ±1 % NBS Traceable

REFERENCE STD

COMPONENTS	CERTIFIED CONC	SRM/CRM NO.	CYL. NO.	CONC.
Carbon Monoxide	90.8 PPM	CRM 2636	CAL-6965	204.0 PPM

GAS ANALYZER

MAKE/MODEL/SERIAL NO.	LAST CAL. DATE	ANALYTICAL PRINCIPLE
Horiba AIA 24	3-17-89	Infra-red
S/N 4564403		

BALANCE GAS Nitrogen

ANALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

Component Carbon Monoxide
First Analysis Date 5-23-89 Units PPM

Z 00.0	R 92.6	T 37.6
R 92.6	Z 00.0	T 37.6
Z 00.1	T 37.6	R 92.6

Mean Test Assay 90.8

Second Analysis Date 5-31-89 Units PPM

Z 00.0	R 92.6	T 37.6
R 92.6	Z 00.0	T 37.6
Z 00.0	T 37.6	R 92.6

Mean Test Assay 90.8

Component _____
Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Component _____
Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Chronology: Date _____
Assay _____

Analyst Maynard Johnson

Approved By: [signature]

TELEX: 510-100-8831 (ScotGas)
FAX: 714-887-0549
PHONE: 714-887-2571

Scott Specialty Gases a division of

Scott Environmental Technology Inc. 2600 CAJON BLVD., SAN BERNARDINO, CA 92405

EMISSION TESTING
ATTN: FRED DOWLING

Shipped From: Scott SAN BERNARDINO
Date Shipped 6-8-89
Our Project No: 00848
Your PO. No: FD051789
Page 1 of 1
Expiration Date: 12-8-90

CERTIFICATE OF ANALYSIS—EPA PROTOCOL GASES*

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM-6129 Cylinder Pressure 1900 psig Certified Accuracy ±1 % NBS Traceable

REFERENCE STD					GAS ANALYZER		
COMPONENTS	CERTIFIED CONC	SRM/CRM NO.	CYL NO.	CONC.	MAKE/MODEL/SERIAL NO.	LAST CAL DATE	ANALYTICAL PRINCIPLE
Nitric Oxide	206.7 PPM	CRM 1685 B	CAL-5683	236 PPM	Thermo-Electron	5-2-89	Chemi-Luminenscent
					10 Ar S/N 14853-150		
NOX	207.1 PPM						

BALANCE GAS Nitrogen

ANALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

Component Nitric Oxide
First Analysis Date 5-31-89 Units PPM

Z 0.05	R 94.15	T 82.38
R 94.28	Z 0.05	T 82.43
Z 0.05	T 82.42	R 94.20

Mean Test Assay 206.4

Second Analysis Date 6-7-89 Units PPM

Z 0.00	R 93.68	T 82.00
R 93.68	Z 0.00	T 81.97
Z 0.00	T 81.95	R 93.43

Mean Test Assay 206.7

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Component _____ Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Chronology: Date _____
Assay _____

Analyst Doug Hagberg

Approved By: [signature]

TELEX: 510-100-8831 (ScotGas)
FAX: 714-887-0549
PHONE: 714-887-2571

Scott Specialty Gases a division of

Scott Environmental Technology Inc. 2600 CAJON BLVD., SAN BERNARDINO, CA 92405

Shipped From: Scott SAN BERNARDINO
Date Shipped 6-8-89
Our Project No: 00848
Your PO. No: FD051789
Page 1 of 1
Expiration Date: 12-8-90

EMISSION TESTING
ATTN: FRED DOWLING

CERTIFICATE OF ANALYSIS—EPA PROTOCOL GASES*

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM-6188 Cylinder Pressure 1900 psig Certified Accuracy ±1 % NBS Traceable

REFERENCE STD					GAS ANALYZER		
COMPONENTS	CERTIFIED CONC	SRM/CRM NO.	CYL NO.	CONC.	MAKE/MODEL/SERIAL NO.	LAST CAL. DATE	ANALYTICAL PRINCIPLE
Nitric Oxide	460.1 PPM	CRM 1687	AAL-19314	966 PPM	Thermo-Electron	5-2-89	Chemi-Luminenscent
					10 Ar S/N 14853-150		
NOX	461.2 PPM						

BALANCE GAS Nitrogen

ANALYZER READINGS: Z = Zero Gas T = Test Gas R = Reference Gas

Component Nitric Oxide
First Analysis Date 5-31-89 Units PPM

Z 0.00	R 95.22	T 45.21
R 95.10	Z 0.02	T 45.19
Z 0.02	T 45.19	R 95.05

Mean Test Assay 458.9

Second Analysis Date 6-7-89 Units PPM

Z 0.00	R 96.38	T 45.87
R 96.28	Z 0.03	T 45.90
Z 0.01	T 46.00	R 96.55

Mean Test Assay 460.1

Component _____
Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Component _____
Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Date _____ Units _____

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay _____

Chronology: Date _____
Assay _____

Analyst Doug Hagberg

Approved By: [signature]

Scott Specialty Gases

a division of
Scott Environmental Technology, Inc.

3714 LAPAS DRIVE, HOUSTON, TEXAS 77023, (713) 644-4820, FAX 644-0244

EMMISSIONS TESTING SERVICE
10389 MAMMOTH DRIVE
BATON ROUGE, LA 70814

Date: SEPTEMBER 28, 1988

Our Project No.: 714023

Your P.O. No.: 880913-3

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. AAL18436 Analytical Accuracy ±1%

Component	Concentration
METHANE	501 PPM
AIR	BALANCE

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 / LONGMONT, COLORADO

ETS
EMISSION TESTING SERVICES, INC.
P.O. BOX 15075 • BATON ROUGE, LA 70895

Company: Scott Specialty Gases Analyst: Brad Latham

Cylinder # AAL-18808 Date: 5/26/89

Instrument: Orsat Analysis

Trial	O_2	CO_2
1	20.9	0.0
2	20.9	0.0
3	20.9	0.0
4	20.9	0.0
5	20.9	0.0
6	20.9	0.0
7	20.9	0.0
8	20.9	0.0
9	20.9	0.0

Mean O_2 = 20.9%

ETS
EMISSION TESTING SERVICES, INC.
P.O. BOX 15075 • BATON ROUGE, LA 70895

OXYGEN CYLINDER CERTIFICATION

Company: Quality Gas

Analyst: Kevin Thibodeaux

Cylinder #: CC83916

Date: 06/01/90

Instrument: Orsat Analysis

Trial	O_2	CO_2
1	13.2	0.0
2	13.2	0.0
3	13.2	0.0
4	13.2	0.0
5	13.2	0.0
6	13.2	0.0
7	13.2	0.0
8	13.2	0.0
9	13.2	0.0

Mean O_2 = 13.20%

INSTRUCTION MANUAL FOR Thermox STACK GAS ANALYZER (254)

Customer: Emission Testing Serv. Serial No.: C054612

Customer P. O. No.: 881027-1 Ship To: Emission Testing Servicing

For Use on 115 Volt, 50/60 Hz Supply (±10%) Date Shipped: 12/15/88
3A

Use Slo-Blo Fuse In Control Unit

Type of Sensor Stack Gas-10 Type of Control Unit Combination

Calibration Temperature: 812 °C Calibration Curve (s): 800-10

	METER	RECORDER		REC. OUTPUT
Range 1	0 to 10% O_2	0 to 10% O_2	=	4 to 20mA Isol. Lin.
Range 2	0 to 25% O_2	0 to 25% O_2	=	4 to 20mA Isol. Lin.

APPLICABLE DRAWINGS:

CONTROL UNIT	Internal Wiring	A112-470
	Card Cage Layout	A112-470
	Dimensions	A203-085
	Signal Attenuation Card Wiring	A117-017
SENSOR UNIT	Internal Wiring	B204-078-5
	Internal Flow	B204-078-5
	Mounting	B204-078-5
	Dimensions	B204-078-5
OVERALL SYSTEM	Interconnecting Wiring	A103-071-1

OPTIONS INCLUDED WITH THIS SYSTEM:

DESCRIPTION	INSTRUCTION SHEET NO.	PRINTED CIRCUIT CARD REPLACEMENT PART NO.
Isolated Linearizer Card	900-581	80215

OTHER NON-STANDARD FEATURES OF THIS SYSTEM WHICH SHOULD BE NOTED:

C. Ancillary Equipment

If any recorder and/or control device, not manufactured by Thermox, has been specified as ancillary equipment, refer to specific instructions provided by the manufacturer of such equipment.

