LNG RESEARCH STUDY - PHASE 1

TESTING OF A HEAT TREATING INDUSTRIAL FURNACE

The Southern California Gas Company

August 2003

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Results Summary

When the total input of the four burners was set at or above 1,390,000 Btu/hr using our base gas - PLG 1013 (HHV: 1013 Btu/cf, Wobbe: 1322 Btu/cf), the introduction of LNG 1107 (HHV: 1107 Btu/cf, Wobbe: 1412 Btu/cf) or PLG 1132 (HHV: 1132 Btu/cf, Wobbe: 1379 Btu/cf) created CO emissions that were higher than what the CO emissions analyzer could measure (20,000 ppm). When the total input of the four burners was lowered to or below 1,390,000 Btu/cf using our base gas PLG 1013, the introduction of LNG 1107 did not create any considerable changes in the emissions.

Equipment Selection Criteria

This type of industrial furnace was tested because: a) most are custom built and the final product is not tested or certified by an independent facility, b) they can generate high emissions levels if the low NO_x burners are not working properly, and c) it is complex for the low NO_x burners to achieve the high operating temperatures (~1,800 °F) while not exceeding the NO_x requirements. The NO_x requirements from the SCAQMD are 50 ppm @ 3% O_2 for any metal heating furnaces which includes metal aging, annealing, forging, heat treating and homogenizing.

Equipment Specifications

Description: Heat treating industrial furnace

Application: Preheating titanium billets

Burner description: Nozzle-mix, low NO_x, and modulating with a turndown of 50:1

Input rate: 400,000 (Btu/cf) per burner (four burners)

Type of fuel: Natural Gas

Required gas supply pressure: 5.0 psig.

Installation

The furnace was installed and tested at the manufacturer's facility before it was delivered to the customer. Thermocouples were installed at the flue vents, furnace doors and skid to measure exhaust, chamber and gas temperatures. A gas meter was installed to measure gas flow and emissions probes were installed in all four-flue vents.

Test Method

For Test on August 01, 2003

Before the test, the burners were slightly adjusted to lower the NO_x level below 50 ppm and increase the input closer to the rated input for the furnace (1,600,000 Btu/hr).

For Test A and B on August 04, 2003

Before the test, the burners were slightly adjusted to lower the NO_x level below 50 ppm and increase the input closer to the rated input for the furnace.

For Test C on August 04, 2003

Before the test, the burners were slightly adjusted to lower the NO_x level below 50 ppm and reduce the input closer to the rated input for the furnace.

For all the Tests

1. All emissions analyzers were calibrated.
2. The data logger was turned on and the furnace program-net was loaded. Temperature, pressure, and gas flow readings were verified to ensure that all probes were working properly.
3. The furnace was turned "on" and allowed to warm up on low-fire while emission, pressure and temperature readings were monitored. This was the beginning of the warm up cycles. On both days the gases used during the warm up cycles where in the following order: PLG 1013, LNG 1107 and PLG 1013.
4. The end of the warm up cycles and the beginning of the high fire cycles were established when the furnace reached the set temperature (1800 °F) and cycled off.
5. On the tests conducted at high fire on August 4, the test gases where introduced in the following order:
   Test A — PLG 1013, LNG 1107, PLG 1013 and LNG 1107.
   Test B — PLG 1132, PLG 1047 and PLG 1002.
6. The end of each cycle was established when the furnace reached the set temperature (1800 °F) and cycled off. Then, the furnace was turned "off" and allowed to cool down to approximately 400 °F.
7. Drift inspections were performed on all emissions analyzers.

Results

All emission, temperature, input data values and averages were calculated from data points taken while industrial furnace burners were "on." Emissions data is reported as follows: O_2, CO_2 in percentage (%) and NO_x, CO and HC in ppm @ 3% O_2.

