SCEC

LONG TERM CONTINUOUS EMISSION MONITORING FOR NO_X, CO AND O_2 EMISSIONS AT MONTECITO RETIREMENT ASSOCIATION (CASA DORINDA) LOCATED IN MONTECITO, CALIFORNIA

Prepared For:
Southern California Gas Company
8101 South Rosemead Boulevard
Pico Rivera, CA 90660

Equipment Location:
Casa Dorinda/Montecito Retirement Association
300 Hot Springs Road
Montecito, California 93108

Monitoring Dates:
August 28-September 12, 2006

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Table of Contents

1.0 Introduction

The Gas Company retained the services of SCEC to perform 15 days of continuous emissions monitoring from the exhaust of a rich burn internal combustion engine located at the Montecito Retirement Association (Casa Dorinda), Montecito, California. The emissions monitoring program was conducted from August 28, 2006 through September 12, 2006. The permit compliance limits for the engine is 9 ppm NOx, corrected to 15% O_2 and 60 ppm CO, corrected to 15% O_2.

The continuous emissions monitoring program was conducted to evaluate the performance of an air to fuel ratio controller, Gill Controls for two weeks. NO, NO_2, CO, and O_2 concentrations were determined according to CARB Method 100. The CARB Method 100 results were recorded using a Data Acquisition System (DAS) in parts per million (ppm) for NO, NO_2, CO and percent volume (%) for O_2, every 2 seconds and presented in one minute averages. The catalyst inlet and outlet temperature and ambient temperature were recorded on the data acquisition system and chart recorder. Fuel meter readings were taken at the beginning of the day and towards the end of the day. VOC analysis is being conducted by EPA Method 18.

The DAS data for whole test program is included on an electronic disc data. Similarly, engine load data for the entire test program is included on an electronic disc data.

The testing was performed by Mr. Bipul K. Saraf, Mr. Thomas R. Taylor and Mr. Mike Schmidt of SCEC. The testing was coordinated by Mr. Gregg Arney of the Gas Company and Mr. Richard Cartwright of RCL & Associates.

2.0 Summary of Results

The results summary for the whole test program is included in Table 2.1. The result summary includes the average of daily NO_x, CO and O_2 data. Also, daily maximum and minimum value for NO_x and CO are included in the table. The test program was divided into two conditions, base load and load following. The engine ran at base load conditions for the first nine days. The load was held steady at 170 kW. On the tenth day, load following condition was initiated. Results for baseline load and load following conditions are presented in Table 2.2 and 2.3. Table 2.4 represent 15 minute average data. The data presented in Table 2.4 is an average of the highest concentration for NO_x and CO observed during that day.

Table 2.1
Summary of Results
Southern California Gas Company/Montecito Retirement Association
Engine No. 1
15 Days Continuous Emission Monitoring Program
August 28-September 12, 2006

Day No.	Parameters										
	O_2	NO	NO_x	CO	NO_x @ 15% O_2	CO @ 15% O_2	Daily NO Max	Daily NO Min	Daily CO Max	Daily CO Min	Average Load
	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	kW
1	0.01	4.83	4.83	11.15	1.37	3.15	8.27	3.82	41.7	3.3	170
2	0.01	5.31	5.29	11.73	1.50	3.31	8.83	3.67	31.4	1.3	170
3	0.01	5.12	5.08	10.46	1.43	2.95	8.12	3.81	37.9	3.4	170
4	0.15	4.90	4.84	8.79	1.38	2.39	5.61	4.37	30	4.9	170
5	0.01	5.37	5.41	11.03	1.53	3.11	10.26	3.97	33.4	3.1	170
6	0.01	5.79	5.78	10.00	1.63	2.82	10.26	4.12	38.4	2.9	170
7	0.01	5.49	5.51	11.76	1.56	3.32	45.64	0	121.8	-0.8	170
8	0.01	6.26	6.28	11.56	1.78	3.26	15.34	3.97	27	3.1	170
9	0.01	6.28	6.27	10.37	1.77	2.93	21.1	4.12	31.4	2.9	170
10	0.01	5.60	5.70	14.04	1.61	3.97	11.67	2.01	74.3	2.5	170
11	0.01	5.79	5.89	9.83	1.66	2.77	9.63	4.32	31.4	2.9	170
12	0.01	6.20	6.19	8.11	1.75	2.29	9.08	4.22	31.7	2.3	170
13	0.02	6.04	6.04	6.43	1.71	1.82	9.43	4.02	18.5	1.3	170
14	0.02	5.80	5.79	3.52	1.64	1.00	7.97	0.02	12.1	-0.8	170
15	0.03	5.70	5.71	11.3	1.61	0.63	7.72	0.02	11.3	-0.8	170