> THE SUCCESSFUL OPERATION OF YOUR ANALYZER DEPENDS TO A VERY LARGE DEGREE ON THE PROPER INSTALLATION OF THE SENSOR. SENSOR INSTALLATION IS COVERED IN SECTION III, C.

II. BASIC PRINCIPLES OF OPERATION

It is strongly recommended that all personnel who will regularly use this instrument become familiar with the following brief explanation of how the instrument works, what is in it, and what can go wrong with it.

A. How It Works

1. The Electrochemical Cell

The working element of the gas sensor is a closed-end tube made of a ceramic oxide, Zirconium Oxide (Zirconia). When it is hot, it becomes a conductor of electricity because of the mobility of the oxygen ions in its crystal structure. Electrodes of porous platinum are coated onto the inside and outside of the cell and are normally connected to a panel meter.

2. Cell Output

When the sensing cell is hot, a voltage is produced that is proportional (logarithmically) to the ratio of the oxygen concentration on the reference side of the cell (usually ambient air) and the oxygen concentration of the sample. All of this voltage (or a portion in the case of expanded scales using a voltage offset power supply) is displayed on the panel meter as a logarithmic display of the concentration of oxygen. Optionally, the display may be linearized. The sensing cell is a partial pressure device, and responds directly to changes in sample pressure.

B. What Is In It -- Three Simple Systems

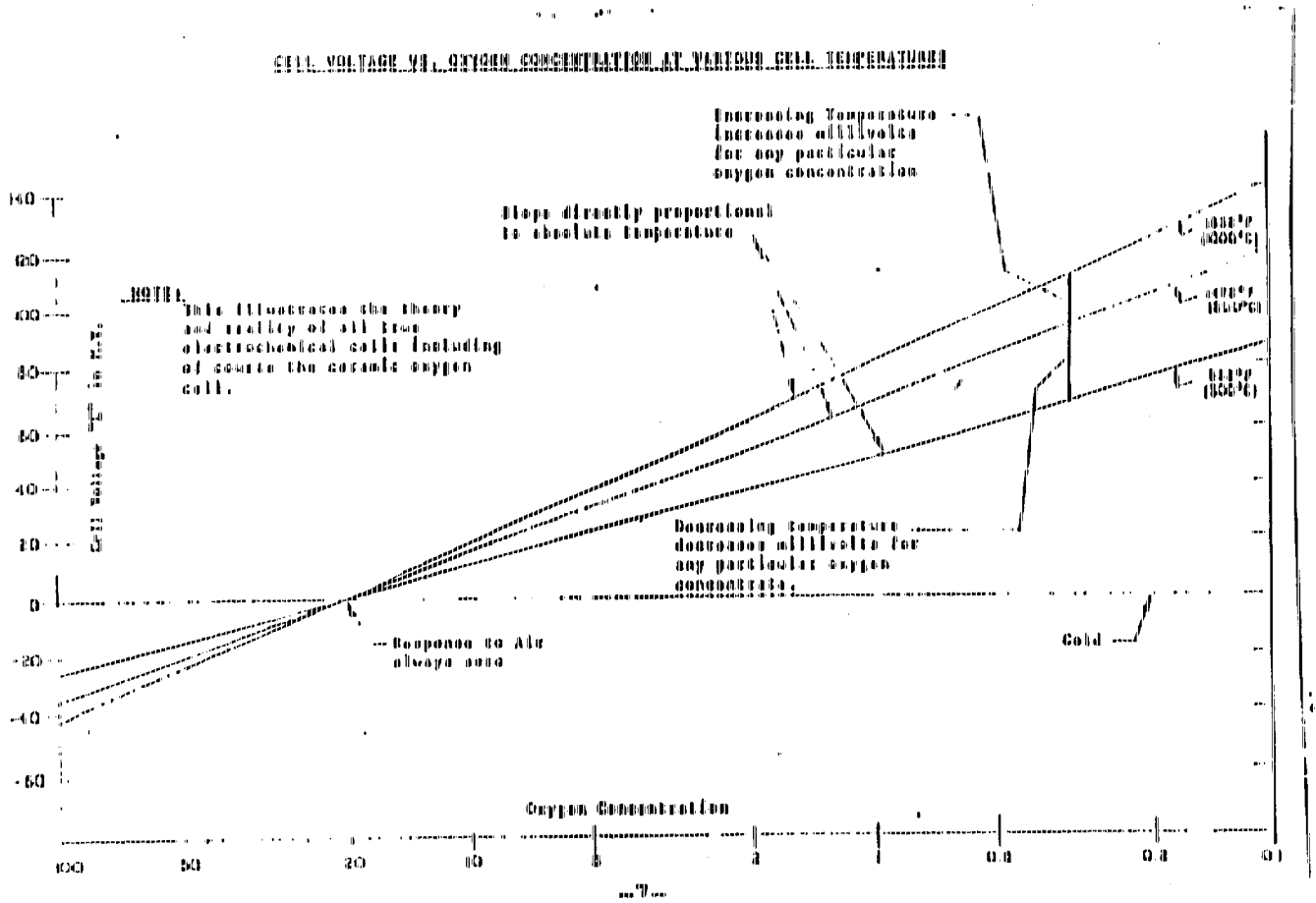
1. The Plumbing: All inlet and outlet tubing, the sensing cell, and sensing cell fittings and flow block assembly.

For measuring oxygen in non-combustible gases, the calibration of the analyzer is obtained from the formula:

$$Emv = AT \log_{10} \frac{20.9}{O_2\%}$$

AT = 48.0 at 695°C (1283°F)
AT = 50.0 at 735°C (1355°F)
AT = 51.7 at 770°C (1418°F)
AT = 53.8 at 812°C (1494°F)

Where A is a constant, T is the cell temperature in degrees Kelvin (deg C + 273) and $O_2\%$ is the oxygen concentration of the gas to be analyzed. The curves below show the temperature/cell output relationship.



The sensing cell does not produce a signal when air is on both sides, and the voltage increases as the oxygen concentration in the sample decreases, relative to air.

MODEL 48

GFC AMBIENT CO ANALYZER

INSTRUCTION MANUAL

Serial Number M 48 21366 197

Thermo Electron Instruments

circuit which may need to have a particular non-linear characteristic (as is the case for the effect of pressure and temperature changes on infrared absorption measurements). Analog diagnostic functions also require more circuitry thereby increasing both complexity and cost while decreasing reliability. Data averaging in analog systems is usually done at considerable extra cost with a separate instrument connected to the output of the basic analyzer.

In contrast, the Model 48 has been designed to perform a large variety of tasks by utilizing appropriate information stored in the system's program memory. For example, the microcomputer is used to process signals from both a pressure and temperature transducer to make corrections to the instrument output, resulting in CO concentration measurements which are unaffected by changes in the temperature or pressure of the gas being sampled. Both linear and non-linear corrections are handled with equal ease. In addition, many diagnostic functions can be selected through the use of front panel pushbutton switches (Figure I-1). User selectable program options include: settable time response for data smoothing; one hour averaged value which may be set for continuous output at a standard secondary pair of output terminals, or can be set to interupt the primary output briefly every hour, or can be de-activated. These options are standard with every instrument and are selected by setting switches on the front panel of the instrument.

Thermo Electron is pleased to have supplied you with a Model 48. We are committed to the manufacture of instruments exhibiting high standards of quality, performance, and workmanship. We are prepared and eager to be of service to you in the use of this instrument.

A. PRINCIPLE OF OPERATION OF THE GAS FILTER CORRELATION SPECTROMETER

The technique of Gas Filter Correlation (GFC) offers improved specificity and sensitivity over conventional non-dispersive infrared (NDIR) techniques. GFC spectroscopy is based upon comparison of the detailed structure of the infrared absorption spectrum of the measured gas to that of other gases also present in the sample being analyzed. The technique is implemented by using a high concentration sample of the measured gas, i.e., CO, as a filter for the infrared radiation transmitted through the analyzer, hence the term GFC.

