LNG Research Study

Rich Burn Engine

April 2006

Prepared By:

The Southern California Gas Company

Engineering Analysis Center – Applied Technologies

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Acknowledgements

The authors express appreciation to the following people whose efforts contributed much to the success of this project.

Monica Clemens

Robert Munoz

Larry Sasadeusz

Rod Schwedler

Kevin Shea

Gregg Arney

Dale Tomlinson

Angel Macias

Henry Lam

Geoff Ashton

Dan McGivney

Jeff Davis

Michael Garibay

Martin Kay

Disclaimer

LEGAL NOTICE

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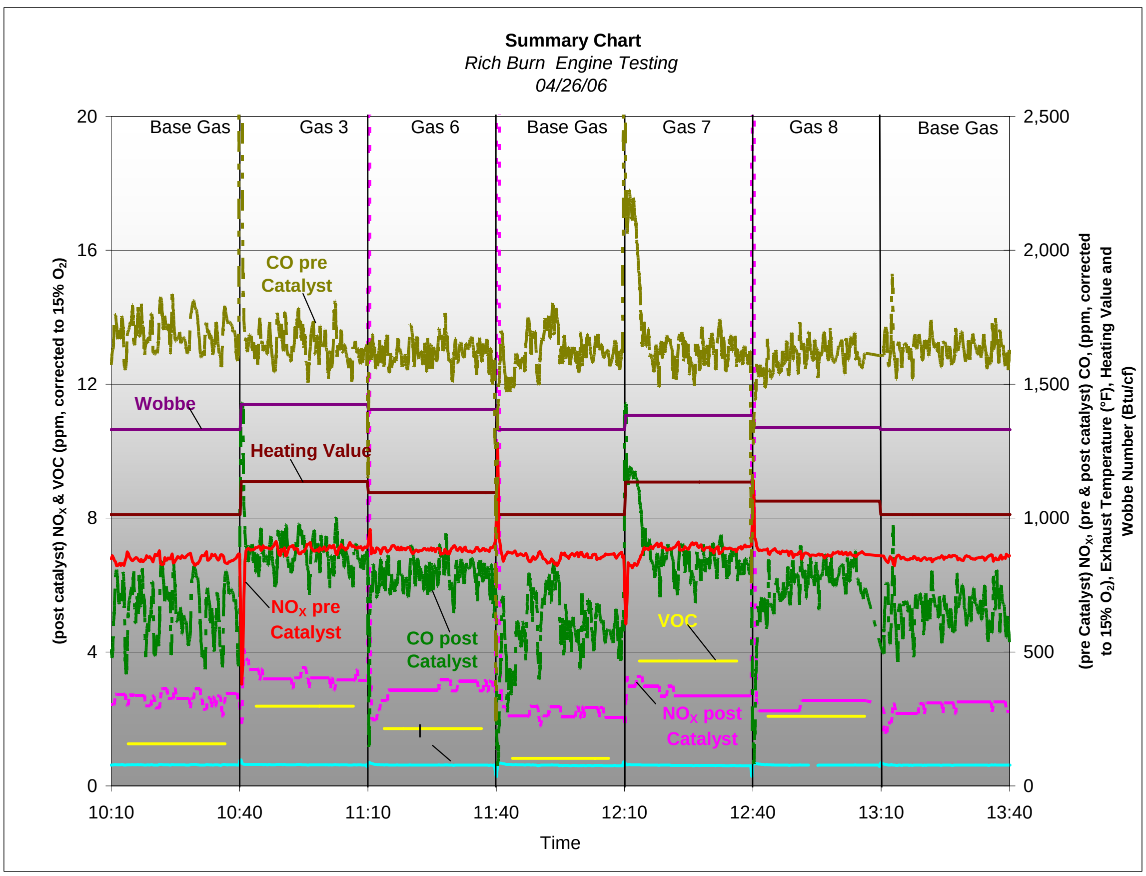
Results Summary

Results obtained from all tests conducted reveal that (a) there were no operational, knocking, or safety problems during testing with the different test gases or during transitions; (b) the average CO, VOC and NO_X emissions increased with the richer gases but remained below levels specified in SCAQMD rules for this type of equipment; (c) the air fuel controller adjusted the air fuel ratio promptly, thus maintaining a constant input rate and lambda with all the different gases; (d) none of the temperature measurements showed a significant increase and (e) there were some emissions spikes after switching with the different gases due to the variation in cylinder pressures between test gases.



NOTE: Emission test results are for information purposes. They were not the result of certified tests. All reported NO_X, CO and VOC emissions values were corrected to 15% O_2.

Other stakeholders that participated and witnessed the test provided the following comments:

Engine Consultant — Geoff Ashton of Advanced Engine Technologies Corporation

> "AETC emissions results correlated well with changes between fuel gases. There was a proportional inverse balance between post catalyst NO_X and CO during gas changes. Initial 'spikes' in Post Catalyst emissions at the start of each gas is accounted for by change in the fuel gas pressure momentarily upsetting air fuel ratio. Pre and Post catalyst temperatures remained well within operating range. The lambda sensor was able to account for changes in emissions in and out of the catalyst, but did not exceed control set point to initiate AFR adjustment."

Engine Operator — Jeff Davis, Senior Industrial Engine Technician, EMWD

> "No abnormal engine or air/fuel ratio controller conditions were noted with the introduction of the various fuel gasses."

Test Witness — Martin Kay, Program Supervisor, South Coast Air Quality Management District.

> "The NOx, CO and VOC emissions generally increased with increasing Wobbe Number and higher heating value (HHV) of the fuel gas. There is a strong linear correlation between NOx and Wobbe Number, CO and HHV, and VOC and % VOC (propane and higher) by volume in the fuel gas. Compared to the Base Gas, the worst case gases, Gas 3 and Gas 7, increased NOx, CO and VOC by 23%, 73% and 259%, respectively. Although the emission increases were within the limits allowed by SCAQMD Rule 1110.2 for this engine, such increases may cause engines with more stringent Best Available Control Technology limits to exceed their emission limits."

Test Witness – Gregg Arney, Team Leader – Air Quality and Compressor Services, Southern California Gas Company.

> "No abnormal engine operations were observed. The air fuel ratio controller took less than one minute to stabilize on each gas, although a reason for the longer transition observed during the switch from Base Gas to Gas 7 was not apparent.

NOx and CO concentrations both increased with an increase in the Wobbe Index; the largest increase in NOx from 2.6 to 3.2 ppm at 15% oxygen (a difference of only 0.6 ppm) and the largest increase in CO was from 587 to 882 ppm (a difference of 295 ppm.) Emissions stayed well below the 36 ppm NOx, and 2000 ppm CO limits and within variations typical observed with NSCR systems – even when running on a constant gas composition fuel. VOC results were much more varied. The highest VOC was measured with a mid-range Wobbe gas was 37.8 ppm, but lower VOC concentrations were measured for the two higher Wobbe gases, 23.8 and 17.1 ppm. As indicated in Appendix H, the VOC measurements were above the maximum level recommended for the method causing the results to be biased low. So, although the data clearly shows an upward trend in VOC with Wobbe Index, it is difficult to reach any specific conclusions. However, all VOC data was a fraction of the 250 ppm limit.

The trends of CO and NOx suggest that the overall emission variation observed would have been less from the lowest to highest Wobbe Index fuel, had the engine been tuned with a mid-range Wobbe fuel."

Equipment Selection Criteria

This engine was selected because:

- The engine made by this manufacturer and the emissions control equipment are commonly used in our service territory.
- Such equipment are subject to very stringent emission requirements.
- Industry experts were concerned that this type of engine could have some operational or knocking problems when running on rich gases.

The engine used for this test was installed before current Best Available Control Technology (BACT) requirments for such equipment were required by the SCAQMD. Thus, emission limits for this engine are set by SCAQMD Rule 1110.2, which has the following emissions requirements:

NO_X: 36, CO: 2,000, VOC: 250 (all in ppm @ 15% O_2)

By comparison, BACT requirements for a new, stationary, non-emergency natural gas-fueled IC engine, currently being permitted at a non-Major Source, are:

NO_X: 0.15, CO: 0.6, ROG: 0.15 (all in g/BHP-hr) or

NO_X: ~9.5, CO: ~64, ROG: ~28 (all in ppm @ 15% O_2)

Equipment Specifications

Description	Rich-Burn Engine
BHP	225 @ 1200 RPM
Emissions Control Equipment	NSCR catalyst, air/fuel ratio controller
Type of fuel	Natural Gas
Required supply pressure	7.5 psig

Standards

A description of the test protocol and rationale used to develop testing procedures are included in Appendix A. The test protocol was developed based on the following test standards.

SCAQMD Rule 1110.2	Emissions from Gaseous - and Liquid-Fueled Internal Combustion Engines *(Amended June 3, 2005)* Emissions limits are: NO_X - 36 ppm, CO - 2,000 ppm and VOC - 250 ppm. All corrected to 15% O_2.
SCAQMD Method 100.1	Instrumental Analyzer Procedure for Continuous Gaseous Emissions

Installation

This engine provides air at a sewage treatment plant. It was installed according to manufacturer specifications for indoor installation. Thermocouples were installed to measure flue gas, natural gas, air intake, and pre/post catalyst temperatures. Pressure transducers were installed to measure gas manifold, gas delivery system and gas supply pressures. A gas meter was installed to measure the gas flow and emissions probes were installed pre and post the catalyst.

Test Gases

Test gases were specifically formulated to cover the range of gas compositions and calorific values of natural gases that could be delivered in the Southern California Gas Company territory by current natural gas suppliers and future LNG suppliers. All test gases adhere to the Southern California Gas Company's Gas Quality Specification (Rule 30), which is approved by the California Public Utilities Commission (CPUC). Gas composition details are specified in Appendix C.

Gas	Wobbe Number (Btu/cf)	Heating Value (Btu/cf)
Base	1,330 (Low Wobbe)	1013 (Low heat content)
3	1,424 (Highest Wobbe)	1,137 (Highest heat content)
6	1,405 (High Wobbe)	1,095 (High heat content)
7	1,384 (High Wobbe)	1,134 (Highest heat content)
8	1,338 (Medium Wobbe)	1,063 (Medium heat content)

Test Procedure

Test procedures were developed based on the above test standard. However, due to cost, time limitations, and facility restrictions, the test procedures were simplified with input from industry experts directed to develop a realistic and sound test procedure.

