PALOS VERDES LANDFILL
REMEDIAL INVESTIGATION REPORT

APPENDIX E.10

EMISSIONS TESTS; PALOS VERDES ENERGY RECOVERY FROM LANDFILL GAS (CARNOT)

EMISSIONS TESTS ON THE PALOS VERDES ENERGY RECOVERY FROM LANDFILL GAS (PVERG) FACILITY, UNIT 1, DECEMBER 1992

Prepared For:

COUNTY SANITATION DISTRICTS OF LOS ANGELES COUNTY
Whittier, California

For Submittal To:

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Prepared By:

Craig H. Fry

CARNOT
Tustin, California

JANUARY 1993

REVIEW AND CERTIFICATION

All work, calculations, and other activities and tasks performed and documented in this report were carried out under my direction and supervision.

Date 2/2/93

Craig H. Fry
Assistant Manager
Emission Measurement Division

I have reviewed, technically and editorially, details, calculations, results, conclusions and other appropriate written material contained herein, and hereby certify that the presented material is authentic and accurate.

Edward Filadelfia

Date 2-3-93

Edward J. Filadelfia
Senior Engineer

TABLE OF CONTENTS

SECTION 1.0

INTRODUCTION

Carnot was contracted by the County Sanitation Districts of Los Angeles County (LACSD) to perform a series of air emission related tests on the Palos Verdes Energy Recovery from Landfill Gas (PVERG) Facility, Unit 1. The tests were required by the South Coast Air Quality Management District (SCAQMD) to satisfy the requirements given in the SCAQMD Rule 1150.2, and the SCAQMD Permit to Construct Application No. 134321. Also, these tests were conducted to satisfy the California EPA (Cal-EPA) Toxic Substance Control requirements for the provisions on ambient air and landfill gas work plan for the Palos Verdes Landfill.

Emission tests were conducted on Unit 1 at the boiler exhaust and the landfill gas fuel supply (inlet). Table 1-1 presents a test matrix of the parameters measured at each location. The emission tests were conducted on December 30, 1992. Testing was performed by Craig Fry, Dave Evans and Robert Madrigal of Carnot. The testing was coordinated by Dr. Moon S. Chung of the LACSD. The boiler was maintained at steady load throughout the testing period by LACSD personnel.

A summary of the emission test results and the applicable permit limits for the parameters measured are presented in Table 1-2. Detailed test results are presented in Section 4.0. A discussion of the results and weather conditions occurring during testing are discussed in Section 5.0. All raw data and calculations can be found in the Appendices.

TABLE 1-1
TEST MATRIX

Parameter	Inlet	Exhaust
Oxygen (O_2)	X	X
Carbon Dioxide (CO_2)	X	X
Carbon Monoxide (CO)		X
Nitrogen Oxides (NO_x)		X
Nitrogen (N_2)	X	X
Moisture (H_2O)	X	X
Methane (CH_4)	X	X
Total Gaseous Non-Methane Organics (TGNMO)	X	X
Flow Rate	X	X
Particulate Matter (PM)		X
Trace Organic Compounds	X	X
Reduced Sulfur Compounds	X	
Hydrogen Sulfide (H_2S)	X	

TABLE 1-2
SUMMARY OF TEST RESULTS
PVERG BOILER
DECEMBER 30, 1992

Parameter	Inlet	Exhaust	Permit Limit	Applicable SCAQMD Rule
O_2, % dry	11.2	5.33		
CO_2, % dry	16.0	12.92		
N_2, % dry	54.5	81.8		
H_2O, %	4.0	14.5		
Flow Rate, scfm	3,722			
Flow Rate, dscfm	3,573	14,615		
Temperature, °F		337		
NO_x:				
ppm		18.4		
ppm @ 3% O_2		21.1	60	P/C
lb/hr (as NO_2)		1.95		
lb/day (as NO_2)		*	149	P/C
CO:				
ppm		13.90	2,000	407
ppm @ 3% O_2		16.0		
lb/hr		0.90		
lb/day		*	152	P/C
HC:				
CH_4 ppm	195,500	ND < 1		
TGNMO ppm	7,200	16.1		
TGNMO lb/hr (as CH_4)	65.07	0.593		
TGNMO lb/day (as CH_4)		*	65	P/C
Destruction Eff. %		99.09		
Particulate:				
Total Particulate gr/dscf		0.0027	0.01	475
gr/dscf @ 3% O_2		0.0056		
gr/dscf @ 12% CO_2		0.0025		
lb/hr		0.34		
lb/day		*	88	P/C
Total Sulfur, ppm	< 26.2		800 Inlet	431.1

NOTE: The results in this table are the averages of all measurements. See Section 4.0 for complete emission test results.

* - not measured.

P/C - SCAQMD Permit Operating Condition Application No. 134321.

SECTION 2.0

TEST UNIT DESCRIPTION

The Palos Verdes Energy Recovery from Landfill Gas Facility (PVERG) consists of two identical Zurn Keystone landfill gas fired boilers. Unit 1 was tested in this emission test series. The steam production of both boilers is used to drive a steam turbine generator with a maximum electrical output of 13.0 megawatts. Each boiler fires approximately 3,600 scfm of landfill gas with supplemental natural gas which makes up 25% of the total Btu content. The natural gas is used because of the low Btu value (200 Btu/scf) of the inactive landfill gas fuel.

SECTION 3.0

TEST DESCRIPTION

3.1 TEST CONDITIONS

LACSD personnel maintained steady load operations throughout the test period. The boiler was set to run at nominal load. Temperature, fuel flow rate and fuel Btu values were monitored by LACSD throughout the test periods. Table 3-1 summarizes the boiler operating conditions.

TABLE 3-1
PVERG TEST OPERATING CONDITIONS

Parameter	Condition
Boiler Excess Oxygen	5.3%
Landfill Gas Flow Rate	3,720 scfm
Natural Gas Flow Rate	209 scfm
Landfill Gas Heating Value	204 Btu/scf
Generator Output	9.2 MW

3.2 SAMPLE LOCATIONS

Samples were collected from two locations in the landfill gas/boiler system. The locations were 1) the landfill fuel gas supplies and 2) the boiler exhausts. Access for sampling in the landfill gas fuel supply (inlet) was gained by removing a pipe plug downstream of the blower outlet and upstream of the boiler inlet. No isokinetic sampling was required at this location.

Samples from the boiler exhaust were collected via two ports in the stack wall. The ports are 4 inch I.D. and are located 90° apart on the circumference of the stack. The ports are 22 feet above the nearest flow disturbance and 5 feet, 5 inches below the stack top. Figure 3-1 is a schematic drawing of the PVERG stack sampling location. All tests requiring isokinetic sampling were conducted using 16

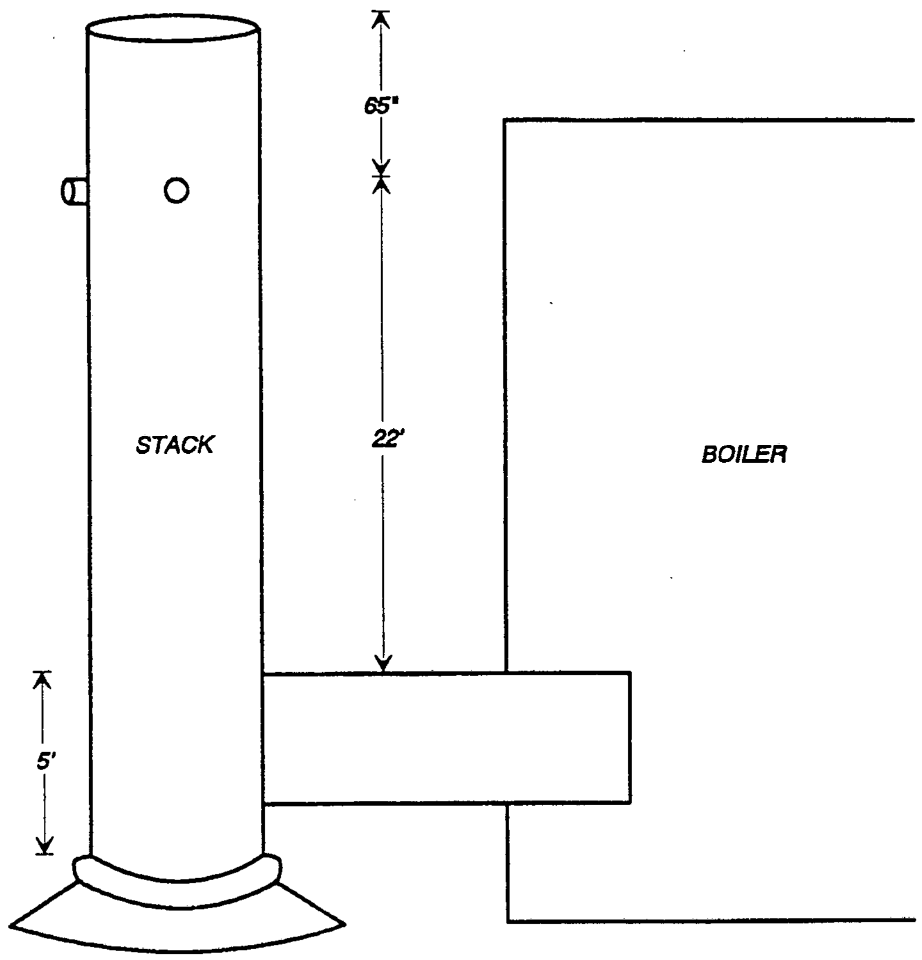


Figure 3-1. PVERG Unit 1, Stack

point traverses of the sample plane.

3.3 TEST PROCEDURES

The test procedures followed for the landfill gas and boiler exhaust measurements are summarized below in Tables 3-2 and 3-3, respectively. The selected procedures are consistent with those recommended by SCAQMD in their "Guidelines for Implementation of Rule 1150.1." Brief discussions of each procedure are given below in Sections 3.3.1 - 3.3.7.

TABLE 3-2
PVERG INLET TEST PROCEDURES

Parameter	Sample Medium	Analytical Technique	Reference Method
Methane and Total Gaseous Non-Methane Organics	Tedlar Bag	GC/FID	SCAQMD 25.2
O_2, CO_2 and N_2	Tedlar Bag	GC/TCD	SCAQMD 10.1
Moisture	Impinger Train	Gravimetric	SCAQMD 4.1
Flow Rate		Plant Flow Meter	
Trace Organics	Tedlar Bag	GC/PID/ELCD	EPA T03
H_2S	Tedlar Bag	GC/FPD/ELCD	EPA 15
Reduced Sulfur Compounds	Tedlar Bag	GC/FPD/ELCD	EPA 15

TABLE 3-3
PVERG EXHAUST TEST PROCEDURES

Parameter	Sample Medium	Analytical Technique	Reference Method
Methane and Total Gaseous Non-Methane Organics	Tedlar Bag	GC/FID	SCAQMD 25.2
O_2	CEM	Micro Fuel Cell	SCAQMD 100.1
CO_2	CEM	NDIR	SCAQMD 100.1
NO_x	CEM	Chemiluminescence	SCAQMD 100.1
CO	CEM	NDIR/GFC	SCAQMD 100.1
Moisture	Impinger train	Gravimetric	SCAQMD 4.1
Flow Rate	Pitot Tube	Differential Pressure	SCAQMD 2.1
Particulate Matter	Wet Impingement Train	Gravimetric	SCAQMD 5.1
Trace Organics	Tedlar Bag	GC/PID/ELCD	EPA T03

3.3.1 Methane and Total Gaseous Non-Methane Organics

Methane and total gaseous non-methane organics were measured using the draft SCAQMD Method 25.2. The inlet and exhaust samples were collected with Tedlar bags and analyzed by the TCA/FID. Atmosphere Assessment Associates performed the analyses on these samples within 72 hours after sampling. Inlet and exhaust were sampled simultaneously for a twenty-minute period.

3.3.2 Oxygen, Nitrogen, Carbon Monoxide, Carbon Dioxide and Nitrogen Oxides

Inlet O_2, CO_2 and N_2 measurements were acquired from Tedlar bag samples and analyzed by GC/TCD using SCAQMD Method 10.1.

Measurements of NO_x, CO, O_2 and CO_2 at the exhaust were conducted using SCAQMD Method 100.1 sampling with a continuous emission monitoring system (CEM).

These CEM measurements were made using Carnot's continuous emissions monitoring system described in Appendix A. The system used a stainless steel probe connected to a 15' heater teflon line.

Then the gaseous sample traveled through a moisture knockout cooled with ice and water. A peristaltic pump continuously drained the knock out. The sample then traveled to the ground via teflon line to an additional conditioning and filtering system.

Leak checks were conducted prior to and at the completion of the test project. The leak checks were conducted by operating the sample pump, plugging the probe inlet and all pressure side system exits except for one analyzer rotameter, then measuring the leakage rate on that rotameter.

EPA Protocol 1 Calibration Gas were used for CO and NO_x analyzer calibration. All other gases were manufacturer certified to be ±1% and traceable to NIST. In accordance with SCAQMD Method 100.1 procedures, a pre- and post-test system bias check was conducted for each test run. The system bias check was conducted by delivering zero and span gas to the CEM probe tip and recording the as-found species concentration. No analyzer adjustments were made between these pre- and post-system bias checks. Calculations for the correction of measured system bias and instrument drift were then applied to each test run. The allowable limit of system bias deviation is 5% of instrument range.

Duplicate emissions measurements were performed to determine nitrogen oxides and carbon monoxide emissions, as well as oxygen and carbon dioxide concentrations. The average concentrations were determined during each test for a period of 64 minutes. This test average was then corrected for measured system bias and drift. Exhaust N_2 data was calculated by difference from the concentration of the other major exhaust gas components.

3.3.3 Moisture

Moisture was measured in both the inlet and outlet streams of the boiler. SCAQMD Method 4.1 was used for the determinations.

Duplicate inlet measurements were made with a separate Method 4.1 train.

The moisture determinations of the flare exhaust were made in combination with the particulate matter tests.

3.3.4 Flow Rate

Landfill gas flow rate into the boiler was set to specification using existing LACSD instrumentation on site, and was monitored and recorded throughout the test period. The inlet gas density is calculated using the concentrations of oxygen, carbon dioxide and methane. Outlet gas flow rate was determined in conjunction with all isokinetic tests using a combined pitot probe system.

3.3.5 Particulate Matter

Particulate matter concentration and emission rate were determined by wet impingement following SCAQMD Method 5.1. A quartz probe with a glass nozzle was used to sample the exhaust stream. Following the probe the sample travels through flexible teflon tubing to the impingers and then to a tared backup filter. A thermocouple and pitot probe are attached to the probe to facilitate isokinetic sampling at each of the 16 traverse points. Two ports were used to access the traverse points. Duplicate 64-minute samples were collected.

3.3.6 Trace Organic Hydrocarbons

Trace organic species were collected by Carnot in Tedlar bags and analyzed by GC/PID/ELCD by the LACSD lab at JWPCP using the EPA Method T03 and analyzed within 72 hours of sampling. Inlet and exhaust were sampled simultaneously for a twenty-minute period. The flow rate used to calculate the lb/hr emission rates are from the particulate matter test flow rate being performed concurrently with trace organic sampling.

3.3.7 Hydrogen Sulfide and Reduced Sulfur Compounds

Samples for determination of hydrogen sulfide and reduced sulfur compounds were collected in Tedlar bags. The samples were analyzed by GC/FPD/ELCD by the LACSD lab at JWPCP and analyzed within 8 hours of sampling.

SECTION 4.0

RESULTS

The results of the test are presented in the following tables:

Table Number	Table Title
4-1	General Results, PVERG, Unit 1
4-2	Trace Organic Species Destruction Efficiency Results, PVERG, Unit 1, Test No. 1
4-3	Trace Organic Species Destruction Efficiency Results, PVERG, Unit 1, Test No. 2

TABLE 4-1
GENERAL RESULTS
PVERG, UNIT 1
DECEMBER 30, 1992

	INLET			EXHAUST GAS		
Parameter	First Run	Second Run	Average	First Run	Second Run	Average
O_2, % dry	11.2	11.2	11.2	5.27	5.39	5.33
CO_2, % dry	15.8	16.1	16.0	13.01	12.83	12.92
N_2, % dry	54.6	54.4	54.5	81.7	81.8	81.8
H_2O, %	3.8	4.2	4.0	14.4	14.6	14.5
Flow Rate, cfm	3730	3714	3722	----	----	----
Flow Rate, dscfm	3589	3557	3573	14576	14654	14615
Temperature, °F				336	337	337
NO_x:						
ppm				18.4	18.3	18.4
ppm @ 3% O_2				21.1	21.1	21.1
lb/hr (as NO_2)				1.95	1.95	1.95
CO:						
ppm				12.0	15.8	13.9
ppm @ 3% O2				13.7	18.2	16.0
lb/hr				0.774	1.025	0.900
HC:						
CH_4 ppm	192000	199000	195500	ND<1	ND<1	ND<1
TGNMO ppm	7040	7360	7200	15.8	16.3	16.1
TGNMO ppm @ 3% O_2	--	--	--	18.1	18.8	18.5
TGNMO lb/hr (as CH_4)	63.92	66.22	65.07	0.583	0.604	0.593
Destruction Eff. %	--	--	--	99.09	99.09	99.09
Particulate:						
Organic Fraction gr/dscf				0.0000	0.0000	0.0000
Inorganic Fraction gr/dscf				0.0034	0.0020	0.0027
Total Particulate gr/dscf				0.0034	0.0020	0.0027
gr/dscf @ 3% O_2				0.0040	0.0071	0.0056
gr/dscf @ 12% CO_2				0.0031	0.0019	0.0025
lb/hr				0.424	0.256	0.340
Sulfur Compounds:						
H_2S, ppm	21	22	22			
Methyl Mercaptan, ppm	0.5	0.5	0.5			
Ethyl Mercaptan, ppm	ND<0.5	ND<0.5	ND<0.5			
Dimethyl Sulfide, ppm	ND<0.6	ND<0.6	ND<0.6			
Dimethyl Disulfide, ppm	ND<0.5	ND<0.5	ND<0.5			
Carbonyl Sulfide, ppm	ND<0.4	ND<0.4	ND<0.4			
Carbon Disulfide, ppm	ND<0.6	ND<0.6	ND<0.6			
Total Sulfur Compounds, ppm	<25.2	<26.2	<26.2			

TABLE 4-2
TRACE ORGANIC SPECIES DESTRUCTION EFFICIENCY RESULTS
PVERG UNIT 1, TEST NO. 1
DECEMBER 30, 1992

Flow rate, Inlet dscfm	3589
Flow rate, Exhaust dscfm	14576

Species	Inlet	Exhaust	Destruction Efficiency, %
Methylene Chloride:	200 ppb	ND < 0.2 ppb	
lb/hr	9.64×10^{-3}	$<3.91 \times 10^{-5}$	> 99.59
Chloroform:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$< 1.35 \times 10^{-2}$	$< 5.50 \times 10^{-5}$	NA
1,1,1-trichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$<1.51 \times 10^{-2}$	$< 6.15 \times 10^{-5}$	NA
Carbon Tetrachloride:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$< 1.75 \times 10^{-2}$	$< 7.09 \times 10^{-5}$	NA
1,1-dichloroethene:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$< 1.10 \times 10^{-2}$	$<4.47 \times 10^{-5}$	NA
Trichloroethylene:	500 ppb	ND < 0.2 ppb	
lb/hr	3.73×10^{-2}	$< 6.06 \times 10^{-5}$	> 99.84
Tetrachloroethylene:	400 ppb	ND < 0.2 ppb	
lb/hr	3.76×10^{-2}	$<7.64 \times 10^{-5}$	> 99.80
Chlorobenzene:	4700 ppb	ND < 0.4 ppb	
lb/hr	3.00×10^{-1}	$< 1.04 \times 10^{-4}$	> 99.97
Vinyl Chloride:	1400 ppb	ND < 0.4 ppb	
lb/hr	4.97×10^{-2}	$< 5.76 \times 10^{-5}$	> 99.88
m-dichlorobenzene:	ND < 200 ppb	ND < 0.2 ppb	
1lb/hr	$< 1.67 \times 10^{-2}$	$< 6.78 \times 10^{-5}$	NA
o+p dichlorobenzene:	1300 ppb	ND < 0.2 ppb	
lb/hr	1.08×10^{-1}	$< 6.78 \times 10^{-5}$	>99.94
1,1-dichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$< 1.12 \times 10^{-2}$	$< 4.56 \times 10^{-5}$	NA
1,2-dichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	$< 1.12 \times 10^{-2}$	$< 4.56 \times 10^{-5}$	NA
Benzene:	11000 ppb	0.2 ppb	
lb/hr	4.88×10^{-1}	3.60×10^{-5}	99.99
Toluene:	24000 ppb	ND < 1 ppb	
lb/hr	1.25×10^{0}	$< 2.12 \times 10^{-4}$	> 99.98
Acetonitrile:	ND < 2000 ppb	ND x 2 ppb	
lb/hr	$< 4.66 \times 10^{-2}$	$< 1.89 \times 10^{-4}$	NA
m-xylenes:	25000 ppb	ND < 0.2 ppb	
lb/hr	1.51×10^{0}	$< 4.89 \times 10^{-5}$	100.00
o+p xylenes:	21000 ppb	ND < 0.2 ppb	
lb/hr	1.27×10^{0}	$< 4.89 \times 10^{-5}$	100.0
1,2-dibromoethane:	ND < 7000 ppb	ND < 7 ppb	
lb/hr	$< 7.46 \times 10^{-1}$	$< 3.03 \times 10^{-3}$	NA
Benzyl Chloride:	ND < 5000 ppb	ND < 5 ppb	
lb/hr	$< 3.59 \times 10^{-1}$	$< 1.46 \times 10^{-3}$	NA

ND< indicates that the species was not detected. Values indicate the detection limit for this species and the concentration is less than the presented value.
NA - indicates that the destruction efficiency cannot be calculated because the concentration is below detection limits.

TABLE 4-3
TRACE ORGANIC SPECIES DESTRUCTION EFFICIENCY RESULTS
PVERG UNIT 1, TEST NO. 2
DECEMBER 30, 1992

Flow rate, Inlet dscfm	3557
Flow rate, Exhaust dscfm	14654

Species	Inlet	Exhaust	Destruction Efficiency, %
Methylene Chloride:	ND < 200 ppb	0.4 ppb	
lb/hr	< 9.55 x 10^{-3}	7.87 x 10^{-5}	< 99.18
Chloroform:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.34 x 10^{-2}	< 5.53 x 10^{-5}	NA
1,1,1-trichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.50 x 10^{-2}	< 6.18 x 10^{-5}	NA
Carbon Tetrachloride:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.73 x 10^{-2}	< 7.13 x 10^{-5}	NA
1,1-dichloroethene:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.09 x 10^{-2}	< 4.49 x 10^{-5}	NA
Trichloroethylene:	400 ppb	ND < 0.2 ppb	
lb/hr	2.96 x 10^{-2}	< 6.09 x 10^{-5}	> 99.79
Tetrachloroethylene:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.87 x 10^{-2}	< 7.68 x 10^{-5}	NA
Chlorobenzene:	2400 ppb	ND < 0.4 ppb	
lb/hr	1.52 x 10^{-1}	< 1.04 x 10^{-4}	> 99.93
Vinyl Chloride:	1400 ppb	ND < 0.4 ppb	
lb/hr	4.92 x 10^{-2}	< 5.79 x 10^{-5}	> 99.88
m-dichlorobenzene:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.65 x 10^{-2}	< 6.81 x 10^{-5}	NA
o+p dichlorobenzene:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.65 x 10^{-2}	< 6.81 x 10^{-5}	NA
1,1-dichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.11 x 10^{-2}	< 4.59 x 10^{-5}	NA
1,2-dichloroethane:	ND < 200 ppb	ND < 0.2 ppb	
lb/hr	< 1.11 x 10^{-2}	< 4.59 x 10^{-5}	NA
Benzene:	1100 ppb	0.1 ppb	
lb/hr	4.83 x 10^{-1}	1.81 x 10^{-5}	100.00
Toluene:	22000 ppb	ND < 1 ppb	
lb/hr	1.14 x 10^{0}	< 2.13 x 10^{-4}	> 99.98
Acetonitrile:	ND < 2000 ppb	ND < 2 ppb	
lb/hr	< 4.62 x 10^{-2}	< 1.90 x 10^{-4}	NA
m-xylenes:	22000 ppb	ND < 0.2 ppb	
lb/hr	1.31 x 10^{0}	< 4.92 x 10^{-5}	100.0
o+p xylenes:	19000 ppb	ND < 0.2 ppb	
lb/hr	1.13 x 10^{0}	< 4.92 x 10^{-5}	100.0
1,2-dibromoethane:	ND < 7000 ppb	ND < 7 ppb	
lb/hr	< 7.40 x 10^{-1}	< 3.05 x 10^{-3}	NA
Benzyl Chloride:	ND < 5000 ppb	ND < 5 ppb	
lb/hr	< 3.56 x 10^{-1}	< 1.47 x 10^{-3}	NA

ND< indicates that the species was not detected. Values indicate the detection limit for this species and the concentration is less than the presented value.
NA - indicates that the destruction efficiency cannot be calculated because the concentration is below detection limits.