The basic components of the GFC CO spectrometer are shown in Figure I-2. Radiation from an IR source is chopped and then passed through a gas filter alternating between CO and N2 due to rotation of the filter wheel. The radiation then passes through a narrow bandpass interference filter and enters a multiple optical pass cell where absorption by the sample gas occurs. The IR radiation then exits the sample cell and falls on an IR detector.

The CO gas filter acts to produce a reference beam which cannot be further attenuated by CO in the sample cell. The N2 side of the filter

wheel is transparent to the IR radiation and therefore produces a measure beam which can be absorbed by CO in the cell. The chopped detector signal is modulated by the alternation between the two gas filters with an amplitude related to the concentration of CO in the sample cell. Other gases do not cause modulation of the detector signal since they absorb the reference and measure beams equally. Thus the GFC system responds specifically to CO.

With the improved rejection of interferences afforded by the GFC technique, it is possible to increase the sensitivity of the analyzer. This is achieved by the multiple pass optics (White Cell) used in the sample cell which leads to a large path length, and thus an improved sensitivity , in a small physical space. This allows full scale sensitivity down to 1 PPM with a lower detectable limit (LDL) of 0.020 PPM to be achieved.

B. INSTRUMENT DESCRIPTION

The instrument can be most conveniently discussed by separating it into the following operational components (Figure 1-3):

1) Optical bench
2) Correlation wheel and chopper motor
3) Source and source power supply
4) Detector, preamplifier, and bias supplies
5) Input signal conditioning board
6) DC power supply
7) Microcomputer
8) Temperature controller
9) Flow components (pump, valves, flowmeter, and plumbing)
10) Temperature and pressure transducers

1) Optical Bench (Figures 1-2 and 3) The optical bench is of the White Cell design. The use of the White Cell multipass optical bench allows one to achieve a long path length, with a large acceptance angle, in a small physical package. The bench has been designed for easy disassembly for cleaning. The source, detector, correlation wheel, and chopper motor mount rigidly to the bench. No realignment should be necessary after routine cleaning.

2) Correlation Wheel and Chopper Motor - The correlation wheel consists of two hemispherical cells, one filled with CO and the other with N2. Integral with the correlation wheel is the chopper pattern necessary to produce the high frequency (360 Hz) chop necessary for the infrared detector. The correlation wheel is rotated by a synchronous motor.

3) Source and Power Supply - The infrared source is a special wire wound resistor. It is heated by passing a highly regulated DC voltage through the resistor. Replacement, when necessary, is straightforward.

C. SPECIFICATIONS

Ranges	0-1, 2, 5, 10, 20, 50, 100, 200, 500, 1000 PPM
Noise	0.05 PPM RMS - with time constant = 30 seconds
Minimum Detectable Limit	0.10 PPM
Zero Drift, 24 hours	+/- 0.2 PPM
Span Drift, 24 hours	+/- 1% Full Scale
Rise, Fall Times (0-95%) (at 1 lpm flow, 30 second response time.)	1 minute
Precision	+/- 0.1 PPM
Linearity	+/- 1%
Flow Rate	0.5 - 2 lpm
Rejection Ratio	Negligible interference from water and CO_2.
Operating Temperature	Performance specifications maintained over the range 15-35°C (may be operated safely over the range 5-45°C)
Power Requirements	105 - 125 VAC, 60Hz 220 - 240 VAC, 50Hz 100 Watts
Physical Dimensions	17"W x 8 3/4"H x 23"D
Weight	45 lbs.
Dual Outputs (Standard)	Individually selectable to 0-10mv, 0-100mv, 0-1V, 0-5V, 0-10V; digital display; 1 hour integrated value. Other outputs available upon request (4-20ma, IEEE-488)

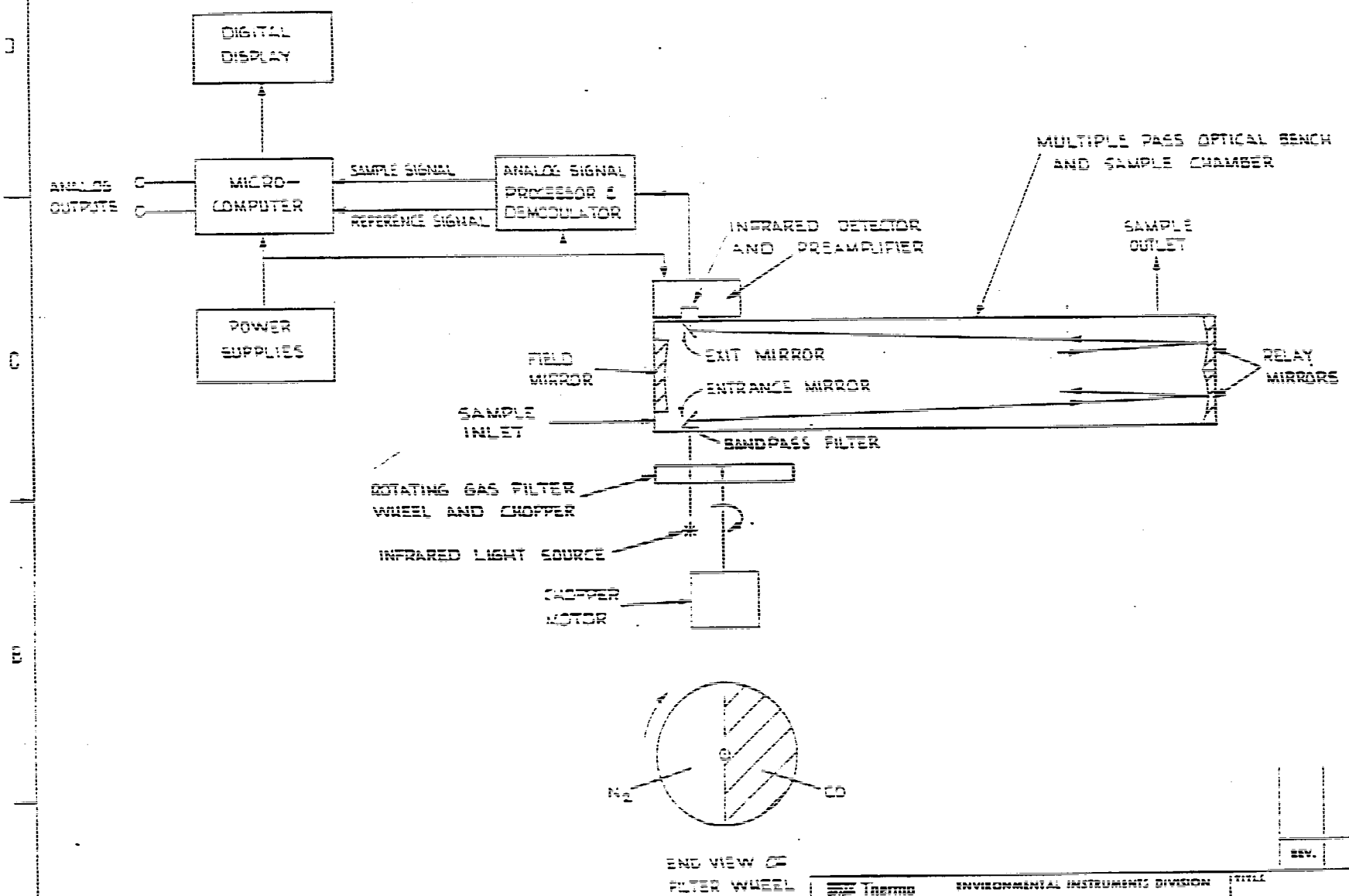


Figure I-3: Block Diagram of a Gas Filter Correlation Spectrometer

Thermo Electron CORPORATION
ENVIRONMENTAL INSTRUMENTS DIVISION

TITLE: BLOCK DIAGRAM OF A GAS FILTER CORRELATION PHOTOMETER

SCALE | DRAWN BY LB | DATE | CHECKED | DATE | DRAWN | FINISH | FIRST USED ON

DO NOT SCALE DWG.