Before the test, the following steps were performed:

- All emissions analyzers were calibrated and linearity was checked.
- Data loggers were checked and temperatures, pressures, and gas flow readings were verified.

During every test, the following steps were performed:

- Setup Gas and Test Gases were run continuously. Each test run was 30 minutes with switching between gases taking less than 14 seconds.

- Emissions, pressures, temperatures and combustion stability were monitored during and after changeover.

After every test, the following steps were performed:

- Test data was downloaded.
- Linearity and drift inspections were performed on all emission analyzers.

Rated Input Test (Tuned w/ Base Gas)

The engine was adjusted by the Operator to achieve the highest possible load while running on baseline gas. No adjustments were made to the engine or air/fuel controller during the test. However, there were small changes to the load.

After operating at steady-state conditions with Base Gas for at least 30 minutes, a high-speed switch to Gas 3 was performed. Any changes in engine operation before, during and after changeover were observed and documented. Since the engine did not experience operational problems and/or none of the emissions constituents exceeded SCAQMD Rule 110.2 limits with Gas 3, the test gases were introduced in the following order:

- Gas 6, Gas 7
- Reestablish Base Gas
- Gas 8
- Reestablish Base Gas.

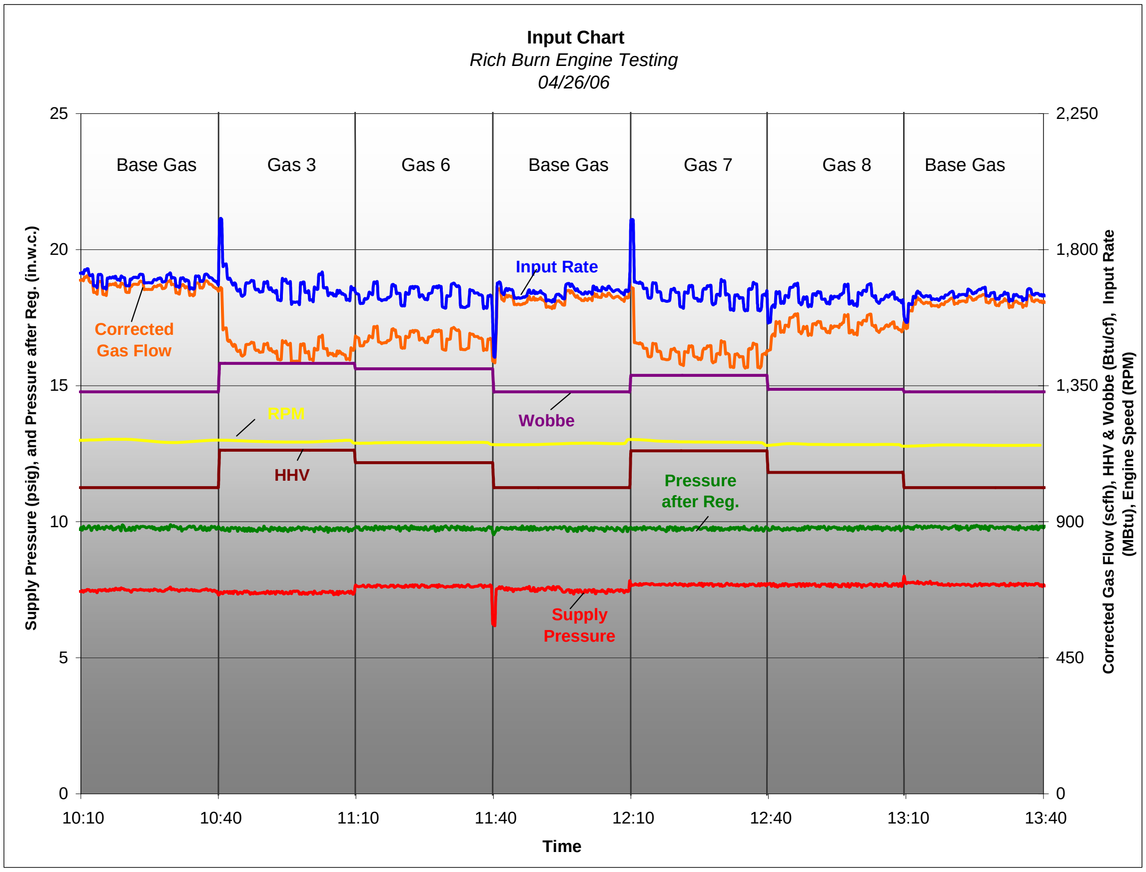
Since the engine did not experience any operational problems and/nor any of the emissions constituents exceed SCAQMD Rule 1110.2 limits, no other tests were conducted.

Results[1, 2]

Tuned w/ Base Gas

Input

The highest input rate was observed with Gas 3 (1,732,720 Btu/hr) whereas the lowest input rate occurred with Gas 8 (1,642,513 Btu/hr). Corrected gas flow rate ranged from 1,462 scfh (Gas 7) to 1,679 scfh (Base Gas). The supply gas pressure exhibited slight changes at the beginning of each test run due to different pressures in the cylinders. However, these pressure changes did not affect the operation of the engine and the gas pressure reading after the regulator remained stable throughout the test.



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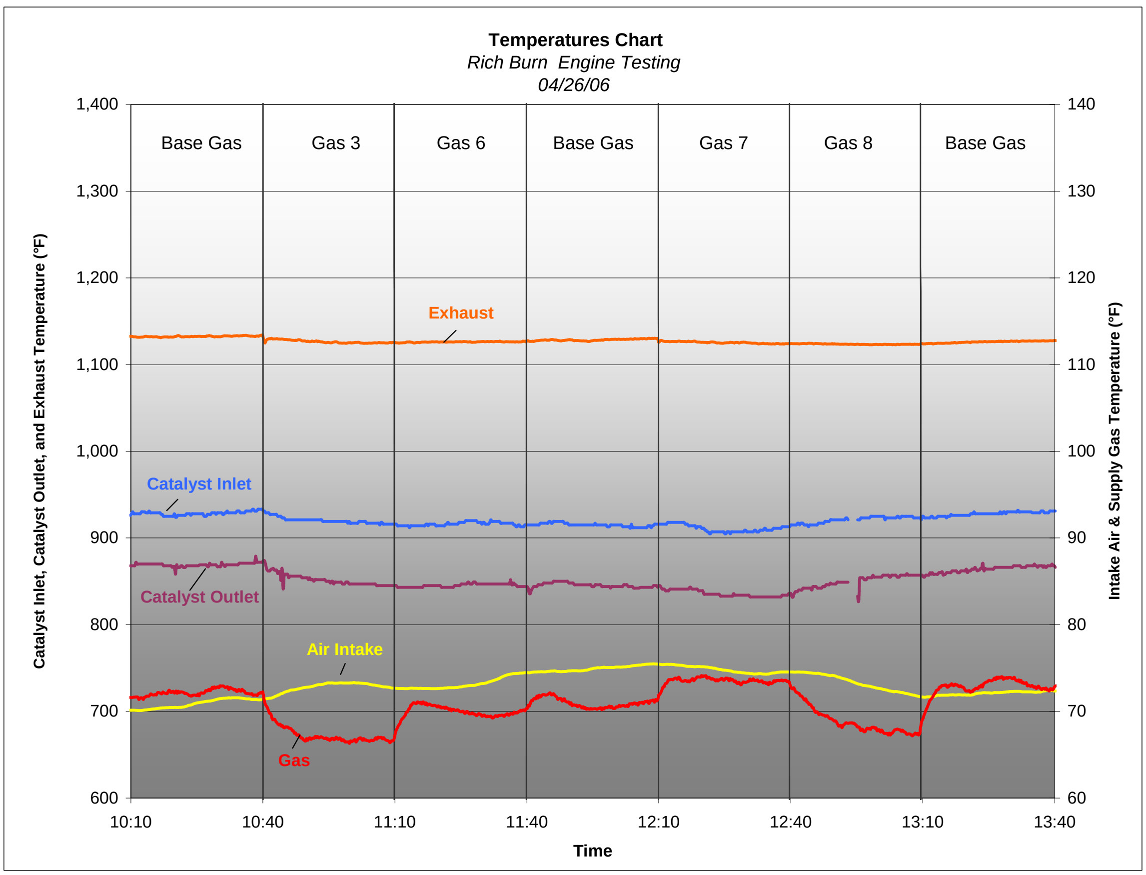
[1] All emissions, temperature and input values mentioned throughout the results section are average values.
[2] CO, VOC & NO_X emissions values are corrected to 15% O_2.

Temperatures

Catalyst inlet and outlet temperatures were highest with Base Gas on its first and third runs. The catalyst inlet temperature ranged from 911°F (Gas 7) to 928°F (Base Gas) whereas the catalyst outlet temperature ranged from 836°F (Gas 7) to 869°F (Base Gas).