APPENDIX A

MEASUREMENT PROCEDURES

Continuous Emissions Monitoring System

Oxygen (O_2) by Continuous Analyzer

Carbon Dioxide (CO_2) by Continuous Analyzer

NO/NO_x by Continuous Analyzer

Carbon Monoxide (CO) by NDIR/Gas Filter Correlation

Total Particulate by SCAQMD Wet Impingement Method

Hydrocarbons by SCAQMD Micro TCA Method

Stack Gas Velocity and Volumetric Flow Rate

Determination of Moisture in Stack Gases

Procedure 280A: Gas Chromatographic Analysis of Volatile Sulfur Compounds

Procedure 600B: Gas Chromatographic Analysis of Organic Compounds in Air and Gas Samples Using a Packed Column

Procedure 600C: Gas Chromatographic Analysis of Acetonitrile in Air and Gas Samples Using a Packed Column

Procedure 1203A: Gas Chromatographic Analysis of Air, Methane and Carbon Dioxide Using a Packed Column

Continuous Emissions Monitoring System

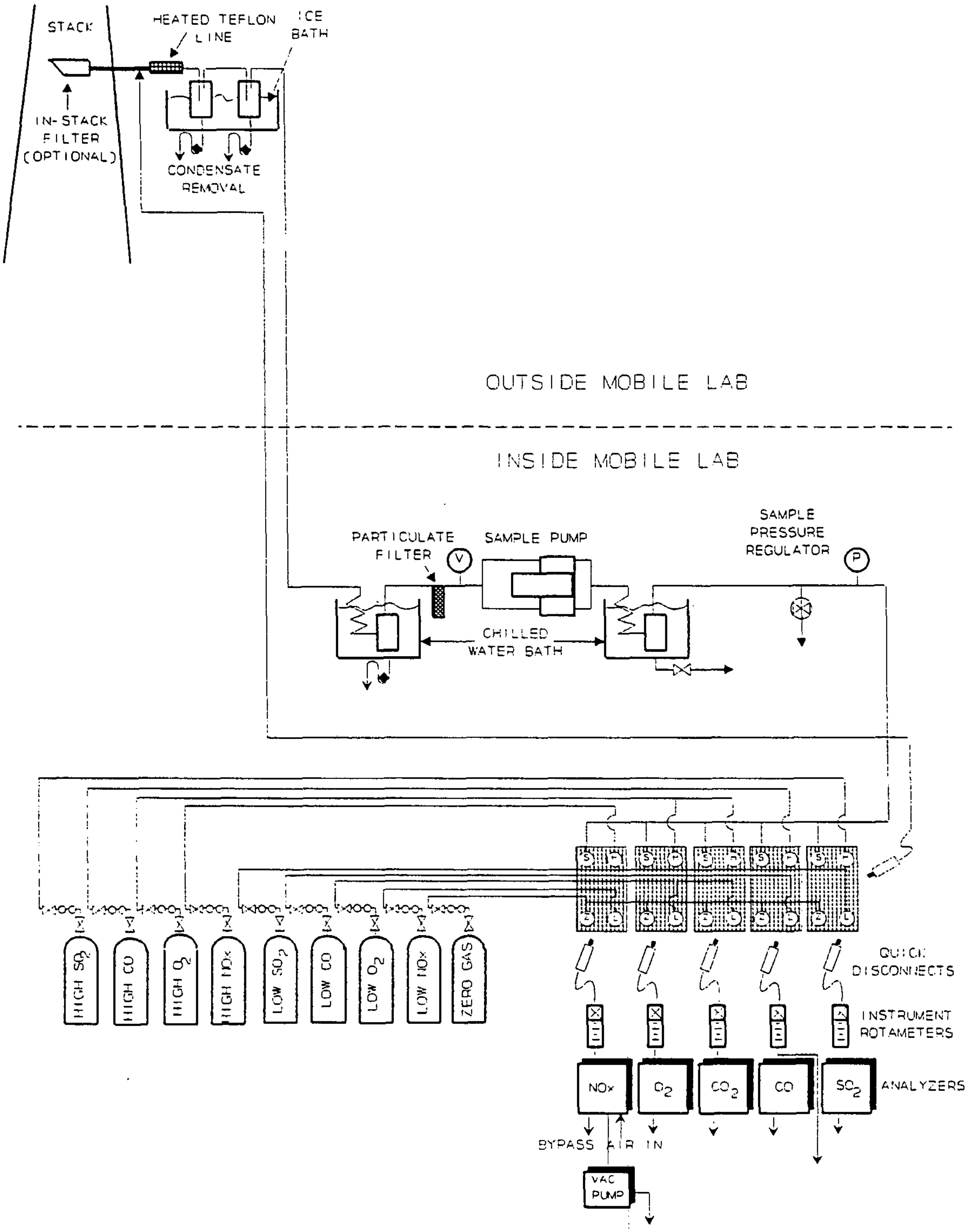
O_2, CO, CO_2, NO, NO_x and SO_2 are measured using an extractive continuous emissions monitoring (CEM) package, shown in the following figure. This package is comprised of three basic subsystems. They are: (1) the sample acquisition and conditioning system, (2) the calibration gas system, and (3) the analyzers themselves. This section presents a description of the sampling and calibration systems. Descriptions of the analyzers used in this program and the corresponding reference test methods follow. Information regarding quality assurance information on the system, including calibration routines and system performance data follows.

The sample acquisition and conditioning system contains components to extract a representative sample from the stack or flue, transport the sample to the analyzers, and remove moisture and particulate material from the sample. In addition to performing the tasks above, the system must preserve the measured species and deliver the sample for analysis intact. The sample acquisition system extracts the sample through a stainless steel probe. The probe is insulated or heated as necessary to avoid condensation. If the particulate loading in the stack is high, a sintered stainless steel filter is used on the end of the probe.

Where water soluble NO_2 and/or SO_2 are to be measured, the sample is drawn from the probe through a heated teflon sample line into an on-stack cooled (approximately 35-40°F) water removal trap. The trap consists of stainless steel flasks in a bath of ice and water. This design removes the water vapor by condensation. The contact between the sample and liquid water is minimized and the soluble NO_2 and SO_2 are conserved. This system meets the requirements of EPA Method 20. The sample is then drawn through a teflon transport line, particulate filter, secondary water removal and into the sample pump. The pump is a dual head, diaphragm pump. All sample-wetted components of the pump are stainless steel or teflon. The pressurized sample leaving the pump flows through a third condensate trap in a refrigerated water bath (≈38°F) for final moisture removal. A drain line and valve are provided to constantly expel any condensed moisture from the dryer at this point. After the dryer, the sample is directed into a distribution manifold. Excess sample is vented through a back-pressure regulator, maintaining a constant pressure of 5-6 psig to the analyzer rotameters.

The calibration system is comprised of two parts: the analyzer calibration, and the system bias check (dynamic calibration). The analyzer calibration equipment includes pressurized cylinders of certified span gas. The gases used are, as a minimum, certified to 1% by the manufacturer. Where necessary to comply with reference method requirements EPA Protocol 1 gases are used. The cylinders are equipped with pressure regulators which supply the calibration gas to the analyzers at the same pressure and flow rate as the sample. The selection of zero, span, or sample gas directed to each analyzer is accomplished by operation of the sample/calibration selector fittings.

The system bias check is accomplished by transporting the same gases used to zero and span the analyzers to the sample system as close as practical to the probe inlet. This is done either by attaching the calibration gas supply line to the probe top with flexible tubing or by actuation of a solenoid valve located at the sample conditioner inlet (probe exit). The span gas is exposed to the same elements as the sample and the system response is documented. The analyzer indications for the system calibration check must agree within 5% of the analyzer calibration. Values are adjusted and changes/repairs are made to the system to compensate for any difference in analyzer readings. Specific information on the analytical equipment and test methods used is provided in the following pages.



Schematic of CEM System

Method:	**Oxygen (O_2) by Continuous Analyzer**
Applicable Reference Methods:	EPA 3A, EPA 20, ARB 100, BA ST-14, SCAQMD 100.1
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of O_2 concentration.
Analyzer:	Teledyne Model 326A
Measurement Principle:	Electrochemical cell
Ranges:	0-5, 0-10, 0-25% O_2
Accuracy:	1% of full scale
Output:	0-100 mV, linear
Interferences:	Halogens and halogenated compounds will cause a positive interference. Acid gases will consume the fuel cell and cause a slow calibration drift.
Response Time:	90% <7 seconds
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously. If Method 20 is used, that method's specific procedures for selecting sample points are used. Otherwise, stratification checks are performed at the start of a test program to select single or multiple-point sample locations.
Analytical Procedure:	An electrochemical cell is used to measure O_2 concentration. Oxygen in the flue gas diffuses through a Teflon membrane and is reduced on the surface of the cathode. A corresponding oxidation occurs at the anode internally, and an electric current is produced that is proportional to the concentration of oxygen. This current is measured and conditioned by the instrument's electronic circuitry to give an output in percent O_2 by volume.
Special Calibration Procedure:	The measurement cells used with the O_2 instrument have to be replaced on a regular basis. After extended use, the cell tend to produce a nonlinear response. Therefore, a three-point calibration is performed at the start of each test day to check for linearity. If the response is not linear ($\pm$ 2% of scale), the cell is replaced.

Method:	**Carbon Dioxide (CO_2) by Continuous Analyzer**
Applicable Reference Methods:	EPA 3A, ARB 100, BA ST-5, SCAQMD 100.1
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of CO_2 concentration.
Analyzer:	Horiba PIR 2000
Measurement Principle:	Non-dispersive infrared (NDIR)
Accuracy:	1% of full scale
Ranges:	0-5, 0-10, 0-25%
Output:	0-10 mV
Interferences:	A possible interference includes water. Since the instrument receives dried sample gas, this interference is not significant.
Response Time:	1.2 seconds
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously.
Analytical Procedure:	Carbon dioxide concentrations are measured by short path length non-dispersive infrared analyzers. These instruments measure the differential in infrared energy absorbed from energy beams passed through a reference cell (containing a gas selected to have minimal absorption of infrared energy in the wavelength absorbed by the gas component of interest) and a sample cell through which the sample gas flows continuously. The differential absorption appears as a reading on a scale of 0 to 100%.

Method: **NO/NO_x by Continuous Analyzer**

Applicable Reference Methods: EPA 7E, EPA 20; ARB 100, BA ST-13A, SCAQMD 100.1

Principle: A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of NO or NO_x.

Analyzer: Teco Model No. 10AR

Measurement Principle: Chemiluminescence

Accuracy: 1% of full scale

Ranges: 0-2.5, 0-10, 0-25, 0-100, 0-250, 0-1000, 0-2500, 0-10,000 ppm

Output: 0-10 mV

Inferences: Compounds containing nitrogen (other than ammonia) may cause interference.

Response Time: 90%, 1.5 seconds (NO mode) and 1.7 seconds (NO_x mode)

Sampling Procedure: A representative flue gas sample is collected and conditioned using the CEM system described previously. If EPA Method 20 is used, that method's specific procedures for selecting sample points are used.

Analytical Procedure: The oxides of nitrogen monitoring instrument is a chemiluminescent nitric oxide analyzer. The operational basis of the instrument is the chemiluminescent reaction of NO and ozone (O_3) to form NO_2 in an excited state. Light emission results when excited NO_2 molecules revert to their ground state. The resulting chemiluminescence is monitored through an optical filter by a high sensitivity photomultiplier tube, the output of which is electronically processed so it is linearly proportional to the NO concentration. The output of the instrument is in ppmV.

When NO_2 is expected to be present in the flue gas, a supercooled water dropout flask will be placed in the sample line to avoid loss of NO_2. Since NO_2 is highly soluble in water, "freezing out" the water will allow the NO_2 to reach the analyzers for analysis. The analyzer measures NO only. In the NO_x mode, the gas is passed through a moly converter which converts NO_2 to NO and a total NO_x measurement is obtained. NO_2 is determined as the difference between NO and NO_x. Use of a moly converter instead of a stainless steel converter eliminates NH_3 interference; NH_3 is converted to NO with a stainless converter, but not with a moly converter.

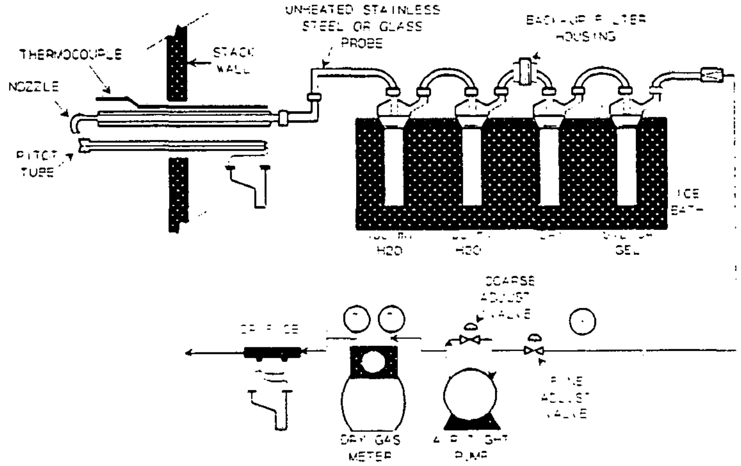
Method:	**Carbon Monoxide (CO) by NDIR/Gas Filter Correlation**
Applicable Reference Methods:	EPA 10; ARB 1-100; BA ST-6, SCAQMD 100.1
Principle:	A sample is continuously drawn from the flue gas stream, conditioned, and conveyed to the instrument for direct readout of CO concentration.
Analyzer:	TECO, Model 48
Measurement Principle:	NDIR/Gas Filter Correlation
Precision:	0.1% ppm
Ranges:	0-5, 0-10, 0-25, 0-50, 0-100, 0-250, 0-500, 0-1000, 0-5000 ppm
Output:	0-100 mV
Interferences:	Negligible interference from water and CO_2
Rise/Fall Times (0-95%)	1 minute @ 1 lpm flow, 30 second integration time
Sampling Procedure:	A representative flue gas sample is collected and conditioned using the CEM system described previously. Sample point selection has been described previously.
Analytical Procedure:	Radiation from an infrared source is chopped and then passed through a gas filter which alternates between CO and N_2 due to rotation of a filter wheel. The radiation then passes through a narrow band-pass filter and a multiple optical pass sample cell where absorption by the sample gas occurs. The IR radiation exits the sample cell and falls on a solid state IR detector.

Method: **Total Particulate by SCAQMD Wet Impingement Method**

Reference: SCAQMD Method 5.1

Principle: A metered flue gas sample is withdrawn isokinetically and particulates are collected in a series of water impingers followed by a backup filter.

Sampling Procedure: The sample train used in the tests is shown in the following figure. The sample is drawn isokinetically through a stainless steel or glass nozzle and probe. The probe is connected to an impinger train by Teflon tubing. The train consists of two Greenburg-Smith impingers which contain 100 ml of distilled water, an empty impinger as a knockout, a 100 mm glass fiber filter, and an impinger containing silica-gel to protect the leak-tight vacuum pump and calibrated dry gas meter from moisture. The impingers are designed to collect particles larger than one micron. and will also collect some smaller water-soluble particles. The backup filter collects any particulate that is not collected in the impingers. Th is material collected in the backup filter consists of submicron-sized droplets of condensed organic vapors.



Sample Train for Determination of Total Particulate by SCAQMD Wet Impingement Method

SCAQMD Method 4.1 (moisture) and Methods 1.1 and 2.1 (velocity) are performed in conjunction with the test. Stack velocity is measured during the test to maintain isokinetic sampling and to measure stack flow rate. Moisture concentration is determined by weighing the impingers before and after sampling to determine the amount of moisture collected.

Sample Recovery and Analysis:	Following testing, the probe, sample line, and impingers are washed with water. The entire rinse and sample is then filtered through a tared filter to recover large particles. An aliquot of the rinse is evaporated in a tared glass beaker at 105°C, and the residue is determined gravimetrically. If the sample contains semi-volatile hydrocarbon species that might be lost by evaporating at 105°C, the sample is extracted with methylene chloride to remove those species, and the methylene chloride fraction is evaporated at ambient temperature and weighed.

The backup filter is baked at 105°C, desiccated, cooled, and weighed, and the weight combined with the boildown and other filter to determine the total particulate catch.

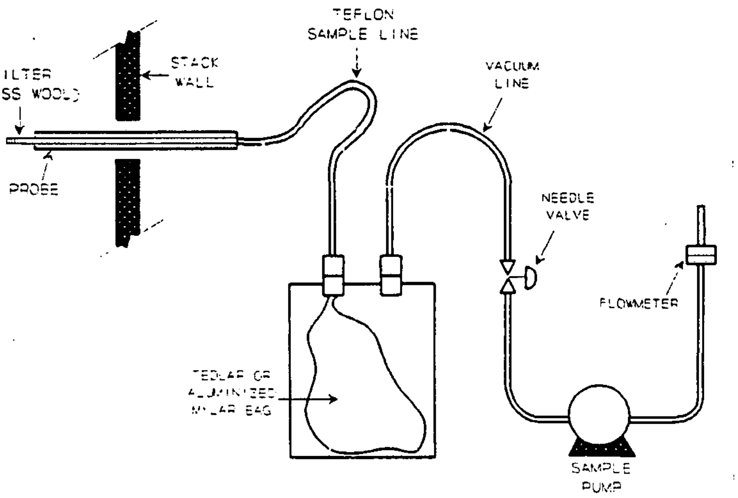
If there are high concentrations of SO_2 in the gas stream, a positive interference can be caused by oxidation of SO_2 to sulfuric acid in the impingers. In this case, the boildown residue is analyzed for sulfuric acid (either by titration or precipitation) and the acid is subtracted from the particulate catch as $H_2SO_4 \cdot 2H_2O$. Since this fraction includes both SO_2-related "pseudo-particulate" as well as the true particulate species SO_3, a separate test for SO_3 is run and the measured SO_3 is added back to the particulate catch as $H_2SO_4 \cdot 2H_2O$.

Method: **Hydrocarbons by SCAQMD Micro Total Carbon Analysis (TCA/FID) Method**

Reference: SCAQMD Method 25.2 (draft Source Test Manual)

Principle: A Tedlar bag is filled with flue gas at a constant rate. The bag contents are analyzed by gas chromatography/flame ionization detection for CO, CO_2, methane and total gaseous non-methane hydrocarbons.

Sampling Procedure: Samples are collected using a lung-type sampling system shown in the attached figure. In this system, a bag is placed in a sealed container and the container is evacuated. Flue gas enters the bag as it expands to fill the container. Sampling rate is monitored by a rotameter on the container exhaust. This system allows sample collection without exposing the sample to pumps, flowmeters, oils, etc.



Sample Train for Determination of Hydrocarbons by SCAQMD Micro TCA Method

Analytical Procedure: In the analytical phase, gaseous carbon compounds from the tank are fractioned on a chromatographic column, eluting in the order: carbon monoxide, methane, carbon dioxide, non-methane hydrocarbons. All resulting vapors are passed through oxidizers where they are combusted to carbon dioxide, then converted to methane and measured by flame ionization detection. CO_2, CO, CH_4, and total gaseous non-methane hydrocarbons are reported separately.

This method provides lower detection limits than the standard TCA procedure, which uses GC/NDIR. Since this method does not use a steel condensate trap, it eliminates positive interferences that have been associated with carbon dioxide dissolved in water frozen in the condensate trap and released during analysis.

The TCA/FID method is appropriate for combustion sources and ambient sampling where low concentrations of hydrocarbons are expected.

Carnot subcontracts TCA analysis to qualified local laboratories experienced in the analytical procedures.

Method: **Stack Gas Velocity and Volumetric Flow Rate**

Reference: EPA Method 2, SCAQMD Method 2.1, ARB Method 2

Principle: The average gas velocity in a stack is determined from the measurement of the gas density and from the measurement of the average velocity head using a Type-S (Stausscheibe) Pitot tube.

Sampling Procedure: The velocity head and temperature are measured at traverse points specified by EPA Method 1 or SCAQMD Method 1.1. The velocity is measured using a Type-S Pitot tube and an inclined water manometer. The flow coefficient of the pitot tube is known. Temperature of the gas is measured using a thermocouple. The stack gas molecular weight is determined from independent measurements of O_2, CO_2, and H_2O concentrations.

Sample Analysis and Recovery: The stack gas velocity is determined from the measured average velocity head, the measured average temperature, the measured average duct static pressure, the measured dry concentrations of O_2 and CO_2, and the measured concentration of H_2O. The velocity is determined from the following set of equations:

$$V_S = 2.90C_p\sqrt{\Delta p T_s\left[\frac{29.92}{P_s}\right]\left[\frac{28.95}{MW_{wet}}\right]} \qquad [\text{ ft/s }]$$

Δp = *Velocity/Head, inches* H_2O [in. H_2O]

T_s = *Gas Temperature, degrees R* [R]

P_s = *Absolute Static Pressure* [in Hg]

C_p = *Pitot Flow Coefficient* [unitless]

$$MW_{wet} = \left[(0.44)(\%CO_2)+(0.32)(\%O_2)+(0.28)(\%N_2)\right](1-\frac{\%H_2O}{100})+(18)(\frac{\%H_2O}{100})$$

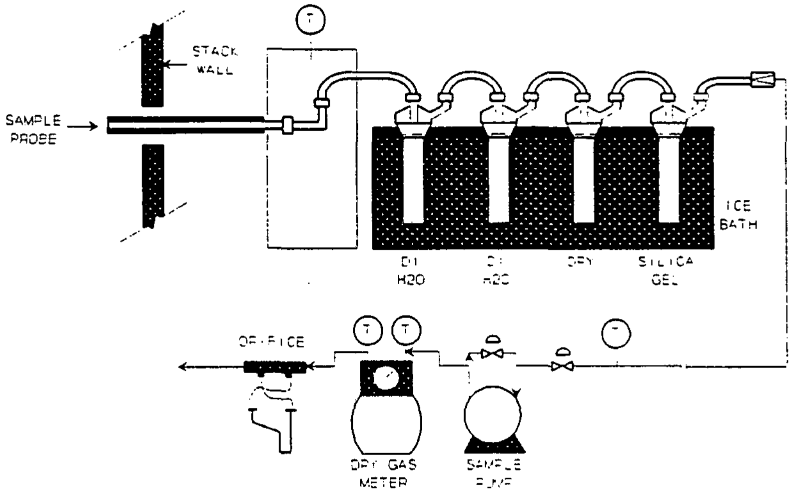
The stack gas volumetric flow rate is determined from the measured stack gas velocity, the area of the stack at the measurement plane, and the measured gas temperature and pressure. The volumetric flow rate is determined from the following set of equations:

$$Q = (V_s)(AREA)(60) \qquad [\text{ wacfm }]$$

$$Q_{ws} = Q\left[\frac{T_{ref}}{T_s}\right]\left[\frac{P_s}{29.92}\right] \qquad [\text{ wscfm }]$$

$$Q_{sd} = Q_{ws}\left[1-\frac{\%H_2O}{100}\right] \qquad [\text{ dscfm }]$$

Method:	**Determination of Moisture in Stack Gases**
Applicable Ref. Methods:	EPA 4, ARB 1-4, SCAQMD 4.1
Principle:	A gas sample is extracted at a constant rate from the source; moisture is removed from the sample stream and determined volumetrically or gravimetrically.
Sampling Procedure:	The sample train used in the tests is shown in the following figure. The sample is drawn at a constant rate through a stainless steel probe. The probe is connected to an impinger train by Teflon tubing. The train consists of two Greenburg-Smith impingers which contain 100 ml water, an empty impinger as a knockout, and an impinger containing silica gel to protect the pump from moisture.



Sample Train for Determination of Moisture by EPA Method 4

Sample Recovery and Analysis:	Following testing, moisture content is determined gravimetrically from initial and final impinger weights.

280A. GAS CHROMATOGRAPHIC ANALYSIS OF VOLATILE SULFUR COMPOUNDS

INTRODUCTION

Gaseous sulfur compounds are cryogenically collected on a solid phase sorbent trap and analyzed by packed column gas chromatography. The gas chromatograph is equipped with two different columns and two different detectors operating in parallel in order to effect positive identification and quantitation of the target analytes.

Procedure 280A: Gas Chromatographic Analysis of Volatile Sulfur Compounds (12-31-91)

1. Scope and Application

1.1 This procedure is used for the identification and quantitation of the sulfur gases listed in Table I. Quantitation may be carried out at the ppb level under proper conditions.

1.2 Samples encountered include landfill, digester and sewer gas and ambient air. This analytical method requires a 30 minute chromatographic run and is used for ppb-level analysis of a wide range of sulfur compounds. An abbreviated method which measures the target compound list of SCAQMD Rule 1150.1 at the part-per-million level requires a 15 minute run.

2. Summary of Procedure

2.1 Known amounts of sample gas are passed through liquid nitrogen-cooled traps. The traps are swept with helium to remove oxygen and nitrogen and are then heated to desorb the trapped sulfur gases onto cooled (-60°C) gas chromatographic columns. The columns are then heated at a rate which allows these compounds to be separated on the respective columns. The two detectors, a flame photometric detector (FPD) and a Hall electrolytic conductivity detector (HECD), may be interchanged if further confirmatory analyses are necessary.

3. Sample Handling and Preservation

3.1 Samples are normally collected in Tedlar (polyvinyl fluoride) bags and brought to the laboratory for analysis. Samples should be stored in the dark and away from heat. Samples should be analyzed within twenty-four hours. This is especially important when high concentrations (1 ppm) of methyl mercaptan are suspected.

4. Interferences

4.1 The flame photometric detector operates by detecting the fluorescence of S_2 molecules formed from sulfur atoms which are liberated when sulfur-containing species are burned in a hydrogen/air flame. Since the fluorescence intensity is directly proportional to the concentration of S_2 molecules and to the square of the sulfur-atom concentration in the flame, the detector signal will be roughly proportional to the square of the amount of sulfur-containing species reaching the detector. For this to be true, equilibrium must be rapidly established in the flame between sulfur atoms and S_2 molecules. This will occur if the concentration of sulfur-containing species is small compared to the concentration of hydrogen and oxygen. If the detector is overloaded, a chemical saturation of the detector will occur and there will be a loss of sensitivity. This chemical saturation will normally occur at a higher concentration than is required to saturate the photomultiplier and so should not be a problem.

4.2 The FPD has a very large rejection ratio for non-sulfur-containing species, so there are very few interferences.

4.3 Ethyl mercaptan and dimethyl sulfide co-elute on the Chromosil 330 column under the conditions used in this procedure, but they are completely separated on the XE-60 column.

4.4 The sulfur mode HECD reacts sulfur-containing compounds with an excess of oxygen to form SO_2/SO_3, which is then detected in the conductivity cell. The response due to any CO_2 formed under these oxidizing conditions is levelled by employing a non-aqueous solvent (reagent methanol) to prevent the formation of carbonic acid. Since hydrogen halides will also be formed even under oxidizing conditions, the sulfur mode HECD employs a copper tube containing a silver wire between the reactor and detector as a hydrogen halide scrubber to eliminate interferences from halogenated compounds. This scrubber is not so effective in removing hydrogen fluoride as it is in removing the other halides, and so interferences due to fluorinated hydrocarbons can occur, especially in the region where the C3 and C4-mercaptans elute. Sewer gas typically shows several large peaks in this region which are not due to sulfur containing compounds.

4.5 Since the Chromosil 330 column has an upper temperature limit of 100°C, the XE-60 column cannot be used close to its upper temperature limit. Under these conditions, the retention times of the C3- and higher mercaptans on the XE-60 may be unacceptably long, and the usefulness of the XE-60 is limited to the quantitation of the C1- and C2-mercaptans and sulfides of the SCAQMD rule 1150.1 list.