The data are not corrected for system bias error. Everyday, a system bias and internal calibration error was performed. All the calibration errors were within CARB Method 100 allowable tolerance limits. A NO_2 converter efficiency test was performed each day and recorded greater than 90% efficiency.

The results indicate Engine No. 1 stayed below the compliance limit throughout the test program. Occasionally a few spikes were seen during the load following condition, the spike data were all below the full scale range.

2.0 Summary of Results (Continued)

Table 2.2 is a data compilation for the base load condition. No unusual spikes were seen during base load monitoring. Daily average emissions demonstrated compliance through the test program.

Table 2.2

Southern California Gas Company/Montecito Retirement Association
Engine No. 1
Base Load Emissions Data
August 28- September 6, 2006

Day No.	Parameters										
	O_2	NO	NO_x	CO	NO_x @ 15% O_2	CO @ 15% O_2	Daily NO Max	Daily NO Min	Daily CO Max	Daily CO Min	Average Load
	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	kW
1	0.01	4.83	4.83	11.15	1.37	3.15	8.27	3.82	41.7	3.3	170
2	0.01	5.31	5.29	11.73	1.50	3.31	8.83	3.67	31.4	1.3	170
3	0.01	5.12	5.08	10.46	1.43	2.95	8.12	3.81	37.9	3.4	170
4	0.15	4.90	4.84	8.79	1.38	2.39	5.61	4.37	30	4.9	170
5	0.01	5.37	5.41	11.03	1.53	3.11	10.26	3.97	33.4	3.1	170
6	0.01	5.79	5.78	10.00	1.63	2.82	10.26	4.12	38.4	2.9	170
7	0.01	5.49	5.51	11.76	1.56	3.32	45.64	0	121.8	-0.8	170
8	0.01	6.26	6.28	11.56	1.78	3.26	15.34	3.97	27	3.1	170
9	0.01	6.28	6.27	10.37	1.77	2.93	21.1	4.12	31.4	2.9	170

Table 2.3 summarizes data for the load following condition. Some NO and CO spikes were recorded on the strip chart but actual emissions stayed below the compliance limit. Data on the strip chart recorded load following conditions after midnight. Although load dropped significantly, there was no impact on the emissions. The controller was able to balance the load distribution and maintain the emissions within the compliance limit.

Table 2.3

Southern California Gas Company/Montecito Retirement Association
Engine No. 1
Load Following Emission Data
September 6 - September 12, 2006

Day No.	Parameters											
	O_2	NO	NO_x	CO	NO_x @ 15% O_2	CO @ 15% O_2	Daily NO Max	Daily NO Min	Daily CO Max	Daily CO Min	Max Load	Min Load
	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	kW	kW
10	0.01	5.60	5.70	14.04	1.61	3.97	11.67	2.01	74.3	2.5	170	99 at 11:33 am
11	0.01	5.79	5.89	9.83	1.65	2.77	9.63	4.32	31.4	2.9	170	148 at 00:17 am
12	0.01	6.20	6.19	8.11	1.75	2.29	9.08	4.22	31.7	2.3	170	142 at 02:08 am
13	0.02	6.04	6.04	6.43	1.71	1.82	9.43	4.02	18.5	1.3	170	141 at 03:00 am
14	0.02	5.80	5.79	3.52	1.64	1.00	7.97	0.02	12.1	-0.8	170	135 at 02:03 am
15	0.03	5.70	5.71	11.3	1.61	0.63	7.72	0.02	11.3	-0.8	170	139 at 02:29 am

2.0 Summary of Results (Continued)

Results presented below are an average of random continuous 15 minutes data. Average data presented below is based upon highest concentration of NOx and CO emissions.