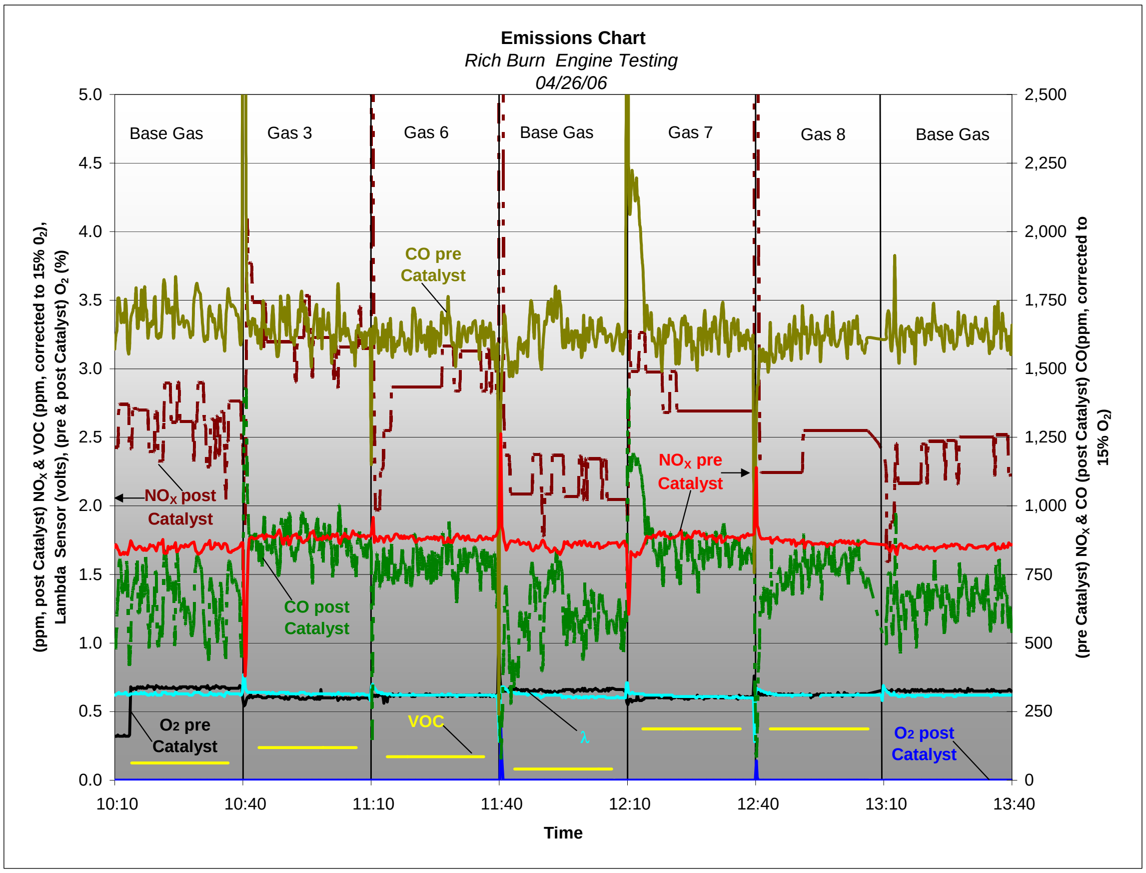
The fluctuation in gas temperatures between test runs was caused by the different pressures of the gas cylinders - higher gas pressure in the gas cylinders cause a higher pressure drop throughout the gas delivery system; lowering the gas temperature.



Emissions

Before the catalyst, NO_X emissions were highest with Gas 6 (883 ppm) and lowest with Base Gas (848 ppm). The NO_X emissions pattern was inversely proportional to the CO emissions pattern. CO emissions were highest with Base Gas (1,704 ppm) and lowest with Gas 8 (1,599 ppm). O_2 averaged 0.63% throughout the test.

After the catalyst, NO_X emissions were highest with Gas 3 (3.2 ppm) and lowest with Base Gas averaging 2.6 ppm for the three runs. The CO emissions ranged from 587 ppm (Base Gas) to 882 ppm (Gas 3). O_2 remained near zero throughout the test. NO_X and CO post catalyst followed the same pattern as the heating value and the Wobbe Number.



NOTE: Emission test results are for information purposes. They were not the result of certified tests

Appendix A: Testing Protocol

Test Arrangement

Basic Setup
The engine will be tested in actual production conditions, and within its normal operating parameters, as verified by the engine mechanic.

Exhaust Pipe
Emissions will be collected pre- and post- catalyst at the existing ports. Post catalyst port is the same one used for adjusting the engine and for SCAQMD certified source tests. Exhaust temperatures will be measured at the same location where the emissions sampling probe was located.

Data Collection and Processing
Temperatures, pressures and emissions data pre-catalyst, will be monitored by the Southern California Gas Company (SoCalGas). Emissions data post-catalyst will be collected by Advanced Engine Technologies Corporation (AETC). All the data will be electronically stored by AETC and analyzed by SoCalGas.

Testing Instrumentation

Instrumentation must adhere as close as possible to the SCAQMD protocol for Rules 1110.2 and SCAQMD Method 100.1. However, due to time limitations, test facility and cost concerns some deviations from the standards were made with industry experts input and approval.

Basic Operating Conditions

Unless required otherwise by specific test requirements, the following are to apply:

Gas Supply Pressure
All test gases will be supplied at pressures required by the engine manufacturer. Inlet pressure will be measured just before the engine gas control and the manifold pressure after the engine gas control or at the supplied pressure taps. Maximum achievable input rate must be measured at a specified time after cold start per required test standard.

Basic Firing Setup
The basic firing setup will deliver rated input with the Base Gas or selected Setup Gas. With gases other than the Base Gas and Setup Gas, the firing rate may *not* be at rated input.

Emissions Calculations
CO and NO_X emissions (ppm, Corrected to 15% O_2) are to be calculated per the SCAQMD protocol for Rule 1110.2 and method 100.1.

Rated Input Test

Adjust engine with Base Gas to operate as close as possible to the rated input and at highest possible load. Also, begin measuring temperature, pressure, input rate and emissions, and verify the firing rate.

Continue steady engine operation with Base Gas for at least 30 minutes and conduct a high-speed switch to Gas 3. Record data before, during and after changeover and observe transient phenomena. Possible phenomena include: high emissions, knocking, noise, or instability, etc. (Note: that the firing rate is not to be manually adjusted but engine controls may independently adjust firing rate in response to changes in the load or gas quality.

If there are no problems with the engine operating on Gas 3 for 30 minutes, conduct a high-speed switch to Gas 6 and record observations and data.

If there are no problems with the engine operating on Gas 6 for 30 minutes, conduct a high-speed switch to Base Gas and record observations and data per above to reestablish base line conditions.

Follow the same procedure with Gas 7 and Gas 8 and reestablish base line conditions by running Base Gas at the end.

However, if the engine experiences operational problems and/or any of the emissions constituents exceed SCAQMD limits after switching to Gas 3 from Base Gas, the test will be suspended. The engine will be retuned with the intermediate gas (Gas 8) and the test will be restarted.

After operating at steady-state condition with Gas 8 for at least 30 minutes, a high-speed switch to Gas 3 will be performed. Again, if the engine experiences operational problems and/or any of the emissions constituents exceed SCAQMD limits with Gas 3, the test will be suspended. If the engine does not experience operational problems and/or none of the emissions constituents exceed SCAQMD limits, operate the engine with Gas 3 for 30 minutes, record observations and data per above.

Conduct a high-speed switch to Gas 6 and record observations and data. If there are no problems with the engine operating on Gas 6 for 30 minutes, conduct a high-speed switch to Gas 8, record observations and data per above.

Follow the same procedure with Gas 7 and Base Gas and reestablish base line conditions by running Gas 8 at the end.

Appendix B: Table of Averages for each 30-minute run.

Table of Averages Rich Burn Engine Testing April 26, 2006							
Gases	**Base**	**3**	**6**	**Base**	**7**	**8**	**Base**
HHV (Btu/cf)	1,013	1,137	1,095	1,013	1,134	1,063	1,013
Wobbe (Btu/cf)	1,330	1,424	1,405	1,330	1,384	1,338	1,330
Input Rate (Btu/hr)	1,701,651	1,732,720	1,649,134	1,655,294	1,658,659	1,642,513	1,647,664
Corrected Flow (scfh)	1,679	1,524	1,506	1,633	1,462	1,545	1,627
Methane Number	102.5	76.1	84.9	102.5	70.4	81.9	102.5
Lambda (volts)	0.63	0.65	0.62	0.62	0.61	0.62	0.62
Emissions (not from certified tests)							
pre Catalyst Emissions							
O_2 (%)	0.63	0.60	0.62	0.66	0.60	0.62	0.65
CO (ppm @ 15% O_2)	1,704	1,679	1,604	1,632	1,684	1,599	1,634
NO_X (ppm @ 15% O_2)	847.7	874.1	883.3	863.4	877.9	872.2	850.6
post Catalyst Emissions							
O_2 (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO (ppm @ 15% O_2)	655.2	882.2	781.6	587.0	880.7	741.0	656.2
NO_X (ppm @ 15% O_2)	2.6	3.2	3.1	2.8	3.0	2.8	2.4
VOC (ppm@15%O_2)	12.6	23.8	17.1	8.2	37.3	20.8	N/A
Temperatures (°F)							
Cat. Inlet	928	920	916	915	911	921	928
Cat. Outlet	869	852	845	845	836	850	864
Air Intake	71	73	73	75	75	73	72
Exhaust	1,132	1,126	1,126	1,128	1,125	1,124	1,126
Supply Gas	72	67	70	71	74	69	73
Pressures							
Supply Gas (psig)	7.48	7.40	7.62	7.47	7.69	7.68	7.70
After Regulator (in. w.c.)	9.77	9.73	9.76	9.75	9.75	9.76	9.79

Appendix C: Test Gases Table, Certificates and GC reports

Base line gas was analyzed with a portable GC during the test. Variation of the baseline gas were minimal during all tests and results shown are an average of all the tests. All the other test gases were analyzed by the supplier before they were shipped to the Southern California Gas Company and then, for quality control, by Chemical Section of the Southern California Gas Company. Copies of the manufacturer certificates and copies of the GC reports from the Southern California Gas Company are included

Gas Sample Date	**Baseline** 4/26/2006	**3** 3/28/2006	**6** 3/28/2006	**7** 3/24/2006	**8** 3/28/2006
COMPONENTS	**MolPct**	**MolPct**	**MolPct**	**MolPct**	**MolPct**
C6 + 57/28/14	0.012	0.000	0.000	0.000	0.000
NITROGEN	0.419	0.337	0.034	3.542	3.999
METHANE	96.533	87.361	92.124	85.943	89.850
CARBON DIOXIDE	1.366	0.003	0.004	0.059	0.151
ETHANE	1.313	8.950	5.654	0.000	0.000
PROPANE	0.244	2.289	1.544	10.359	5.987
i-BUTANE	0.046	1.008	0.633	0.000	0.000
n-BUTANE	0.044	0.000	0.000	0.000	0.000
NEOPENTANE	0.000	0.000	0.000	0.000	0.000
i-PENTANE	0.015	0.000	0.000	0.000	0.000
n-PENTANE	0.010	0.000	0.000	0.000	0.000
OXYGEN	0.000	0.053	0.007	0.097	0.012
TOTAL	**100.000**	**100.000**	**100.000**	**100.000**	**100.000**
Compressibility Factor	0.9978	0.9973	0.9976	0.9972	0.9976
HHV (Btu/real cubic foot)	**1013.38**	**1136.77**	**1095.09**	**1134.45**	**1063.08**
LHV (Btu/real cubic foot)	912.85	1027.71	988.70	1026.62	960.19
Specific Gravity	0.5809	0.6375	0.6071	0.6719	0.6315
WOBBE Index	**1329.59**	**1423.75**	**1405.47**	**1383.99**	**1337.76**