5. Apparatus

5.1 Varian Model 3400 gas chromatograph equipped with a Varian dual-flame FPD and a Tracor Model 700A HECD operated in the sulfur mode.

5.1.1 Columns:

a. 8'(6' packed) x 1/8"OD Teflon (FEP) packed with Chromosil 330.

b. 6' x 1/4"OD (2 mm id) glass packed with 1.5% XE-60/1.0% H_3PO_4 on Carbopak B. (The glass column must be deactivated before packing by baking at 130°C for six hours with a carrier gas flow rate of 100-200 mL/min.)

5.1.2 Operating Parameters

Carrier gas: Helium (carrier grade), 25 mL/min (column a), 30 mL/min (column b).
Detector temperature: 180°C
FPD Range: 10exp(-8)
PMT voltage: 480-520 volts
HECD Range: 100
HECD Solvent: 100% methanol (reagent grade)

Temperature program: 3.5 minute hold at initial temperature of -60°C. Program to 40°C at 40° C/minute and hold for 4.5 minutes. Program to 65° C at 40°C per minute and hold for 3.0 minutes. Program to 95°C at 40°C/min and hold for 15 minutes. Vent closes at 4.5 min. and opens at 14.75 min.

5.2 Data System: Nelson Analytical (3000 Series) chromatography software installed on an IBM PS/2 with a two-channel buffer box (760 Series) to collect raw data from both detectors simultaneously.

5.3 Cryo-adsorbent Trapping System

5.3.1 Plumbing: 1/8" or 1/16" Teflon tubing used throughout.

5.3.2 Trap design: Two similar U-shaped traps are constructed of 1/8" OD Teflon-lined stainless steel (1.8 mm ID) and packed with 0.1 gram 50/80 mesh Porapak QS. The jacket consists of 1/4" OD copper tubing with Swagelock TEE fittings at the ends. The jacket is wrapped with 12' x 3/16" nichrome heating cord controlled by a Cole-Parmer model 2149-00 temperature control relay. The trap is heated to approximately 210°C during the desorption cycle. The trap is cooled by flowing liquid nitrogen through its outer jacket.

5.4 Sample Loading:

a) small volume samples (1-50 mL) are injected by gas-tight syringe directly into the sweep helium and are deposited on the trap.

b) large volume samples are withdrawn from sample bags with 100 mL glass syringe with Teflon plunger and forced through trap.

5.5 Sample Injection: Samples are transferred from the two traps and injected onto the two columns using twin Valco E60 two-position electric actuator/valve assemblies. Valves are actuated by relays controlled by the GC method which injects at 0.5 min and returns to load position at 10 min. Valves are fabricated from Hastelloy C in order to minimize sulfur gas adsorption and reactivity.

5.5.1 Pneumatics and valves. Samples are introduced through the syringe or through a septum port. The sample gas flows though the trap switch valve into the proper injection valve and liquid nitrogen-cooled trap. With the trap switch valve in the LOAD A position, the sample is directed to injection valve A and the sweep helium flows through injection valve B. When this valve is in the LOAD B position, sample gas flows to valve B and sweep helium to valve A. Sweep helium can be directed to both injection valves and traps simultaneously by removing the sample needle from the sample bag and inserting it in the sweep helium septum port.

When the sample gas reaches the proper injection valve, it is directed to the liquid nitrogen-cooled trap where the less-volatile species are adsorbed on the Porapak QS. The sweep helium then removes most oxygen, nitrogen and other permanent gases and sends them out the vent. When the valve is turned to the INJECT position, the carrier helium flow is directed to backflush the trap onto the gas chromatographic column and the sweep helium is vented. The two injection valves are configured identically.

After the separated analytes exit the chromatographic columns, they are directed to the detector switch valve. This is a four-port Hastelloy C valve which allows column effluent to be directed to either of the two detectors. Normal configuration has Chromosil 330 effluent going to the flame photometric detector and XE-60 effluent to the HECD.

5.6 Electrical connections. Electrical connections are made between the Varian 3400, the Nelson 760 buffer box, the IBM PS/2. and the cryo-adsorbent system.

The 760 interface is the heart of the system, as it provides the interface between the other members. The connections to the 760 are shown. J101 is the connection to the IBM PC/AT. J1 is the 14-pin connector carrying the relays which control the injection valves, the liquid nitrogen flow to the traps and the trap heaters. Only relays 2 through 7 are used; relays 1 and 8 are reserved by Nelson for use with autosamplers. DET A +/- and DET B +/- are the inputs from the FPD and HECD, respectively. The FPD signal is taken from the side port on the Varian 3400 and HECD signal is taken from the 10VFS and COMP COM terminals on the back of the Tracor 700A module. The START NO IN/COM terminals are connected to J23 in the Varian 3400. This terminal provides a one-second contact closure when the START button in the GC is pushed and is used to provide a "start" signal to the Nelson system. Unused terminals on the Nelson 760 box include the J2 BCD connector and the READY IN/COM connections.

Relay 2 activates the liquid nitrogen flow to the traps and can be manually deactivated at the toggle switch mounted below the traps. Relay 3 controls the trap heaters and can also be manually deactivated by a Cole-Parmer 2149 temperature control relay. Relays 4 and 5 control the position of injection valve A. Relay 4 is activated to move the valve to the INJECT position and relay 5 is activated to return the valve to the LOAD position. Relays 6 and 7 serve the analogous functions on injection valve B. The relays are normally controlled by the Nelson software.

Output from the detectors is also directed to a strip chart recorder in order to provide real-time monitoring of the chromatographic runs.

5.7 Safety Precautions

Liquid nitrogen is used as a coolant for both the adsorbent traps and the column oven. Caution must be exercised due to the possibility of freeze burns caused by exposure of skin to extremely low temperatures. Avoid contact with any metal tubing through which liquid nitrogen is flowing and make sure that the exhaust vents on the adsorbent traps are pointing away from anyone in the laboratory.

Gaseous nitrogen is also an asphyxiant. Since the adsorbent traps use large quantities of liquid nitrogen during each run, the possibility exists that room oxygen could be depleted if the ventilation system fails. Do not operate the system if the laboratory ventilation system is not functioning properly.

When liquified gases vaporize, they expand to approximately 700 times their liquid volumes. Thus, the very real possibility exists for a violent rupture of the liquid nitrogen line if liquid nitrogen is confined between two valves with no access to a relief valve. Make absolutely sure that there is a relief valve between any two closures or valves. ANY SECTION OF ISOLATED LINE MUST BE VENTED OR HAVE A PRESSURE RELIEF VALVE!

6. Standards

6.1 Hydrogen sulfide, carbonyl sulfide, methyl mercaptan, ethyl mercaptan, carbon disulfide and dimethyl sulfide are obtained from Scott Specialty Gas cylinders in 100 ppm v/v (nominal) concentrations. A second cylinder containing approximately 5 ppm v/v H_2S and 2 ppm v/v each of the other above-named species except ethyl mercaptan is used for daily calibrations. Sulfur dioxide, ethyl mercaptan, and DMDS are taken from separate cylinders containing 5 ppm v/v SO_2, 2 ppm ethyl mercaptan, and 4.6 ppm v/v DMDS in nitrogen.

A stock solution of 0.5% v/v (in methanol) of the heavier components (C3 and higher mercaptans and sulfides) is used to make up the rest of the standards, if needed. The stock solution is prepared by using a 0.05 mL syringe to place 0.05 mL of each of the neat compounds in a 10 mL volumetric flask partially filled with methanol and then diluting to 10 mL. These compounds are obtained from Aldrich (typically 98-99% purity) and are used with no further purification.

6.2 Preparation of standards. The Scott 5 ppm/2 ppm v/v standards are taken directly from the cylinder with no further preparation. Two ppm bag standards are made from 100 ppm v/v Scott cylinders by injecting 40 mL of the gas into a Tedlar bag filled with 1960 mL of nitrogen. Bag standards of the heavier components are made by injecting 1 microliter of the 0.5% liquid standard into a Tedlar bag filled with 1 liter of nitrogen. This will give the following concentrations: C3 mercaptans, 1.3 ppm; C4 mercaptans, 1.1 ppm; dimethyl disulfide, 1.4 ppm; and thiophene (if used), 2.2 ppm.

7. Procedure

7.1 Load method CROM33AD into the Nelson box.

7.9 Calibration curves. Six-point calibration data are generated by injecting 0.5, 1, 2, 5, 10 or 15 mL of the Scott 5 ppm/2 ppm v/v standard on the FPD side, and 0.2, 1, 2, 5, 10, or 15 ml on the HECD side. The C3-C4 mercaptan standard is injected on the Chromosil 330 side only, due to the unacceptably long retention times of these compounds on the XE-60 column. Since dimethyl sulfide and ethyl mercaptan co-elute on the Chromosil 330 column, ethyl mercaptan is injected only on the XE-60 column. The areas and retention times are stored under MMDDFVV for FPD (VV=volume injected) and MMDDHVV for HECD.

Calibration curves are generated by entering peak area counts versus component concentration in the appropriate recalculation method. Calibration data are generated by using a varying injection volume of constant concentration instead of a constant volume of varying concentration, so a universal unit of ppm-mL is used in the recalculation methods instead of a concentration. Differences in injection volume are accounted for in the recalculation methods. The 15 mL injection of hydrogen sulfide is not used on the FPD calibration due to poor fit on the curve.

7.10 Updating calibration curves. Calibration curves are updated by averaging the current peak areas with the existing peak areas. This procedure weights the updated calibration point heavily in favor of the current day's response, but does not ignore the past history of the instrument response. The new calibration points should agree to within +/- 20% of the current point since these should not be taken until after "normal" response has been verified. If there is a gross discrepancy, a faulty injection should be suspected.

7.11 Recalculation methods. The Nelson method CROM33AD is used to control the relays and data acquisition. Data are stored in files named CHROMxxx (FPD data) and DHROMxxx (HECD data). Recalculation methods for these data are MMFPDDD and MMSHALDD, respectively, which contain the calibration curves for each column/detector combination.

7.12 The calibration curves cover a concentration range of greater than one order of magnitude. There are many samples which will generate analyte peaks which are either above or below the range of peak areas covered by the curves. In these cases it may be necessary to perform a second analysis using a larger or smaller injection volume, as appropriate.

7.13 Each chromatographic run must be reviewed soon after its completion in order to detect any range, interference or instrumental problems which would require a repeat analysis. Next-day review is not acceptable due to the possibility of sample degradation. Although the stability limits of the target compounds have been established when they are at low concentration in pure air or nitrogen, the complex nature of the samples usually received precludes the assumption of their long-term stability.

8. Calculations

8.1 The flame photometric detector response is inherently nonlinear, and calibration data are fitted to a quadratic function of the form

$$A = a(X)^2 + b(X) + c$$

where A is the peak area, (X) is the analyte concentration in ppm-mL units, and a, b, and c are coefficients generated by the Nelson curve-fitting algorithm. To find the actual sample concentration, Nelson solves for X and divides this value by the injection volume:

$$\text{Concentration} = (X)/V$$

where V is the injection volume.

The Nelson software should find the analyte concentration by solving the quadratic equation when given the analyte peak area and injection volume. However, several versions of the Nelson software are known to contain bugs which prevent the quadratic from being solved correctly. It is then necessary to manually perform the required calculations.

8.2 The Hall detector calibration data is plotted on a point to point curve. At higher concentrations, the hydrogen sulfide data is better fitted on a cubic fit equation.

8.3 Detection limits have been established for the Chromosil 330/FPD and XE-60/HECD combinations according to the EPA approved method of Glaser, et.al. Most of the target analytes containing one sulfur atom have a detection limit of about 2.5 ppb (assuming a 500 mL injection) on the Chromosil 330/FPD. Compounds such as carbon disulfide and dimethyl disulfide which have two sulfur atoms have somewhat lower limits. Detection limits on the XE-60/HECD have not been completely determined; however it is known that they are well below one part-per-billion (again assuming a 500 mL injection) for all target analytes. If a 5 mL injection volume is used the reporting limits will be <0.1 ppm for the aforementioned areas. Any components that are below the lowest calibration point are reported as less than whatever that calibration point is. Because the XE-60/HECD combination is more sensitive and it separates all 1150.1 compounds, the reported detection limits for the 1150.1 compounds are usually based on this detector/column combination.

8.4 Equations used in standards preparation. Concentrations of Tedlar bag standards prepared from Scott cylinders may be calculated from the equation

$$C(\text{bag}) = C(\text{Scott}) \times V(s)/V(\text{tot})$$

Where C(bag) is the concentration of the standard, C(Scott) is the concentration of the relevant component in the Scott cylinder, V(s) is the volume of the standard injected into the bag, and V(tot) is the total volume of standard and diluent in the bag.

Concentrations of standards prepared from the 0.5% liquid standards may be calculated from the equation

$$C(bag) = \frac{V \times d \times 10 \times 22.4 \text{ L/mole} \times C(comp)}{Mw \times V(bag)}$$

where V is the volume of liquid standard in microliters injected into the Tedlar bag, d is the density of the relevant component in g/mL, C(comp) is the concentration of a given component of the liquid standard in volume percent, 22.4 L/mole is the molar volume of a gas at room temperature, Mw is the molecular weight of the component in amu, and V(bag) is the volume of diluent gas in liters. If C(comp) is assumed to be 0.5%, this equation reduces to

$$C(bag) = \frac{V \times d \times 112}{Mw \times V(bag)}$$

Note that if a new liquid standard is prepared with a component concentration other than 0.5%, the constant term in this equation will have to be multiplied by a factor of

$x/0.5 \quad (=2x)$

where x is the per cent concentration of a given component in the new standard.

9. Quality Assurance Guidelines

9.1 A duplicate and spike will be run every tenth sample.

9.2 AUTOSQC. The area tables should be entered under FPDSGC and HECDSGC. The retention times are entered under FPD-RT and HECDS-RT. For each detector, a "warning situation" exists whenever any component is out by two standard deviations. A "out of control" situation exists whenever any component is out by 3 standard deviations. Since two detectors are used, you may still be able be able to do the analysis using the other detector, if it is in control.

If a "warning" or "out of control" situation occurs, then re-inject the standard. If a "out of control" situation repeats, then investigate for possible causes of the problem. If the problem cannot be resolved, then the detector response must be re-calibrated. If a "warning" situation repeats, then investigate for possible causes of the problem. If the problem cannot be resolved, then the samples may still be run. If a "warning" situation persists for three days, then it is considered "out of control".

After the problem has been resolved, then delete all "out of control" points from the control charts. Do not remove the "warning" points.

9.3 Spikes for qualitative analysis.

9.3.1 Spikes are employed to confirm the identity of the higher molecular weight analytes eluting on the Chromosil 330/FPD combination. Many interfering compounds have retention times very close to those of the target analytes, and positive identification cannot be made on the basis of retention time alone. The low molecular weight analytes are usually free of interferences with the exception of carbonyl sulfide. Spikes are sometimes necessary to confirm its identity on the Chromosil 330/FPD side. In some samples, a large concentration of a condensable gas will give rise to pressure surges which will shift the retention times of the early eluting peaks. A spike will be necessary to confirm their identities in this case.

Since the target compounds can exist in any combination, concentration range and/or ratio, it is impractical to make up a spiking mixture corresponding to each sample. A standard spiking mixture can be made up which contains all of the standard compounds. "Overspiking" (where a standard is added to a sample that has previously been loaded on a cryogenic trap) with compounds not in the sample is desirable as they can be used to determine whether the spike recovery is quantitative.

Use a quantity of spike approximately equal to the amount of the target compound measured. If there is a wide range of apparent analyte concentrations, use a quantity approximately midway between the highest and lowest concentrations of the target analytes.

9.4 Analyte identification. The primary identifying characteristic of the target analytes is their retention time on each of the columns. These are listed in Table I. Note that the retention times will vary somewhat. While the C1-C2 mercaptans elute with very few interfering compounds, the heavier compounds normally elute in a region with many interfering peaks. "Overspiking" is usually necessary for positive identification of these. In some cases, it may be advantageous to switch detectors so that Chromosil 330 effluent goes to the HECD and XE-60 effluent goes to the FPD. Since the two detectors operate on different physical principles and have different interferences, a positive response on both detectors can be taken as a positive confirmation. Detector switching may be useful when a dirty sample is being run which gives many peaks in the region of the target analyte and an overspike does not unambiguously determine peak identity.

The lighter compounds are normally confirmed by the observation of a positive response on both column/ detector combinations. The calculated concentrations of the analyte on both detectors should agree reasonably well. However, because dimethyl sulfide co-elutes with ethyl mercaptan on the Chromosil 330 column, the calculated concentrations of dimethyl sulfide may not agree on the two detectors. If the calculated concentrations do not agree for any of the other components, an interference should be suspected and an overspike may be necessary.

In some instances, a positive response will be seen on one column and not the other. Since at very low concentration levels, the HECD is more sensitive than the FPD, it is possible that a compound could be observed in the XE-60/HECD combination but not on the Chromosil 330/FPD. This will usually occur at the sub-ppb V/V level. Since the heavier compounds are normally measured on the Chromosil 330/FPD only, an overspike is used to provide confirmation rather than relying on dual-column observation.

10. Precision and Accuracy

10.1 No precision or accuracy data are currently available in the literature.

10.2 Repetitive injections of a known standard on the Chromosil 330/FPD side over a two month period indicate that long-term reproducibility on the FPD is approximately 20%. Back-to-back injections of standards are normally reproducible to 1-2%.

10.3 This analytical method was developed at the JWPCP Water Quality Laboratory.

11. References

1. Glaser, J.A., Foerst, D.L., McKee, G.D., Quave, S.A., and Budde, W.L., *Environ. Sci. Technol.*, 1981, 15, 1426.

2. ACS Subcommittee on Environmental Analytical Chemistry, *Anal. Chem.*, 1980, 52, 2242.

TABLE I

Volatile Sulfur Compounds Analyzed by Gas Chromatography

Chromosil 330/FPD	RT(min)	XE-60/HECD	RT(min)
carbonyl sulfide	6.04	hydrogen sulfide	5.31
hydrogen sulfide	6.29	carbonyl sulfide	6.27
methyl mercaptan	7.74	sulfur dioxide	7.06
carbon disulfide	8.29	methyl mercaptan	7.22
sulfur dioxide	10.0	ethyl mercaptan	11.02
dimethyl sulfide	9.6	dimethyl sulfide	11.34
ethyl mercaptan	9.6	carbon disulfide	11.87
iso-propyl mercaptan	10.85		
n-propyl mercaptan	12.85		
t-butyl mercaptan	13.26		
thiophene	14.6		
sec-butyl mercaptan	15.0		
iso-butyl mercaptan	15.4		
n-butyl mercaptan	16.0		
dimethyl disulfide	16.5		

1203A: GAS CHROMATOGRAPHIC ANALYSIS OF AIR, METHANE AND CARBON DIOXIDE USING A PACKED COLUMN

INTRODUCTION

Permanent gases are relatively stable gases (oxygen, argon, nitrogen, carbon dioxide, methane and carbon monoxide) present in air. The relative amounts of these light gases provide us with important information regarding aerobic and anaerobic operations at District facilities and nearby areas. Additionally, permanent gas analyses can be used as screens to give laboratory personnel an approximate volume to inject on other gas chromatographs when trace levels of volatile organics are to be analyzed. Samples are analyzed for permanent gases by packed column chromatography utilizing thermal conductivity detection (TCD). The detector signals are collected by a data system for identification and quantitation of the sample components.

Procedure 1203A: Gas Chromatographic Analysis of Air, Methane, and Carbon Dioxide Using a Packed Column (12-26-91)

1. Scope and Application

This instrumental procedure is to be used for the identification and quantitation of air, methane, and carbon dioxide. Digester gas, engine exhaust, flare exhaust, and landfill gas have been analyzed using this procedure.

2. Summary of Procedure

2.1 The sample is injected directly onto a packed column with a 1.0 mL gas-tight syringe.

2.2 The gas chromatograph is operated isothermally to separate the components and TCD is used for component detection.

3. Sample Handling

3.1 Samples are collected in the field in either glass bulbs or aluminized, Mylar-coated bags equipped with screw valves or Tedlar (polyvinylfluoride) bags equipped with screw valves.

3.2 Glass bulbs are flushed with laboratory air prior to sampling and are then evacuated. One end of the bulb is connected to the sampling port and both stopcocks are opened. The sample is allowed to purge the bulb for 30 to 60 sec. The stopcocks are then closed and the sample is transported to the laboratory for analysis.

3.3 Aluminized or Tedlar bags are evacuated in the laboratory prior to use. The screw valve is opened and connected to the sampling port. The bag is then allowed to fill under pressure. The valve is closed and disconnected from the sampling port.

3.4 Samples are to be analyzed within 48 h.

4. Apparatus

4.1 Gas Chromatograph

4.1.1 Varian 3400 Series gas chromatograph equipped with thermal conductivity detectors.

4.1.2 Packed column: 2m x 2mm Pyrex packed with 80/100 mesh Porapak QS (Alltech Associates, Inc.).

4.2 Data System

4.1.1 Nelson Analytical (3000 series) chromatography software system based on an IBM AT or PS/2 personal computer with a two channel capacity buffer box (760 series) to collect the raw data from the TCD. The data system draws baselines and identifies components according to the software and preselected parameters. The data may be recalculated by the operator by changing the drawn baselines.

4.1.2 Permgas.Bas is a basic program written using the BASIC interpreter. This program is designed to calculate the oxygen and argon concentrations using the O_2-Ar concentration obtained from the Nelson data system. See 7.3 and 7.4. It also averages the methane results from the two permanent gas methods and sums the components for a total permanent gas concentration.

4.3 Syringes

One mL glass Pressure-Lok Series A-2 syringes equipped with a Teflon plunger and push-button valve (Precision Scientific) are used.

5. Procedure

5.1 Set the gas chromatograph to the following parameters:

5.1.1 Carrier grade Helium (99.9995% purity) at 80 mL/min.

5.1.2 Injector temperature: 110 C.

5.1.3 Column temperature: 60 C isothermal.

5.1.4 Detector temperature: 110 C.

5.2 Set the thermal conductivity detector as follows:

5.2.1 Carrier grade Helium (99.9995% purity) reference gas at 80 mL/min.

5.2.2 Filament temperature: 130 C.

5.2.3 Filament current: 220 mA.

5.2.4 Detector polarity: Positive.

5.2.5 Detector initial range: 0.5

5.5.6 Detector initial attenuation: 8

5.5.7 TCD autozero on: YES

5.3 Ready the data system for Nelson data collection prior to the start of the run.

5.4 Inject 1.0 mL of standard or sample onto the column of the gas chromatograph.

5.5 After a 2.0 min analysis, analytes are quantitated by the data system.

6. Standards

6.1 A standard calibration is performed each day a sample is run. Linearity studies indicate that the TCD response to these compounds is quite linear over the concentration ranges shown in Table 1. All samples currently analyzed using this method fall within these concentration ranges.

6.2 An air blank is run each day before the standard. This blank is used to determine the amount of contamination of air due to the syringe technique and to insure that the standard line is not contaminated with air. The standard line should be purged for 30 seconds. The pressure in the line should then be adjusted to between 1 and 5 PSI. One mL of the CH_4/CO_2 standard is then drawn and injected. The area count for Air must be below 1,000 before proceeding. This blank value is entered into the calibration curve.

6.3 The syringe is filled with 0.50 mL of a 63.8% CH_4 and 36.3% CO_2 mix (Scott Specialty Gases), and it is then diluted with 0.50 mL of desiccated laboratory air. The air is desiccated by drawing laboratory air through a glass tube filled with silica gel desiccant. This mix is then injected as a standard. If the results obtained are 97% to 103% of the theoretical values (as compared to the previous calibration standard), the standard run is accepted for the calibration standard. If the results are not within this range, two or three standard injections are performed. If the results still fall out of range, trouble-shooting procedures are initiated.

7. Calculations

7.1 The data system identifies and quantifies sample components

7.2 Two-point calibration curves (point-to-point) are established for each component using the Nelson data system.

7.3 Air, methane, and carbon dioxide are calculated by the data system as follows:

$$\text{amount of component (\%) in sample} = \frac{\text{(std amt (\%)-blank amt)}}{\text{(std area-blank area)}} \times \text{sample area}$$

The blank value is determined for air only. Blank areas and amounts are assumed to be zero for methane and carbon dioxide.

7.4 Values below the method detection limit (MDL) are reported as less than the MDL value. See Table 1. Three significant figures are used for reporting data. Figures past the decimal place of the MDL are not used.

8. Quality Assurance Guidelines

8.1 Method detection limits have been established per US EPA Appendix B to Part 136-Definition and Procedure for the Determination of the Method Detection Limit-Revision 1.11. 40 CFR Part 136, 43430, *Federal Register*, Volume 49, No.209. Method detection limits and acceptable linear ranges are presented in Table 1.

8.2 Duplicate injections are performed 10% of the time.

8.3 Duplicate sample analyses are performed 10% of the time if extra sampling can be scheduled.

9. Precision and Accuracy

There is no data available at this time for precision and accuracy.

10. References

This procedure is similar to that published by Supelco, Inc., Analyzing Mixtures of Permanent Gases and Light (C_1-C_3) Hydrocarbons on a Single GC Column, GC Bulletin 712F, Supelco, Inc., Bellefonte, PA. 1983.

Table 1. Method Detection Limits (MDLs), Linear Ranges (% V/V) and Linear Correlation Coefficients for Permanent Gases Analyzed using Porapak QS and TCD detection (11-9-89).

Component	MDL	Linear Range	Corr. Coef.
Carbon Dioxide	0.2 %	0%-40 %	0.9998
Methane	0.02%	0%-100%	0.9995
Air	0.2 %	------	------

600C: GAS CHROMATOGRAPHIC ANALYSIS OF ACETONITRILE IN AIR AND GAS SAMPLES USING A PACKED COLUMN

INTRODUCTION

Acetonitrile is analyzed by packed column gas chromatography with a flame ionization detector (FID). The detector signal is collected by a data system for identification and quantitation of acetonitrile.

Procedure 600C: Analysis of Acetonitrile in Air And Gas Samples (Jan 2,1992)

1. Scope and Application

   1.1 This instrumental procedure is to be used for the identification of acetonitrile.

   1.2 Ambient air, flare exhaust, landfill surface gas, landfill boundary probe, digester gas, landfill gas, engine exhaust and other sample types are analyzed according to this procedure.