August 1, 2003 - Warm up

Emissions Data

During the warm up, the emissions data of the 1st cycle did not follow the same pattern as the 2nd (LNG) and 3rd (PLG) cycles — in the middle of the 1st cycle the NO_x emissions increased from ~27 to ~55 and the CO emissions also increased from ~220 to ~584. We were unable to explain such increases since both the input and temperature data for this cycle follows the same pattern as the 2nd (LNG) and 3rd (PLG) cycles. Thus, there were some drastic changes in the emissions while there where no changes in the temperature or input data. During the 2nd (LNG) and 3rd (PLG) cycles the emissions were stable and these cycles were used for the following comparison. While running on LNG the average NO_x emissions values slightly increased from 55.8 to 56.5, the average CO emissions values increased from 121 to 283 and the average HC emissions values increased from 151 to 452. Results are shown in Figure 1.

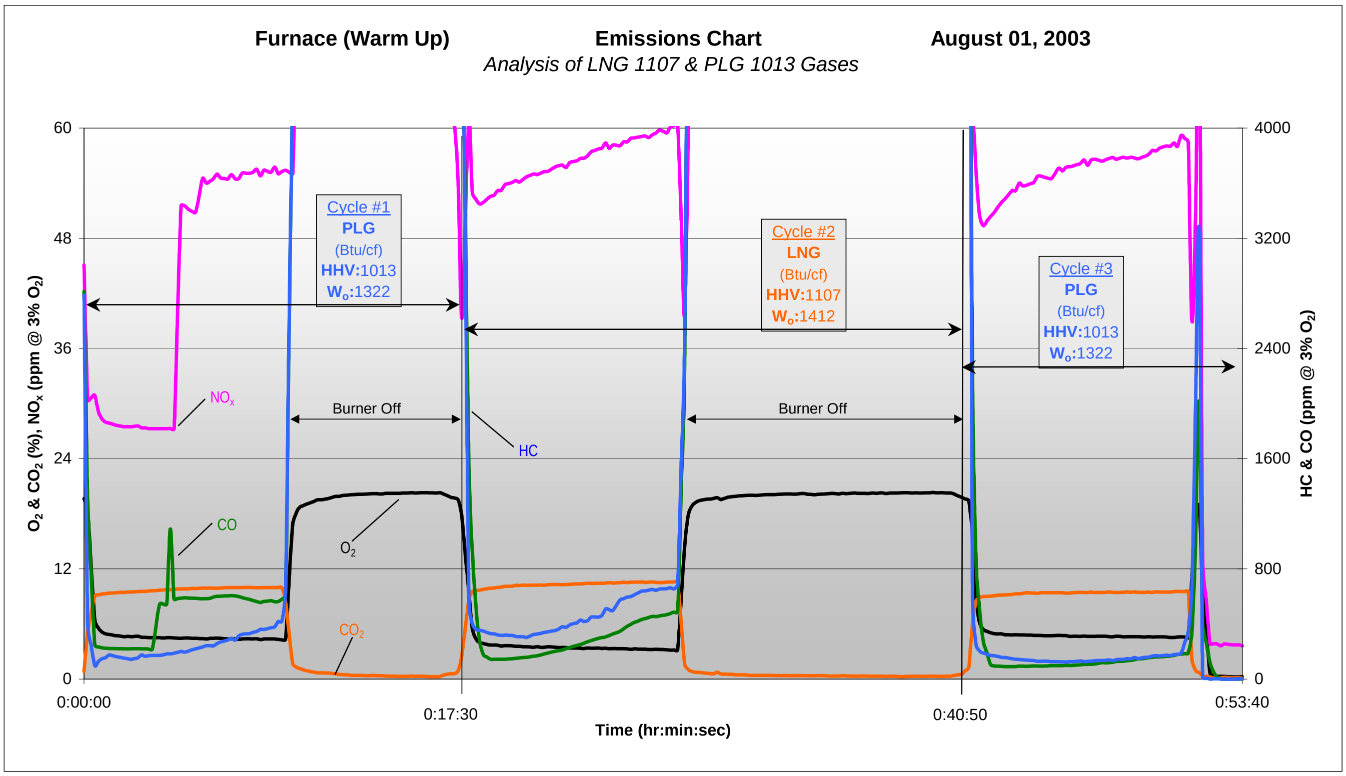

Figure 1

Temperature Data

While the industrial furnace was operating on LNG, the average exhaust temperature increased by approximately 3.9% and the average chamber temperature increased by approximately 6.2%. The gas temperature changed due to the pressure drop in the two-stage regulator system. Temperature results can be seen in Figure 2.