Certificates and GC reports

Southern California Gas Company
Engineering Analysis Center
BTU content of Natural Gas by Gas Chromatography

Sample ID: Gas 3 Pod 1 03/28/06 1208-01
Data File ID: HC03475.dat_DA... **GC Used:** Hydrocarbon BTU GC
Analysis Date: 3/28/06 2:32:41 PM **Analyst:** lab

Component	Norm Mole %	(a) HHV	(b) LHV	(c) SG	Xi * HHV Btu/SCF	Xi * LHV Btu/SCF	Xi * SG	Unnorm
Methane	87.3607	1012.3	911.5	0.5539	884.4	796.3	0.4839	87.1949
Ethane	8.9496	1773.8	1622.4	1.0382	158.7	145.2	0.0929	8.9326
Propane	2.2889	2522.0	2320.3	1.5226	57.7	53.1	0.0349	2.2845
i-Butane	1.0084	3259.5	3007.3	2.0068	32.9	30.3	0.0202	1.0065
n-Butane	0.0000	3269.9	3017.8	2.0068	0.0	0.0	0.0000	0.0000
i-Pentane	0.0000	4010.2	3707.6	2.491	0.0	0.0	0.0000	0.0000
n-Pentane	0.0000	4018.0	3715.5	2.491	0.0	0.0	0.0000	0.0000
C6+	0.0001	5194.5	4421.3	3.2522	0.0	0.0	0.0000	0.0001
Oxygen	0.0526	0.0	0.0	1.1048	0.0	0.0	0.0006	0.0525
Nitrogen	0.3369	0.0	0.0	0.9672	0.0	0.0	0.0033	0.3363
CO2	0.0029	0.0	0.0	1.5196	0.0	0.0	0.0000	0.0029
	100.000				1133.7	1024.9	0.6358	99.8103

(d) Compressibility Factor (Z) for mixed gases

Total Inorganics:	0.3924
A=(Total SG)(0.0101)	0.0064
B=(Total Ing.)(0.007)	0.0000
Z = 1.00369 - A + B	0.9973

(e) Adjusted Values (14.73 psia, 60F, Gross, Dry, real volume basis)

High Heating Value	1136.773 BTU/real cubic foot
Low Heating Value	1027.708 BTU/real cubic foot
Specific Gravity	0.6375

(a) Higher Heating Value per Ideal CF @ 14.73 psia, GPA Standard 2145-03
(b) Lower Heating Value per Ideal CF @ 14.73 psia, GPSA Vol. II - Sec. 23 - Fig. 23-2 (1987)
(c) Specific Gravity, GPA Standard 2195 - 03
(d) Empirical Formula for Compressibility Factor, AGA Transmission Report No. 5
(e) Values reflect real volumes instead of ideal by dividing by the compressibility factor
(EXAMPLE: BTU/Ideal Gas Volume)/Z, Where Z = (real gas volume/ideal gas volume)

Analysts: ________________

QAQC: ________________

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CERTIFIED WORKING CLASS
Single-Certified Calibration Standard

Scott Specialty Gases
2600 CAJON BLVD, SAN BERNARDINO, CA 92411
Phone: 909-887-2571 Fax: 909-887-0549

CERTIFICATE OF ACCURACY: Certified Working Class Calibration Standard

Product Information
Project No.: 02-42264-001
Item No.: 0202E400093TK
P.O. No.: 4400050784

Cylinder Number: K025375
Cylinder Size: K
Certification Date: 07Mar2006
Expiration Date: 06Mar2008

Customer
SOUTHERN CALIFORNIA GAS
BLDG H-EAC-M.L. 723B
8730 E. SLAUSON AVE.
PICO RIVERA, CA 90660

CERTIFIED CONCENTRATION

Component Name	Concentration (Moles)	Accuracy (+/-%)
ETHANE	9.23 %	5
ISOBUTANE	1.0 %	5
METHANE	87.0 %	2
PROPANE	2.76 %	5

TRACEABILITY

Traceable To

NIST

APPROVED BY: B. McCully BLM DATE: 3/7/06

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SPECIFICATIONS

Component Name	Requested Concentration (Moles)	Certified Concentration (Moles)	Blend Tolerance Result (+/- %)	Certified Accuracy Result (+/- %)
ETHANE	9.23 %	9.23 %	.0	5.00
ISOBUTANE	0.99 %	1.0 %	1.0	5.00
METHANE	87.02 %	87.0 %	.0	2.00
PROPANE	2.76 %	2.76 %	.0	5.00

TRACEABILITY

Traceable To
NIST

PHYSICAL PROPERTIES

Cylinder Size: K

Pressure: 1833 PSIG
Expiration Date: 06Mar2008

Valve Connection: CGA 350 BRASS

SPECIAL HANDLING INSTRUCTIONS

Do not use or store cylinder at or below the stated dew point temperature. Possible condensation of heavier components could result. In the event the cylinder has been exposed to temperatures at or below the dew point, place cylinder in heated area for 24 hours and then roll cylinder for 15 minutes to re-mix.

Use of calibration standards at or below dew point temperature may result in calibration error.

COMMENTS

PGS# 58
BTU VALUE: 1146.8
WOBBE FACTOR: 1433.6
CYLINDER CONTENTS: APPROX. 275 CUBIC FEET

Page 2 of 2

Southern California Gas Company
Engineering Analysis Center
BTU content of Natural Gas by Gas Chromatography

Sample ID: Gas 6 Single Pico Rivera 1208-03
Data File ID: HC03476.dat_DA... **GC Used:** Hydrocarbon BTU GC
Analysis Date: 3/28/06 2:49:56 PM **Analyst:** lab

Component	Norm Mole %	(a) HHV	(b) LHV	(c) SG	Xi * HHV Btu/SCF	Xi * LHV Btu/SCF	Xi * SG	Unnorm
Methane	92.1242	1012.3	911.5	0.5539	932.6	839.7	0.5103	92.0700
Ethane	5.6543	1773.8	1622.4	1.0382	100.3	91.7	0.0587	5.6510
Propane	1.5437	2522.0	2320.3	1.5226	38.9	35.8	0.0235	1.5427
i-Butane	0.6332	3259.5	3007.3	2.0068	20.6	19.0	0.0127	0.6328
n-Butane	0.0000	3269.9	3017.8	2.0068	0.0	0.0	0.0000	0.0000
i-Pentane	0.0000	4010.2	3707.6	2.491	0.0	0.0	0.0000	0.0000
n-Pentane	0.0000	4018.0	3715.5	2.491	0.0	0.0	0.0000	0.0000
C6+	0.0000	5194.5	4421.3	3.2522	0.0	0.0	0.0000	0.0000
Oxygen	0.0070	0.0	0.0	1.1048	0.0	0.0	0.0001	0.0070
Nitrogen	0.0338	0.0	0.0	0.9672	0.0	0.0	0.0003	0.0338
CO2	0.0038	0.0	0.0	1.5196	0.0	0.0	0.0001	0.0038
	100.000				1092.4	986.3	0.6057	99.9412

(d) Compressibility Factor (Z) for mixed gases

Total Inorganics:	**0.0446**
A=(Total SG)(0.0101)	**0.0061**
B=(Total Ing.)(0.007)	**0.0000**
Z = 1.00369 - A + B	**0.9976**

(e) Adjusted Values (14.73 psia, 60F, Gross, Dry, real volume basis)

High Heating Value	**1095.094**	**BTU/real cubic foot**
Low Heating Value	**988.704**	**BTU/real cubic foot**
Specific Gravity	**0.6071**	

(a) Higher Heating Value per Ideal CF @ 14.73 psia, GPA Standard 2145-03
(b) Lower Heating Value per Ideal CF @ 14.73 psia, GPSA Vol. II - Sec. 23 - Fig. 23-2 (1987)
(c) Specific Gravity, GPA Standard 2195 - 03
(d) Empirical Formula for Compressibility Factor, AGA Transmission Report No. 5
(e) Values reflect real volumes instead of ideal by dividing by the compressibility factor
(EXAMPLE: BTU/Ideal Gas Volume)/Z, Where Z = (real gas volume/ideal gas volume)

Analysts: ________________

QAQC: ________________

03/28/06 02:49:58 PM 1/1 - 1

CERTIFIED WORKING CLASS

Single-Certified Calibration Standard

Scott Specialty Gases
2600 CAJON BLVD. SAN BERNARDINO,CA 92411
Phone: 909-887-2571 Fax: 909-887-0549

CERTIFICATE OF ACCURACY: Certified Working Class Calibration Standard

Product Information
Project No.: 02-42264-002
Item No.: 0202E400094TK
P.O. No.: 4400050784

Cylinder Number: K025371
Cylinder Size: K
Certification Date: 03Mar2006
Expiration Date: 03Mar2008

Customer

SOUTHERN CALIFORNIA GAS
BLDG H-EAC-M.L. 723B
8730 E. SLAUSON AVE.
PICO RIVERA, CA 90660

CERTIFIED CONCENTRATION

Component Name	Concentration (Moles)	Accuracy (+/-%)
ETHANE	5.81 %	5
ISOBUTANE	0.62 %	5
METHANE	91.82 %	2
PROPANE	1.74 %	5

TRACEABILITY

Traceable To

NIST

APPROVED BY: B. McNally BLM DATE: 3/3/06

Page 1 of 2

SPECIFICATIONS

Component Name	Requested Concentration (Moles)	Certified Concentration (Moles)	Blend Tolerance Result (+/- %)	Certified Accuracy Result (+/- %)
ETHANE	5.81 %	5.81 %	.0	5.00
ISOBUTANE	0.62 %	0.62 %	.0	5.00
METHANE	91.83 %	91.82 %	.0	2.00
PROPANE	1.74 %	1.74 %	.0	5.00

TRACEABILITY

Traceable To
NIST

PHYSICAL PROPERTIES

Cylinder Size: K
Dew Point: 32 F
Pressure: 2000 PSIG
Expiration Date: 03Mar2008
Valve Connection: CGA 350, BRASS

SPECIAL HANDLING INSTRUCTIONS

Do not use or store cylinder at or below the stated dew point temperature. Possible condensation of heavier components could result. In the event the cylinder has been exposed to temperatures at or below the dew point, place cylinder in heated area for 24 hours and then roll cylinder for 15 minutes to re-mix.