2. Summary of Procedure

   2.1 The sample is injected, cryogenically trapped and thermally desorbed onto a cooled gas chromatographic column.

   2.2 The gas chromatograph is temperature programmed to separate the components. The FID detector is used to analyze acetonitrile.

3. Sample Handling and Preservation

   3.1 Tedlar (polyvinylfluoride) sample bags are bought commercially. The bags are filled with ultrapure nitrogen, allowed to sit overnight, flushed and filled again. This process is repeated ten or more times and then a sample of the blank nitrogen in the bag is analyzed after remaining in the bag overnight. At least two bags from every lot of ten are randomly selected to represent the lot. If the two bags are clean, then the entire set is placed in service. The new bag data is compared to previous lots of new bags to determine acceptability. If the bags are contaminated, they are returned for another round of flushing with ultrapure nitrogen and tested again for suitability.

   3.2 Tedlar sample bags are leak checked after each use. Each sample bag is filled with ultrapure nitrogen and allowed to sit overnight with a weight on it. If the bag's volume is reduced significantly, the bag is either repaired or discarded.

   3.3 After leak checking, the Tedlar sample bags are cleaned. Each bag is flushed and filled three times with ultrapure nitrogen and allowed to sit overnight. This is repeated two more times and then the bag is returned to service.

3.4 The Tedlar sample bags are dedicated for specific sample type and segregated for storage to avoid contamination. Presently we have four sample bag types:

3.4.1 Ambient air bags for ambient air, landfill surface gas, landfill boundary probes, and flare exhaust samples.
3.4.2 Raw bags for raw digester and landfill gas.
3.4.3 Scrubber bags for sewer gas.
3.4.4 Scrubber exhaust bags for exhaust from sewer gas scrubbers.

3.5 Samples are collected in the field in Tedlar bags and transported to the laboratory in cardboard boxes to minimize photochemical decomposition. Sample bags are flushed with ultrapure nitrogen (either in the laboratory or the field office) just prior to sample collection.

3.6 Samples must be analyzed within 72 hours, but are normally analyzed the day of sampling or the next day.

4. Apparatus

4.1 Gas Chromatography

4.1.1 Varian 6000 gas chromatograph equipped with a flame ionization detector connected to column B.

4.1.2 Column: 2 m x 2 mM ID Pyrex packed with 60/80 mesh Carbopack B coated with 1% SP-1000.

4.1.3 Operating parameters:

Reaction gas for FID:
Fuel gas: Hydrogen (Ultra high purity), 25 mL/min.
Oxidant: Hydrocarbon free air, 300 mL/min.
Carrier gas: Helium (carrier grade), 25 mL/min
Sweep gas: Helium (carrier grade), 40 mL/min
Injector temperature: 150 C
Detector base temperature: 300 C for GC 1 and 200 C for GC2
Range 10E-12 for FID
Temperature program for GC 1: A 10-min hold at an initial temperature of -99 C. Program to 40 C at 40 C/min and hold for 5 min. Program to 220 C at 8 C/min and hold for 14 min.
Temperature program for GC 2: Hold 11 min at -20 C. Program to 30 C at 10 C/min and hold for 12 min then program to 65 C at 8 C/min and hold for 12 min. Program to 170 C at 20 C/min and hold for 5 min. Program to 220 C at 40 C/min and hold until all components have eluted.

4.2 Data System:

4.2.1 Nelson Analytical (3000 series) chromatography software system based on an

IBM AT or PS/2 personal computer with a two channel capacity buffer box (760 series) to collect the raw data from the FID. The data system draws baselines and identifies components according to the software and preselected parameters. The data may be recalculated by the operator by changing the drawn baselines.

4.2.2 NWA Quality Analyst version 3.1 statistical program for quality control charting and analysis.

4.2.3 Analytical Automation Specialists AUTOSQC software package which integrates Nelson Analytical 3000 software with NWA Quality Analyst to provide Shewhart quality control charts from chromatographic data.

4.2.4 "Limitgc1" and "SP1L20" are basic programs written using the BASIC interpreter. "Limitgc1" is designed to set up tables with component names and calculated acceptable area count range for these components and then produce a hard copy of these tables. "SP1L20.bas" is a basic program that is used to check the daily 100 mL standard injection. Lines 10-330 were modified from Nelson Analytical's "User.Bas" program. "SP1L20.Bas" imports ASCII data from previously saved area tables, compares the proper areas with the limits set up by "Limitgc1.Bas", and prints an exception report listing all compounds that exceed the limit.

4.3 Strip Chart Recorder: Linear Instruments Model 282/MM with dual pens.

4.4 Cryotrap System

4.4.1 Plumbing: 1/8" nickel tubing kept at approximately 200 using 3/16" nichrome wire heating cord controlled by a Glas-Col Model PL-312 Minitrol voltage regulator set at 2.

4.5 Sample Loading System

4.5.1 A 100 mL glass syringe with a Teflon plunger is used to measure the larger sample volumes. Volumes less than 100 mL are loaded onto the cryotrap by injecting the volume through a septum with a gas tight syringe.

4.5.2 Trap utilizing 1/4" ID nickel tubing in a "U" configuration packed with silanized glass beads. The trap is wrapped with 3/16" nichrome wire heating cord controlled by a Glas-Col Model PL-312 Minitrol temperature controller. The trap can be heated to approximately 400 C. Trap B is used for the column connected to the FID (side B).

5. Reagents

5.1 Standard mixture was obtained from Scott-Marrin,Inc. in a cylinder at nominal concentrations of 100 ppb V/V in nitrogen. Table I shows the components in the

Scott-Marrin standard currently in use and their concentrations. Working standard is prepared by transferring a volume of 100 ppb V/V standard to a Tedlar bag. See Table II for components and concentrations.

6. Procedure

6.1 The data collection method is loaded into the interface box prior to the start of the run. The data collection method instructs the data system how to acquire the data to be generated during the run (i.e. during what times and at what rate the data should be collected). The data system controls all valves through timed event relays.

6.2 The cryotrap is immersed into a liquid nitrogen bath for 1 min prior to sample trapping. The valve actuator is placed in the load position. This allows the helium sweep gas to flow through the cryotrap systems and maintains helium carrier flow through the column.

6.3 A gaseous sample of up to 500 mL is loaded onto the cryotrap side B with a gas tight syringe. The sweep gas carries sample onto the cryotrap.

6.4 The gas chromatograph oven should be cooled to -99 C and ready for injection.

6.5 Three min after the gas sample has been loaded onto the cryotrap, the liquid nitrogen bath is removed. After waiting 15 sec (to allow the CO2 and NOx to vent) the run is started.

6.6 When the run is started several electrically controlled events occur. The valve controlling the sample flow is switched to "inject", allowing helium sweep gas to carry the sample from the trap to the gas chromatograph column. The cryotrap is heated to approximately 400 C for 4 min and then allowed to cool for 3 min while sweeping sample from the trap onto the column. At the end of this sequence the sample valve is switched back to "load".

6.7 Periodically, 10-point calibration curves are generated for the FID detector. The lifetime of this curve is determined by detector performance. Retention time is updated on a daily basis.

7. Calculations

7.1 The data system identifies and quantifies sample components.

7.2 Ten-point calibration curve (point-to-point) is established for acetonitrile. A correction factor may be applied if the daily response is found to vary by more than 20% from when the calibration curve was established.

7.3 The peaks that are identified are calculated by the data system as follows:

$$\text{Conc. of sample in ppb, V/V} = \frac{\text{sample peak area}}{\text{sample Vol, mLs}} \times \frac{\text{ppb std} \times \text{mLs of std}}{\text{std area}} \times \text{correction factor (if needed)}$$

$$\text{correction factor} = \frac{\text{calibration curve area count}}{\text{daily standard area count}}$$

8. Quality Assurance

8.1 The acceptability of the calibration curve is monitored by injecting 100 mL of the Scott-Marrin gas standard each day the gas chromatograph is used. The area count from the standard is entered into the AUTOSQC statistical program. If the daily standard does not meet the statistical criteria, then corrective action is taken.

8.2 Weekly QA includes trip blanks (Tedlar bags filled with ultrapure nitrogen that travel with sample bags to the sampling destination and back to the laboratory for analysis), duplicate samples from the sampling site, and duplicate injections of the same sample (to validate laboratory precision).

8.3 Method detection limits have not been documented. Presently a "quantitation limit" is used where a value is not reported if the signal is lower than the lowest signal used in the calibration curve. Quantitation limits are raised when high blank values are found. Typical values are listed in Table I, for both landfill gas (0.5 mL) and ambient air (500 mL) injection volumes.

8.4 Sample spiking techniques have not been established.

Table I - Component Currently Analyzed Using FID Cryotrap Method, Test Code and the Current Limits of Quantitation in ppb V/V.

		Limit of Quantitation		
Test Code	Component	sample volume 0.5 mL	sample volume 500 mL	Detector Used
665	Acetonitrile	5000	5.0	FID

Table II - Scott-Marrin Standard Currently Used And Its Concentrations.

Scott-Marrin Standard I

Component	ppb V/V
Acetonitrile	90
Nitrogen	BALANCE

600B: GAS CHROMATOGRAPHIC ANALYSIS OF ORGANIC COMPOUNDS IN AIR AND GAS SAMPLES USING A PACKED COLUMN

INTRODUCTION

Volatile organic compounds are analyzed by packed column gas chromatography with a photoionization detector (PID) in series with a Hall electrolytic conductivity detector (HECD). The detector signals are collected by a data system for identification and quantitation of the sample components.

Procedure 600B: Analysis of Organic Compounds in Air and Gas (Jan 2, 1992)

1. Scope and Application

   1.1 This instrumental procedure is to be used for the identification and quantitation of volatile organic compounds. The components currently analyzed by this method and their test codes are listed in Table I.

   1.2 Ambient air, flare exhaust, landfill surface gas, landfill boundary probe, digester gas, landfill gas, engine exhausts and other sample types are analyzed according to this procedure.

2. Summary of Procedure

   2.1 The sample is injected, cryogenically trapped and thermally desorbed onto a cooled gas chromatographic column.

   2.2 The gas chromatograph is temperature programmed to separate the components. Aromatics and unsaturated hydrocarbons are analyzed using the PID. The effluent from the PID is analyzed for halocarbons by HECD.

3. Sample Handling and Preservation

   3.1 Tedlar (polyvinylfluoride) sample bags are bought commercially. The bags are filled with ultrapure nitrogen, allowed to sit overnight, flushed and filled again. This process is repeated ten or more times and then a sample of the blank nitrogen in the bag is analyzed after remaining in the bag overnight. At least two bags from every lot of ten are randomly selected to represent the lot. If the two bags are clean, then the entire set is placed in service. The new bag data is compared to previous lots of new bags to determine acceptability. If the bags are contaminated, they are returned for another round of flushing with ultrapure nitrogen and tested again for suitability.

   3.2 Tedlar sample bags are leak checked after each use. Each sample bag is filled with ultrapure nitrogen and allowed to sit overnight with a weight on it. If the bag's volume is reduced significantly, the bag is either repaired or discarded.

   3.3 After leak checking, the Tedlar sample bags are cleaned. Each bag is flushed and filled three times with ultrapure nitrogen and allowed to sit overnight. This is repeated two more times and then the bag is returned to service.

3.4 The Tedlar sample bags are dedicated for specific sample type and segregated for storage to avoid contamination. Presently we have four sample bag types:

- 3.4.1 Ambient air bags for ambient air, landfill surface gas, landfill boundary probes, and flare exhaust samples.
- 3.4.2 Raw bags for raw digester and landfill gas.
- 3.4.3 Scrubber bags for sewer gas.
- 3.4.4 Scrubber exhaust bags for exhaust from sewer gas scrubbers.

3.5 Samples are collected in the field in Tedlar bags and transported to the laboratory in cardboard boxes to minimize photochemical decomposition. Sample bags are flushed with ultrapure nitrogen (either in the laboratory or the field office) just prior to sample collection.

3.6 Samples must be analyzed within 72 hours, but are normally analyzed the day of sampling or the next day.

4. Apparatus

4.1 Gas Chromatography

4.1.1 Varian 6000 gas chromatograph equipped with a 10.2 eV HNu model PI-52-02 photoionization detector in series with a Hall model 700A electrolytic conductivity detector (Tracor) operated in the halogen mode.

4.1.2 Column: 2 m x 2 mM ID Pyrex packed with 60/80 mesh Carbopack B coated with 1% SP-1000.

4.1.3 Operating parameters:

Carrier gas: Helium (carrier grade), 25 mL/min
Sweep gas: Helium (carrier grade), 40 mL/min
Injector temperature: 150 C
Detector base temperature: 300 C
Range: 10 for PID and HECD
HECD electrolyte: n-propanol at 0.5 mL/min
Temperature program: A 10-min hold at an initial temperature of -99 C. Program to 40 C at 40 C/min and hold for 5 min. Program to 220 C at 8 C/min and hold for 14 min.

4.2 Data System:

4.2.1 Nelson Analytical (3000 series) chromatography software system based on an

IBM AT or PS/2 personal computer with a two channel capacity buffer box (760 series) to collect the raw data from both PID and HECD. The data system draws baselines and identifies components according to the software and preselected parameters. The data may be recalculated by the operator by changing the drawn baselines.

4.2.2 NWA Quality Analyst version 3.1 statistical program for quality control charting and analysis.

4.2.3 Analytical Automation Specialists AUTOSQC software package which integrates Nelson Analytical 3000 software with NWA Quality Analyst to provide Shewhart quality control charts from chromatographic data.

4.2.4 "Limitgc1" and "SP1L20" are basic programs written using the BASIC interpreter. "Limitgc1" is designed to set up tables with component names and calculated acceptable area count ranges for these components and then produce a hard copy of these tables. "SP1L20.bas" is a basic program that is used to check the daily 50 mL standard injection. Lines 10-330 were modified from Nelson Analytical's "User.Bas" program. "SP1L20.bas" imports ASCII data from previously saved area tables, compares the proper areas with the limits set up by "Limitgc1.bas", and prints an exception report listing all compounds that exceed the limit.

4.3 Strip Chart Recorder: Linear Instruments Model 282/MM with dual pens for PID and HECD.

4.4 Cryotrap System

4.4.1 Plumbing: 1/8" nickel tubing kept at approximately 200 °C using 3/16" nichrome wire heating cord controlled by a Glas-Col Model PL-312 Minitrol voltage regulator set at 2.

4.4.2 1/16" ID Nafion tubing leading from the trap to a stainless steel Valco E60 injection valve. The Nafion tubing (a perfluorinated monomer membrane) is available from Perma Pure Products, Inc., Oceanport, N.J. Water vapor is selectively diffused through the membrane (References 1 and 2).

4.5 Sample Loading System

4.5.1 A 100 mL glass syringe with a Teflon plunger is used to measure the larger sample volumes. Volumes less than 100 mL are loaded onto the cryotrap by injecting the volume through a septum with a gas tight syringe.

4.5.2 Trap utilizing 1/4" ID nickel tubing in a "U" configuration packed with silanized glass beads. The trap is wrapped with 3/16" nichrome wire heating cord controlled by a Glas-Col Model PL-312 Minitrol temperature controller. The trap can be heated to approximately 400°C.

5. Reagents

5.1 A 1,3-butadiene and benzyl chloride standard mixture was obtained in a Scott "Aculife" polished aluminum cylinder from Scott Specialty Gases with nitrogen as a balance gas. Working standards are prepared by transferring a volume of 100 ppb V/V nominal standard to a Tedlar bag. See Table III for concentrations.

5.2 Standard mixtures were obtained from Scott-Marrin, Inc. in cylinders at nominal concentrations of 100 ppb V/V in nitrogen. Table II shows the components in the three Scott-Marrin standards currently in use and their concentrations. Working standards are prepared by transferring a volume of 100 ppb V/V standard to a Tedlar bag.

5.3 Quality assurance standards obtained from the National Institute of Standards and Technology (NIST) at nominal concentrations of 250 and 5.0 ppb V/V. The components and concentrations of the nominal 250 ppb V/V standards are listed in Table IV and the nominal 5.0 ppb V/V standards are listed in Table V. NIST gas standards are certified for 2 years.

6. Procedure

6.1 The data collection methods are loaded into the interface boxes prior to the start of the run. The data collection method instructs the data system how to acquire the data to be generated during the run (i.e. during what times and at what rate the data should be collected). The data system controls all valves through timed event relays.

6.2 The cryotrap is immersed into a liquid nitrogen bath for 1 min prior to sample trapping. The valve actuator is placed in the load position. This allows the helium sweep gas to flow through the cryotrap system and maintains helium carrier flow through the column.

6.3 A gaseous sample of up to 500 mL is loaded onto the cryotrap with a gas tight syringe. The sweep gas carries sample onto the cryotrap.

6.4 The gas chromatograph oven should be cooled to -99 C and ready for injection.

6.5 Three min after the gas sample has been loaded onto the cryotrap, the liquid nitrogen bath is removed. After waiting 15 sec (to allow the CO2 and NOx to vent) the run is started.

6.6 When the run is started, several electrically controlled events occur. The valve controlling the sample flow is switched to "inject", allowing helium sweep gas to carry the sample from the trap to the gas chromatograph column. The cryotrap is heated to approximately 400 C for 4 min and then allowed to cool for 3 min while sweeping sample from the trap onto the column. At the end of this sequence the sample valve is switched back to "load".

6.7 Periodically, 10-point calibration curves are generated for each detector. The lifetime of these curves is determined by detector performance. Retention times are updated on a daily basis.

7. Calculations

7.1 The data system identifies and quantifies sample components.

7.2 Ten-point calibration curves (point-to-point) are established for each detector and component. Correction factors may be applied if the daily response is found to vary by more than 20% from when the calibration curve was established.

7.3 The peaks that are identified are calculated by the data system as follows:

$$\underset{\text{in ppb, V/V}}{\text{Conc. of sample}} = \frac{\text{sample peak area}}{\text{sample Vol, mLs}} \times \frac{\text{ppb std} \times \text{mLs of std}}{\text{std area}}$$

$$\times \text{ correction factor (if needed)}$$

$$\text{correction factor} = \frac{\text{calibration curve area count}}{\text{daily standard area count}}$$

8. Quality Assurance

8.1 The acceptability of the calibration curves are monitored by injecting 50 mL of the Scott-Marrin and the Scott Specialty gas standards each day the gas chromatograph is used. The area counts from the standards are entered into the AUTOSQC statistical program. If the daily standards do not meet the statistical criteria, then corrective action is taken.

8.2 Weekly QA includes trip blanks (Tedlar bags filled with ultrapure nitrogen that travel with sample bags to the sampling destination and back to the laboratory for analysis), duplicate samples from the sampling site, and duplicate injections of the same sample (to validate laboratory precision).

8.3 Method detection limits have not been documented. Presently a "quantitation limit" is used where a value is not reported if the signal is lower than the lowest signal used in the calibration curve. Quantitation limits are raised when high blank values are found. Typical values are listed in Table I, for both landfill gas (0.5 mL) and ambient air (500 mL) injection volumes.

8.4 Sample spiking techniques have recently been established. Spiked samples are run weekly and the data is entered into a data base.

8.5 Mixtures obtained from the National Institute of Standards and Technology are run weekly. The results are entered into the AUTOSQC statistical program. If the results do not meet statistical criteria, then corrective action is taken.

Table II - Scott-Marrin Standards Currently Used And Their Concentrations.

Scott-Marrin Standard I

Component	ppb V/V
Vinyl Chloride	99.5
Carbon Tetrachloride	103
1,1-Dichloroethylene	106
cis-1,2-Dichloroethylene	109
Tetrachloroethylene	100
Benzene	103
Toluene	115
1,2-Dibromoethane	111
Acetonitrile	90
Nitrogen	BALANCE

Scott-Marrin Standard II

Component	ppb V/V
Methylene Chloride	99.5
Chloroform	106
1,1-Dichloroethane	104
1,2-Dichloroethane	102
1,1,1-Trichloroethane	103
Trichloroethylene	100
m+p-Xylene	214
Chlorobenzene	103
m-Dichlorobenzene	115
o-Dichlorobenzene	115
o-Xylene	106
Nitrogen	BALANCE

Scott-Marrin Standard III

Component	ppb V/V
Freon-11	100.3
Nitrogen	BALANCE

Table III - Scott Specialty Gases Standard

Component	ppb V/V
1,3-Butadiene	94.7
Benzyl Chloride	109
Nitrogen	BALANCE

Table IV - High Level NIST Standards Currently Used And Their Concentrations

Halocarbon Standard

Component	ppb V/V
Carbon Tetrachloride	245
Chloroform	247
Tetrachloroethylene	250
Vinyl Chloride	241
Nitrogen	BALANCE

Aromatic Standard

Component	ppb V/V
Benzene	238
Toluene	225
Chlorobenzene	223
Bromobenzene	226
Nitrogen	BALANCE

Table V - Low Level NIST Standards Currently Used And Their Concentrations

Component	ppb V/V
Vinyl Chloride	5.3
Dichloromethane	5.0
Chloroform	5.0
1,2-Dichloroethane	5.0
1,1,1-Trichloroethane	5.1
Benzene	5.0
Carbon Tetrachloride	5.0
Trichloroethylene	5.0
Toluene	4.9
Tetrachloroethylene	5.0
Chlorobenzene	5.0
O-Xylene	5.0
1,3-Butidiene	4.7 (not certified)
1.2-Dibromoethane	4.8 (not certified)
Nitrogen	BALANCE

APPENDIX B
QUALITY ASSURANCE

Appendix B.1

Quality Assurance Program Summary

QUALITY ASSURANCE PROGRAM SUMMARY AND ARB CERTIFICATION

Carnot ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA Officer and encompasses seven major areas:

1. Development and use of an internal QA manual.
2. QA reviews of reports, laboratory work, and field testing.
3. Equipment calibration and maintenance.
4. Chain of custody.
5. Training.
6. Knowledge of current test methods.
7. Agency certification.

Each of these areas is discussed individually below.

Quality Assurance Manual. Carnot has prepared a QA Manual according to EPA guidelines. The manual serves to document and formalize all of Carnot's QA efforts. The manual is constantly updated, and each member of the Source Test Division is required to read and understand its contents. The manual includes details on the other six QA areas discussed below.

QA Reviews. Carnot's review procedure includes review of each source test report by the QA Officer, and spot check reviews of laboratory and field work.

The most important review is the one that takes place before a test program begins. The QA Officer works closely with Source Test Division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of any interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance. The equipment used to conduct the emissions measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the California Air Resources Board (CARB). The schedule for maintenance and calibrations are given in Tables B-1 and B-2. Quality control checks are also conducted in the field for each test program. The following is a partial list of checks made as part of each CEM system test series.

- Sample acquisition and conditioning system leak check.
- 2-point analyzer calibrations (all analyzers)
- 3-point analyzer calibrations (analyzers with potential for linearity errors).
- Complete system calibration check ("dynamic calibration" through entire sample system).

- Periodic analyzer calibration checks (once per hour) are conducted at the start and end of each test run. Any change between pre- and post-test readings are recorded.

- All calibrations are conducted using gases certified by the manufacturer to be + 1% of label value (NBS traceable).

Calibration and CEM performance data are fully documented, and are included in each source test report.

Chain of Custody. Carnot maintains full chain of custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, Carnot documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.).

Samples are stored in a locked area to which only Source Test Division personnel have access. Neither other Carnot employees nor cleaning crews have keys to this area.

Data sheets are copied immediately upon return from the field, and this first generation copy is placed in locked storage. Any notes made on original sheets are initialed and dated.

Training. Personnel training is essential to ensure quality testing. Carnot has formal and informal training programs which include:

1. Attendance at EPA-sponsored training courses.
2. Enrollment in EPA correspondence courses.
3. A requirement for all technicians to read and understand Carnot's QA Manual.
4. In-house training and QA meetings on a regular basis.
5. Maintenance of training records.

Knowledge of Current Test Methods. With the constant updating of standard test methods and the wide variety of emerging test methods, it is essential that any qualified source tester keep abreast of new developments. Carnot subscribes to services which provide updates on EPA and CARB reference methods, and on EPA, CARB and SCAQMD rules and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences. Carnot personnel maintain membership in the Air Pollution Control Association, the Source Evaluation Society, and the ASME Environmental Control Division.

AGENCY CERTIFICATION

Carnot is certified by the CARB as an independent source test contractor for gaseous and particulate measurements. Carnot also participates in EPA QA audit programs for Methods 5, 6 and 7.

TABLE B-1
SAMPLING INSTRUMENTS AND EQUIPMENT CALIBRATION SCHEDULE
As Specified by the CARB

Instrument Type	Frequency of Calibration	Standard of Comparison or Method of Calibration	Acceptance Limits
Orifice Meter (large)	12 months	Calibrated dry test meter	± 2% of volume measured
Dry Gas Meter	12 months or when repaired	Calibrated dry test meter	± 2% of volume measured
S-Type Pitot (for use with EPA-type sampling train	6 months	EPA Method 2	Cp constant (+5%) over working range; difference between average Cp for each leg must be less than 2%
Vacuum Gauges Pressure Gauges	6 months	Manometer	± 3%
Field Barometer	6 months	Mercury barometer	± 0.2" Hg
Temperature Measurement	6 months	NBS mercury thermometer or NBS calibrated platinum RTD	± 4°F for <400°F ± 1.5% for >400°F
Temperature Readout Devices	6 months	Precision potentiometer	± 2% full scale reading
Analytical Balance	12 months (check prior to each use)	Should be performed by manufacturer or qualified laboratory	± 0.3 mg of stated weight
Probe Nozzles	12 Months	Nozzle diameter check micrometer	Range < ± 0.10 mm for three measurements
Continuous Analyzers	Depends upon use, frequency and performance	As specified by manufacturers operating manuals, EPA NBS gases and/or reference methods	Satisfy all limits specified in operating specifications

TABLE B-2
EQUIPMENT MAINTENANCE SCHEDULE
Based on Manufacturer's Specifications and Carnot Experience

Equipment	Performance Requirement	Maintenance Interval	Corrective Action
Pumps	1. Absence of leaks 2. Ability to draw manufacturer required vacuum and flow	Every 500 hours of operation or 6 months, whichever is less	1. Visual inspection 2. Clean 3. Replace worn parts 4. Leak check
Flow Measuring Device	1. Free mechanical movement 2. Absence of malfunction	Every 500 hours of operation or 6 months, whichever is less After each test, if used in H_2S sampling or other corrosive atmospheres	1. Visual inspection 2. Clean 3. Calibrate
Sampling Instruments	1. Absence of malfunction 2. Proper response to zero, span gas	As required by the manufacturer	As recommended by manufacturer
Integrated Sampling Tanks	Absence of leaks	Depends on nature of use	1. Steam clean 2. Leak check
Mobile Van Sampling Systems	Absence of leaks	Depends on nature of use	1. Change filters 2. Change gas dryer 3. Leak check 4. Check for system contamination
Sampling Lines	Sample degradation less than 2%	After each test or test series	Blow filtered air through line until dry

Appendix B.2

ARB Certification

State of California
AIR RESOURCES BOARD

Executive Order G-767

Approval to Carnot
To Conduct Testing as an Independent Contractor

WHEREAS, the Air Resources Board ("Board"), pursuant to Section 41512 of the California Health and Safety Code, has established the procedures contained in Section 91200-91220, Title 17, California Code of Regulations, to allow the use of independent testers for compliance tests required by the Board; and

WHEREAS, pursuant to Sections 91200-91220, Title 17, California Code of Regulations, the Executive Officer has determined that Carnot meets the requirements of the Board for conducting ARB Test Methods 1, 2, 3, 4, 5, 6, 8, 10, and 100 (NOx, O2) when the following conditions are met:

1. Carnot conducts ARB Test Method 100 for O2 using a Teledyne 326 analyzer with either a A5 or a B1 sensor, or a paramagnetic analyzer.