SIZE C | DRAWING NUMBER | REV

REV. | REVISIONS | ZONE

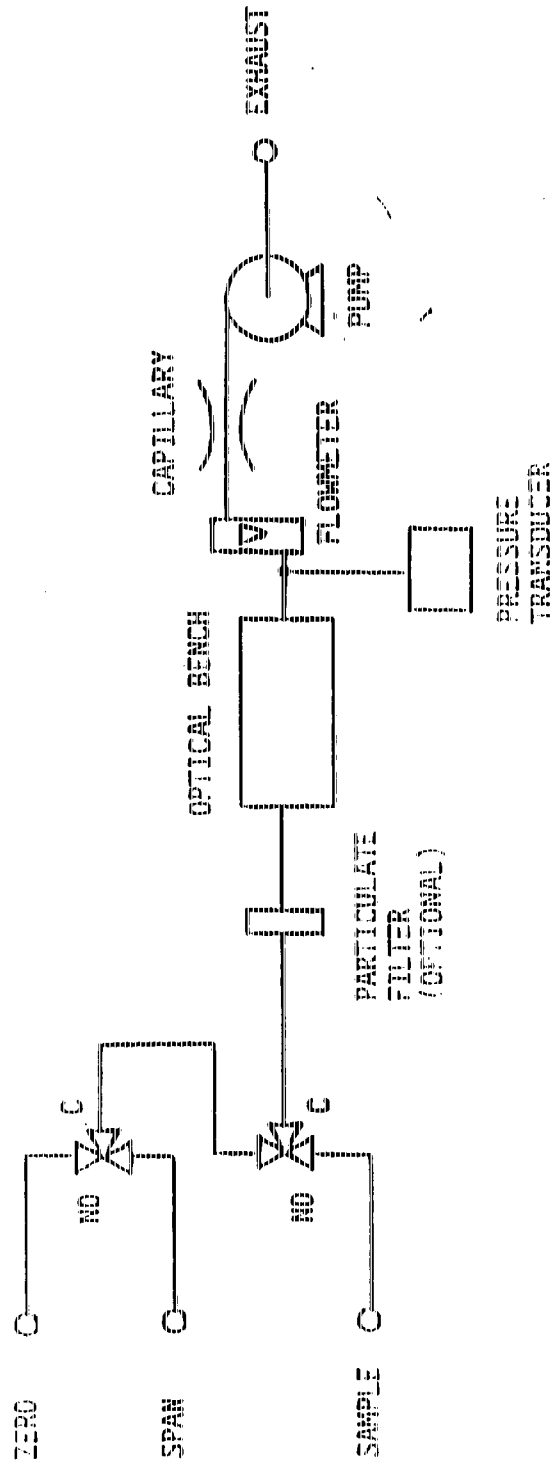


Figure I-4: Flow Schematic of Model 48

FID HYDROCARBON ANALYZER

MODEL HC500-2C

Operation, Maintenance, and

Parts Manual

MELOY LABORATORIES, INC.
Instruments & Systems Division
6715 Electronic Drive
Springfield, Virginia 22151
703-354-2600

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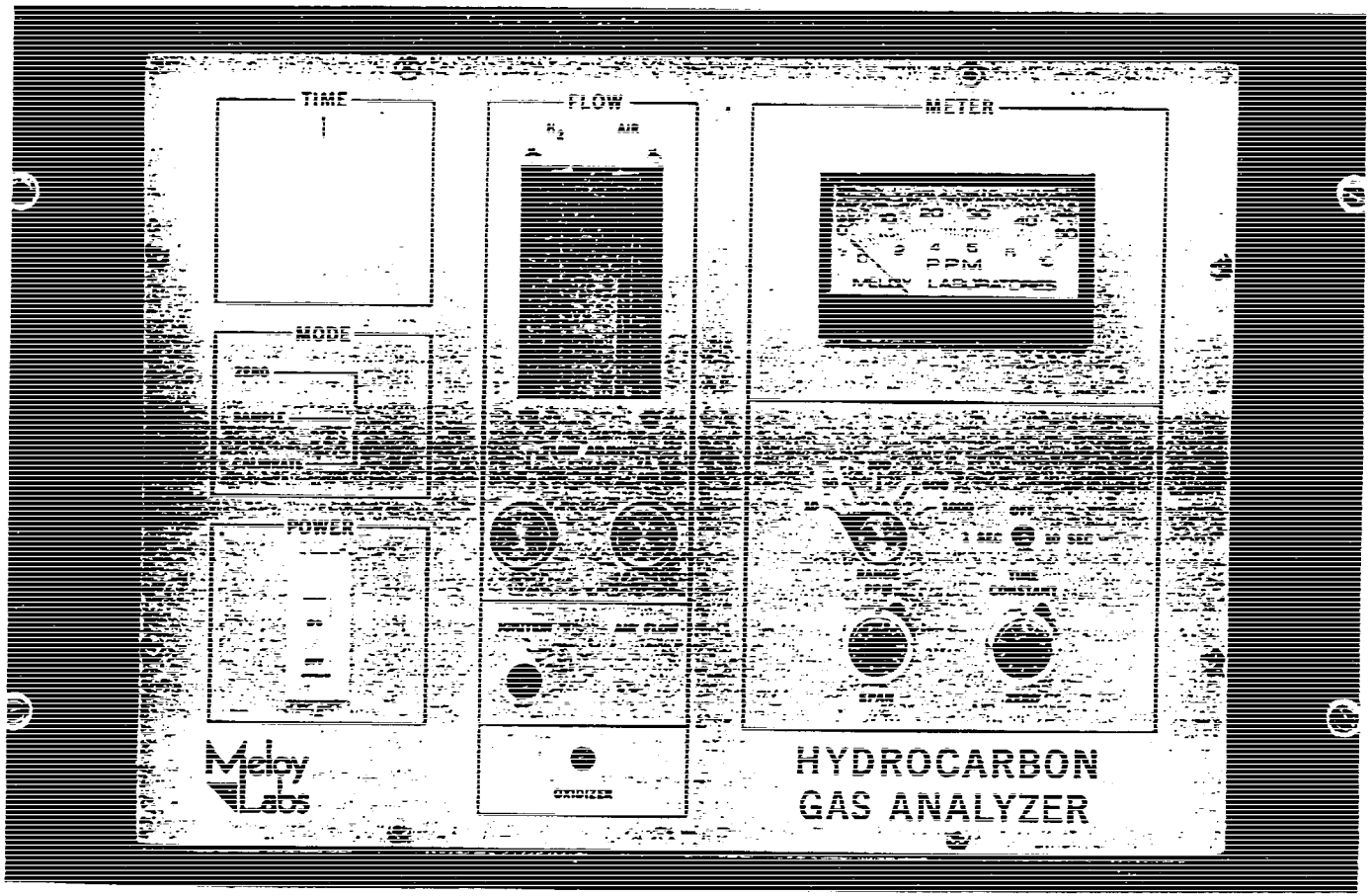

FIGURE IV-I FRONT VIEW OF ANALYZER

SECTION I

INTRODUCTION

The Meloy Laboratories, Inc. Model HC500-2C Hydrocarbon Analyzer is a self-contained system for monitoring ambient concentrations of non-methane hydrocarbons (NMHC), methane and total hydrocarbons.

Sample air is first introduced directly into the FID detector to yield a total hydrocarbon reading which is stored in an electrical circuit. The pneumatic system is automatically switched so that the sample air passes through a catalytic converter before it is introduced into the detector. The catalytic converter converts substantially all the NMHC to a non detectable species. Therefore in this mode only the methane present in the sample will be detected. The methane reading is stored in another electrical holding circuit. A differential amplifier substracts the methane reading from the total hydrocarbon reading to provide a NMHC reading as the output signal.

The hydrocarbon detection system utilizes the well established technique of flame ionization. Hydrocarbons passing through the hydrogen rich flame are converted to ions. An electrostatic field in the burner causes these ions to migrate and collect on an electrode. An electric current is produced which is proportional to the concentration of ions collected.