Use of calibration standards at or below dew point temperature may result in calibration error.

COMMENTS

PGS# 58
BTU VALUE: 1096.7
WOBBE FACTOR: 1406.6
CYLINDER CONTENTS: APPROX. 299 CUBIC FEET

Page 2 of 2

Southern California Gas Company
Engineering Analysis Center
BTU content of Natural Gas by Gas Chromatography

Sample ID: Gas 7 Pod 1 1205-03
Data File ID: HC03461.dat_DA... **GC Used:** Hydrocarbon BTU GC
Analysis Date: 3/24/06 12:18:49 ... **Analyst:** lab

Component	Norm Mole %	(a) HHV	(b) LHV	(c) SG	Xi * HHV Btu/SCF	Xi * LHV Btu/SCF	Xi * SG	Unnorm
Methane	85.9429	1012.3	911.5	0.5539	870.0	783.4	0.4760	85.5596
Ethane	0.0000	1773.8	1622.4	1.0382	0.0	0.0	0.0000	0.0000
Propane	10.3588	2522.0	2320.3	1.5226	261.2	240.4	0.1577	10.3126
i-Butane	0.0000	3259.5	3007.3	2.0068	0.0	0.0	0.0000	0.0000
n-Butane	0.0000	3269.9	3017.8	2.0068	0.0	0.0	0.0000	0.0000
i-Pentane	0.0000	4010.2	3707.6	2.491	0.0	0.0	0.0000	0.0000
n-Pentane	0.0000	4018.0	3715.5	2.491	0.0	0.0	0.0000	0.0000
C6+	0.0000	5194.5	4421.3	3.2522	0.0	0.0	0.0000	0.0000
Oxygen	0.0974	0.0	0.0	1.1048	0.0	0.0	0.0011	0.0970
Nitrogen	3.5421	0.0	0.0	0.9672	0.0	0.0	0.0343	3.5263
CO2	0.0587	0.0	0.0	1.5196	0.0	0.0	0.0009	0.0585
	100.000				1131.2	1023.7	0.6700	99.5540

(d) Compressibility Factor (Z) for mixed gases

Total Inorganics:	**3.6982**
A=(Total SG)(0.0101)	**0.0068**
B=(Total Ing.)(0.007)	**0.0003**
Z = 1.00369 - A + B	**0.9972**

(e) Adjusted Values (14.73 psia, 60F, Gross, Dry, real volume basis)

High Heating Value	**1134.447 BTU/real cubic foot**
Low Heating Value	**1026.619 BTU/real cubic foot**
Specific Gravity	**0.6719**

(a) Higher Heating Value per Ideal CF @ 14.73 psia, GPA Standard 2145-03
(b) Lower Heating Value per Ideal CF @ 14.73 psia, GPSA Vol. II - Sec. 23 - Fig. 23-2 (1987)
(c) Specific Gravity, GPA Standard 2195 - 03
(d) Empirical Formula for Compressibility Factor, AGA Transmission Report No. 5
(e) Values reflect real volumes instead of ideal by dividing by the compressibility factor
(EXAMPLE: BTU/Ideal Gas Volume)/Z, Where Z = (real gas volume/ideal gas volume)

Analysts: ________________

QAQC: ________________

03/24/06 12:18:50 PM 1/1 - 1

CERTIFIED WORKING CLASS
Single-Certified Calibration Standard

Scott Specialty Gases
2600 CAJON BLVD. SAN BERNARDINO,CA 92411
Phone: 909-887-2571 Fax: 909-887-0549

CERTIFICATE OF ACCURACY: Certified Working Class Calibration Standard

Product Information
Project No.: 02-42264-003
Item No.: 0202M300087TK
P.O. No.: 4400050784

Cylinder Number: K025385
Cylinder Size: K
Certification Date: 13Mar2006
Expiration Date: 12Mar2008

Customer
SOUTHERN CALIFORNIA GAS
BLDG H-EAC-M.L. 723B
8730 E. SLAUSON AVE.
PICO RIVERA, CA 90660

CERTIFIED CONCENTRATION

Component Name	Concentration (Moles)	Accuracy (+/-%)
METHANE	86.1 %	2
NITROGEN	2.97 %	5
PROPANE	10.9 %	5

TRACEABILITY

Traceable To

NIST

APPROVED BY: B. McCully BLM

DATE: 3/14/06

Page 1 of 2

SPECIFICATIONS

Component Name	Requested Concentration (Moles)	Certified Concentration (Moles)	Blend Tolerance Result (+/- %)	Certified Accuracy Result (+/- %)
METHANE	86.1 %	86.1 %	.0	2.00
NITROGEN	3. %	2.97 %	1.0	5.00
PROPANE	10.9 %	10.9 %	.0	5.00

TRACEABILITY

Traceable To
NIST

PHYSICAL PROPERTIES

Cylinder Size: K

Pressure: 630 PSIG
Expiration Date: 12Mar2008

Valve Connection: CGA 350, BRASS

SPECIAL HANDLING INSTRUCTIONS

Do not use or store cylinder at or below the stated dew point temperature. Possible condensation of heavier components could result. In the event the cylinder has been exposed to temperatures at or below the dew point, place cylinder in heated area for 24 hours and then roll cylinder for 15 minutes to re-mix.

Use of calibration standards at or below dew point temperature may result in calibration error.

COMMENTS

PGS# 58
DUE: 3-22-06
BTU VALUE: 1147
WOBBE FACTOR: 1399.2

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Southern California Gas Company
Engineering Analysis Center
BTU content of Natural Gas by Gas Chromatography

Sample ID: Gas 8 Pod 1Pico Rivera 1208-07
Data File ID: HC03478.dat_DA... **GC Used:** Hydrocarbon BTU GC
Analysis Date: 3/28/06 3:22:57 PM **Analyst:** lab

	Norm	(a)	(b)	(c)	Xi * HHV	Xi * LHV		
Component	**Mole %**	**HHV**	**LHV**	**SG**	**Btu/SCF**	**Btu/SCF**	**Xi * SG**	Unnorm
Methane	89.8502	1012.3	911.5	0.5539	909.6	819.0	0.4977	89.3975
Ethane	0.0000	1773.8	1622.4	1.0382	0.0	0.0	0.0000	0.0000
Propane	5.9872	2522.0	2320.3	1.5226	151.0	138.9	0.0912	5.9570
i-Butane	0.0000	3259.5	3007.3	2.0068	0.0	0.0	0.0000	0.0000
n-Butane	0.0000	3269.9	3017.8	2.0068	0.0	0.0	0.0000	0.0000
i-Pentane	0.0000	4010.2	3707.6	2.491	0.0	0.0	0.0000	0.0000
n-Pentane	0.0000	4018.0	3715.5	2.491	0.0	0.0	0.0000	0.0000
C6+	0.0000	5194.5	4421.3	3.2522	0.0	0.0	0.0000	0.0000
Oxygen	0.0122	0.0	0.0	1.1048	0.0	0.0	0.0001	0.0121
Nitrogen	3.9994	0.0	0.0	0.9672	0.0	0.0	0.0387	3.9792
CO2	0.1511	0.0	0.0	1.5196	0.0	0.0	0.0023	0.1503
	100.000				1060.5	957.9	0.6300	99.4961

(d) Compressibility Factor (Z) for mixed gases

Total Inorganics:	**4.1626**
A=(Total SG)(0.0101)	**0.0064**
B=(Total Ing.)(0.007)	**0.0003**
Z = 1.00369 - A + B	**0.9976**

(e) Adjusted Values (14.73 psia, 60F, Gross, Dry, real volume basis)

High Heating Value	**1063.081**	**BTU/real cubic foot**
Low Heating Value	**960.191**	**BTU/real cubic foot**
Specific Gravity	**0.6315**	

(a) Higher Heating Value per Ideal CF @ 14.73 psia, GPA Standard 2145-03
(b) Lower Heating Value per Ideal CF @ 14.73 psia, GPSA Vol. II - Sec. 23 - Fig. 23-2 (1987)
(c) Specific Gravity, GPA Standard 2195 - 03
(d) Empirical Formula for Compressibility Factor, AGA Transmission Report No. 5
(e) Values reflect real volumes instead of ideal by dividing by the compressibility factor
(EXAMPLE: BTU/Ideal Gas Volume)/Z, Where Z = (real gas volume/ideal gas volume)

Analysts: ________________

QAQC: ________________

03/28/06 03:22:58 PM 1/1 - 1

CERTIFIED WORKING CLASS

Single-Certified Calibration Standard

Scott Specialty Gases
2600 CAJON BLVD., SAN BERNARDINO, CA 92411
Phone: 909-887-2571 Fax: 909-887-0549

CERTIFICATE OF ACCURACY: Certified Working Class Calibration Standard

Product Information
Project No.: 02-42264-004
Item No.: 0202M300086TK
P.O. No.: 4400050784

Cylinder Number: 1D1727
Cylinder Size: K
Certification Date: 16Mar2006
Expiration Date: 15Mar2008

Customer

SOUTHERN CALIFORNIA GAS
BLDG H-EAC-M.L. 723B
8730 E. SLAUSON AVE.
PICO RIVERA, CA 90660

CERTIFIED CONCENTRATION

Component Name	Concentration (Moles)	Accuracy (+/-%)
METHANE	89.6 %	2
NITROGEN	3.98 %	5
PROPANE	6.40 %	5

TRACEABILITY

Traceable To

NIST

APPROVED BY: B. McCully
BLM

DATE: 3/17/06

Page 1 of 2

SPECIFICATIONS

Component Name	Requested Concentration (Moles)	Certified Concentration (Moles)	Blend Tolerance Result (+/- %)	Certified Accuracy Result (+/- %)
METHANE	89.6 %	89.6 %	.0	2.00
NITROGEN	4. %	3.98 %	.5	5.00
PROPANE	6.4 %	6.40 %	.0	5.00

TRACEABILITY

Traceable To
NIST

PHYSICAL PROPERTIES

Cylinder Size: K

Pressure: 1071 PSIG
Expiration Date: 15Mar2008

Valve Connection: CGA 350, BRASS

SPECIAL HANDLING INSTRUCTIONS

Do not use or store cylinder at or below the stated dew point temperature. Possible condensation of heavier components could result. In the event the cylinder has been exposed to temperatures at or below the dew point, place cylinder in heated area for 24 hours and then roll cylinder for 15 minutes to re-mix.