Table 2.4

Southern California Gas Company/Montecito Retirement Association
Engine No. 1
Representative 15 Minutes Highest Daily Average
August 28-September 1, 2006

Day No.	Time	Parameters					
		O_2, %	NO, ppm	NO_x, ppm	CO, ppm	NO_x ppm @ 15% O_2	CO ppm @ 15% O_2
1	1500-1515	0.01	5.53	5.79	7.50	1.63	2.12
2	1315-1330	0.01	6.21	6.05	6.74	1.71	1.90
3	1244-1259	0.01	5.13	4.97	10.56	1.40	2.98
4	0715-0730	0.20	4.88	4.83	22.34	1.38	6.37
5	1912-1927	0.01	5.52	5.49	8.98	1.55	2.54
6	2301-2316	0.01	5.22	5.33	15.64	1.50	4.42
7	2346-0001	0.01	5.43	5.59	13.96	1.58	3.94
8	1446-1501	0.01	7.55	8.07	9.37	2.28	2.65
9	1305-1320	0.01	7.85	7.38	9.83	2.09	2.77
10	1137-1152	0.01	4.92	4.99	16.55	1.41	4.67
11	1137-1152	0.01	6.05	6.19	9.79	1.75	2.77
12	0336-0351	0.02	5.21	5.17	10.31	1.46	2.91
13	1530-1545	0.02	7.60	7.58	3.00	2.14	0.85
14	0716-0731	0.02	5.62	5.62	5.15	1.59	1.46
15	1102-1117	0.03	5.96	5.96	2.74	1.68	0.77

Table 2.5

Southern California Gas Company/Montecito Retirement Association

Engine No. 1

TGNMO Results (Raw)

Parameter	Unit	Results	
		Run No. 1	Run No. 2
Methane	ppmv	164	141
Ethane	ppmv	2.1	2.03
TGNMO	ppmv	5.66	7.12

Note: TGNMO Analyzed by EPA Method 18. TGNMO results reported as raw concentration.

3.0 Test Description

3.1 Test Conditions

The IC engine was operated at base load condition for the first 9 days followed by load following condition for remaining 6 days while firing on 100% natural gas fuel for the test programs. Engine data were monitored and recorded throughout the test period. These data can be found in Appendix J – Process Data. The following data were collected, fuel flow, catalyst inlet, catalyst outlet and ambient temperatures.

3.2 Sample Locations

All samples were collected from the IC engine at its main stack exhaust. Emission testing was conducted on the four-inch diameter discharge stack located approximately 12 feet from ground level. Two sample ports 90° apart were utilized for sampling on the exhaust stack. The sample ports for Engine No. 1 were located approximately 30.0 duct diameters downstream and 7.5 duct diameters upstream from a flow disturbance.

3.3 Test Procedures

The test procedures and sampling log used for the exhaust measurements are consistent with CARB and EPA source test methods. Brief discussions of each procedure are provided in Section 5.0.