The design of the Meloy HC500-2C was implemented with the emphasis focused on obtaining stable and reliable performance and ease of service and maintenance. Precise pneumatic and thermal control of critical elements and the utilization of proven solid state circuitry contribute to the performance characteristics of the instrument.

In addition to the basic HC 500-2C Meloy Laboratories, Inc. provides a variety of options and accessories to meet most user's requirements. For example, flow control, automatic reignite, and automatic zero-span check system are some of the options.

SECTION II

PRINCIPLE OF OPERATION

The Meloy Flame Ionization Detector (FID) is based on the ionization of hydrocarbon molecules in a hydrogen hyperventilated flame. Hydrocarbons are fragmented by the flame to carbon radicals, e.g. CH·. These radicals react with oxygen radicals to form positive carbon ions and electrons. The positive ions can undergo further reactions with water molecules to produce hydronium ions.

The following equations summarize some of the possible reactions:

$$C_xH_y \longrightarrow CH\cdot$$

$$CH. + O\cdot \longrightarrow CHO^+ + e^-$$

$$CHO^+ + H_2O \longrightarrow H_3O^+ + CO$$

A 84 volt battery is used to produce an electrostatic field between the ionization probe inside the burner chamber and the burner block. This causes the positively charged ions to migrate to the negatively charged probe and the negative ions to the burner block. The resulting current is proportional to the ions collected. An electrometer amplifier converts the current to voltage which is fed to the amplifier output recorder jacks.

The Meloy FID detector is designed to optimize the sensitivity and stability of these reactions. Sample air is drawn into the detector block by means of a vacuum pump. Hydrogen is supplied under a slight pressure from a cylinder or hydrogen generator. Both these gas streams are controlled and regulated to provide stable flow ratès to the burner.

The catalytic oxidizer is solid substrate in which carbon compounds are converted to carbon dioxide and water. Neither of these compounds respond with the FID. The temperature of the converter is held at a point where no methane is converted while nearly 99% of ambient NMHC compounds are converted.

SECTION III

SPECIFICATIONS

Performance Specifications

	Hydrocarbon FID Detector
Ranges:	0 - 10 ppm 0 - 50 ppm 0 - 100 ppm 0 - 500 ppm 0 - 1000 ppm
Minimum Detectable Sensitivity:	0.1 ppm CH_4
Noise:	$\pm$0.05 ppm CH_4
Lag Time:	Less than 15 sec.
Rise Time to 90%:	Less than 30 sec.
Fall Time to 90%	Less than 30 sec.
Updating Time (Switching Time):	5 min.
Total cycle time:	10 min.
Precision:	$\pm$1% FS
Zero Drift:	$\pm$2% FS/day $\pm$3% FS/3 days
Span Drift:	$\pm$2% FS/day $\pm$3% FS/3 days
Linearity:	$\pm$1% FS
Selectable Time Constant:	1 second or 10 seconds

Operational Specifications

Unattended Operation: (No adjustment of flow or electrical systems)	7 days
Sample Flow Rate:	Approx. 200 ml/min
Hydrogen Flow Rate:	Approx. 140 ml/min
Power Requirements:	115 ± 10 VAC (50-60 Hz) 250 watts
Recorder Outputs (for each of the three channels)	0-100 mv 0-1 v 4-20 ma (optional)
Relative Humidity:	0 to 99%
Ambient Temperature Range:	10 - 40°C for specified specifications

Configurational Specifications

Weight:	40 lbs
Case Dimensions:	17" W x 20" L x 12 1/4" H
Mounting Available:	Bench Rack (Optional)
Sample Pump:	Internal

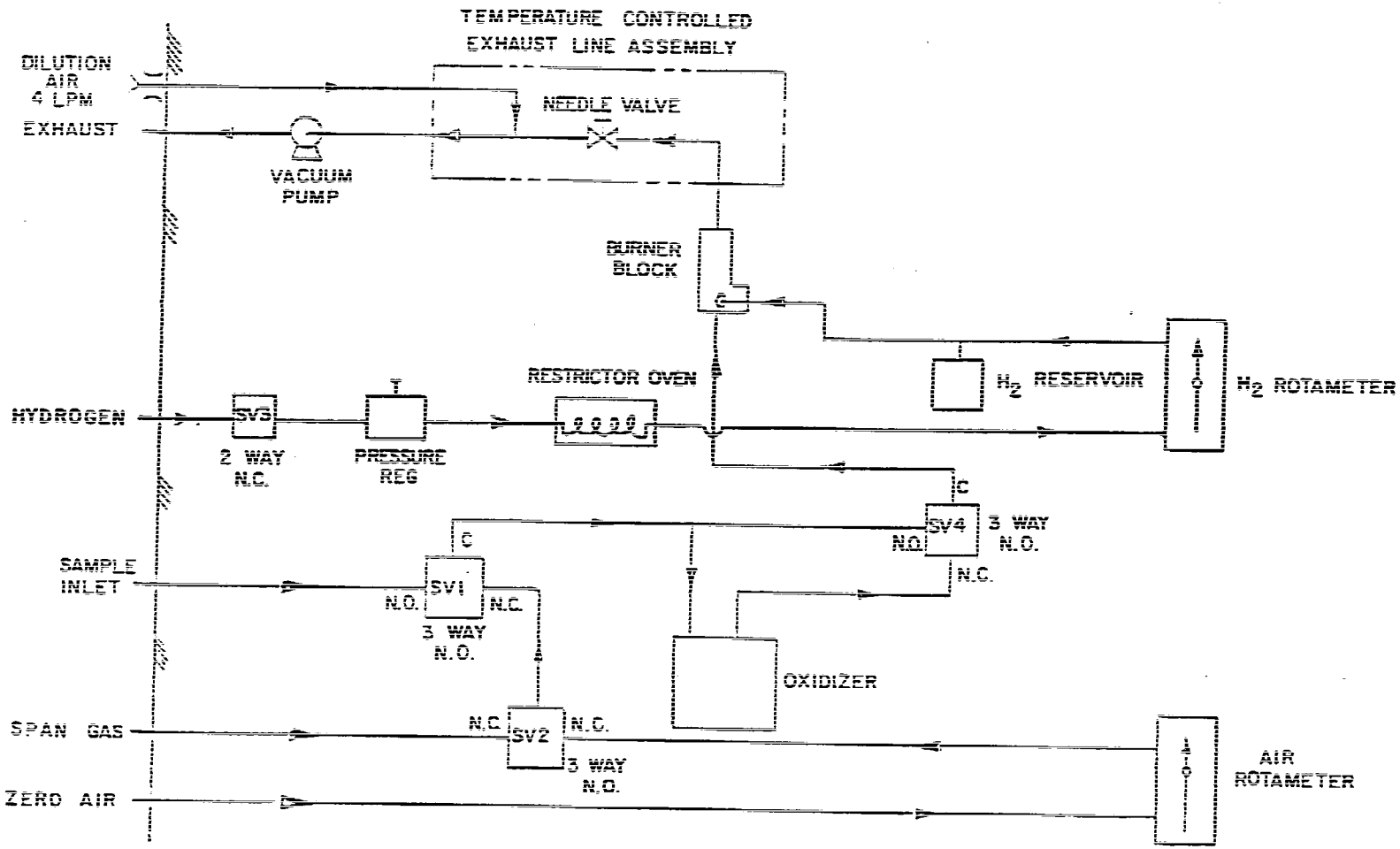

FIGURE IV-C Pneumatic System of HC500-2C With all Options

Thermo Electron
CORPORATION

INSTRUCTION MANUAL

MODEL 10A
RACK-MOUNTED
CHEMILUMINESCENT
NO-NO_x GAS ANALYZER

Thermo Electron Corporation
Environmental Instruments Division
108 South Street
Hopkinton, Massachusetts 01748
(617) 435-5321

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I. INTRODUCTION

Thermo Electron's Model 10A Rack-Mounted Chemiluminescent $NO-NO_x$ Gas Analyzer (Figure 1) is a versatile instrument that continues to fill the need for a sensitive and accurate means of measuring nitric oxide (NO) and the total oxides of nitrogen ($NO + NO_2$) in stack-monitoring and automotive-emission applications.

The instrument you have received is a product worthy of the highest praise in terms of performance and quality, with superb performance characteristics of response time, accuracy and signal-to-noise ratio.