Use of calibration standards at or below dew point temperature may result in calibration error.

COMMENTS

PGS# 58
DUE: 3-22-06
BTU VALUE: 1068.7
WOBBE FACTOR: 1343.9

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Appendix D: Zero, Span and Linearity Table and Certificates

	Zero, Span & Linearity Data Rich Burn Engine Testing April 26, 2006	O_2 (%)	CO_2 (%)	CO (ppm)	HC (ppm)	NO_x (ppm)
Zero	**Analyzer Emission Ranges**	**0-5**	**0 - 20**	**0-10,000**	**0-10,000**	**0-10,000**
Zero	**Zero Calibration Gas (Low-Range Values)**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Zero	**Allowable Zero Drift (Less Than ± 3% of Range)**	**0.75**	**0.60**	**6.00**	**300.00**	**3.00**
Zero	Zero Calibration - 9:22:00 AM	0.02	0.00	0.00	0.00	-0.01
Zero	Zero Drift Check -2:02:00 PM	0.05	0.00	0.00	0.00	0.00
Zero	**Total Drift Over Test Period**	**0.03**	**0.00**	**0.00**	**0.00**	**0.01**
Zero	**Was the Zero Drift Within Allowable Deviation?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Span	**Span Calibration Gas (High-Range Values)**	**3.96[2]**	**16.03[2]**	**8613[2]**	**2800[4]**	**3819**
Span	**Allowable Span Drift (Less Than ± 3% of Range)**	**0.75**	**0.60**	**6.00**	**300**	**3.00**
Span	Span Calibration - 9:23:00 AM	3.97	15.89	8615	2800	3819
Span	Span Drift Check - 1:40:00 PM	3.93	15.90	8616	2820	3818
Span	**Total Drift Over Test Period**	**0.04**	**0.01**	**1.00**	**20**	**1.00**
Span	**Was the Span Drift Within Allowable Deviation?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Linearity	**Linearity Calibration Gas (Mid-Range Values)**	**1.98[1]**	**7.88[1]**	**4471[1]**	**2800[4]**	**476.2[3]**
Linearity	**Allowable Linearity Drift (Less Than ±1% of Range)**	**0.25**	**0.20**	**2.00**	**100**	**1.00**
Linearity	Linearity Check - 09:52:00 AM	1.98	7.89	4471.30	2800	477.10
Linearity	**Difference From Mid-Range Values**	**0.00**	**0.01**	**0.30**	**0.00**	**0.90**
Linearity	**Was the Linearity Within Allowable Deviation?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Linearity	Linearity Check - 01:48:00 PM	2.02	7.80	4472	2820	477.90
Linearity	**Difference From Mid-Range Values**	**0.04**	**0.09**	**0.70**	**20.00**	**0.80**
Linearity	**Was the Linearity Within Allowable Deviation?**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

1 - Tank CC -128558: CO_2 7.88%, CO 4,471 ppm, O_2 1.977%

2 - Tank CC - 94500: CO_2 16.03%, CO 8,613 ppm, O_2 3.96%

3 - Tank AAL - 4788: NO_X 476.2 ppm

4 - Tank CC - 126804: HC 2,800 ppm

Certificates

SPECTRA GASES

3434 Route 22 West • Branchburg, NJ 08876 USA Tel: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811

Website: http://www.spectra-gases.com

SHIPPED FROM: 80 INDUSTRIAL DRIVE ALPHA, NJ. 08865 TEL: (908) 454-7455

SHIPPED TO: Southern California Gas Co.
8730 E. Slauson Ave, Bldg H
Pico Rivera, CA 90660

CERTIFICATE
OF
ANALYSIS

SGI ORDER # : 0054412
ITEM# : 8
CERTIFICATION DATE: 6/7/2004
P.O.# : Verbal-Cyrus
BLEND TYPE: CERTIFIED

CYLINDER # : CC-126804
CYLINDER PRES: 2000 psig
CYLINDER VALVE: CGA 350

ANALYTICAL ACCURACY: + / - 2%

COMPONENT	REQUESTED GAS CONC	ANALYSIS
Methane	2,780 ppm	2,800 ppm
Nitrogen	Balance	Balance

ANALYST: Cheryl Patino (signature)
Cheryl Patino

DATE: 6/10/2004

USA • United Kingdom • Germany • Japan
ISO 9001

SPECTRA GASES INC.

3434 Route 22 West • Branchburg, NJ 08876 USA Tel.: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811
Shipped From: 80 Industrial Drive • Alpha, NJ 08865

CERTIFICATE OF ANALYSIS

2A SIZE

EPA PROTOCOL MIXTURE

PROCEDURE # : G1

CUSTOMER: Southern California Gas Co.
SGI ORDER # : 0053375
ITEM# : 2
P.O.# : 8595072200-1180
8245072200 1180

CYLINDER # : CC-128558
CYLINDER PRES: 2000 PSIG
CGA OUTLET: 350

CERTIFICATION DATE: 5/20/2004
EXPIRATION DATE: 5/20/2007

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Carbon Dioxide	5/20/2004	7.88 %	7.88 %	+/- 1%
Carbon Monoxide	5/13/2004 5/20/2004	4472 ppm 4471 ppm	4471 ppm	+/- 1%
Oxygen	5/20/2004	1.977 %	1.977 %	+/- 1%

BALANCE Nitrogen

PREVIOUS CERTIFICATION DATES: None

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Carbon Dioxide	GMIS-1	CC-90832	9.99 %
Carbon Monoxide	GMIS-1	CC-118667	5023 ppm
Oxygen	GMIS-1	CC-94813	2.02 %

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL #	DETECTOR	CALIBRATION DATE(S)
Carbon Dioxide	Horiba VIA-510	571417045	NDIR	4/29/2004
Carbon Monoxide	Horiba VIA-510	42331960012	NDIR	5/6/2004
Oxygen	Horiba MPA-510	570694081	PM	5/20/2004

THIS STANDARD IS NIST TRACEABLE. IT WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES.
DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST: Cheryl Patino
CHERYL PATINO

DATE: 5/20/2004

SPECTRA GASES INC.

3434 Route 22 West • Branchburg, NJ 08876 USA Tel.: (908) 252-9300 • (800) 932-0624 • Fax: (908) 252-0811
Shipped From: 80 Industrial Drive • Alpha, NJ 08865 www.spectra-gases.com

CERTIFICATE OF ANALYSIS

EPA PROTOCOL MIXTURE
PROCEDURE # : G1

CUSTOMER: Southern California Gas Co.
SGI ORDER # : 0072392
ITEM# : 1
P.O.# : SG824507GS

CYLINDER # : CC-94500
CYLINDER PRES: 2000 PSIG
CGA OUTLET: 350

CERTIFICATION DATE: 6/10/2005
EXPIRATION DATE: 6/10/2008

CERTIFICATION HISTORY

COMPONENT	DATE OF ASSAY	MEAN CONCENTRATION	CERTIFIED CONCENTRATION	ANALYTICAL ACCURACY
Carbon Dioxide	6/10/2005	16.03 %	16.03 %	+/- 1%
Carbon Monoxide	6/3/2005 6/10/2005	8608 ppm 8618 ppm	8613 ppm	+/- 1%
Oxygen	6/10/2005	3.96 %	3.96 %	+/- 1%

BALANCE Nitrogen

PREVIOUS CERTIFICATION DATES: None

REFERENCE STANDARDS

COMPONENT	SRM/NTRM#	CYLINDER#	CONCENTRATION
Carbon Dioxide	NTRM-82745x	CC-79803	20.0 %
Carbon Monoxide	GMIS-1	CC-113877	0.995 %
Oxygen	GMIS-1	CC-106741	4.99 %

INSTRUMENTATION

COMPONENT	MAKE/MODEL	SERIAL #	DETECTOR	CALIBRATION DATE(S)
Carbon Dioxide	CAI-300	S03001	NDIR	6/1/2005
Carbon Monoxide	Horiba VIA-510	42331960012	NDIR	6/3/2005
Oxygen	Horiba MPA-510	570694081	PM	6/1/2005

THIS STANDARD IS NIST TRACEABLE. IT WAS CERTIFIED ACCORDING TO THE EPA PROTOCOL PROCEDURES.
DO NOT USE THIS STANDARD IF THE CYLINDER PRESSURE IS LESS THAN 150 PSIG.

ANALYST: [signature] CHERYL PATINO

DATE: 6/10/2005

RATA CLASS

Scott Specialty Gases

Dual-Analyzed Calibration Standard

2600 CAJON BLVD., SAN BERNARDINO, CA 92411 Phone: 909-887-2571 Fax: 909-887-0549

CERTIFICATE OF ACCURACY: EPA Protocol Gas

Assay Laboratory

SCOTT SPECIALTY GASES
2600 CAJON BLVD.
SAN BERNARDINO, CA 92411

P.O. No.: FG85950722002200118
Project No.: 02-33900-001

Customer

SOUTHERN CALIFORNIA GAS
APPLIED TECH AIR QUALITY
ENG ANALYSIS CTR BLDG H
8730 E. SLAUSON AVENUE
PICO RIVERA CA 90660

ANALYTICAL INFORMATION

This certification was performed according to EPA Traceability Protocol For Assay & Certification of Gaseous Calibration Standards; Procedure G-1; September, 1997.

Cylinder Number: AAL4788 **Certification Date:** 19Oct2004 **Exp. Date:** 19Oct2006

Cylinder Pressure*:** 2000 PSIG

COMPONENT	CERTIFIED CONCENTRATION (Moles)		ANALYTICAL ACCURACY**	TRACEABILITY
NITRIC OXIDE	473.4	PPM	+/- 1%	Direct NIST and NMi
NITROGEN - OXYGEN FREE		BALANCE		
TOTAL OXIDES OF NITROGEN	476.2	PPM		Reference Value Only

*** Do not use when cylinder pressure is below 150 psig.
** Analytical accuracy is based on the requirements of EPA Protocol Procedure G1, September 1997.
Product certified as +/- 1% analytical accuracy is directly traceable to NIST or NMI standards.