TABLE 3.1
Sampling Log
Engine No. 1

Day No.	Parameters Measured	Date	Time	Conditions
1	$NO_x/CO/O_2$	Aug 28-29, 2006	13:11 – 07:02	Base Load
2	$NO_x/CO/O_2$	Aug. 29-30, 2006	07:49 – 07:15	Base Load
3	$NO_x/CO/O_2$	Aug 30-31, 2006	08:14 – 07:14	Base Load
4	$NO_x/CO/O_2$	Aug .31-1, 2006	09:00 – 07:30	Base Load
5	$NO_x/CO/O_2$	Sept .1-2, 2006	10:04 – 07:07	Base Load
6	$NO_x/CO/O_2$	Sept .2-3, 2006	08:25 – 07:25	Base Load
7	$NO_x/CO/O_2$	Sept. 3-4, 2006	12:09 – 07:27*	Base Load
8	$NO_x/CO/O_2$	Sept. 4-5, 2006	08:10 - 06:47	Base Load
9	$NO_x/CO/O_2$	Sept. 5-6, 2006	07:28 – 07:31	Base Load
10	$NO_x/CO/O_2$	Sept. 6-7, 2006	09:39 – 07:56	Load Following
11	$NO_x/CO/O_2$	Sept. 7-8, 2006	08:39-07:56	Load Following
12	$NO_x/CO/O_2$	Sept. 8-9, 2006	10:30-07:41	Load Following
13	$NO_x/CO/O_2$	Sept. 9-10, 2006	10:43-07:41	Load Following
14	$NO_x/CO/O_2$	Sept. 10-11, 2006	09:02-08:04	Load Following
15	$NO_x/CO/O_2$	Sept. 11-12, 2006	09:37-07-33	Load Following

* Engine No. 1 shutdown. Engine started at 1200 hours.

4.0 Discussion of Results

A fifteen day emission monitoring program for NO, NO_x, CO and O_2 measurements was conducted following CARB Method 100. Daily system bias calibration error and direct internal calibration error was performed in the morning. A NO and NO_2 converter efficiency was performed each day.

The test program was conducted smoothly with few noted anomalies. On day No. 4, a high vacuum was recorded by the sampling gauge. The blockage was due to a clogged Balston filter. The filter was replaced and normal sampling condition was continued. Intermittent voltage loss between recorder and the signal output from the analyzer was noted during the first few days of monitoring. This intermittent voltage generated erroneous emission and temperature data. The erroneous data were excluded from the monitoring program. During day No. 5 of the monitoring, the computer recording the DAS data locked up. The sampling data for the entire 24 hour period was lost; however, the strip chart recorder was functional and continued to record data in that mode. Average emission data was derived from the strip chart recorder data. The computer was replaced and the DAS was started the following day. With the replaced computer, no unusual voltage spikes were seen and data were very consistent. On day No. 7, Engine No. 1 shut down due to a power system grid spike. Calibration was completed and extra time was spent for the unit to be brought back online. The unit was started remotely. The unit took about 10 minutes to stabilize and the emission monitoring program was continued. On Day No. 8, NO spikes were observed but were below the compliance limit. On Day No. 9, no anomalies were seen.

Day No. 10 marked the beginning of load following conditions. The load following conditions naturally occur around midnight. To simulate varied load conditions, a trial run was conducted around 1000 am on September 6, 2006. When the load was varied, occasional NO and CO spikes were recorded on the chart. The spikes recorded were significantly lower than the compliance limit. Day No. 11 did not experience any abnormality. On Day No. 12, the NO_x analyzer was reset. The entire calibration sequence was repeated and the monitoring program was continued. No sampling anomalies were seen on Day No. 12, 13, 14 and 15.

5.0 Source Information and Equipment Location;

Legal Owner:
Casa Dorinda/Montecito Retirement Association
300 Hot Springs Road
Montecito, CA 93108

Facility Contact:
Timothy Gallagher
Casa Dorinda/Montecito Retirement Association
300 Hot Springs Road
Montecito, CA 93108
Phone No.: 805 969-8083

Equipment Location:
Casa Dorinda/Montecito Retirement Association
300 Hot Springs Road
Montecito, CA 93108

Equipment Description:

Engine No. 1 is Daewoo Heavy Industries, Model No. GE12TIR/Hess200i rich burn internal combustion engine Serial No. EEING20, generated 317,000 KWHRS and engine run time of 1820 hour meter. The engine is a 6 cylinders, four-stroke spark-ignited unit, natural gas fueled, 180 kW, 254 BHP, with 3-way catalytic converter to minimize CO, VOC and NO_x emissions. The catalyst is DCL 2DC-49, 2 stage 3-way catalyst with 1820 hours run time. The air to fuel ration controller is Gill, Model No. AF-120. The engine is directly coupled to synchronous generator.