NOW, THEREFORE, BE IT ORDERED that Carnot is granted an approval, from the date of execution of this order, until June 30, 1993 to conduct the tests listed above, subject to compliance with Section 91200-91220, Title 17, California Code of Regulations.

BE IT FURTHER ORDERED that during the approved period the Executive Officer or his or her authorized representative may field audit one or more tests conducted pursuant to this order for each type of testing listed above.

Executed this 10TH day of August 1992, at Sacramento, California.

James J. Morgester, Chief
Compliance Division

State of California

Air Resources Board

Approved Independent Contractor

Carnot

This is to certify that the company listed above has been approved by the Air Resources Board to conduct compliance testing, pursuant to Section 91207, Title 17, California Code of Regulations, until June 30, 1993, for those test methods listed below:

ARB Source Test Methods:
1, 2, 3, 4, 5, 6, 8, 10, 100 (NOx, O2),

James J. Morgester, Chief
Compliance Division

McKinney
for H. Roye Jackson, Manager
Field Evaluation Section

Appendix B.3

Calibration Data

CARNOT

DRY GAS METER CALIBRATION

FIELD GAS METER I.D....ES-28

TEST METER ID....... ES-13

DATE...................12/22/92

TEST METER LAST CAL..12/08/92

BAROMETRIC PRESSURE....30.18

TEST METER CAL FACTOR 1.0006 = Yt

CALIBRATION BY......... BC

LEAK CHECK...........GOOD @ 8 IN. H2O VAC

FIELD METER			TEST METER				RESULTS				
VOLUME cu.ft.	TEMP.a 'F	DELTA H "H2O	TIME min.	VOLUME cu.ft.	TEMP. 'F	PRESS. "H2O	Q cfm	Y	H@	AVE.Y	AVG. H@
6.062	61.8	0.50	15	5.962	54.5	-0.17	0.404	0.996	1.70	1.0002	1.72
6.062	64.5	0.50	15	5.957	54.5	-0.17	0.404	1.001	1.69		
5.952	67.5	0.50	15	5.843	55.5	-0.17	0.397	1.004	1.75		
5.941	71.3	0.80	12	5.823	56.0	-0.21	0.495	1.007	1.80	1.0066	1.80
5.955	72.0	0.80	12	5.826	56.5	-0.21	0.496	1.006	1.80		
5.985	72.3	0.80	12	5.858	56.5	-0.21	0.499	1.007	1.78		
5.536	74.0	1.00	10	5.413	57.5	-0.25	0.554	1.006	1.81	1.0074	1.82
5.536	75.8	1.00	10	5.414	57.5	-0.25	0.554	1.010	1.81		
5.531	74.8	1.00	10	5.402	58.0	-0.25	0.553	1.006	1.82		
5.322	76.3	2.00	7	5.296	58.0	-0.46	0.760	1.025	1.86	1.0130	1.92
5.317	75.5	2.00	7	5.210	58.0	-0.46	0.760	1.008	1.93		
5.260	66.8	2.00	7	5.266	61.0	-0.46	0.751	1.007	1.94		
5.545	74.5	3.00	6	5.539	62.0	-0.63	0.924	1.014	1.92	1.0111	1.92
5.585	74.3	3.00	6	5.550	62.0	-0.63	0.931	1.009	1.92		
5.623	76.8	3.00	6	5.570	62.0	-0.63	0.937	1.010	1.89		

AVERAGE = 1.0076 1.83

AVERAGE cfm @^H=1.0 = 0.553

******* *********

CARNOT

DRY GAS METER CALIBRATION

FIELD GAS METER I.D....ES-42

DATE..................12/28/92

BAROMETRIC PRESSURE....29.91

CALIBRATION BY......... BC

TEST METER ID....... ES-13

TEST METER LAST CAL..12/08/92

TEST METER CAL FACTOR 1.0006 = Yt

LEAK CHECK...........GOOD @ 8 IN. H2O VAC

FIELD METER			TEST METER				RESULTS				
VOLUME cu.ft.	TEMP.a 'F	DELTA H "H2O	TIME min.	VOLUME cu.ft.	TEMP. 'F	PRESS. "H2O	Q cfm	Y	H@	AVE.Y	AVG. H@
5.869	67.8	0.50	15	5.776	68.0	-0.13	0.391	0.983	1.90	0.9899	1.88
5.886	74.5	0.50	15	5.761	65.3	-0.13	0.392	0.995	1.86		
5.926	75.5	0.50	15	5.780	66.0	-0.13	0.395	0.992	1.85		
5.911	76.8	0.80	12	5.791	66.5	-0.20	0.493	0.997	1.89	0.9960	1.93
5.858	78.0	0.80	12	5.711	66.5	-0.20	0.488	0.994	1.94		
5.861	78.3	0.80	12	5.725	66.5	-0.20	0.488	0.997	1.93		
5.781	79.0	1.00	10	5.653	66.5	-0.25	0.578	0.999	1.72	0.9938	1.83
5.381	79.3	1.00	10	5.235	67.0	-0.25	0.538	0.993	2.01		
5.799	79.0	1.00	10	5.625	67.0	-0.25	0.580	0.990	1.74		
5.258	78.8	2.00	7	5.141	66.0	-0.40	0.751	0.996	2.05	0.9969	2.00
5.316	80.0	2.00	7	5.182	66.0	-0.40	0.759	0.995	2.01		
5.408	79.8	2.00	7	5.294	66.0	-0.40	0.773	0.999	1.93		
5.501	80.5	3.00	6	5.400	66.0	-0.58	0.917	1.000	2.05	1.0007	2.03
5.558	80.8	3.00	6	5.455	66.0	-0.58	0.926	1.001	2.01		
5.546	81.8	3.00	6	5.433	66.0	-0.58	0.924	1.001	2.02		

AVERAGE = 0.9954 1.93

AVERAGE cfm @^H=1.0 = 0.565

******* *********

CARNOT
SPAN GAS RECORD

CLIENT/LOCATION: PVERG DATE: 12-30-92

BY: CHF

GAS	SPAN CYLINDER		AUX. SPAN CYLINDER	
	CYLINDER NO.	CONCENTRATION	CYLINDER NO.	CONCENTRATION
ZERO	AAL 1254	99.998 N_2		
NOx	ALM006719	12.49 NO 12.68 NOx	AAL 18584	22.43 NO 22.81 NOx
O_2	ALM006709	5.162	AAL 3966	8.013
CO	ALM015919	11.22	A 1445	16.17
CO_2	ALM006709	15.15	AAL3966	22.74
SO_2				

CARNOT
INSTRUMENT LINEARITY

	ANALYZER				
	O_2	CO_2	CO	NOx	~~SO_2~~ Co
ANALYZER RANGE	0-10	0-25	0-20	0-25	0-100
SET TO HIGH STD (80-90% OF RANGE)	8.013	22.74/90%	16.17	22.81	16.17
ACTUAL VALUE OF LOW STD	5.162	15.15/6	11.22	12.68	11.22
AS-FOUND LOW STD (50-60% OF RANGE)	5.22	15.35	11.34	12.50	11.4
DIFFERENCE IN % OF FULL SCALE	0.6	0.8	0.6	-0.7	0.2

% ERROR CALCULATION:

$$\frac{\text{(AS FOUND - ACTUAL VALUE OF SPAN)}}{\text{RANGE}} \times 100$$

ALLOWABLE DEVIATION IS 2% OF FULL SCALE (2 SQUARES ON STRIP CHART).

CARNOT

Scott Specialty Gases, Inc.
FAX 714-887-0549
PHONE: 714-887-2571
2600 CAJON BLVD., SAN BERNARDINO, CA 92411

Shipped From: Scott SAN BERNARDINO, CA
Date Shipped 11/19/92
Our Project No: 22392
Your P.O. No: 9059
Page 1 of 1
Expiration Date: 5/94

CARNOT
ATTN: RICK MADRIGAL
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

CERTIFICATE OF ANALYSIS – EPA PROTOCOL GASES

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. AAL18584 Cylinder Pressure 2000 PSIG Certified Accuracy ±1% % NIST 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	22.43 PPM	GMIS TRACEABLE	ALM017542	48.20 PPM	THERMO-ELECTRON	10/29/92	CHEMI-LUMINESCENT
		TO CRM1684B			10AR 14853-150		
NOX	22.81 PPM						

BALANCE GAS NITROGEN

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

Component NITRIC OXIDE

First Analysis Date 11/10/92 Units mv

Z 0.00	R 58.12	T 27.06
R 58.10	Z 0.00	T 27.03
Z 0.06	T 27.02	R 58.02

Mean Test Assay 22.43 PPM

Second Analysis Date 11/17/92 Units mv

Z 0.00	R 60.02	T 27.81
R 60.23	Z -0.08	T 28.08
Z -0.01	T 27.94	R 60.03

Mean Test Assay 22.43 PPM

Component
Date Units mv

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay

Date Units mv

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay

Component
Date Units mv

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay

Date Units mv

Z	R	T
R	Z	T
Z	T	R

Mean Test Assay

Chronology: Date
Assay

Analyst G. KING

Approved By: A Lange
A.F. LANGE, Ph.D., MANAGER, QA

Scott Specialty Gases, Inc.
FAX 714-887-0549
PHONE: 714-887-2571
2600 CAJON BLVD., SAN BERNARDINO, CA 92411

Shipped From: Scott SAN BERNARDINO, CA
Date Shipped 04/06/92
Our Project No: 18768
Your P.O. No: 8195
Page 1 of 1
Expiration Date: 10/93

CARNOT
ATTN: JIM MULLIGAN
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

CERTIFICATE OF ANALYSIS – EPA PROTOCOL GASES

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM006719 Cylinder Pressure 2000 PSIG Certified Accuracy ±1% % NIST 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	12.49 PPM	SRM2629A	FF28500	19.4 PPM	THERMO-ELECTRON	12/18/91	CHEMI-LUMINESCENT
					10AR 14853-150		
NOX	12.68 PPM						

BALANCE GAS NITROGEN

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

Component NITRIC OXIDE

First Analysis Date	03/26/92			Units	mv
Z	0.00	R	71.14	T	46.06
R	71.20	Z	0.74	T	45.92
Z	-0.49	T	45.82	R	71.29
			Mean Test Assay		12.51 PPM
Second Analysis Date	04/02/92			Units	mv
Z	0.00	R	75.54	T	48.15
R	75.40	Z	-1.25	T	48.26
Z	-1.20	T	48.10	R	75.36
			Mean Test Assay		12.46 PPM

Component

Date				Units	mv
Z		R		T	
R		Z		T	
Z		T		R	
			Mean Test Assay		
Date				Units	mv
Z		R		T	
R		Z		T	
Z		T		R	
			Mean Test Assay		

Component

Date				Units	mv
Z		R		T	
R		Z		T	
Z		T		R	
			Mean Test Assay		
Date				Units	mv
Z		R		T	
R		Z		T	
Z		T		R	
			Mean Test Assay		

Chronology: Date
Assay

Analyst G. KING

Approved By:
A.F. LANGE, Ph.D., MANAGER, QA

Scott Specialty Gases, Inc.
FAX 714-887-0549
PHONE: 714-887-2571
2600 CAJON BLVD., SAN BERNARDINO, CA 92411

Shipped From: Scott SAN BERNARDINO, CA
Date Shipped 01/24/92
Our Project No: 17560
Your P.O. No: 7967
Page 1 of 1
Expiration Date: 07/93

CARNOT
JIM MULLIGAN
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

CERTIFICATE OF ANALYSIS – EPA PROTOCOL GASES

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. ALM015919 Cylinder Pressure 2000 PSIG Certified Accuracy +1% % NIST 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	11.22 PPM	SRM1677	CAL5078	9.90 PPM	HORIBA AIA-24 4564403	10/23/91	INFRA-RED

BALANCE GAS NITROGEN

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

Component CARBON MONOXIDE
First Analysis Date 01/13/92 Units mv
Z 00.00 R 19.6 T 22.2
R 19.6 Z 00.06 T 22.2
Z -00.02 T 22.2 R 19.6
Mean Test Assay 11.25 PPM

Second Analysis Date 01/20/92 Units mv
Z 00.00 R 19.6 T 22.1
R 19.6 Z 00.06 T 22.1
Z 00.07 T 22.1 R 19.6
Mean Test Assay 11.19 PPM

Component
Date Units mv
Z R T
R Z T
Z T R
Mean Test Assay
Date Units mv
Z R T
R Z T
Z T R
Mean Test Assay

Component
Date Units mv
Z R T
R Z T
Z T R
Mean Test Assay
Date Units mv
Z R T
R Z T
Z T R
Mean Test Assay

Chronology: Date
Assay

Analyst M. JOHNSON

Approved By: Jim Ross
JIM ROSS, PLANT MANAGER

JIM MULLIGAN
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

Scott Specialty Gases, Inc.

FAX: 714-887-0549
PHONE: 714-887-2571

2600 CAJON BLVD., SAN BERNARDINO, CA 92405

Shipped From: Scott SAN BERNARDINO, CA
Date Shipped 05/18/92
Our Project No: 19562
Your P.O. No: 8346
Page 1 of 1
Expiration Date: 11/93

CERTIFICATE OF ANALYSIS – EPA PROTOCOL GASES

Certified Per Traceability Protocol No. 1 Procedure No. G1 Cylinder No. A1445 Cylinder Pressure 2015 PSIG Certified Accuracy ±1% % NIST 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	16.17 PPM	CRM2635	AAL9760	24.30 PPM	HORIBA AIA-24 4564403	02/10/92	INFRA-RED

BALANCE GAS NITROGEN

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

Component CARBON MONOXIDE

First Analysis Date 05/05/92 Units mv

Z	00.00	R	47.8	T	31.9
R	47.8	Z	00.02	T	31.9
Z	-00.03	T	31.9	R	47.8

Mean Test Assay 16.17 PPM

Second Analysis Date 05/14/92 Units mv

Z	00.00	R	47.8	T	31.9
R	47.8	Z	00.04	T	31.9
Z	-00.02	T	31.9	R	47.8

Mean Test Assay 16.17 PPM

Component

Date Units mv

Z		R		T	
R		Z		T	
Z		T		R	

Mean Test Assay

Date Units mv

Z		R		T	
R		Z		T	
Z		T		R	

Mean Test Assay

Component

Date Units mv

Z		R		T	
R		Z		T	
Z		T		R	

Mean Test Assay

Date Units mv

Z		R		T	
R		Z		T	
Z		T		R	

Mean Test Assay

Chronology: Date
Assay

Analyst M. JOHNSON

Approved By:
A.F. LANGE, Ph.D., MANAGER, QA

Scott Specialty Gases, Inc.

Shipped from: 2600 CAJON BLVD.
SAN BERNARDINO CA 92411
Phone: 714-887-2571 Fax: 714-887-0549

CERTIFICATE OF ANALYSIS

CARNOT
ATTN: RICK MADRIGAL
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

PROJECT #: 02-22304
PO#: 8957
ITEM #: 0202C3013601AL
DATE: 10/29/92

CYLINDER #: AAL5966
FILL PRESSURE: 1950 PSIG
ANALYTICAL ACCURACY: +/-1%

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
CARBON DIOXIDE	22.5	PCT	22.74	PCT
OXYGEN	8.	PCT	8.003	PCT
NITROGEN		BAL		BAL

CARNOT 1/5 [illegible]
CERTIFIED TO HAVE BEEN BLENDED AND VERIFIED TO BE CORRECT BY ANALYSIS.

GRAVIMETRIC MASTER GAS -
AGAINST NIST CERTIFIED BY [illegible]
INDEPENDENT LABORATORY

ANALYST: JDLT
JOSEPH DE LA TORRE

APPROVED BY:
DR. ARMAND [illegible]

Scott Specialty Gases, Inc.

Shipped From: 2600 CAJON BLVD.
SAN BERNARDINO CA 92411
Phone: 714-887-2571 Fax: 714-887-0549

CERTIFICATE OF ANALYSIS

CARNOT
ATTN: RICK MADRIGAL
15991 RED HILL AVE
SUITE 110
TUSTIN CA 92680

PROJECT #: 02-22304
PO#: 8957
ITEM #: 02020300070IAL
DATE:10/26/92

CYLINDER #: ALK006709 ANALYTICAL ACCURACY: +/-1%
FILL PRESSURE: 2000 PSIG

COMPONENT	REQUESTED GAS CONC MOLES		ANALYSIS (MOLES)	
CARBON DIOXIDE	15.	PCT	15.13	PCT
OXYGEN	5.	PCT	5.160	PCT
NITROGEN		BAL		BAL

CARNOT [illegible] BINS
CERTIFIED TO HAVE BEEN BLENDED
AND VERIFIED TO BE CORRECT BY
ANALYSIS.

GRAVIMETRIC MASTER GAS -
AGAINST NIST CERTIFIED WEIGHTS
INDEPENDENT LABORATORY

ANALYST: MJ
MAYNARD JOHNSON

APPROVED BY:
[illegible]

Appendix B.4

Chain of Custody

CERTIFICATION OF SAMPLE RECEIPT

PROJECT # 54700
OUTSIDE LAB: Y
SAMPLE DATE 12/30/92
PROJECT MANAGER Craig Fry
SAMPLE LOCATION In & Out
METHOD(S) 25.2
TECHNICIAN
COMPLIANCE TEST (Y/N) Y
DATE DUE

TEST #	COMPLETE DESCRIPTION
1-Hc-In	Tedlar Bag Samples
1-HC-Out	SCAQMD Method 25.2 Analysis
2-Hc-In	
2-Hc-Out	In - Landfill Gas
	Out - Boiler Exhaust

CHAIN OF CUSTODY PRIOR TO SHIPMENT:

RELEASED BY	DATE	TIME	RECEIVED BY	DATE	TIME
	12/30/92	3:21		/ /	:
	/ /	:		/ /	:
	/ /	:		/ /	:

OUTSIDE LAB INFORMATION

SAMPLES SHIPPED TO AtmAA Inc.

PHONE: ( ) -

CARNOT SHIPPER Right of Way
DATE / /
CARRIER #
AIR BILL #

RECIPIENT
COMPANY
DATE / /

CHAIN OF CUSTODY

PROJECT # 54700

CLIENT/LOCATION PVERG

SAMPLE LOCATION Stack

COMPLIANCE TEST (Y/N) Y

OUTSIDE LAB REQUIRED (Y/N) N

METHOD(S) 5.1

SAMPLE DATE 12 /30/

PROJECT MANAGER Craig Fry

TECHNICIAN

DATE DUE 1/8/92

DATE	TIME	TEST #	SAMPLE DESCRIPTION	CONTAINERS	SAMPLER	COMMENTS
12/30	:	1-PM-PV	Method 5.1	2	C.F	
12/30	:	2-PM-PV	" 5.1	2	CF	
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					
/	:					

TRANSFER OF SAMPLES FROM FIELD SAMPLE CUSTODIAN (FSC):

RELEASED BY (FSC)	DATE AND TIME	RECEIVED BY	DATE AND TIME
	12/30/92 3:45	Marc Rodabaugh	12/30/92 15:45
	/ / :		/ / :
	/ / :		/ / :

ANALYSIS REQUIRED: SCAQMD Method 5.1 w/ Organic Extraction

CHAIN OF CUSTODY FORM

FIELD PERSONNEL

SAMPLE NO.	1	2	3	4	5	6	7
SAMPLE TYPE *	STGS						
SAMPLING DATE	12/30/92						
LANDFILL	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF
SUBLOCATION	—						
OVA READING - - - OR - - - CH4/O2	- - - 0/.5	- - -	- - -	- - -	- - -	- - -	- - -
BAG NO.	796						
COMMENTS	PVERG Boiler Emissions Testing						

SAMPLE TAKEN BY : NAVLOUAK EDWARDS DATE : DEC/30/92

DELIVERED BY : #92 DATE : DEC/30/92

LAB PERSONNEL

SAMPLE NO.	1	2	3	4	5	6	7
LOG NO.	95194						
BAG COND. **	F						
COMMENTS							

SAMPLE RECEIVED BY : DATE : 12/30/92

*AIR - AMBIENT AIR
ILSS - SURFACE GAS
LFGS - LANDFILL GAS (RAW)
STGS - FLARE EXHAUST
LPGP - BOUNDARY PROBE

** F = MORE THAN 1/2 FULL
L = 1/4 TO 1/2 FULL
E = LESS THAN 1/4 FULL BUT CONTAINS SOME SAMPLE
N = NO SAMPLE IN BAG

RETURN THIS FORM TO MOON CHUNG AFTER SAMPLES ARE RECEIVED BY LAB PERSONNEL.

CHAIN OF CUSTODY FORM

FIELD PERSONNEL

SAMPLE NO.	1	2	3*	4	5	6	7
SAMPLE TYPE *	LFGS	LFGS	STGS				
SAMPLING DATE	12/30	12/30	12/30				
LANDFILL	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF	2-PVLF
SUBLOCATION	—	—	—				
OVA READING - - - OR - - - CH4/O2	— - - - 20/11	— - - - 20/11	— - - - 0/5	- - -	- - -	- - -	- - -
BAG NO.	612	512	797				
COMMENTS	PVERG Emissions Testing →	→	→				

*Sample #3 obtained from Carnot

SAMPLE TAKEN BY : DATE : 12/30/92

DELIVERED BY : #92 DATE : 12/30/92

LAB PERSONNEL

SAMPLE NO.	1	2	3	4	5	6	7
LOG NO.	95191	95192	95192				
BAG COND. **	F	F	F				
COMMENTS							

SAMPLE RECEIVED BY : DATE : 12/30/92

*AIR - AMBIENT AIR
ILSS - SURFACE GAS
LFGS - LANDFILL GAS (RAW)
STGS - FLARE EXHAUST
LPGP - BOUNDARY PROBE

** F = MORE THAN 1/2 FULL
L = 1/4 TO 1/2 FULL
E = LESS THAN 1/4 FULL BUT CONTAINS SOME SAMPLE
N = NO SAMPLE IN BAG

RETURN THIS FORM TO Moon Chung AFTER SAMPLES ARE RECEIVED BY LAB PERSONNEL.