EFERENCE STANDARD

TYPE/SRM NO.	EXPIRATION DATE	CYLINDER NUMBER	CONCENTRATION	COMPONENT
NTRM 1687	01Feb2007	AAL0678891	976.5 PPM	NITRIC OXIDE

INSTRUMENTATION

INSTRUMENT/MODEL/SERIAL#	DATE LAST CALIBRATED	ANALYTICAL PRINCIPLE
MKS Online/2030/0929060	16Sep2004	FTIR

ANALYZER READINGS

(Z = Zero Gas R = Reference Gas T = Test Gas r = Correlation Coefficient)

NITRIC OXIDE

First Triad Analysis

Date: 11Oct2004	Response Unit:PPM	
Z1 = -0.04171	R1 = 242.7311	T1 = 474.1067
R2 = 242.7329	Z2 = -0.02780	T2 = 474.2849
Z3 = 0.01280	T3 = 474.5177	R3 = 242.7413
Avg. Concentration:	472.1	PPM

Second Triad Analysis

Date: 19Oct2004	Response Unit: PPM	
Z1 = -0.06649	R1 = 971.3696	T1 = 472.7895
R2 = 972.9679	Z2 = 0.02269	T2 = 473.0930
Z3 = 0.10862	T3 = 473.1233	R3 = 974.0912
Avg. Concentration:	474.8	PPM

Calibration Curve

Concentration = A + Bx + Cx2 + Dx3 + Ex4
r = 9.99992E-1

Constants:	A = 0.00000E + 0
B = 4.23978E-1	C = 2.90000E-5
D = 0.00000E + 0	E = 0.00000E + 0

Special Notes: PGS# 78 DUE: 11-3-04

APPROVED BY: ____________
Carolyn Gin

Appendix E: Calculations

Emission Concentrations

Corrected to O_2 Standard (15% O_2)

$$\text{CO, HC \& NO}_x \text{ Concentrations (corrected to 15\% O}_2\text{)} = \text{Raw Concentrations (ppm)} \times \left[\frac{20.9 - 15}{20.9 - \%O_2}\right]$$

Where

Raw Concentration = Measured CO, VOC & NO_x concentrations, by volume (ppm)

% O_2 = Measured O_2 Concentration

Gas Meter Accuracy Table

The gas meter used during testing was compared to a certified bell prover to determine its accuracy (error percentage) at various flow rates.

The gas meter accuracy table (below) shows the prover flow rates that the meter was tested, error percentage for each accuracy test and an average meter error.

Also included on the table is a gas meter flow rate. The gas meter flow rate is the meter's reading at each prover flow rate when the average meter error is factored in. This flow rate was calculated using the meter accuracy equation:

$$\%\,\text{Error} = \left(\frac{\text{Gas Meter Flow - Prover Flow}}{\text{Prover Flow}}\right) \times 100$$

Through algebraic manipulation, the gas meter flow is determined using the following equation:

$$\text{Gas Meter Flow} = \text{Prover Flow} \times \left(1 + \frac{\%\,\text{Error}}{100}\right)$$

A negative error percentage indicates the gas meter flow rate was below the prover flow rate whereas a positive error percentage indicates the gas meter flow rate was above the prover flow rate.

Model Number: 3M175 **Date:** June 30, 2006 **Meter Number:** 10266179 **Prepared By:** David Ceballos **Serial Number:** 9590094 CPUC CERTIFICATE OF BELL PROVER				
REPEATABILITY				
Prover Flow Rate cfh	**Gas Meter Error Percentage**		**Average Meter Error**	**Gas Meter Flow Rate** cfh
	% CORR.	**% CORR.**		
300	0.26%	0.32%	**0.29%**	**300.87**
600	0.33%	0.28%	**0.31%**	**601.83**
1500	0.49%	0.48%	**0.49%**	**1507.28**
2100	0.58%	0.58%	**0.58%**	**2112.18**
2700	0.59%	0.58%	**0.59%**	**2715.80**

Actual Gas Flow with Meter Correction (acfh)

To correct the actual gas flow that was measured during testing, a gas meter flow rate range is selected from the meter accuracy table. The gas meter flow rates and the average meter error (divided by 100) will be used to calculate the meter correction factor at any given gas flow rate.

Setting y = average meter error (divided by 100) and x = gas meter flow rate, the error can be calculated using the following equation:

$$\frac{y - y_0}{y_1 - y_0} = \frac{x - x_0}{x_1 - x_0}$$

Manipulating the right side of the equation algebraically:

$$\alpha = \frac{x - x_0}{x_1 - x_0}$$

The equation would then simplify into:

$$y = \frac{y_1 - y_0}{x_1 - x_0}(x - x_0) + y_0$$

If the appliance has an actual gas flow rate (F_A) of 610.0 actual cubic feet per hour (acfh), the gas meter flow rate range would be 601.83 to 1507.28 acfh and the average meter error range (divided by 100) would be 0.0031 to 0.0049. Using this information, the meter error (y) is:

$$y = \frac{0.0049 - 0.0031}{1507.28\,\text{acfh} - 601.83\,\text{acfh}}\left(610.0\,\text{acfh} - 601.83\,\text{acfh}\right) + 0.0031 = 0.003116$$

Once the meter error is known, the actual gas flow rate with meter correction ($F_{meter.}$) can be calculated using the following equation:

$$F_{meter} = \frac{F_A}{(1+y)}$$

$$F_{meter} = \frac{610.0\,\text{acfh}}{(1+0.003116)} = 608.105\,\text{acfh}$$

Corrected Gas Flow (scfh)

$$F_{corrected} = F_{meter} \times \left[\frac{P_{Fuel}\,(\text{psig}) + P_1\,(\text{psia})}{P_{standard}}\right] \times \left[\frac{T_{standard}}{T_{Fuel}\,(^{\circ}\text{F}) + 459.67}\right]$$

Where

$F_{corrected}$ = Gas flow corrected to standard temperature and pressure (scfh)

F_{meter} = Actual gas flow with meter correction (acfh)

P_{Fuel} = Natural gas inlet pressure (psig)

P_1 = Average pressure in Pico Rivera at an average elevation of 161 ft (psia)

$P_{standard}$ = Standard atmospheric pressure (14.735 psia @ 60°F)

$T_{standard}$ = Standard atmospheric temperature (519.67 R @ 1 atm)

T_{Fuel} = Fuel temperature (°F)

Input Rate (Btu/cf)

$$\text{Input Rate} = \text{Corrected Gas Flow} \times \text{HHV}$$

Where

HHV = Higher Heating Value (Btu/cf)

Wobbe Number (Btu/cf)

$$W_0 = \frac{\text{HHV}}{\sqrt{G}}$$

Where

W_0 = Wobbe Number (Btu/cf)

HHV = Higher Heating Value (Btu/cf)

G = Specific gravity of gas sample

Appendix F: Test Equipment from SoCalGas

Emissions Analyzer and Conditioner				
Analyzer Range	**Manufacturer**	**Model**	**Type**	**Accuracy**
NO/NO_X 0 - 10,000 ppm	Thermo Environmental Instruments Inc.	10AR	Chemiluminescent	± 1% of full scale
CO 0 - 10,000 ppm	Thermo Environmental Instruments Inc.	48H	Nondispersive infrared (NDIR) gas analyzer	± 1% of full scale
CO_2 0 - 20 %	Fuji	ZRH	Nondispersive infrared (NDIR) gas analyzer	± 1% of full scale
HC 0 - 10,000 ppm	California Analytical Instruments, Inc.	300 HFID	Flame ionization detector (FID)	± 1% of full scale
O_2 0 - 5 %	Teledyne	326RA	Electrochemical cell	± 1% of full scale
Flow Rate 0 - 10 L/M (at STP)	Universal Analyzers Inc.	Blower Series 3080	Thermoelectric gas sample cooler	n/a

Calibration & Span Gases			
Gas	**Manufacturer**	**Type**	**Accuracy**
Calibration	Scott Specialty Gases	EPA Protocol Gas	± 1%
NO/NO_X	Praxair	EPA Protocol Gas	± 1%
CO	Spectra	EPA Protocol Gas	± 1%
CO_2	Spectra	EPA Protocol Gas	± 1%
HC	Scott Specialty Gases	Certified Master Class	± 2%
O_2	Spectra	EPA Protocol Gas	± 1%

Gas Delivery System				
Equipment Range	**Manufacturer**	**Model**	**Type**	**Accuracy**
Data logger	Delphin	Top Message	Data logging system	n/a
Gas Meter	Roots Meter	3M175	Dry meter - 3000 cfh max	99.90%
Pressure Sensor 0 - 10 in. w.c	Dwyres	607-8	Pressure Transducer	± 0.5%
Pressure Sensor 0 - 15 psig	Omega Engineering Co.	PX205-015GI	Pressure Transducer	0.25%
Pulser	IMAC System Inc	300-5D-100	100 pulses per 10 cu ft	n/a

Thermocouples & Pressure Transducers			
Type	**Manufacturer**	**Model**	**Accuracy**
K	Omega Engineering Co.	KMQSS	4.0^{o} F or 0.75%
J	Omega Engineering Co.	JMQSS	4.0^{o} F or 0.75%

Appendix F: Test Equipment from Advance Engine Technology Corporation

AETC Mobile CEMS is based on a transportable office trailer carrying a fully automated CEMS. The 15' insulated, air-conditioned trailer houses the workspace, communications, PC's, calibration gasses and CEMS rack. The Mobile CEMS has been used for many District approved Alternative Continuous Emission Monitoring System (ACEMS) certification tests and recent research projects.

The CEMS rack houses the Rosemount analyzers, sample conditioning unit, DAQ and alarm panel. Analyzers are- Rosemount NO2 NGL/PMP paramagnetic, Rosemount NOx/NO CDL chemiluminescent, and Rosemount CO 880A NDIR (with high pressure capillary CO2 compensation). Stack gas was taken from a single point in the port normally used for reference method tests. Calibration gas is administered at the probe. Stack gas travels in a heated umbilical, 300deg F to the CEMS rack. A model 3050 Universal Analyzer sample conditioning unit handles water knockout and constant pressure sample gas delivery to the analyzers.