6.0 Sampling Procedure

6.1 CARB Method 100 - Reference Method Continuous Gaseous Emissions Sampling

Ref.: California Air Resources Board (CARB), July 1997, Method 100.
United States Environmental Protection Agency (USEPA) 40 CFR 60, Appendix A, Method 3A, 6C, and 7E, July 2001.

A continuous sample was extracted from the stack through a heated (via stack gas) stainless steel probe, coarse filter, heated sample line maintained at temperatures above dew point of water (220° F), and sample conditioner (condensate train) fully iced. Immediately after leaving the condensate train, the sample passed through a Baldwin Environmental Model 5210 electronic water condenser maintained at approx. 0.7 degrees Celsius. The gas was then drawn via 3/8" Teflon line to the mobile emissions laboratory. The sample was filtered again through a fine Balston filter and finally delivered to the analyzers through the sample manifold and dedicated flow meters. The sample conditioner consists of two modified impingers; shortened stems and bottom water drainage ports. Temperature of flue gas leaving the sample conditioner and the electronic water condenser was checked, twice per run, to ensure dry sample gas and compliance with CARB Method 100.

Prior to beginning the test, a system leak check was performed. The leak check was accomplished by plugging the probe tip and drawing at least 25"Hg vacuum on the entire sampling system. When all flow meters indicate 0.0 CFH flow, the system was shown to be leak-free. A calibration check was performed before and after each run. After zeroing all analyzers, EPA Protocol 1 gases were used to locally calibrate each analyzer within 40-60% and 80-90% full scale of the selected range.

A system bias calibration was performed before and after each sampling run by sending calibration gas to a three way valve, located between the probe and coarse filter, and drawing sample at the same flow rate as the manifold calibration. All systems bias calibrations were below 5% of span.

All concentrations from the NO_x, CO, CO_2, and O_2 analyzers were recorded on a Yokogawa DR240 Hybrid chart recorder in conjunction with a data acquisition system (DAS) polling the analyzers every two seconds.

Equations

$$\text{Corrected Conc.} = (\text{Raw Conc.} - \text{Avg. Zero}) \times \frac{\text{Cal. Gas Value}}{\text{Avg. Span} - \text{Avg. Zero}}$$

$$\text{Conc. @ 3\% } O_2 = \text{Corrected Conc.} \times 17.9 / (20.9 - \%O_2)$$

$$\text{Conc. @ 15\% } O_2 = \text{Corrected Conc.} \times 5.9 / (20.9 - \%O_2)$$

Emission Rate = Corrected Conc. x (1.583×10^{-7}) x Q_{sd} x M_d (@ 60° F)

6.0 Sampling Procedure (Continued)

CARB Method 100 - Reference Method Continuous Gaseous Emissions Sampling

Where:

M_d = Dry molecular weight of NO_x = 46.01, CO = 28

Q_{sd} = Volume Flow rate - DSCFM

$\%O_2$ = Stack O_2

6.0 Sampling Procedure (Continued)

CONTINUOUS MONITORING LAB

NO_x CHEMILUMINESCENT ANALYZER	THERMO ELECTRON MODEL 42C-HLS/N 42CHL
Response Time (0-90%)	2.5 seconds in NO mode 5.0 seconds in NO_x mode
Noise	0.20 PPB
Zero Drift (24 hrs)	0.40 PPB
Detection Limit	0.40 PPB
Span Drift (24 hrs)	± 1% of full scale
Linearity	+1% of full scale
Sample Flow Rate	0.6 l/min.
Output Voltage	NO, NO_2, NO_x, 0-10V, Selectable 4-20 mA, RS-232
Ranges	0-0.05 ppm to 0-100 ppm (every whole value in between)
O_2 ANALYZER, CELL TYPE	AMI MODEL 200 Series S/N 980514-1
Response Time (0-90%)	< 10 Seconds
Accuracy	± 1% of scale at constant temperatures; ± 1% of scale or ± 5% of reading, whichever is greater, over the operating temperature range
Output	0-1V
Range	0-5%, 0-10%, 0-25%

6.0 Sampling Procedure (Continued)

CONTINUOUS MONITORING LAB

CO GAS FILTER CORRELATION	THERMO ELECTRON MODEL 48H
Non-Dispersive Infrared	S/N 48H-35546-250
Response Time (0-95%)	10 seconds
Span Drift	± 1% full scale in 24 hours
Zero Drift	± 0.2 ppm in 24 hours
Linearity	± 1% full scale, all ranges
Accuracy	± 0.1 ppm
Output 10V	0-10mV, 0-100mV, 0-1V, 0-5V, 0-
Range 10000,	100, 200, 500, 1000, 2000, 5000, 20000, and 50000 ppm

6.0 Sampling Procedure (Continued)

CONTINUOUS MONITORING LAB

ELECTRONIC WATER CONDENSER	BALDWIN ENVIRONMENTAL MODEL 5210
Max. Sample Gas Flow Rate	5 *l* /min. or ll scfh
Max. Inlet Temperature	400 deg. F
Max. Inlet Dewpoint	180 deg. F
Max. Inlet Pressure	45 psig.
Max. Cooling Rate	440 Btu/hr.
Ambient Temperature Range	+40 to 104 deg. F
Outlet sample Gas Dewpoint	+36 deg. F 1□
Power	365 Watts
Water Removal	Peristaltic drain pump
STRIP CHART RECORDER	YOKOGAWA HYBRID RECORDER MODEL HR 2400
Scan Cycle Time	1-60 seconds
Scanning Rate	60ms/Channel
Input Impedance	More than 10 M ohms for 2V or lower ranges, Approximately 1 M ohms on 6V or higher ranges
Input Bias	Less than 10mA
Temperature Spread on Terminals	0.3% among input terminals
Temperature Coefficient	Zero drift 0.01% of range/°C Full span 0.01% of range/°C
Max. Allowable Input Voltage	60 VDC
Chart Speed	1-15,000 mm/hr
Recording Accuracy	± 0.1% of effective
Chart Speed Accuracy	± 0.1% for recordings greater than 1m
Data Acquisition System (DAS)	Darwin Software

6.0 Sampling Procedure (Continued)

6.2 EPA Method 18 - Measurement of Gaseous Organic Compound Emissions by Gas Chromatography

Ref: EPA Code of Federal Regulations, Title 40, Part 60, Appendix A, Method 18, 2003

The Method 18 sampling apparatus was used to collect volatile organic compounds in three liter Tedlar bags.

The apparatus consisted of a stainless steel probe connected by Teflon line to a Tedlar sample bag contained in an air tight canister. Upon evacuation of the air in the canister, sample gas was drawn into the bag.

On completion of each run, the bag sample was sealed and immediately transported to the laboratory. Sample was drawn through a septum and injected into the GC with a Flame Ionization Detector (FID) for speciation of C_1 - C_6^+ compounds.

CALCULATIONS

$$\frac{lb}{hr} = PPMv * DSCFM * C.F. * M.W.$$

Where:

PPMv = Parts Per Million (Volume)
DSCFM = Dry Standard Cubic Feet Per Minute
M.W. = Molecular Weight of Specific Hydrocarbon
C.F. = Conversion Factor = 1.583E-07 @ 60°F

List of Appendices