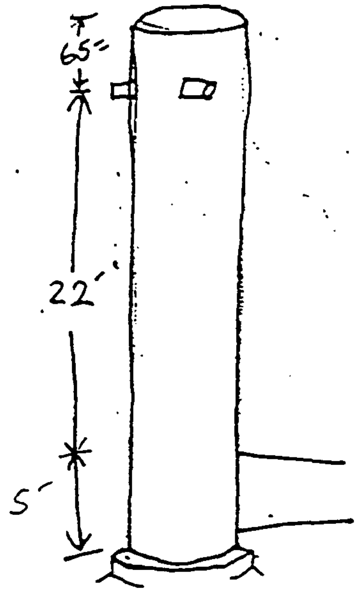
APPENDIX C
FIELD AND LAB DATA SUMMARIES

Appendix C.1

Sample Locations

CARNOT
SAMPLING POINT LOCATION DATA - EPA METHOD 1

PLANT: PV Unit 1
DATA BY: RM
DATE: 12/30/92
TEST LOCATION: Stack



Port Dia. = 4"
Stack Dia. = 41"

Diagram of Sampling Location

UPSTREAM DIST./DIA.: 1.58
DOWNSTREAM DIST./DIA.: 6.44
COUPLING LENGTH: 5.5"
NO. OF SAMPLING PTS.: 16
STACK DIMENSION: 41"
STACK AREA, FT²: 9.168

SAMPLE POINT	% OF DIAMETER	IN. FROM NEAR WALL	IN. FROM NOZZLE*
1	3.2	1.3	6.8
2	10.5	4.3	9.8
3	19.4	7.95	13.5
4	32.3	13.2	18.7
5	67.7	27.8	33.3
6	80.6	33.0	38.5
7	89.5	36.7	42.2
8	96.8	39.7	45.2

**INCHES FROM WALL PLUS COUPLING LENGTH*

CEM System Bias and Linearity Correction Calculations

Test No. 1-CEM-PV	O2	CO2	CO	NOx	Acceptance Criteria	Run Status
Linearity						
Analyzer Range	10	25	100	25		
High Cal	8.01	22.74	16.17	22.81		
Low Cal	5.16	15.15	11.22	12.68		
Analyzer Reads	5.22	15.35	11.40	12.50		
Analyzer Cal. Error,%	0.6	0.8	0.2	-0.7	< 2%	PASS
System Bias						
Pretest Bias						
Zero	0.02	0.00	0.00	0.00	< 5%	PASS
Span	5.14	15.20	11.16	12.55	< 5%	PASS
Posttest Bias						
Zero	0.02	0.08	0.00	0.00	< 5%	PASS
Span	5.30	14.95	10.70	12.50	< 5%	PASS
Span Value	5.16	15.15	11.22	12.68		
Zero Drift, %	0.00	0.32	0.00	0.00	< 3%	PASS
Span Drift, %	1.60	-1.00	-0.46	-0.20	< 3%	PASS
Test Ave.	5.33	12.95	11.67	18.18		
Corrected Ave.	5.27	13.01	11.98	18.40		

CEM System Bias and Linearity Correction Calculations

Test No. 2-CEM-PV	O_2	CO_2	CO	NO_x	Acceptance Criteria	Ru[illegible] Status
Linearity						
Analyzer Range	10	25	100	25		
High Cal	8.01	22.74	16.17	22.81		
Low Cal	5.16	15.15	11.22	12.68		
Analyzer Reads	5.22	15.35	11.40	12.50		
Analyzer Cal. Error,%	0.6	0.8	0.2	-0.7	< 2%	PASS
System Bias						
Pretest Bias						
Zero	0.02	0.05	0.00	0.05	< 5%	PASS
Span	5.14	15.10	10.80	12.60	< 5%	PASS
Posttest Bias						
Zero	0.10	0.10	0.00	0.05	< 5%	PASS
Span	5.13	15.30	10.00	12.40	< 5%	PASS
Span Value	5.16	15.15	11.22	12.68		
Zero Drift, %	0.80	0.20	0.00	0.00	< 3%	PASS
Span Drift, %	-0.10	0.80	-0.80	-0.80	< 3%	PASS
Test Ave.	5.36	12.88	14.67	18.02		
Corrected Ave.	5.39	12.83	15.83	18.30		

CARNOT
CEM PERFORMANCE DATA

CLIENT/LOCATION: PVERG
DATE: 12-30-92
BY: CHF

SYSTEM CONFIGURATION

ANALYZERS IN SERVICE				
ANALYZERS:	O_2	CO_2	CO	NOx
MODEL:	Teledyne	Horiba	Teco	Teco 10
SERIAL NO.:			48	

PROBE		**SAMPLE CONDITIONER**	
LENGTH:	4'	CONDENSER-VACUUM SIDE (CHECK FLOW):	✓
LINER MATERIAL:	SS	CONDENSER-PRESSURE SIDE (CHECK FLOW):	✓
HEATED PROBE (Y/N):	N	CONDENSER TEMPERATURE:	34
HEATED LINE (Y/N):	Y	FILTER CONDITION (COND. OR DATE LAST CHANGED):	12-10-92
SAMPLE LINE		**SYSTEM LEAK CHECK**	
LENGTH:	100	PRE-TEST (cfh):	
LINER MATERIAL:	Teflon	POST-TEST (cfh):	
SYSTEM BIAS LINE:	Poly	LEAK RATE (%) = $\frac{\text{POST-TEST (cfh)}}{\text{SYSTEM FLOW RATE (cfm) x 60}}$ x 100 = ______ %	
ON-STACK CONDITIONER		**NOx CONVERSION EFFICIENCY**	
IN SERVICE (Y/N):	Y	HIGH CAL NOx	22.81
KNOCK-OUT CONDITION (CHECK FLOW):		HIGH CAL NO (AS FOUND)	22.357 22.43
COOLANT:	Ice	LOW CAL NOx	
		LOW CAL NO (AS FOUND)	/

OPERATING CONDITIONS

SAMPLE PRESSURE:	5	SYSTEM RESPONSE TIME CHECK	
SAMPLE VACUUM:		UPSCALE:	______ sec.
NOx VACUUM:	29	DOWNSCALE:	______ sec.

CARNOT

PAGE 1 OF 1

REFERENCE METHOD GASEOUS MEASUREMENTS

CLIENT/LOCATION: PVERG

CONDITION:

DATE: 12-30-92

OPERATOR: CHF

TEST NUMBER: 2-CEM-PV

TEST LOCATION:

TEST NO.	TIME.		SAMPLE POINT/ CONDITION	DRY, UNCORRECTED							CORRECTED TO ___% ___, DRY		
				O_2	CO_2	CO	NOx	NO	NO_2	SO_2	CO	NOx	SO_2
SPAN GAS CONCENTRATION													
			AS FOUND ANAL. SPAN										
			SYSTEM ZERO	.02	.05	0.0	.05						
			SYSTEM SPAN	5.14	15.1	10.8	12.6						
	BEGIN *END*	1122 1132	Start	5.4	12.9	12	18.0						
	BEGIN *END*	1132 1142		5.35	12.9	12	18.2						
	BEGIN *END*	1142 1152		5.35	12.9	15	18.1						
	BEGIN *END*	— — —	Port Change										
	BEGIN *END*	1200 1210	New Port	5.3	12.8	14	18.3						
	BEGIN *END*	1210 1220		5.35	12.9	15	17.9						
	BEGIN *END*	1220 1230	End	5.4	12.9	20	17.6						
	BEGIN *END*	— — —											
	BEGIN *END*	— — —											
	BEGIN *END*	— — —											
	BEGIN *END*	— — —											
	BEGIN *END*	— — —											
			SYSTEM ZERO	.1	.1	0.0	.05						
			SYSTEM SPAN	5.13	15.13	10.0	12.4						
RAW AVERAGE				5.36	12.88	14.67	18.02						
CORRECTED AVERAGE				✓	✓	✓	✓						
COMMENTS:													

CARNOT

PAGE 1 OF 1

REFERENCE METHOD GASEOUS MEASUREMENTS

CLIENT/LOCATION: PVERG

CONDITION:

DATE: 12-30-92

OPERATOR: CHF

TEST NUMBER: 1-CEM-PV

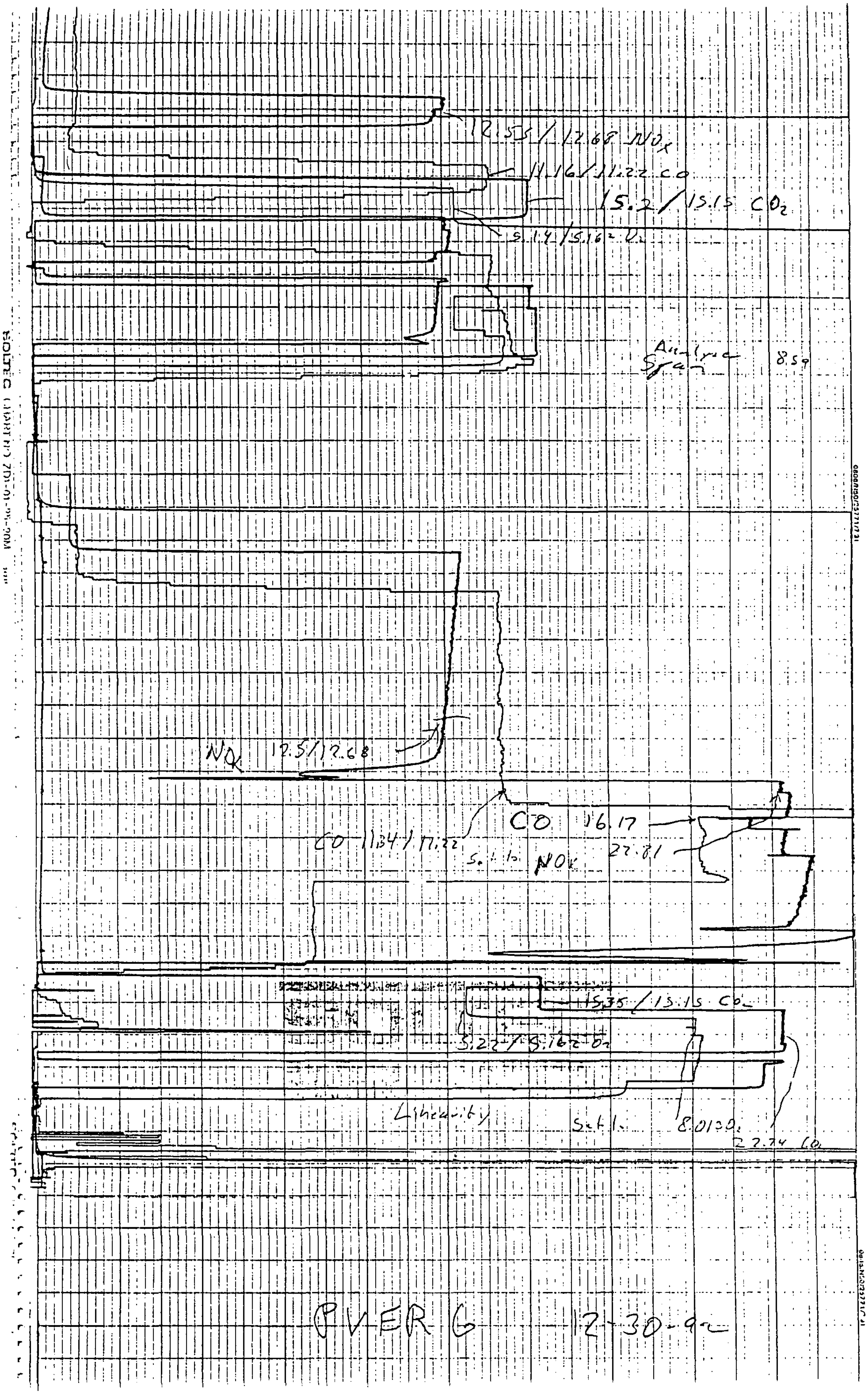
TEST LOCATION: Stack

TEST NO.	TIME.	SAMPLE POINT/ CONDITION	DRY, UNCORRECTED							CORRECTED TO ___% ___, DRY		
			O_2	CO_2	CO	NOx	NO	NO_2	SO_2	CO	NOx	SO_2
SPAN GAS CONCENTRATION				60.60	56.10	50.72						
		AS FOUND ANAL. SPAN	5.162	15.15	11.22	12.68						
		SYSTEM ZERO	.02	0.0	0.0	0.0						
		SYSTEM SPAN	5.14	15.2	11.16	12.55						
	BEGIN 935 END 945	Start	5.35	13.0	10.0	17.8						
	BEGIN 945 END 955		5.35	12.9	10	17.8						
	BEGIN 955 END 1005	Port Change	5.4	12.9	12	17.8						
	BEGIN 1015 END 1025	Next Port	5.3	13.0	12	18.3						
	BEGIN 25 END 35		5.35	12.9	14	18.6						
	BEGIN 35 END 1045		5.25	13.0	12	18.8						
	BEGIN END											
	BEGIN END											
	BEGIN END											
	BEGIN END											
	BEGIN END											
	BEGIN END											
		SYSTEM ZERO	.02	.08	0.0	0.0						
		SYSTEM SPAN	5.3	14.95	10.7	12.5						
RAW AVERAGE			5.33	12.95	11.67	18.18						
CORRECTED AVERAGE			✓	✓	✓	✓						
COMMENTS:												

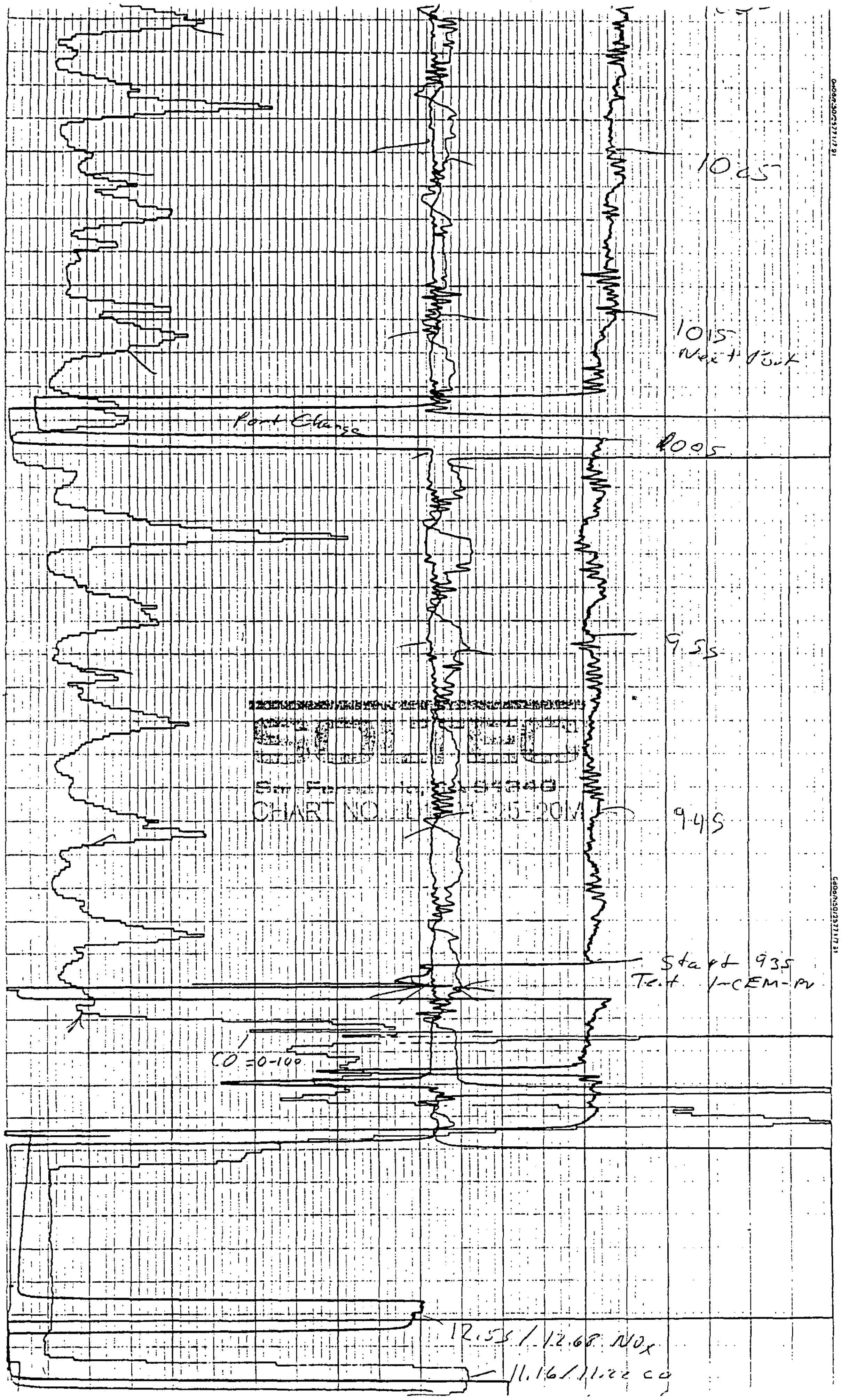
CARNOT

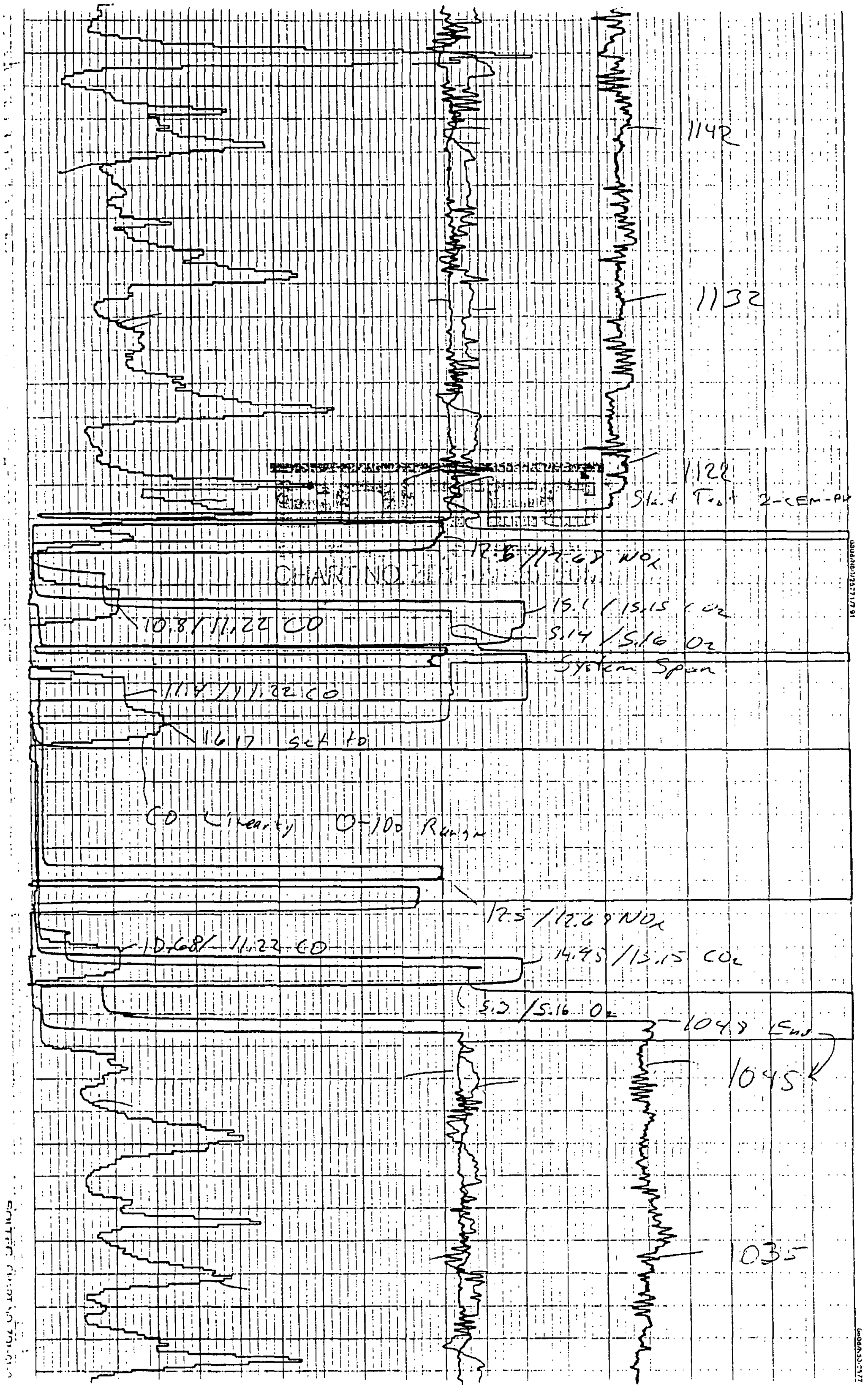
PMF-039

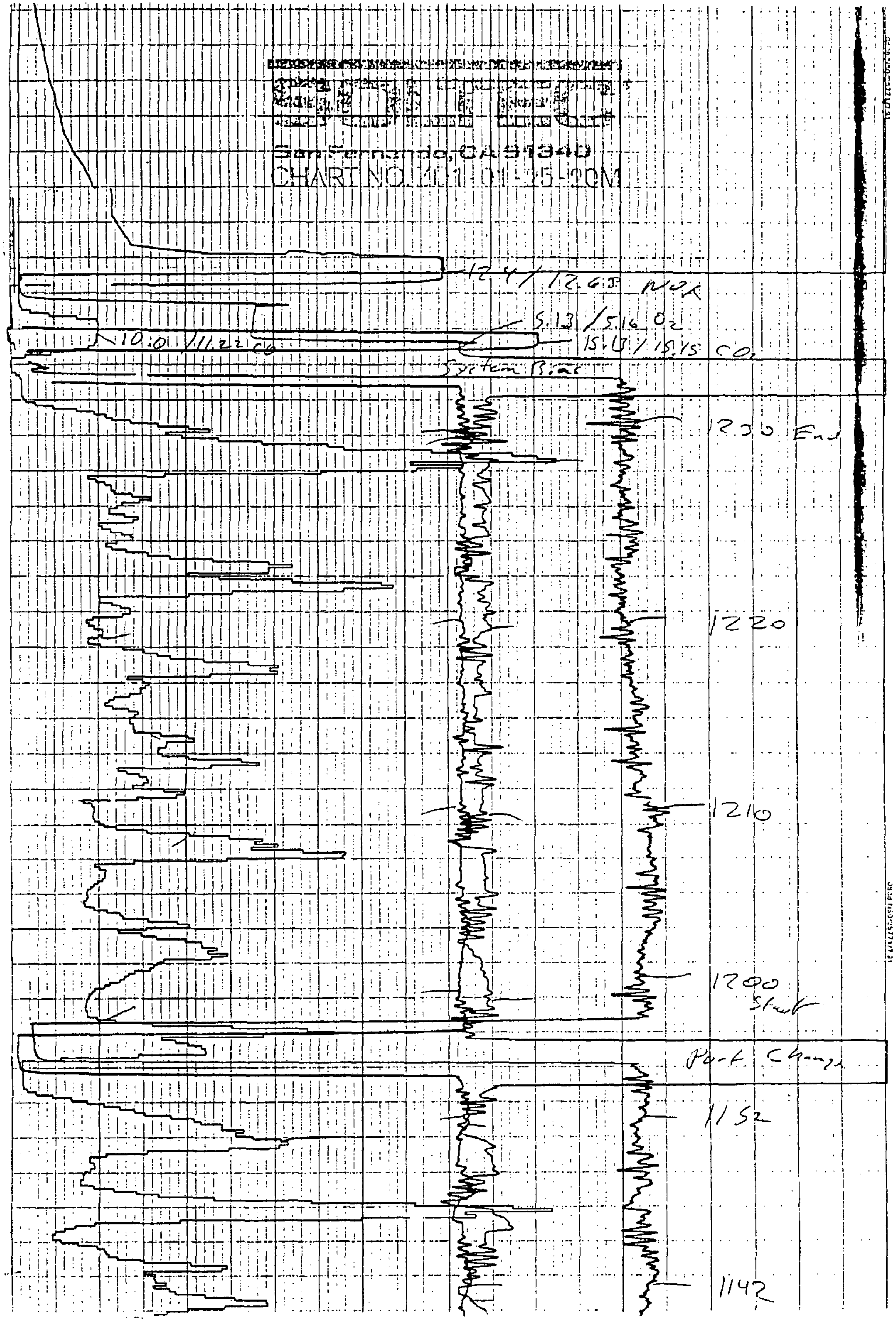
CO Range Switched from 0-20 to 0-100 Before Start of Test



PVER 6 12-30-92


1025
1015
Next Port
Port Change
1005
955
SOLTEC
San Fernando, CA 91340
CHART NO.
945
Start 935
Test 1-CEM-PV
CO = 0-100
12.55/12.68 NOx
11.16/11.22 CO


1142
1132
1122
Start Test 2-CEM-PV
12.6/12.68 NOx
CHART NO.
15.1/15.15 CO2
10.8/11.22 CO
5.14/5.16 O2
System Span
11.4/11.22 CO
16.17 sck to
CO Linearity 0-100 Range
12.5/12.68 NOx
10.68/11.22 CO
14.95/15.15 CO2
5.2/5.16 O2
1048 End
1045
1035


San Fernando, CA 91340
CHART NO. 111-01-25-20M
12.4 / 12.65 NOx
5.13 / 5.16 O_2
15.13 / 15.15 CO_2
10.0 / 11.22 CO
System Bias
1230 End
1220
1210
1200 Start
Port Change
1152
1142

Appendix C.3

Particulate and Calculated Exhaust Flow Rate Data

CARNOT

SOURCE TEST DATA SUMMARY

Client/Location	PVERG	Date	12/30/92
Test Number	1-PM-PV	Data By	CHF
Test Method	5.1	Sample Location	EXHAUST
Fuel	LFG	Reference Temp (F)	60
Sample Train	ES-42	Unit	1
Pitot Factor	0.840	Meter Cal Factor	0.9990
Stack Area (sq ft)	9.168	Sample Time (Min)	64
Bar Press (in Hg)	29.96	Nozzle Diam (in)	0.247
Meter Vol (acf)	32.939	Meter Temp (F)	71.4
Stack Press (iwg)	0.145	Stack Temp (F)	335.7
Vel Head (iwg)	0.46790	Stack O2 (%)	5.27
Liquid Vol (ml)	117.4	Stack CO2 (%)	13.01
Meter Press (iwg)	0.923	Start/Stop Time	0935/1047

Std Sample Vol (SCF)	32.314
Moisture Fraction	0.144
Stack Gas Mol Wt	28.52
Stack Gas Velocity (ft/sec)	47.32
Stack Flow Rate (wacfm)	26032
Stack Flow Rate (dscfm)	14576
Isokinetic Ratio (%)	95.41

Particulate Catch, mg	7.10
Particulate Catch,(organic fraction) mg	0.00
Grain Loading, gr/dscf	0.0034
Grain Loading, (organic fraction) gr/dscf	0.0000
Grain Loading, gr/dscf @ 12% CO2	0.0031
Part Emission lb/hr	0.4236

CARNOT

SOURCE TEST DATA SUMMARY

Client/Location	PVERG	Date	12/30/92
Test Number	2-PM-PV	Data By	CHF
Test Method	5.1	Sample Location	EXHAUST
Fuel	LFG	Reference Temp (F)	60
Sample Train	ES-42	Unit	1
Pitot Factor	0.840	Meter Cal Factor	0.9990
Stack Area (sq ft)	9.168	Sample Time (Min)	64
Bar Press (in Hg)	29.96	Nozzle Diam (in)	0.247
Meter Vol (acf)	33.677	Meter Temp (F)	79.8
Stack Press (iwg)	0.118	Stack Temp (F)	336.8
Vel Head (iwg)	0.47500	Stack O2 (%)	5.39
Liquid Vol (ml)	120.0	Stack CO2 (%)	12.83
Meter Press (iwg)	0.955	Start/Stop Time	1122/1232

Std Sample Vol (SCF)	32.526
Moisture Fraction	0.146
Stack Gas Mol Wt	28.47
Stack Gas Velocity (ft/sec)	47.75
Stack Flow Rate (wacfm)	26268
Stack Flow Rate (dscfm)	14654
Isokinetic Ratio (%)	95.52

Particulate Catch, mg	4.30
Particulate Catch,(organic fraction) mg	0.00
Grain Loading, gr/dscf	0.0020
Grain Loading, (organic fraction) gr/dscf	0.0000
Grain Loading, gr/dscf @ 12% CO2	0.0019
Part Emission lb/hr	0.2562

CARNOT

LACSD

SAMPLE TRAIN TEST DATA

CLIENT PV Boiler Unit 1
UNIT 1
TEST NO. 1-PM-PV
METHOD 5.1
PAGE 1 OF 1
SAMPLE LOCATION Stack #1
TEST CONDITION
AMB. TEMP., °F
PROJECT # 54700
OPERATOR/ASSISTANT DE / RM
METER VOL. (START/END) /
DATE 12/30/92

PRE-TEST DATA:	
Barometric Press., In. Hg.	29.96
Assumed Stack Press.	
Assumed Moisture	15.9
Assumed Molecular Wt.	
Assumed ΔP	
Assumed ΔH	
Stack Diameter, in.	
Sample Time: Total	64
per point	4
Total of Traverse Points	16