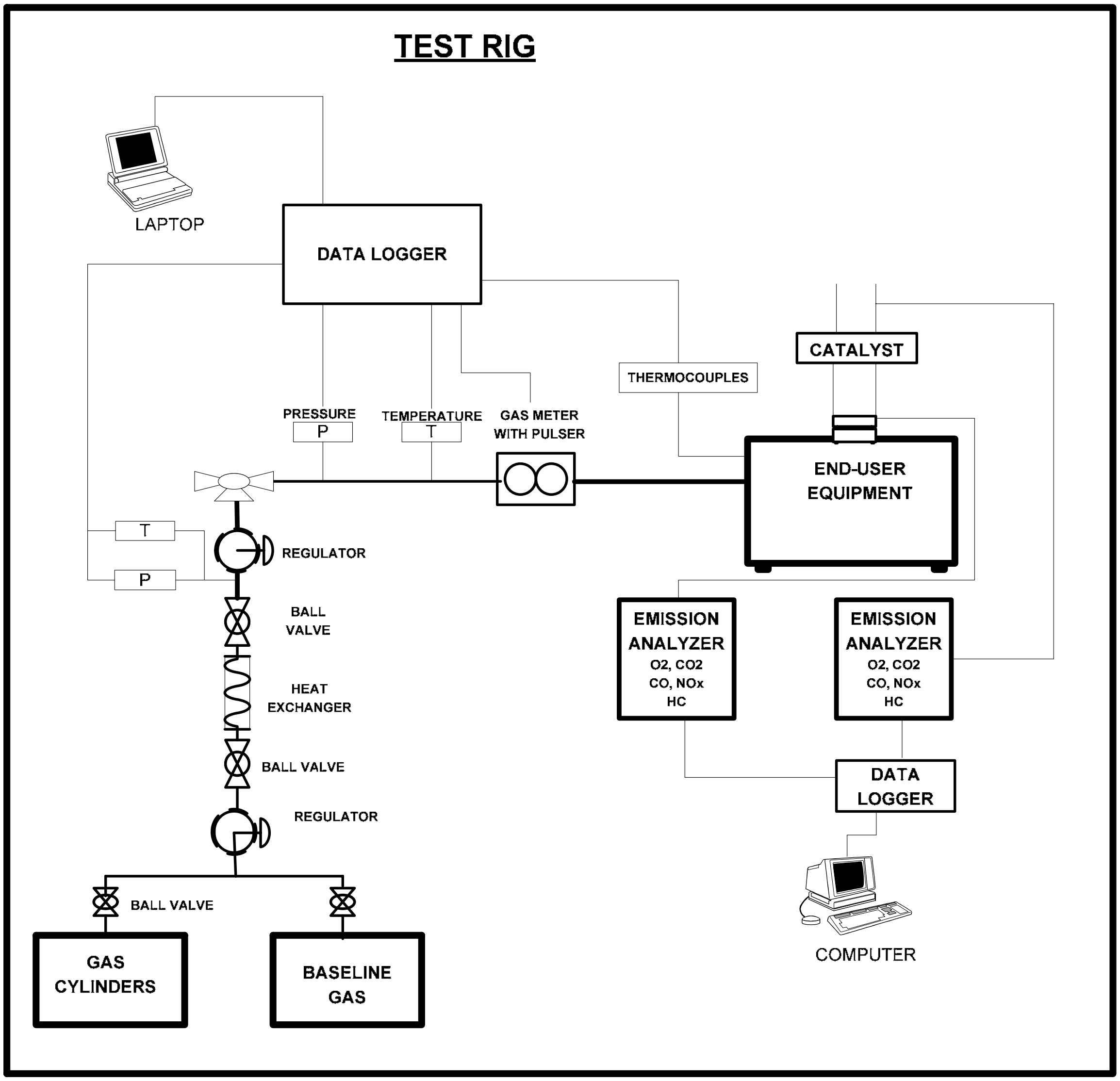
CEMS DAQ program automatically challenges (calibration) all analyzers local/remote bias daily with zero and span gasses. All analyzers were set up with linearity, bias, converter and interference checks. The CEMS DAQ writes to a 15 minute average database. Mapping runs are preformed at a 15 second interval. For this test, calibration was checked immediately before and after the test, and data was collected at the 15 second interval.

Analyzer ranges are indicated below, and calibration gases with the following values and Scott Specialty Gas EPA certification numbers were used:

Zero gas N2		FDU623
O2 0-5%	3.96%O2/9.25CO2	SG9151224
NOx 0-50ppm	44.1ppm	CC485885
NOx linearity check	25.1ppm	CC48585
CO 0-10,000ppm	874ppm	CC146055
CO linearity check	176ppm	CC44551
NO2 converter check	15.08	CA01957

Appendix G: Test Set-Up/Schematic

Equipment utilized for testing adheres to industry standards for testing laboratories that certify such equipment. The test rig is transportable and includes a data logger, emissions cart, gas meter, thermocouples and pressure transducers; plus, a gas regulation system that can take natural gas from 3,000 PSIG and deliver up to 2,000 CFH at low pressure (~8" w.c.). The test rig is illustrated below



Appendix H: Source Test Report

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SOURCE TEST REPORT

06-0252

Conducted at

Eastern Municipal Water District
1301 Case Road
Perris, CA

Determination of VOC Emissions from a Rich Burn IC Engine Fired on Various Qualities (HHV & Wobbe Index) of Natural Gas.

TESTED: April 26, 2006

ISSUED:

REPORTED BY: Carey A. Willoughby
Air Quality Engineer II

REVIEWED BY:

Michael Garibay
Supervising Air Quality Engineer

SOURCE TEST ENGINEERING BRANCH

MONITORING AND ANALYSIS DIVISION

SUMMARY

a. Firm. .... Eastern Municipal Water District

b. Test Location ....1301 Case Street Perris, CA

c. Unit Tested ....Rich Burn IC Engine w/Various Qualities of Natural Gas

d. Test Requested by.....................................Marty Kay, Engineering & Compliance, x3115

e. Reason for Test Request............................Emission Determination

f. Date of Test ....April 26, 2006

g. Source Test Performed by..........................Mike Garibay, Ron Lem
Wayne Stredwick, Carey Willoughby

h. Test Arrangements Made Through ....Gregg Arney, Sempra Utilities, (562) 806-4349

i. Source Test Observed by ....Marty Kay
Ed Filadelfia, EMWD; Dan McGivney, EMWD

South Coast
Air Quality Management District
21865 Copley Drive, Diamond Bar, CA 91765-4182 (909) 396-2000

INTRODUCTION

On April 26th, 2006 personnel from the South Coast Air Quality Management District (SCAQMD) Source Test Engineering Branch conducted several source tests on a rich burn IC engine owned by the Eastern Municipal Water District (EMWD). The tests were conducted at the EMWD facility in Perris, CA. The tests were conducted to determine Volatile Organic Compound (VOC) emissions from firing the engine on various qualities of natural gas. The testing was requested by the SCAQMD TAO Division.

RESULTS

RUNS	PARAMETERS	NMNEOC (PPM)	O_2 (%)	CO_2 (%)	CO (PPM)
1	Gas 1 Baseline (Pipeline) Low Wobbe (1,303 Btu/cf) Low heat content gas (1,002 Btu/cf)	43	0.80	11.60	1,040
2	Gas 3 Highest Wobbe (1,437 Btu/cf) Highest heat content gas (1,150 Btu/cf)	81	0.85	11.05	1,720
3	Gas 6 Medium Wobbe (1,400 Btu/cf) High heat content gas (1,100 Btu/cf)	58	0.85	11.45	1,395
4	Gas 1 Baseline (Pipeline) Low Wobbe (1,303 Btu/cf) Low heat content gas (1,002 Btu/cf)	28	0.65	11.45	1,055
5	Gas 7 High Wobbe (1,400 Btu/cf) High heat content gas (1,142 Btu/cf)	127	0.80	11.75	1,805
6	Gas 8 Medium Wobbe (1,342 Btu/cf) Medium heat content gas (1,066 Btu/cf)	71*	0.79*	11.59*	1,381*

***** ***Correction Factor of 1.241 used to compensate for high O_2 due to external wind event during final run using average O_2 from other runs.***

TEST METHODOLOGY

All VOC sampling was conducted using District Method 25.3 from the exhaust of the NSCR.

SCAQMD Method 25.3

Integrated gas samples were collected from the exhaust of the NSCR using a SCAQMD Method 25.3 sampling apparatus. The apparatus consisted of 0.5 micron filters and stainless steel probes inserted entirely into the stack so that they are heated by the stack gases. The probes were connected to 18 inch lengths, 0.125 inch o.d. Perfluoroalkoxy (also known as PFA, a type of Teflon) line for connection to small 4 ml glass impingers containing 2 ml of hydrocarbon free water. The impingers were immersed in ice water baths with the outlets connected to six liter summa polished canisters as shown in Figure 3. The ice bath heights were adjusted so that the water level did not exceed the level of any impinger connections as to avoid potential contamination. A constant sampling rate was maintained by using small orifice flow controllers. Such samples were collected continuously and concurrently for a period of 30 minutes.

The sample canisters were checked for leaks by observing the internal vacuum gauges over a period of several hours. An observation of a zero loss in vacuum indicated an acceptable canister leak check. The remainder of the sampling apparatus was checked for leaks both before and after sampling by blocking the flow at the probe tip with a clean tubing cap and introducing a portion of the tank vacuum into the remainder of the sampling system. An observation of the resulting cease in the gauge for a period of one minute indicated an acceptable leak check.

After the post-test leak check the PFA lines were disconnected from the probe. The condensate present in the lines were rinsed into the impingers with hydrocarbon free water. This was accomplished by introducing a small amount of the remaining tank vacuum to the line while dipping the open end of the line into the water. After the impingers were filled to approximately 80-90% of capacity, the impinger bodies were disconnected, capped, sealed, and stored at approximately 32 ^{o}F. This method is designed for non-methane organics concentration below 50 ppm.

The liquid within the impinges was analyzed with an infrared total carbon analyzer. The contents of the canister were analyzed for Carbon Dioxide (CO_2), Carbon Monoxide (CO), Methane (CH_4), Ethane (C_2H_6), Nitrogen (N_2), and Oxygen (O_2), and Non-Methane Non-Ethane Organic Compounds (NM/NEOC). The gases were separated by gas chromatography. Carbon Monoxide, Carbon Dioxide, Methane, Ethane, and Total Non-Methane Non-Ethane Organic Compounds were analyzed by draft SCAQMD Method 25.3 (TCA-FID & TOC). Oxygen and Nitrogen were analyzed by SCAQMD Method 10.1, gas chromatography with a thermal conductivity detector (GC/TCD).

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TEST CRITIQUE

It must be noted that most of the results of NMNEOC are above the maximum Method 25.3 applicability limit of 50 ppm. Therefore these results are biased low. The results are, however, adequate to do a relative comparison.