The chemiluminescent reaction of nitric oxide and ozone is the heart of Thermo Electron's Model 10 Series Instruments for continuous measurement of $NO-NO_x$ with eight linear, full-scale ranges from 2.5 to 10,000 parts per million (ppm). The series 10 instruments include an NO_2-to-NO Converter for the thermal conversion of nitrogen dioxide to nitric oxide for subsequent measurement via the chemiluminescent process.

Compared to other available techniques, chemiluminescent analysis of the oxides of nitrogen affords several important advantages:

Sensitivity: 0.1 ppm with ranges of 0 to 2.5 ppm, 0 to 10 ppm, 0 to 25 ppm, 0 to 100 ppm, 0 to 250 ppm, 0 to 1000 ppm, 0 to 2500 ppm and 0 to 10,000 ppm;

Selective detection of NO with negligible interference from water vapor or other frequently encountered chemical species;

Continuous monitoring with rapid response;

Linear output on all ranges and from range to range;

Excellent stability.

II. PRINCIPLE OF OPERATION

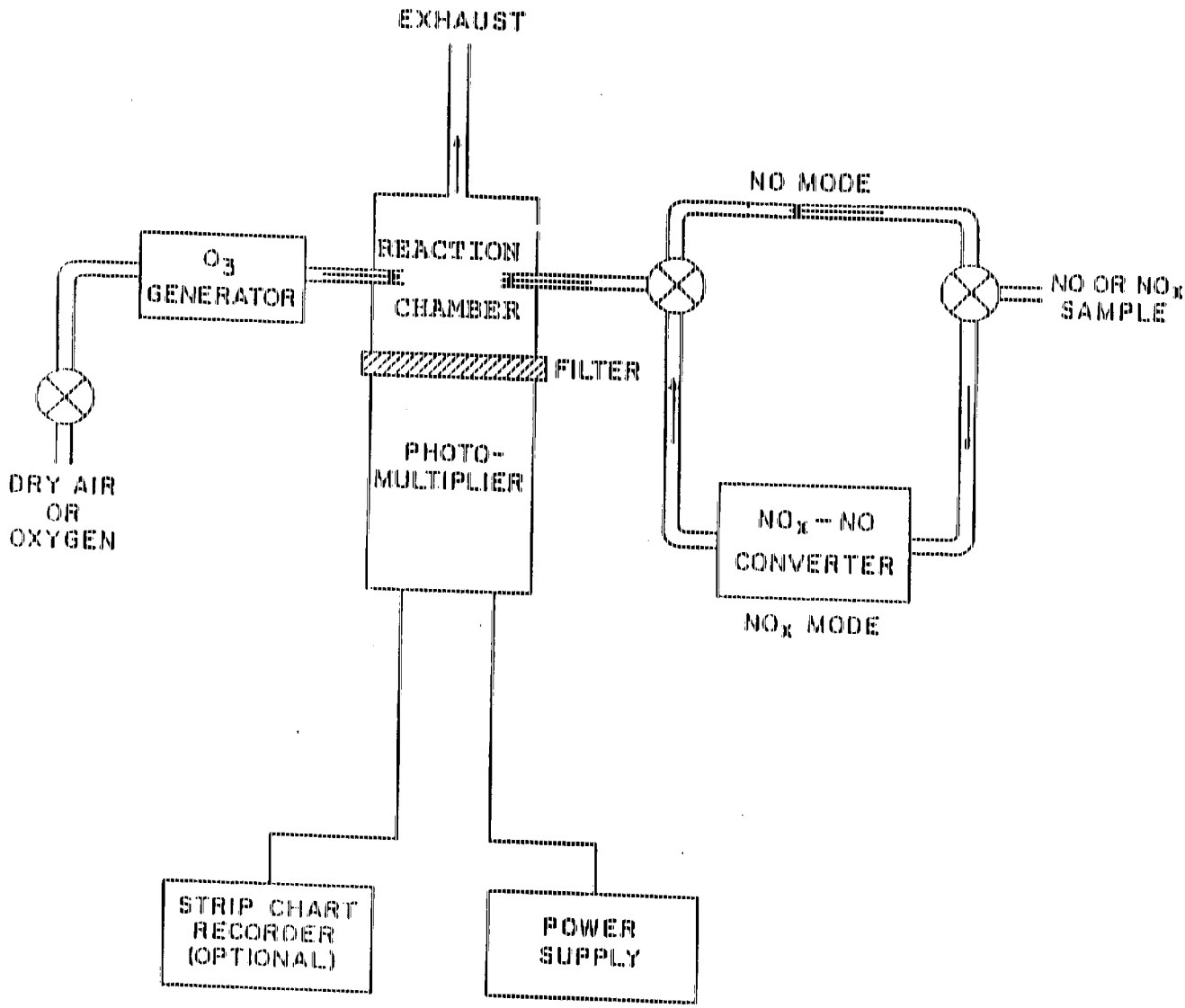
The chemiluminescent reaction of NO and O_3 provides the basis for this improved group of instruments. Specifically,

$$NO + O_3 \longrightarrow NO_2 + O_2 + h_\nu .$$

Light emission results when electronically excited NO_2 molecules revert to their ground state.

To measure NO concentrations, the gas sample to be analyzed is blended with O_3 in a reaction chamber (Figure 2). The resulting chemiluminescence is monitored through an optical filter by a high-sensitivity photomultiplier positioned at one end of the chamber. The filter/photomultiplier combination responds to light in a narrow-wavelength band unique to the above reaction (hence, no interference). The output from the photomultiplier is linearly proportional to the NO concentration.

To measure NO_x concentrations (i.e., NO plus NO_2), the sample gas flow is diverted through an NO_2-to-NO converter. The chemiluminescent response in the reaction chamber to the converter effluent is linearly proportional to the NO_x concentration entering the converter.



Chemiluminescent NO-NO_x Gas Analyzer Conceptual Schematic.