ΔH = 2.06 / 1.96 x ΔP

EQUIPMENT INFO:		
Meter No.		42
Meter, Yd.		.999
CFM @ ΔH = 1.0		.553
Pitot ID, Cp		.84
O_2/CO_2 Method		Y
Teflon Connecting Line (Y/N)		Y
Probe:	Mat'l	4'
	Length	glass
Nozzle:	Mat'l	"
	Diam.	.247
Filter:	No.	63-706
	Mat'l	Glass

Imp.	Mat'l	Wt.(End)	Wt.(Start)	Wt.(g)
#1	H_2O	684.5	577.0	107.5 ✓
#2	H_2O	637.5	634.6	2.9 ✓
#3	Ø	491.9	492.0	-0.1 ✓
#4	SG	775.0	767.9	7.1 ✓
#5				
Total				

POST TEST INFO:
Filter Appearance Clean
Impinger Appearance Very Clean
Silica Gel Spent (Y/N) N

SAMPLE TRAIN LEAK CHECK:

	CFM	Vac.	Pitot	Init.
Pre-Test	.004	15	✓	DE
Post-Test	.008	11	✓	DE

PRE-TEST CALIBRATION CHECK:

	Time	ΔH	Meter Reading	Meter Temp. In	Meter Temp. Out
Init.					
Final					

70

SAMPLE POINT	TIME	METER CONDITIONS ΔP	ΔH	METER READING	299 TEMPERATURES, °F STACK	PROBE	METER IN	METER OUT	OVEN	IMP. OUT	O_2	VAC.	STATIC PRESS. Iwg
SE 8	935	.47	.97	575.238	335		67	65		ICED		4	
7	39	.52	1.01	577.400	338		69	65		"		4	+.15
6	43	.55	1.08	579.570	337		71	65		"		4	
5	47	.57	1.12	581.799	336		71	65		"		4	
4	51	.52	1.01	583.900	334		72	65		"		4	
3	55	.43	.84	586.200	335		73	65		"		3.5	
2	59	.35	.69	588.010	335		73	66		"		3	
1	1003	.33	.65	589.990	335		73	66		"		3	
	07	—	—	591.603	—								
NE 8	1015	.51	.99	591.603	339		70	68		"		3.8	
7	19	.51	.99	593.811	339		76	70		"		3.8	
6	23	.52	1.01	595.868	338		78	70		"		4.0	
5	27	.55	1.08	598.030	338		79	71		"		4.2	
4	31	.51	.99	600.380	334		81	72		"		4.0	+.14
3	35	.47	.92	602.431	333		80	72		"		4	
2	39	.39	.76	604.711	333		80	72		"		4	
1	43	.34	.66	606.411	332		82	73		"		4	
—	47	—	—	608.177	—								

CHAIN OF CUSTODY INFORMATION	
Impingers Loaded	CHF
Impingers Recovered	CHF
Filter Loaded	CHF
Filter Recovered	CHF
Probe Wash	CHF
TEST SUMMARY	
Calculated by:	DE
Checked by:	DE CHF ✓
Sample Vol., c.f.	32.939 ✓
Stack Press., iwg	+.145 ✓
ΔH, iwg	~~.9168~~ .923 ✓
ΔP, iwg	.4679 ✓
Meter Temp., °F	71.4 ✓
Stack Temp., °F	335.7 ✓
Water Collected, g	117.4 ✓
O_2/CO_2	
Comments:	

CARNOT

SAMPLE TRAIN TEST DATA

CLIENT LACSD-PV UNIT #1 TEST NO. 2-PM-PV METHOD 5.1 PAGE 1 OF 1
SAMPLE LOCATION Boiler #1, Stack TEST CONDITION AMB. TEMP., °F PROJECT #
OPERATOR/ASSISTANT DE / RM METER VOL. (START/END) / DATE 12/30/92

PRE-TEST DATA:

Barometric Press., In. Hg.	29.96
Assumed Stack Press.	.1
Assumed Moisture	15.9
Assumed Molecular Wt.	
Assumed ΔP	
Assumed ΔH	
Stack Diameter, In.	41"
Sample Time: Total	64
per point	4
Total of Traverse Points	16

ΔH = 1.96 x ΔP
1.98 2.05

EQUIPMENT INFO:

Meter No.	42
Meter, Yd.	.999
CFM @ ΔH = 1.0	.553
Pitot ID, Cp	.84
O_2/CO_2 Method	Y
Teflon Connecting Line (Y/N)	Y
Probe: Mat'l	Glass
Length	4'
Nozzle: Mat'l	.247
Diam.	Glass
Filter: No.	63-707
Mat'l	

Imp.	Mat'l	Wt.(End)	- Wt.(Start)	= Wt.(g)
#1	H_2O	685.8	575.4	110.4 ✓
#2	H_2O	604.8	603.2	1.6 ✓
#3	0	491.9	491.7	0.2 ✓
#4	SG	769.2	761.4	7.8 ✓
#5				
Total				

POST TEST INFO:
Filter Appearance
Impinger Appearance
Silica Gel Spent (Y/N)

✓***SAMPLE TRAIN LEAK CHECK:***

	CFM	Vac.	Pitot	Init.
Pre-Test	.008	15	✓	DE
Post-Test	.008	15	✓	DE

PRE-TEST CALIBRATION CHECK:

	Time	ΔH	Meter Reading	Meter Temp. In	Meter Temp. Out
Init.					
Final					

SAMPLE POINT	TIME ✓	METER CONDITIONS .4943 ΔP	 .4687 ΔH	✓ METER READING	TEMPERATURES, °F 336.75 ✓ STACK	78.375 ✓ PROBE	METER IN	 OUT	 OVEN	 IMP. OUT	O_2	VAC.	STATIC PRESS. Iwg
NE 8	1122	.55	1.08	608.605	338		74	73		ICED		4	
7	26	.52	1.01	610.900	339		79	74		"		3.8	
6	30	.54	1.06	613.011	338		79	74		"		4	+.15
5	34	.59	1.16	615.400	338		82	75		53		4.1	
4	38	.55	1.08	617.531	337		83	76		"		4.0	
3	42	.48	.94	619.785	335		84	77		"		3.5	
2	46	.39	.76	621.935	335		84	77		"		3	
1	50	.36	.71	623.777	334		85	78		"		3	
—	54			625.564									
SE 8	1200	.50	.99	625.564	339		81	78		"		3.5	
7	04	.51	1.01	627.800	339		83	78		"		3.8	
6	08	.54	1.11	629.911	338		85	78		"		4	
5	12	.59	1.20	632.211	338		85	78		"		4.1	
4	16	.48	.98	634.535	334		85	78		"		3.8	
3	20	.41	.84	636.685	335		85	78		"		3.5	
2	24	.38	.78	638.700	336		85	78		"		3.2	+.09
1	28	.28	.57	640.511	335		85	79		"			
—	32			642.282									
		.4561 ✓	.9249 ✓		336.75 ✓		[illegible]75 ✓						

CHAIN OF CUSTODY INFORMATION	
Impingers Loaded	CHF
Impingers Recovered	
Filter Loaded	CHF
Filter Recovered	
Probe Wash	

TEST SUMMARY	
Calculated by:	DE
Checked by:	DE CHF ✓
Sample Vol., c.f.	33.677 ✓
Stack Press., iwg	+.1181 ✓
ΔH, iwg	~~.9467~~ .955 ✓
ΔP, iwg	.4750 ✓
Meter Temp., °F	79.78 ✓
Stack Temp., °F	336.75 ✓
Water Collected, g	120.0 ✓
O_2/CO_2	
Comments:	

PMF-05

PARTICULATE
SCAQMD 5.1, WET IMPINGEMENT

PROJECT # 54700
CLIENT/LOCATION PVERG
SAMPLE LOCATION STACK
TEST # 1-PM-PV

#5383
WATER BLANK mg/ml 0.0017 mg/mL
#5384
$MeCl_2$ BLANK mg/ml 0.0056 mg/mL

SAMPLE DATE 12/30/92
DATA ANALYSIS DATE 1/4/93
ANALYST INITIALS MR

ITEM	NUMBER	FINAL WEIGHT (g)	TARE WEIGHT (g)	GAIN WEIGHT (mg)	BLANK CORRECTION (mg)	ALIQUOT CORRECTION (ml/ml)	NET GAIN (mg/ SAMPLE)
1. GLASS FIBER FILTER (BACKUP FILTER)	63-706	0.1995	0.1992	0.3	–	–/–	0.3
2. INSOLUBLE SOLIDS FILTER	63-708	0.1971	0.1974	0.0	–	TV/TV 700/700	0.0
3. IMPINGERS a. WATER FRACTION	5385	28.5150	28.5110	4.0	0.6	700/350	6.8
b. ORGANIC EXTRACTION 125 ml $MeCl_2$	5386	28.3449	28.3442	0.7	0.7	700/350	0.0
				.		/	.
H_2O BLANK	5383	31.8716	31.8710	0.6	–	–/350	.
$MeCl_2$ EXTRACTION BLANK	5384	28.5008	28.5001	0.7	–	–/125	.

TOTAL PARTICULATE = 7.1 mg

METHOD OF SAMPLE PREP/NOTES

PML-048

CARNOT

PARTICULATE
SCAQMD 5.1, WET IMPINGEMENT

PROJECT # 54700

#5383 WATER BLANK mg/ml 0.0017 mg/mL

CLIENT/LOCATION PYERG

#5384 MeCl$_2$ BLANK mg/ml 0.0056 mg/mL

SAMPLE DATE 12/30/92

SAMPLE LOCATION STACK

DATA ANALYSIS DATE 1/4/93

TEST # 2-PM-PV

ANALYST INITIALS MR

ITEM	NUMBER	FINAL WEIGHT (g)	TARE WEIGHT (g)	GAIN WEIGHT (mg)	BLANK CORRECTION (mg)	ALIQUOT CORRECTION (ml/ml)	NET GAIN (mg/ SAMPLE)
1. GLASS FIBER FILTER (BACKUP FILTER)	63-707	0.1983	0.1978	0.5	–	–/–	0.5
2. INSOLUBLE SOLIDS FILTER	63-709	0.1971	0.1973	0.0	–	TV/TV 720/720	0.0
3. IMPINGERS a. WATER FRACTION	5387	31.1122	31.1097	2.5	0.6	720/360	3.8
b. ORGANIC EXTRACTION 125 ml MeCl$_2$	5388	28.6491	28.6484	0.7	0.7	720/360	0.
				.		/	.
				.		/	.
				.		/	.

TOTAL PARTICULATE = 4.3 mg

METHOD OF SAMPLE PREP/NOTES

PML-048

CARNOT

Appendix C.4

Inlet Moisture and Calculated Flow Rate Data

SOURCE TEST DATA SUMMARY

Client/Location..........	PVERG	Date.....................	12/30/92
Test Number.............	1-H2O-PV	Data By..................	CHF
Test Method..............	4.1	Sample Location..........	INLET
Fuel.....................	LFG	Reference Temp (F).......	60
Sample Train.............	ES-28	Unit.....................	1
Pitot Factor	N/A	Meter Cal Factor.........	1.0000
Stack Area (sq ft).......	N/A	Sample Time (Min)........	30
Bar Press (in Hg)........	29.96	Nozzle Diam (in).........	N/A

Meter Vol (acf)..........	23.808	Meter Temp (F)...........	77.67
Stack Press (iwg)........	N/A	Stack Temp (F)...........	N/A
Vel Head (iwg)...........	N/A	Duct O2 (%).............	11.20
Liquid Vol (ml)..........	19.60	Duct CO2 (%).............	15.80
		Duct CH4 (%).............	19.20
Meter Press (iwg)........	2.00	Start/Stop Time..........	0952/1022

Std Sample Vol (SCF)......................................	23.15
Moisture Fraction...	0.038
Stack Gas Mol Wt..	28.27
Stack Gas Velocity (ft/sec)...............................	0.00
Stack Flow Rate (scfm)....................................	3730
Stack Flow Rate (dscfm)...................................	3589

SOURCE TEST DATA SUMMARY

Client/Location..........	PVERG	Date....................	12/30/92
Test Number.............	2-H2O-PV	Data By..................	CHF
Test Method..............	4.1	Sample Location..........	INLET
Fuel.....................	LFG	Reference Temp (F).......	60
Sample Train.............	ES-28	Unit.....................	1
Pitot Factor	N/A	Meter Cal Factor.........	1.0000
Stack Area (sq ft).......	N/A	Sample Time (Min)........	35
Bar Press (in Hg)........	29.96	Nozzle Diam (in).........	N/A

Meter Vol (acf)..........	25.170	Meter Temp (F)...........	68.00
Stack Press (iwg)........	N/A	Stack Temp (F)...........	N/A
Vel Head (iwg)...........	N/A	Duct O2 (%)..............	11.20
Liquid Vol (ml)..........	23.60	Duct CO2 (%).............	16.10
		Duct CH4 (%).............	19.90
Meter Press (iwg)........	2.00	Start/Stop Time..........	1130/1205

Std Sample Vol (SCF)......................................	24.93
Moisture Fraction...	0.042
Stack Gas Mol Wt..	28.19
Stack Gas Velocity (ft/sec)...............................	0.00
Stack Flow Rate (scfm)....................................	3714
Stack Flow Rate (dscfm)...................................	3557

CARNOT

SAMPLE TRAIN TEST DATA

CLIENT PVERG
UNIT 1
TEST NO. 1-H2O-PV
METHOD 4.1
PAGE 1 OF 1
SAMPLE LOCATION Inlet
TEST CONDITION
AMB. TEMP., °F
PROJECT #
OPERATOR/ASSISTANT CHF
METER VOL. (START/END) /
DATE 12-30-97

PRE-TEST DATA:

Barometric Press., In. Hg. 29.96
Assumed Stack Press.
Assumed Moisture
Assumed Molecular Wt.
Assumed ΔP
Assumed ΔH
Stack Diameter, In.
Sample Time: Total
per point
Total of Traverse Points

ΔH = ______ x ΔP

EQUIPMENT INFO:

Meter No. ES-28
Meter, Yd. 1.00
CFM @ ΔH = 1.0
Pitot ID, Cp
O_2/CO_2 Method
Teflon Connecting Line (Y/N)
Probe: Mat'l
Length
Nozzle: Mat'l
Diam.
Filter: No.
Mat'l

Imp.	Mat'l	Wt.(End)	Wt.(Start)	Wt.(g)
#1	H_2O	625.8	614.6	11.2
#2	H_2O	614.8	613.5	1.3
#3	0	515.3	514.6	0.7
#4	SG	779.9	773.5	6.4
#5				
Total				

POST TEST INFO:

Filter Appearance
Impinger Appearance
Silica Gel Spent (Y/N)

SAMPLE TRAIN LEAK CHECK:

	CFM	Vac.	Pitot	Init.
Pre-Test	.001	10		CHF
Post-Test	.001	10		CHF

PRE-TEST CALIBRATION CHECK:

	Time	ΔH	Meter Reading	Meter Temp. In	Meter Temp. Out
Init.					
Final					

SAMPLE POINT	TIME	METER CONDITIONS ΔP	METER CONDITIONS ΔH	METER CONDITIONS METER READING	TEMPERATURES, °F STACK	TEMPERATURES, °F PROBE	TEMPERATURES, °F METER IN	TEMPERATURES, °F METER OUT	TEMPERATURES, °F OVEN	TEMPERATURES, °F IMP. OUT	O_2	VAC.	STATIC PRESS. Iwg
	952		2.0	145.307			79	72		48	–	0	
	1002		2.0	153.75			84	74		52		0	
	1012		2.0	160.25			83	74		52		0	
	1022		2.0	169.115									

CHAIN OF CUSTODY INFORMATION

Impingers Loaded
Impingers Recovered
Filter Loaded
Filter Recovered
Probe Wash

TEST SUMMARY

Calculated by: CHF
Checked by: CHF ✓
Sample Vol., c.f. 23.808 ✓
Stack Press., iwg
ΔH, iwg 2.0 ✓
ΔP, iwg
Meter Temp., °F 77.67 ✓
Stack Temp., °F
Water Collected, g 19.6 ✓
O_2/CO_2
Comments:

PMF-057

CARNOT

SAMPLE TRAIN TEST DATA

CLIENT PVERG
UNIT 1
TEST NO. 2-H2O-In
METHOD 4.1
PAGE 1 OF 1
SAMPLE LOCATION Inlet
TEST CONDITION
AMB. TEMP., °F
PROJECT #
OPERATOR/ASSISTANT CHF
METER VOL. (START/END) /
DATE 12-30-92

PRE-TEST DATA:

Barometric Press., In. Hg.	24.46
Assumed Stack Press.	
Assumed Moisture	
Assumed Molecular Wt.	
Assumed ΔP	
Assumed ΔH	
Stack Diameter, In.	
Sample Time: Total	
per point	
Total of Traverse Points	

ΔH = ________ x ΔP

EQUIPMENT INFO:

Meter No.		ES-28
Meter, Yd.		1.000
CFM @ ΔH = 1.0		
Pitot ID, Cp		
O_2/CO_2 Method		
Teflon Connecting Line (Y/N)		
Probe:	Mat'l	
	Length	
Nozzle:	Mat'l	
	Diam.	
Filter:	No.	
	Mat'l	

Imp.	Mat'l	Wt.(End)	-	Wt.(Start)	=	Wt.(g)
#1	H_2O	640.8	-	625.8	=	15.0
#2	H_2O	616.6	-	614.8	=	1.8
#3	0	515.8	-	515.3	=	0.5
#4	SG	786.2	-	779.9	=	6.3
#5			-		=	
Total						

POST TEST INFO:

Filter Appearance
Impinger Appearance
Silica Gel Spent (Y/N)

SAMPLE TRAIN LEAK CHECK:

	CFM	Vac.	Pitot	Init.
Pre-Test	.001	10		CHF
Post-Test	.001	10		CHF

PRE-TEST CALIBRATION CHECK:

	Time	ΔH	Meter Reading	Meter Temp. In	Meter Temp. Out
Init.					
Final					

SAMPLE POINT	TIME	METER CONDITIONS ΔP	METER CONDITIONS ΔH	METER CONDITIONS METER READING	TEMPERATURES, °F STACK	TEMPERATURES, °F PROBE	TEMPERATURES, °F METER IN	TEMPERATURES, °F METER OUT	TEMPERATURES, °F OVEN	TEMPERATURES, °F IMP. OUT	O_2	VAC.	STATIC PRESS. Iwg
	1130		2.0	169.435			60	58		52		0	
	1140		2.0	177.710			73	60		54		0	
	1150		2.0	184.52			79	65		56		0	
	1205		2.0	194.605			80	69		56		0	

CHAIN OF CUSTODY INFORMATION

Impingers Loaded
Impingers Recovered
Filter Loaded
Filter Recovered
Probe Wash

TEST SUMMARY

Calculated by:	CHF
Checked by:	CHF ✓
Sample Vol., c.f.	25.170 ✓
Stack Press., iwg	
ΔH, iwg	2.0
ΔP, iwg	
Meter Temp., °F	68.0 ✓
Stack Temp., °F	
Water Collected, g	23.6 ✓
O_2/CO_2	
Comments:	

Appendix C.5

Total Hydrocarbon Lab Results

AtmAA Inc.
21354 Nordhoff St., Suite 113, Chatsworth, CA 91311 (818) 718-6070 • FAX (818) 718-9779
environmental consultants
laboratory services

January 6, 1993

LTR/005/93

JAN 11 1993
CARNOT

Craig Fry
CARNOT
15991 Red Hill Ave. Suite 110
Tustin, CA 92680

re: 54700

Dear Craig:

Please find enclosed the laboratory analysis report, quality assurance summary, and the original chain of custody form for four Tedlar bag samples received on December 31, 1992.

The samples were analyzed for methane and total gaseous non-methane organics.

Sincerely,

AtmAA, Inc.

Michael Porter

Michael L. Porter
Laboratory Director

Encl.
MLP/krp

AtmAA Inc.
21354 Nordhoff St., Suite 113, Chatsworth, CA 91311 (818) 718-6070 • FAX (818) 718-9779
environmental consultants
laboratory services

LABORATORY ANALYSIS REPORT

Methane & Total Gaseous Non-Methane Organics Analysis in Tedlar Bag Samples

Report Date:	January 6, 1993
Client:	CARNOT
P.O. No.:	9307
Project No.:	54700
Date Received:	December 31, 1992
Date Analyzed:	December 31, 1992

ANALYSIS DESCRIPTION

Methane and total gaseous non-methane organics were measured by flame ionization detection/total combustion analysis portion (FID/TCA).

AtmAA Lab No.:	93662-2	93662-3	93662-4	93662-5
Sample I.D.:	1-HC-In	1-HC-Out	2-HC-In	2-HC-Out
Components:	(Concentration in ppm, v/v)			
Methane	192000	<1	199000	<1
TGNMO	7040	15.8	7360	16.3

TGNMO is total gaseous non-methane organics measured and reported as ppm methane.

Michael L. Porter
Laboratory Director

QUALITY ASSURANCE SUMMARY

(Repeat Analysis)

Project No.: 54700
Date Received: December 31, 1992

	Sample ID	Repeat Analysis		Mean	% Diff.
Component:		Run #1	Run #2	Conc.	From Mean
		(Concentration in ppm, v/v)			
Methane	1-HC-In	192000	193000	192000	0.26
	1-HC-Out	< 1	< 1	---	---
	2-HC-Out	< 1	< 1	---	---
TGNMO	1-HC-In	7150	6930	7040	1.6
	1-HC-Out	15.6	16.1	15.8	1.6

A set of 4 Tedlar bag samples laboratory numbers, 93662-(2-5) was analyzed for methane and TGNMO. Agreement between repeat analyses is a measure of precision and is shown above in the column "% Difference from Mean." Repeat analyses are an important part of AtmAA's quality assurance program. The average % Difference from Mean for 3 repeat measurements from the sample set of 4 Tedlar bag samples is 1.6%.

CARNOT
TEDLAR BAG SAMPLE DATA

CLIENT/PROJECT: PVERG

DATE: 12-30-97 UNIT: 7 BY: RM

	BAG ID 797	BAG ID 796	BAG ID
TEST NO.	1-THC-Out	2-THC-Out	1-HC-Out
SAMPLE RATE			
START TIME	1005	1122	0940
STOP TIME	1025	1142	1000
SAMPLE LOCATION	Stack	Stack	Stack

DATE: UNIT: BY:

	BAG ID	BAG ID	BAG ID
TEST NO.	2-HC-Out		
SAMPLE RATE			
START TIME	1145		
STOP TIME	1205		
SAMPLE LOCATION	Stack		

NOTES:

CARNOT
TEDLAR BAG SAMPLE DATA

CLIENT/PROJECT: PVERG

DATE: 12-30-92 UNIT: PVERG #1 BY: CHR

	BAG ID	BAG ID	BAG ID
TEST NO.	1-HC-In	2-HC-In	
SAMPLE RATE	.5lpm	.5lpm	
START TIME	950	1145	
STOP TIME	1010	1205	
SAMPLE LOCATION	Inlet	Inlet	

DATE: UNIT: BY:

	BAG ID	BAG ID	BAG ID
TEST NO.			
SAMPLE RATE			
START TIME			
STOP TIME			
SAMPLE LOCATION			

NOTES:

Appendix C.6

Trace Hydrocarbon and Trace Sulfur Results

TRACE ORGANIC SPECIES DESTRUCTION EFFICIENCY RESULTS
PVERG UNIT 1, TEST No. 1
DECEMBER 30, 1992

Flow rate, Inlet dscfm	3589
Flow rate, Exhaust dscfm	14576

Species	Inlet	Exhaust	Destruction Efficiency,%
Methylene Chloride:	200 ppb	ND< 0.2 ppb	
lb/hr	9.64E-03	< 3.91E-05	99.59
Chloroform:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.35E-02	< 5.50E-05	99.59
1,1,1 Trichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.51E-02	< 6.15E-05	99.59
Carbon Tetrachloride:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.75E-02	< 7.09E-05	99.59
1,1-Dichloroethene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.10E-02	< 4.47E-05	99.59
Trichloroethylene:	500 ppb	ND< 0.2 ppb	
lb/hr	3.73E-02	< 6.06E-05	99.84
Tetrachloroethylene:	400 ppb	ND< 0.2 ppb	
lb/hr	3.76E-02	< 7.64E-05	99.80
Chlorobenzene:	4700 ppb	ND< 0.4 ppb	
lb/hr	3.00E-01	< 1.04E-04	99.97
Vinyl Chloride:	1400 ppb	ND< 0.4 ppb	
lb/hr	4.97E-02	< 5.76E-05	99.88
m-Dichlorobenzene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.67E-02	< 6.78E-05	99.59
o+p Dichlorobenezene:	1300 ppb	ND< 0.2 ppb	
lb/hr	1.08E-01	< 6.78E-05	99.94
1,1-Dichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.12E-02	< 4.56E-05	99.59
1,2-Dichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.12E-02	< 4.56E-05	99.59
Benzene:	11000 ppb	0.2 ppb	
lb/hr	4.88E-01	3.60E-05	99.99
Toluene:	24000 ppb	ND< 1 ppb	
lb/hr	1.25E+00	< 2.12E-04	99.98
Acetonitrile:	ND< 2000 ppb	ND< 2 ppb	
lb/hr	< 4.66E-02	< 1.89E-04	99.59
m-Xylenes:	25000 ppb	ND< 0.2 ppb	
lb/hr	1.51E+00	< 4.89E-05	100.00
o+p Xylenes:	21000 ppb	ND< 0.2 ppb	
lb/hr	1.27E+00	< 4.89E-05	100.00
1,2-Dibromoethane:	ND< 7000 ppb	ND< 7 ppb	
lb/hr	< 7.46E-01	< 3.03E-03	99.59
Benzyl Chloride:	ND< 5000 ppb	ND< 5 ppb	
lb/hr	< 3.59E-01	< 1.46E-03	99.59

ND< - indicates that the species was not detected. Values indicate the detection limit for this species and the concentration is less than the presented value.

NA - indicates that the destruction efficiency cannot be calculated because the concentration is below the detection limits.