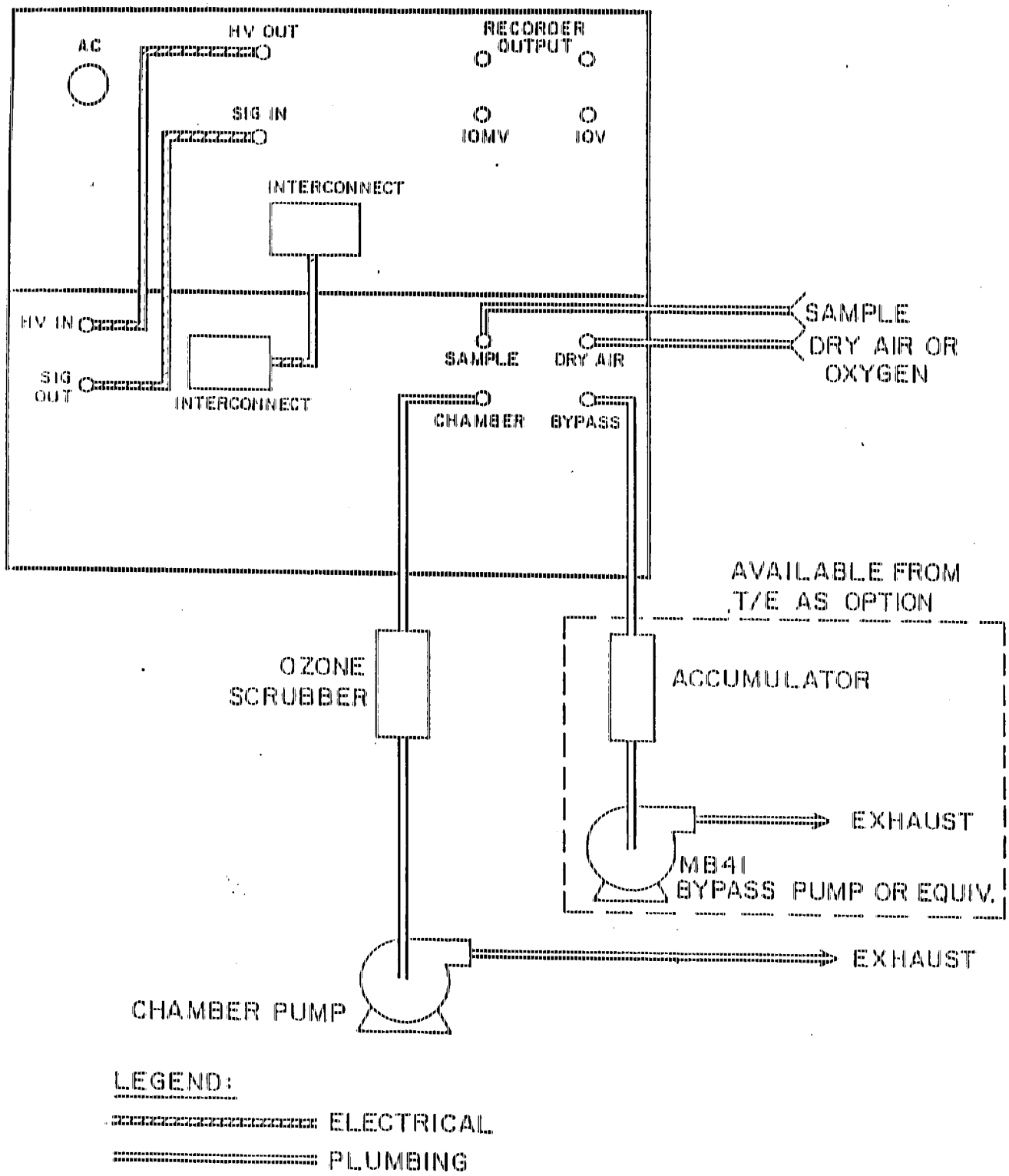


Figure 3. NO-NO_x Analyzer System

For convenience in setting the background suppression, a bottle of zero gas may prove useful. Depending upon the concentration to be measured and the level of NO in the test area, it may prove convenient to use room air as the zero gas.

In addition to the Model 10A Analyzer, the following customer-furnished equipment is recommended:

a. Pressurized cylinder of NO/N_2 with an NO concentration of approximately 90% of the range to be used, and a pressure regulator suitable for adjusting the cylinder pressure from 1 to 20 psig.

b. Pressurized cylinder of oxygen (dry with 99% purity is satisfactory) or pressurized air (hydrocarbon and moisture-free), and a pressure regulator suitable for adjusting cylinder pressure to 10 psig. If desired, room air suitably filtered and dried can be utilized in lieu of pressurized oxygen or air for operation up to 2500 ppm.

c. Particle filter for regulator-air inlet (Balston No. 90 with Grade C element or equivalent is satisfactory).

d. Thermo Electron Model 100B NO_x Generator.

The following steps must be taken to prepare the instrument for operation:

1. Connect the ozone scrubber to the input port of the pump, as shown in Figure 4. Attach the 3/8-inch diameter Teflon line to the input port of the ozone scrubber.

2. Assemble the Model 10 instrument in a 19-inch cabinet or position it on a work bench so that the rear panels are accessible.

CAUTION

WHEN USING THE INSTRUMENT ON A TABLETOP, THE BOTTOM DRAWER (ANALYZER SECTION) SHOULD NOT BE FULLY EXTENDED UNLESS IT HAS PROPER SUPPORT.

V. TECHNICAL DESCRIPTION

Thermo Electron's Model 10A Rack-Mounted Chemiluminescent $NO-NO_x$ Gas Analyzer is packaged for console mounting where easy access is desirable. Both the analyzer and control units are serviceable from the front.

A. CONTROL UNIT

The chemiluminescent signal in the reaction chamber is detected by a high sensitivity photomultiplier tube. By proper selection of the filter transmittance/photocathode response characteristics, the detection is limited to a narrow wavelength band produced only by the $NO-O_3$ reaction.

The photomultiplier provides a current gain in the order of 1×10^6. However, the signal still requires further amplification and conversion to voltage as it leaves the tube. The electrometer amplifier (310J on the schematic, Figure 9) provides not only the current-to-voltage conversion, but also additional gain. This gain is selected by the range switch setting and varies in steps as a function of this setting.

The amplifier-voltage output supplies signals for the meter circuit and the recorder output.

The front panel of the control unit contains the range switch for selection of sensitivity from eight available full-scale ranges (2.5, 10, 25, 100, 250, 1000, 2500 and 10,000 ppm) and the ten-turn precision potentiometer which provides for instrument calibration by varying the voltage applied to the photomultiplier. A second ten-turn potentiometer is provided for suppression of thermally generated dark current from the photomultiplier.

The meter on the control unit has a dual scale which allows the direct reading of NO or NO_x concentrations in parts per million (ppm).

Mounted within the control unit are the photomultiplier high-voltage power supply, the printed circuit (PC) card containing the output circuit, and the dual ±15 VDC power supply for the PC card. See Figure 7 for their locations.

Located on a bracket within the control unit are: a three-position toggle switch to select "LOW", "MEDIUM" and "HIGH" voltage ranges for calibration control; the "CAL OUTPUT" test jacks; "HI-LO" Suppression toggle switch; and "METER CAL" potentiometer. These components, shown in Figures 6 and 7, are readily accessible by sliding the front panel and chassis forward from the housing.

The rear of the control unit (Figure 6) has connectors for:

a. the main AC power input
b. the analyzer interconnect cable
c. the photomultiplier high-voltage output "HV OUT"
d. the photomultiplier signal input "SIG IN"
e. one set of recorder output jacks.

B. CONTROL UNIT CALIBRATION

During factory adjustment of the control unit, the potentiometer on the PC card is properly set. This should not require readjustment when the instrument is received. However, if recalibration is indicated, follow the procedure listed below:

1. Slide the unit forward to provide access to the internal chassis.

2. Connect an accurate voltmeter (±0.1% or better) to the "CAL OUTPUT" jacks within the control unit.

3. Set the range selector switch to the "ZERO" position.

4. If necessary, adjust the amplifier zero potentiometer mounted on the front panel (see Figure 1) to obtain a zero indication on the external voltmeter.

5. Set the range selector switch to the fullscale position.

6. Adjust the fullscale potentiometer, if necessary, to obtain a ten volt output on the external voltmeter (see Figure 6).

7. Adjust the "METER CAL" potentiometer to obtain a fullscale indication on the control unit meter (see Figure 7).

8. Connect an accurate millivoltmeter (±1% or better) to the 0 - 10mV recorder output (rear panel of the analyzer in the case).

9. With the range selector switch still in the fullscale position, turn the 10mV Recorder Adjust potentiometer on the PC card to obtain a 10mV output.

10. The control unit is now electrically adjusted.

C. ANALYZER UNIT

The analyzer unit contains such key system components as the reaction chamber, the photomultiplier tube, the ozonator, the ozonator power supply, the oxygen and gas sample lines, capillaries and pressure regulators.

A flow diagram of the analyzer unit is shown in Figure 10. The heart of the analyzer is the cylindrical reaction chamber (Figure 8), where sample gas containing NO molecules mixes with O_3 molecules from the ozonator. Electronically

excited NO_2 molecules are created which emit light (chemiluminescence) as the orbital electrons decay to their ground states.

The chemiluminescence is monitored through an optical filter by a high sensitivity photomultiplier tube positioned at one end of the chamber. The filter/photomultiplier combination responds to light in a narrow wavelength band unique to the desired electron decay. Sample flow is controlled so that the output from the photomultiplier tube is linearly proportional to the NO concentration.

O_2 enters the analyzer unit at the rear-panel connection labeled "DRY AIR" (Figure 5). After passing through a pressure regulator that is used to regulate the flow rate, the O_2 enters the ozonator. A fraction of the O_2 is converted to O_3, and the mixture passes through an 0.008 inch diameter glass capillary to the reaction chamber.

Dry air may be used either at room pressure or from a pressurized cylinder set at 10 psig for the O_2 supply for the ozonator. However, when using air as the source of oxygen, the instrument will only be linear to 2500 ppm. In order to maintain linearity to 10,000 ppm, oxygen feed to the ozonator is necessary.

Sample gas enters the instrument at the rear-panel connection labeled "SAMPLE" (Figure 5). After passing through a 0.02 inch diameter glass capillary, a fraction of the sample is bled off through a 0.005 inch diameter glass capillary into a line leading to the reaction chamber. That portion of the entering sample not directed to the reaction chamber passes through the front panel flowmeter and out to the bypass pump. The external bypass pump is used to pull the sample through the instrument. If excessive moisture or particulate matter is present in the sample, a particle filter and cold trap may be necessary in the sample inlet.

The portion of the entering gas sample directed towards the reaction chamber flows through or around the NO_2-to-NO converter, depending upon the mode selected, "NO_x or "NO", respectively. The sample then enters the reaction chamber, where the NO reacts with O_3, giving the characteristic chemiluminescent light output.

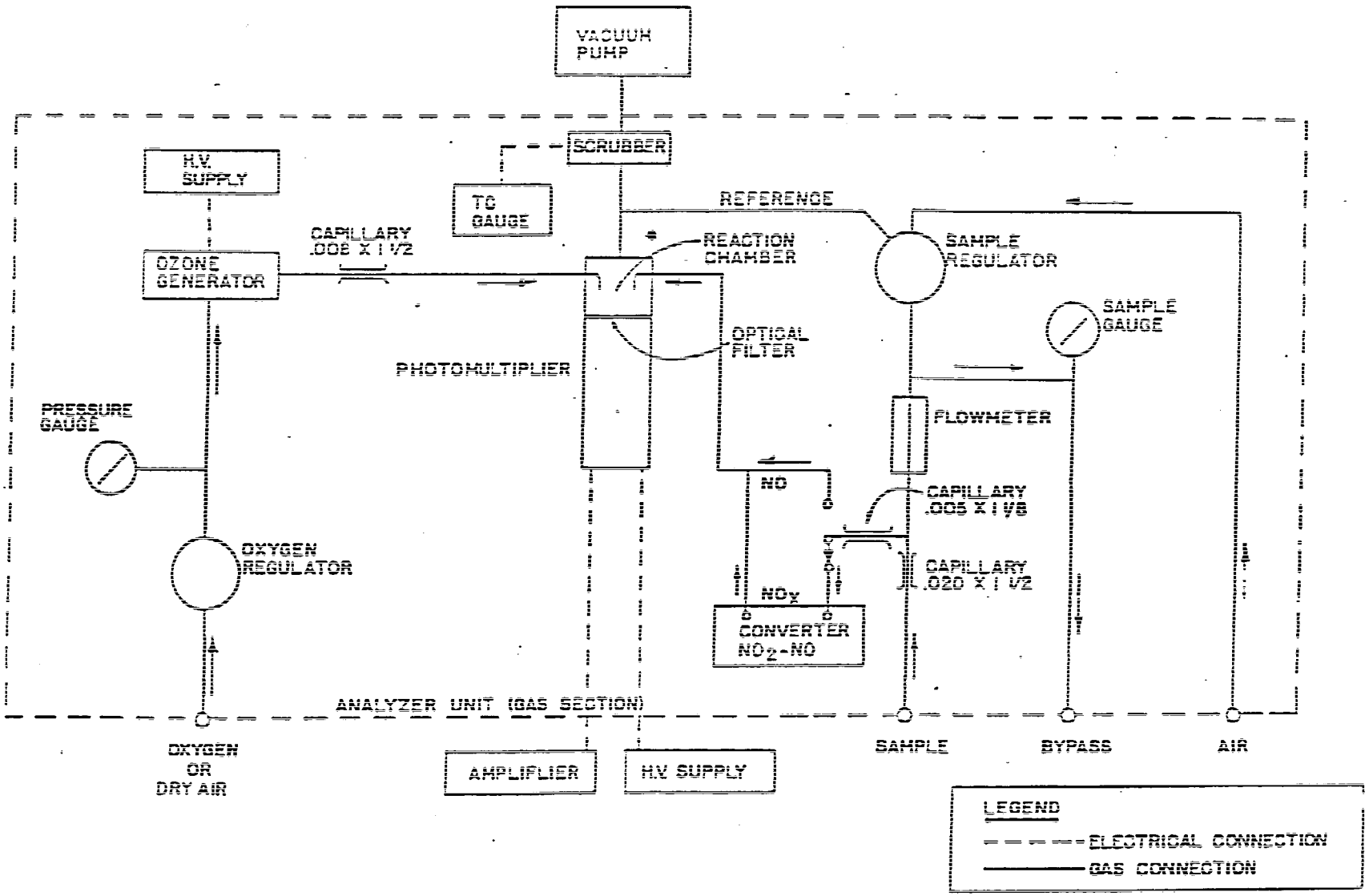
A reaction chamber pressure gauge appears on the analyzer front panel for the purpose of monitoring the pressure in the reaction chamber. The gauge should indicate pressures between -29 and -30 inches Hg. If the pressure exceeds -28 inches Hg, check all connections for possible leaks.

Pressures have been adjusted at the factory so that the gauge on the analyzer front panel labeled "SAMPLE" reads -5 inches Hg, and the gauge labeled "OXYGEN" (mounted within the analyzer) reads +2 psi (see Figure 10). These settings assure proper gas flows. Pressure readjustment, should it become necessary, can be accomplished by sliding the analyzer drawer forward to expose the screwdriver-slotted adjustment shaft of the pressure control regulator.

A sample bypass flowmeter is located in the middle of the analyzer unit front panel. The sample flow to the instrument should be adjusted externally until this flowmeter reads 2 SCFH.

The "ON-OFF" switch for the ozonator high-voltage power supply is located on the control unit front panel. During normal operation, the ozonator switch should be in the "ON" position.

The capillary holders have thumbscrew seals for easy access to the glass capillaries. These seals are designed for normal finger tightening; if overtightened, the glass capillary could be damaged.


VACUUM PUMP
SCRUBBER
H.V. SUPPLY
TC GAUGE
REFERENCE
CAPILLARY .008 X 1 1/2
REACTION CHAMBER
SAMPLE REGULATOR
OZONE GENERATOR
SAMPLE GAUGE
OPTICAL FILTER
PHOTOMULTIPLIER
PRESSURE GAUGE
FLOWMETER
NO
CAPILLARY .005 X 1 1/8
OXYGEN REGULATOR
CAPILLARY .020 X 1 1/2
NOx
CONVERTER NO2-NO
ANALYZER UNIT (GAS SECTION)
OXYGEN OR DRY AIR
AMPLIFIER
H.V. SUPPLY
SAMPLE
BYPASS
AIR
LEGEND
ELECTRICAL CONNECTION
GAS CONNECTION

D. NO_2-TO-NO CONVERTER

The basic chemiluminescent analyzer is only sensitive to NO molecules. To measure NO_x (i.e., NO_2 plus NO), the NO_2 must first be converted to NO. The conversion is accomplished by passing the sample gas through a thermally insulated, resistance-heated, stainless steel coil. With the application of heat, NO_2 molecules in the sample gas are reduced to NO molecules.

A temperature controller is used to maintain a constant coil temperature to within±5°C. The controller is adjusted to the proper temperature at the factory; however, readjustment may become necessary. This can be accomplished by pushing in and turning the knob on the temperature controller to select the desired value. The recommended temperature is 650°C.

One three-way solenoid valve located near the converter either directs the sample gas through the converter to measure NO_x or bypasses the converter to measure NO. The operation of this mode valve is controlled from a switch on the control unit.

VI. SPECIFICATIONS

Sensitivity	Each instrument is equipped with the following ranges: 0 - 2.5 ppm; 0 - 10 ppm; 0 - 25 ppm; 0 - 100 ppm; 0 - 250 ppm; 0 - 1000 ppm; 0 - 2500 ppm; 0 - 10000 ppm
Accuracy	Derived from the NO or NO_2 calibration gas, ±1% of fullscale.
Response time (0-90%) Typical	1.5 seconds - NO Mode 1.7 seconds - NO_x Mode
Output	0 - 10mV and 0 - 10V standard. Other outputs available upon request.
Zero Drift	Negligible after 1/2-hour warm-up.
Linearity	±1% of full scale.
Input Power Requirements	Standard: 115v/50Hz; 115v/60Hz Optional: 220v/50Hz; 220v/60Hz