TRACE ORGANIC SPECIES DESTRUCTION EFFICIENCY RESULTS
PVERG UNIT 1, TEST No. 2
DECEMBER 30, 1992

Species	Inlet	Exhaust	Destruction Efficiency,%
Flow rate, Inlet dscfm	3557		
Flow rate, Exhaust dscfm	14654		
Methylene Chloride:	ND< 200 ppb	0.4 ppb	
lb/hr	< 9.55E-03	7.87E-05	99.18
Chloroform:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.34E-02	< 5.53E-05	99.59
1,1,1 Trichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.50E-02	< 6.18E-05	99.59
Carbon Tetrachloride:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.73E-02	< 7.13E-05	99.59
1,1-Dichloroethene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.09E-02	< 4.49E-05	99.59
Trichloroethylene:	400 ppb	ND< 0.2 ppb	
lb/hr	2.96E-02	< 6.09E-05	99.79
Tetrachloroethylene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.87E-02	< 7.68E-05	99.59
Chlorobenzene:	2400 ppb	ND< 0.4 ppb	
lb/hr	1.52E-01	< 1.04E-04	99.93
Vinyl Chloride:	1400 ppb	ND< 0.4 ppb	
lb/hr	4.92E-02	< 5.79E-05	99.88
m-Dichlorobenzene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.65E-02	< 6.81E-05	99.59
o+p Dichlorobenezene:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.65E-02	< 6.81E-05	99.59
1,1-Dichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.11E-02	< 4.59E-05	99.59
1,2-Dichloroethane:	ND< 200 ppb	ND< 0.2 ppb	
lb/hr	< 1.11E-02	< 4.59E-05	99.59
Benzene:	11000 ppb	0.1 ppb	
lb/hr	4.83E-01	1.81E-05	100.00
Toluene:	22000 ppb	ND< 1 ppb	
lb/hr	1.14E+00	< 2.13E-04	99.98
Acetonitrile:	ND< 2000 ppb	ND< 2 ppb	
lb/hr	< 4.62E-02	< 1.90E-04	99.59
m-Xylenes:	22000 ppb	ND< 0.2 ppb	
lb/hr	1.31E+00	< 4.92E-05	100.00
o+p Xylenes:	19000 ppb	ND< 0.2 ppb	
lb/hr	1.13E+00	< 4.92E-05	100.00
1,2-Dibromoethane:	ND< 7000 ppb	ND< 7 ppb	
lb/hr	< 7.40E-01	< 3.05E-03	99.59
Benzyl Chloride:	ND< 5000 ppb	ND< 5 ppb	
lb/hr	< 3.56E-01	< 1.47E-03	99.59

ND< - indicates that the species was not detected. Values indicate the detection limit for this species and the concentration is less than the presented value.

NA - indicates that the destruction efficiency cannot be calculated because the concentration is below the detection limits.

PALOS VERDES LANDFILL
PVERG BOILER
Test Date: 12/30/92

JWPCP LAB SAMPLE NO.	RAW GAS TEST #1 JW95191	RAW GAS TEST #2 JW95192	FLARE EXHAUST TEST #1 JW95193	FLARE EXHAUST TEST #2 JW95194	AMBIENT AIR AT FLARE STATION N/A
COMPOUND					
1. HYDROGEN SULFIDE, ppm	21	22			
2. METHYL MERCAPTAN, ppm	0.5	0.5			
3. ETHYL MERCAPTAN, ppm	< 0.5	< 0.5			
4. CARBONYL SULFIDE, ppm	< 0.4	< 0.4			
5. CARBON DISULFIDE, ppm	< 0.6	< 0.6			
6. DIMETHYL SULFIDE, ppm	< 0.6	0.6			
7. DIMETHYL DISULFIDE, ppm	< 0.5	< 0.5			
8. PERMANENT GASES, TOT %	99.6	99.9	97.8	99	
9. OXYGEN (O2) %	11.2	11.2	5.99	5.81	
10. ARGON (AR) %	0.62	0.62	0.8	0.81	
11. NITROGEN (N2) %	54.6	54.4	79	79.9	
12. METHANE (CH4) %	17.3	17.5	< 0.02	< 0.02	
13. CARBON DIOXIDE (CO2) %	15.8	16.1	12	12.5	
14. METHYLENE CHLORIDE, ppb	200	< 200	< 0.2	0.4	
15. CHLOROFORM, ppb	< 200	< 200	< 0.2	< 0.2	
16. 1,1,1-TRICHLOROETHANE, ppb	< 200	< 200	< 0.2	< 0.2	
17. CARBON TETRACHLORIDE, ppb	< 200	< 200	< 0.2	< 0.2	
18. 1,1-DICHLOROETHENE, ppb	< 200	< 200	< 0.2	< 0.2	
19. TRICHLOROETHYLENE, ppb	500	400	< 0.2	< 0.2	
20. TETRACHLOROETHYLENE, ppb	400	< 200	< 0.2	< 0.2	
21. CHLOROBENZENE, ppb	4700	2400	< 0.4	< 0.4	
22. VINYL CHLORIDE, ppb	1400	1400	< 0.4	< 0.4	
23. M-DICHLOROBENZENE, ppb	< 200	< 200	< 0.2	< 0.2	
24. 1,1,-DICHLOROETHANE, ppb	< 200	< 200	< 0.2	< 0.2	
25. 1,2-DICHLOROEHTANE, ppb	< 200	< 200	< 0.2	< 0.2	
26. BENZENE, ppb	11000	11000	0.2	0.1	
27. TOLUENE, ppb	24000	22000	< 1	< 1	
28. ACETONITRILE, ppb	< 2000	< 2000	< 2	< 2	
29. M-XYLENE, ppb	25000	22000	< 0.2	< 0.2	
30. O+P XYLENE, ppb	21000	19000	< 0.2	< 0.2	
31. 1,2-DIBROMOETHANE, ppb	< 7000	< 7000	< 7	< 7	
32. O+P DICHLOROBENZENE, ppb	1300	< 200	< 0.2	< 0.2	
33. BENZYL CHLORIDE, ppb	< 5000	< 5000	< 5	< 5	

f/n: pv9212

Appendix C.7

Unit Operation Data

```
30DEC92 WEDNESDAY          PVERG B-501 PERFORMANCE DATA              TREND LOG

                JI-626      GEN   JI-209    PLANT   FI-397    BLR 1   FR-303
                     MEGAWATTS     PARASITIC LOAD     NAT GAS FLOW       SUPPLY

                JI-210   SCF      FI-335    BLR 1   AR-304      LFG
                MEGAWATTS                 LFG FLOW        SUPPLY BTU

                JI-626   JI-210   JI-209   FI-335   FI-397   AR-304   FR-303

                MW       MW       KW       KSCFM    SCFM     BTU/CF   KSCFM
30DEC92 00:01   9.0625   8.1563   908.00   3.6875   209.50   187.00   4.2344
        00:16   9.0938   8.1875   910.00   3.6875   209.50   187.00   4.2344
        00:31   9.0938   8.1875   908.00   3.6875   209.50   187.50   4.2344
        00:46   9.0625   8.1563   910.00   3.6875   209.00   186.50   4.2344
        01:01   9.0938   8.1875   910.00   3.6875   208.50   187.00   4.2344
        01:16   9.0625   8.1563   908.00   3.6875   209.00   187.00   4.2344

        01:31   9.0625   8.1563   912.00   3.6875   208.00   186.00   4.2344
        01:46   9.0000   8.0938   906.00   3.6875   207.00   185.50   4.2344
        02:01   9.0313   8.0938   908.00   3.6875   207.50   185.00   4.2344
        02:16   9.0000   8.0938   902.00   3.6797   207.00   185.50   4.2188
        02:31   9.0000   8.0938   904.00   3.6954   207.50   185.00   4.2344
        02:46   9.0000   8.0938   906.00   3.6954   207.50   184.50   4.2344

        03:01   8.9375   8.0313   904.00   3.6875   208.00   183.00   4.2344
        03:16   8.7813   7.9063   908.00   3.6875   207.50   180.50   4.2344
        03:31   8.5938   7.7188   890.00   3.6016   208.00   178.50   4.1563
        03:46   8.5938   7.7188   892.00   3.6094   207.50   178.00   4.1719
        04:01   8.5938   7.7188   896.00   3.6329   207.00   178.00   4.1875
        04:16   8.5625   7.7032   892.00   3.6250   207.00   177.50   4.1719

        04:31   8.5938   7.7032   896.00   3.6329   207.00   177.50   4.1875
        04:46   8.5313   7.6407   890.00   3.6172   207.00   176.50   4.1719
        05:01   8.5313   7.6407   892.00   3.6329   207.00   176.00   4.1719
        05:16   8.5000   7.5938   892.00   3.6094   206.50   174.50   4.1719
        05:31   8.4688   7.5938   894.00   3.6329   205.50   175.00   4.1719
        05:46   8.5313   7.6250   891.00   3.6329   205.00   176.50   4.1719

        06:01   8.7188   7.8438   878.00   3.6329   204.50   180.50   4.1563
        06:16   8.8125   7.9844   864.00   3.6485   204.00   183.50   4.1719
        06:31   8.9063   8.0313   872.00   3.6407   203.50   184.50   4.1875
        06:46   8.9688   8.0625   878.00   3.6407   203.50   184.50   4.2188
        07:01   9.0000   8.1250   892.00   3.6954   203.50   184.00   4.2657
        07:16   9.0000   8.0938   884.00   3.6954   203.50   184.50   4.2657

        07:31   8.9688   8.0625   890.00   3.6954   203.50   184.00   4.2500
        07:46   8.9688   8.0625   890.00   3.7032   204.00   184.00   4.2657
        08:01   8.9688   8.0625   886.00   3.6954   204.50   185.50   4.2657
        08:16   8.9688   8.0625   886.00   3.6797   205.00   213.00   4.2500
        08:31   9.0313   8.0938   908.00   3.6797   205.00   271.00   4.2500
        08:46   9.0938   8.1563   910.00   3.7032   205.00   186.00   4.2813

        09:01   9.1250   8.2188   914.00   3.7266   208.50   187.00   4.2969
        09:16   9.1250   8.2188   922.00   3.7344   212.50   187.50   4.3125
        09:31   9.1250   8.2188   922.00   3.7266   212.50   187.00   4.3125
        09:46   9.0938   8.1875   918.00   3.7266   213.00   187.50   4.3125
        10:01   9.1250   8.1875   956.00   3.7266   213.00   189.00   4.3125
        10:16   9.1250   8.1875   962.00   3.7266   213.50   189.50   4.3125
 Test 1
        10:31   9.1563   8.1875   960.00   3.7266   214.50   191.00   4.3282
        10:46   9.1563   8.1875   960.00   3.7422   210.50   192.00   4.3125
        11:01   9.1563   8.1875   962.00   3.7500   208.00   193.00   4.3282
        11:16   9.1563   8.2188   962.00   3.7500   208.50   194.00   4.3282
        11:31   9.2500   8.2813   958.00   3.7500   208.50   195.50   4.3282
        11:46   9.2500   8.3438   926.00   3.7500   209.00   196.50   4.3438
 Test 2
        12:01   9.2188   8.3125   914.00   3.6719   209.00   197.50   4.2969
        12:16   9.2500   8.3438   916.00   3.6875   208.50   199.00   4.2969
        12:31   9.2813   8.3750   912.00   3.7110   203.00   199.50   4.2969
        12:46   9.3125   8.4063   912.00   3.7266   200.00   201.00   4.2969
        13:01   9.3438   8.4375   908.00   3.7266   200.00   201.00   4.2969
```

```
30DEC92 WEDNESDAY           PVERG B-501 DAILY EMISSIONS               TREND LOG :

                     BTU-501  B-501     NOX1-PPH B-501     AI-421     BLR 1    NOXC-1   B-
                     MBTU INPUT         TOTAL NOX-PPH           EXCESS O2      CORR NOX FO

                     FI-523    BLR 1    AI-425    BLR 1    AI-426     BLR 1
                         STEAM FLOW         STACK NOX         STACK OXYGEN

                     BTU-501  FI-523    NOX1-PPH AI-425    AI-421     AI-426    NOXC-1

                     MMBTU    KLB/HR    PPH      PPM       %          %         PPM
30DEC92 00:02        54.750   44.500    1.5743   22.063    1.7188     5.1407    25.125
        00:17        54.750   44.625    1.5743   22.063    1.7266     5.2188    25.188
        00:32        54.750   44.500    1.5625   21.875    1.7305     5.2344    25.000
        00:47        54.500   44.375    1.5704   22.125    1.7266     5.1407    25.125
        01:02        54.625   44.500    1.5586   21.813    1.7227     5.2344    24.938
        01:17        54.625   44.500    1.5743   22.125    1.7305     5.2188    25.250

        01:32        54.375   44.375    1.5625   21.938    1.7266     5.1563    25.000
        01:47        54.125   44.125    1.5430   21.875    1.7461     5.2500    25.000
        02:02        54.125   44.125    1.5547   21.938    1.7266     5.1719    25.063
        02:17        54.125   44.000    1.5586   22.063    1.7500     5.1563    25.125
        02:32        54.125   44.125    1.5625   22.125    1.7188     5.0938    25.063
        02:47        54.125   44.000    1.5586   22.063    1.7461     5.1563    25.063

        03:02        53.750   43.750    1.5274   21.813    1.7539     5.2657    25.000
        03:17        53.000   43.125    1.5235   22.063    1.7618     5.1250    25.063
        03:32        51.875   41.875    1.4688   21.875    1.7696     5.1719    24.938
        03:47        51.750   41.875    1.4766   22.000    1.7657     5.1719    25.063
        04:02        51.875   41.875    1.4649   21.688    1.7618     5.2657    24.938
        04:17        51.750   41.750    1.4766   21.938    1.7774     5.1563    25.000

        04:32        51.750   41.750    1.4649   21.813    1.7696     5.1094    24.688
        04:47        51.375   41.250    1.4571   21.813    1.7657     5.1563    24.813
        05:02        51.250   41.375    1.4610   21.813    1.7813     5.1250    24.813
        05:17        50.750   41.000    1.4180   21.375    1.7696     5.4844    24.875
        05:32        51.000   41.125    1.4414   21.625    1.7735     5.2813    24.875
        05:47        51.375   41.250    1.4727   22.000    1.7813     5.1250    25.000

        06:02        52.500   42.375    1.4961   21.938    1.7383     5.1407    24.938
        06:17        53.000   43.125    1.5196   22.000    1.7383     5.2500    25.125
        06:32        53.125   43.250    1.5235   21.938    1.7539     5.2188    25.125
        06:47        53.125   43.375    1.5430   22.250    1.7383     5.1407    25.313
        07:02        53.875   44.000    1.5743   22.313    1.7422     5.0625    25.250
        07:17        53.875   44.000    1.5743   22.375    1.7461     5.2500    25.563

        07:32        53.750   43.875    1.5586   22.188    1.7422     5.2813    25.438
        07:47        53.875   43.875    1.5821   22.438    1.7266     5.1250    25.500
        08:02        51.250   43.750    1.3633   19.375    1.7305     7.2188    22.438
        08:17        66.750   43.625    2.2579   32.125    1.7266     9.8438    27.938
        08:32        68.750   43.750    2.7032   38.375    1.7579     7.1094    33.625
        08:47        54.375   44.000    4.2032   59.250    1.7461     0.5313    51.000

        09:02        55.000   44.500    2.0235   28.438    1.7110     4.2344    29.438
        09:17        55.375   44.500    1.5664   21.813    1.7188     5.2032    24.875
        09:32        55.250   44.375    1.5391   21.438    1.7539     5.2032    24.500
        09:47        55.375   44.250    1.5508   21.625    1.7110     5.0938    24.563
        10:02        55.875   44.375    1.5313   21.250    1.7500     5.2032    24.250
        10:17        56.000   44.375    1.5274   21.250    1.7071     5.0782    24.063

        10:32        56.250   44.500    1.5235   21.125    1.7383     5.1250    24.000
        10:47        56.500   44.500    1.5118   20.875    1.7305     5.2344    23.875
        11:02        56.625   44.625    1.4922   20.500    1.7110     5.2188    23.438
        11:17        56.750   44.875    1.5000   20.563    1.7149     5.1563    23.438
        11:32        57.250   45.125    1.4883   20.250    1.7188     5.2188    23.125
        11:47        57.375   45.125    1.5079   20.500    1.7383     5.2032    23.375

        12:02        56.750   44.375    1.4805   20.500    1.7149     5.1719    23.375
        12:17        57.125   44.875    1.5000   20.625    1.7071     5.1563    23.500
        12:32        57.250   45.000    1.4922   20.313    1.7110     5.1719    23.188
        12:47        57.625   45.125    1.5274   20.813    1.7188     5.2344    23.813
        13:02        57.750   45.375    1.5274   20.688    1.7227     5.2032    23.625
```

APPENDIX D
CALCULATIONS

Appendix D.1

General Emissions Calculations

EMISSION CALCULATIONS

1. Sample Volume and Isokinetics

a. Sample gas volume, dscf

$$V_{m\ std} = 0.03342\ V_m \left(P_{bar} + \frac{H}{13.6}\right)\left(\frac{T_{ref}}{T_m}\right)(Y)$$

b. Water vapor volume, scf

$$V_{w\ std} = 0.0472\ V_{lc} \left(\frac{T_{ref}}{528\ ^\circ R}\right)$$

c. Moisture content, nondimensional

$$B_{wo} = \frac{V_{w\ std}}{V_{m\ std} + V_{w\ std}}$$

d. Stack gas molecular weight, lb/lb mole

$$MW_{dry} = 0.44\ (\%CO_2) + 0.32\ (\%O_2) + 0.28\ (\%N_2)$$

$$MW_{wet} = MW_{dry}\ (1 - B_{wo}) + 18\ (B_{wo})$$

e. Absolute stack pressure, iwg

$$P_s = P_{bar} + \frac{P_{sg}}{13.6}$$

f. Stack velocity, ft/sec

$$V_s = 2.90\ C_p\ \sqrt{\Delta P T_s}\ \sqrt{\left(\frac{29.92}{P_s}\right)\left(\frac{28.95}{MW_{wet}}\right)}$$

g. Actual stack flow rate, wacfm

$$Q = (V_s)(A_s)(60)$$

h. Standard stack gas flow rate, dscfm

$$Q_{sd} = Q\ (1 - B_{wo})\left(\frac{T_{ref}}{T_s}\right)\left(\frac{P_s}{29.92}\right)$$

i. Percent isokinetic

$$I = \left(\frac{17.32(T_s)(V_{m\ std})}{(1 - B_{wo})(\Theta)(V_s)(P_s)(D_n^2)}\right)\left(\frac{528\ ^\circ R}{T_{ref}}\right)$$

2. Particulate Emissions

   a. Grain loading, gr/dscf

$$C = 0.01543\left(\frac{M_n}{V_{m\,std}}\right)$$

   b. Grain loading at 12% CO_2, gr/dscf

$$C_{12\%\,CO_2} = C\left(\frac{12}{\%CO_2}\right)$$

   c. Mass emissions, lb/hr

$$M = C(Q_{sd})\,\frac{(60\ min/hr)}{(7000\ gr/lb)}$$

3. Gaseous Emissions, lb/hr

$$M = (ppm)(10^{-6})\left(\frac{MW_i\ lb/lb\ mole}{SV}\right)(Q_{sd})(60\ min/hr)$$

where,

SV = *specific molar volume of an ideal gas:*

$$SV = 385.3\ ft^3/lb\ mole \quad for\ T_{ref} = 528\ °R$$

$$SV = 379.5\ ft^3/lb\ mole \quad for\ T_{ref} = 520\ °R$$

4. Emissions Rates, lb/10^6 Btu

   a. Fuel factor at 68 °F, dscf/10^6 Btu at 0% O_2

$$F_{68} = \frac{10^6[3.64(\%H) + 1.53(\%C) + 0.14\ (\%N) + 0.57(\%S) - 0.46(\%O_2,fuel)]}{HHV,\ Btu/lb}$$

   b. Fuel factor at 60 °F

$$F_{60} = F_{68}\left(\frac{520\ °R}{528\ °R}\right)$$

   c. Gaseous Emissions factor

$$\left(\frac{lb}{10^6\ Btu}\right)_i = (ppm)_i\ (10^{-6})\left(\frac{MW_i\ lb}{lb\ mole}\right)\left(\frac{1}{SV}\right)(F)\left(\frac{20.9}{20.9\ -\ \%O_2}\right)$$

   d. Paticulate emission factor

$$\left(\frac{lb}{10^6\ Btu}\right) = C\left(\frac{1\ lb}{7000\ gr}\right)(F)\left(\frac{20.9}{20.9\ -\ \%O_2}\right)$$

Nomenclature:

A_s = stack area, ft^2

B_{wo} = flue gas moisture content

$C_{12\%\ CO_2}$ = particulate grain loading, gr/dscf corrected to 12% CO_2

C = particulate grain loading, gr/dscf

C_p = pitot calibration factor, dimensionless

Dn = nozzle diameter, in.

F = fuel F factor, dscf/10^6 Btu at 0% O_2

H = orifice pressure differential, iwg

I = % isokinetics

M_n = mass of collected particulate, mg

M_i = mass emissions of species i, lb/hr

MW = molecular weight of flue gas

MW_i = molecular weight of species i:

NO_x : 46
CO : 28
SO_x : 64
HC : 16

θ = sample time, min.

ΔP = average velocity head, iwg = $\left(\overline{\sqrt{\Delta P}} \right)^2$

P_{bar} = barometric pressure, in.Hg

P_s = stack absolute pressure, in.Hg

P_{sg} = stack static pressure, iwg

Nomenclature (Continued):

Q = wet stack gas flow rate at actual conditions, wacfm

Qsd = dry stack gas flow rate at standard conditions, dscfm

SV = specific molar volume of an ideal gas at standard conditions, ft^3/lb mole

Tm = meter temperature, °R

T_{ref} = reference temperature, °R

Ts = stack temperature, °R

V_s = stack velocity, ft/sec

V_{lc} = volume of liquid collected in impingers, ml

Vm = dry meter volume uncorrected, dcf

$V_{m\ std}$ = dry meter volume at standard conditions, dscf

$V_{w\ std}$ = volume of water vapor at standard conditions, scf

Y = meter calibration coefficient

Appendix D.2

Sample Calculations

SUBJECT Sample Calculations for Flow Rate, Moisture and Particulate Matter
JOB NO.
SHEET NO. 1 of 5
COMPUTED BY C. Fry DATE 1-18-93 CHECKED BY DATE

Test No. 2-PM-PV

See Appendix D.1 for Nomenclature

Note: $\text{avg } \Delta P = (\Sigma \sqrt{\Delta P})^2$

V_{std} = Standard Sample Volume Metered (scf)

$$V_{m\,std} = 0.03342\,(V_m)\left(P_{Bar} + \frac{\Delta H}{13.6}\right)\left(\frac{T_{ref}}{T_m}\right)Y$$

$$V_{m\,std} = 0.03342\,(33.677)\left(29.96 + \frac{0.955}{13.6}\right)\frac{520}{(79.78+460)}$$

$$V_{m\,std} = 32.526$$

$V_{w\,std}$ = Water Vapor Volume (scf)

$$V_{w\,std} = 0.0472\,(V_k)\left(\frac{T_{ref}}{528\,°R}\right)$$

$$V_{w\,std} = 0.0472\,(120.0)\,\frac{520}{528}$$

$$V_{w\,std} = 5.57818$$

CARNOT

SUBJECT Sample Calculations Continued JOB NO.

SHEET NO. 2 of 5

COMPUTED BY C. Fry DATE CHECKED BY DATE

B_{wo} = Moisture Content

$$B_{wo} = \frac{V_{w\,std}}{V_{m\,std} + V_{w\,std}}$$

$$B_{wo} = \frac{5.57818}{32.526 + 5.57818}$$

$B_{wo} = 0.146$ or $\times 100 = 14.6\ \%$

MW = Stack Gas Molecular Weight

$$MW_{dry} = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$$

$$MW_{dry} = 0.44(12.83) + 0.32(5.39) + 0.28(81.8)$$

$$MW_{dry} = 30.274$$

$$MW_{wet} = MW_{dry}(1 - B_{wo}) + 18(B_{wo})$$

$$MW_{wet} = 30.274(1 - 0.146) + 18(0.146)$$

$$MW_{wet} = 28.482$$

SUBJECT Sample Calculations, Continued JOB NO.

SHEET NO. 3 of 5

COMPUTED BY C. Fry DATE CHECKED BY DATE

P_s = Absolute Stack Pressure

$$P_s = P_{bar} + \frac{P_{st}}{13.6}$$

$$P_s = 29.96 + \frac{+.1181}{13.6}$$

$$P_s = 29.969$$

V_s = Stack Velocity ft/sec

$$V_s = 2.90(C_p)\sqrt{(\Delta P)(T_s)}\sqrt{\left(\frac{29.92}{P_s}\right)\left(\frac{28.95}{MW_{wet}}\right)}$$

$$V_s = 2.90(.84)\sqrt{(.4750)(336.75+460)}\sqrt{\frac{29.92}{29.969}\ \frac{28.95}{28.482}}$$

$$V_s = 2.90(.84)(19.45395)(1.00736)$$

$$V_s = 47.738$$

Note: T_s = Temp Stack F° + 460

SUBJECT Sample Calculations, Continued JOB NO.

SHEET NO. 4 of 5

COMPUTED BY DATE CHECKED BY DATE

Q = Stack Flow Rate, Wet actual (wacfm)

$Q = (V_s)(A_s)\,60\ \text{sec/min}$

A_s = Stack Area

$Q = (47.738)(9.168)\,60$

$Q = 26259.9$

Q_{std} = Standard Stack Flow Rate, dscfm

$$Q_{std} = Q\,(1 - B_{wo})\left(\frac{T_{ref}}{T_s}\right)\left(\frac{P_s}{29.92}\right)$$

$$Q_{std} = 26{,}259.9\,(1 - .146)\,\frac{520}{460 + 336.75}\quad\frac{29.969}{29.92}$$

$Q_{std} = 14660$

SUBJECT Sample Calculations, Continued JOB NO.

SHEET NO. 5 of 5

COMPUTED BY C. Fry DATE CHECKED BY DATE

C = particulate grain loading gr/dscf

$$C = 0.01543 \left(\frac{M_n}{V_{m\,std}} \right)$$

$$C = 0.01543 \left(\frac{4.30}{32.526} \right)$$

$$C = 0.0020$$

M = Mass Emissions lb/hr

$$M = (C)(Q_{std}) \frac{60 \text{ min/hr}}{7000 \text{ gr/lb}}$$

$$M = 0.0020 \; \frac{14660}{7000} \times 60$$

$$M = 0.256$$

Appendix C.2

CEM Data and Strip Charts