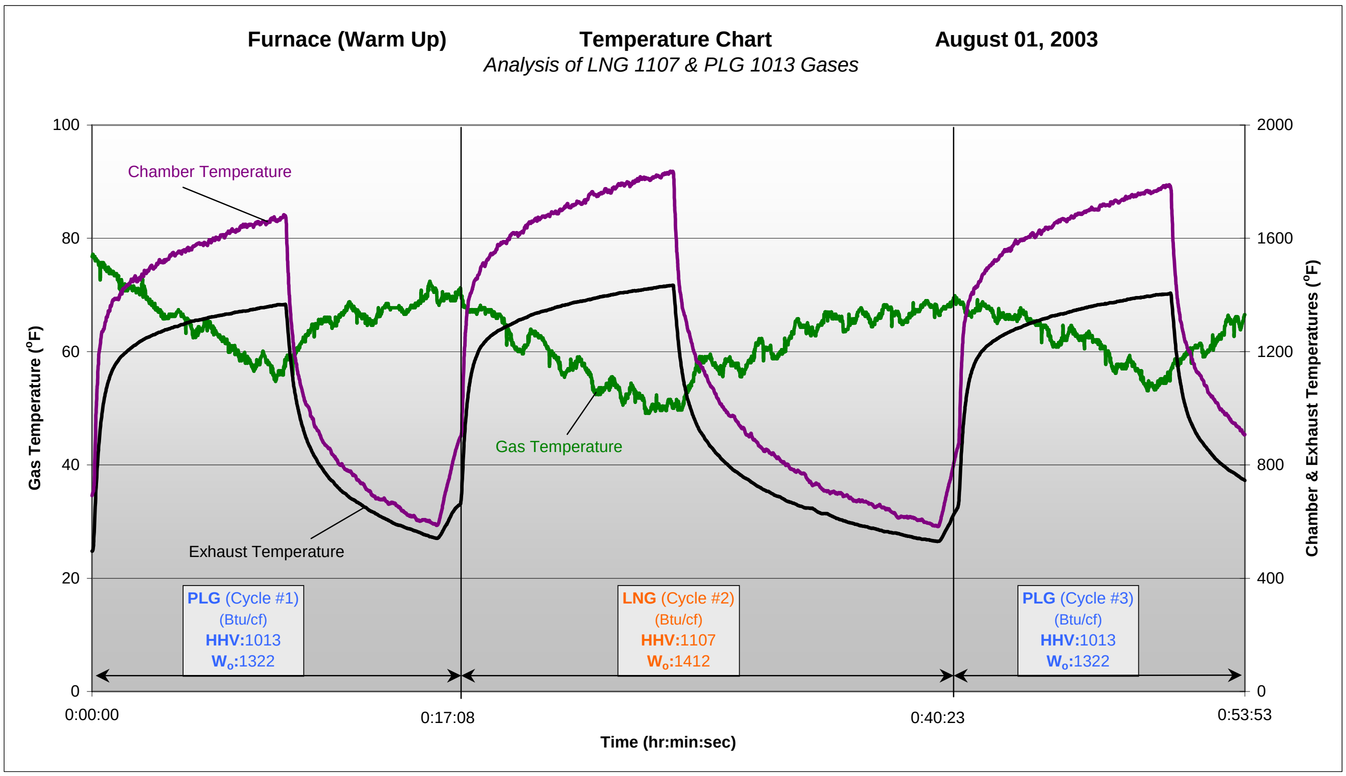

Figure 2

Input Data

During all three cycles the average input was below the rated input for the furnace (1,600,000 Btu/hr). During the two PLG cycles the maximum input rate was about 1,390,000 Btu/hr, which is about 210,000 Btu/hr less than the rated input. When LNG was introduced, the input rate increased to a maximum of 1,480,000 Btu/hr, which is about 120,000 Btu/hr less than the rated input. Compared to the PLG cycles, the average input increased by 7.4% while the volume of gas (SCFH) decreased by 1.7% while running on LNG. During all the cycles, the manifold and supply pressures remained fairly constant and when the burner was turned off both pressures increased. Input data results are depicted below in Figure 3.

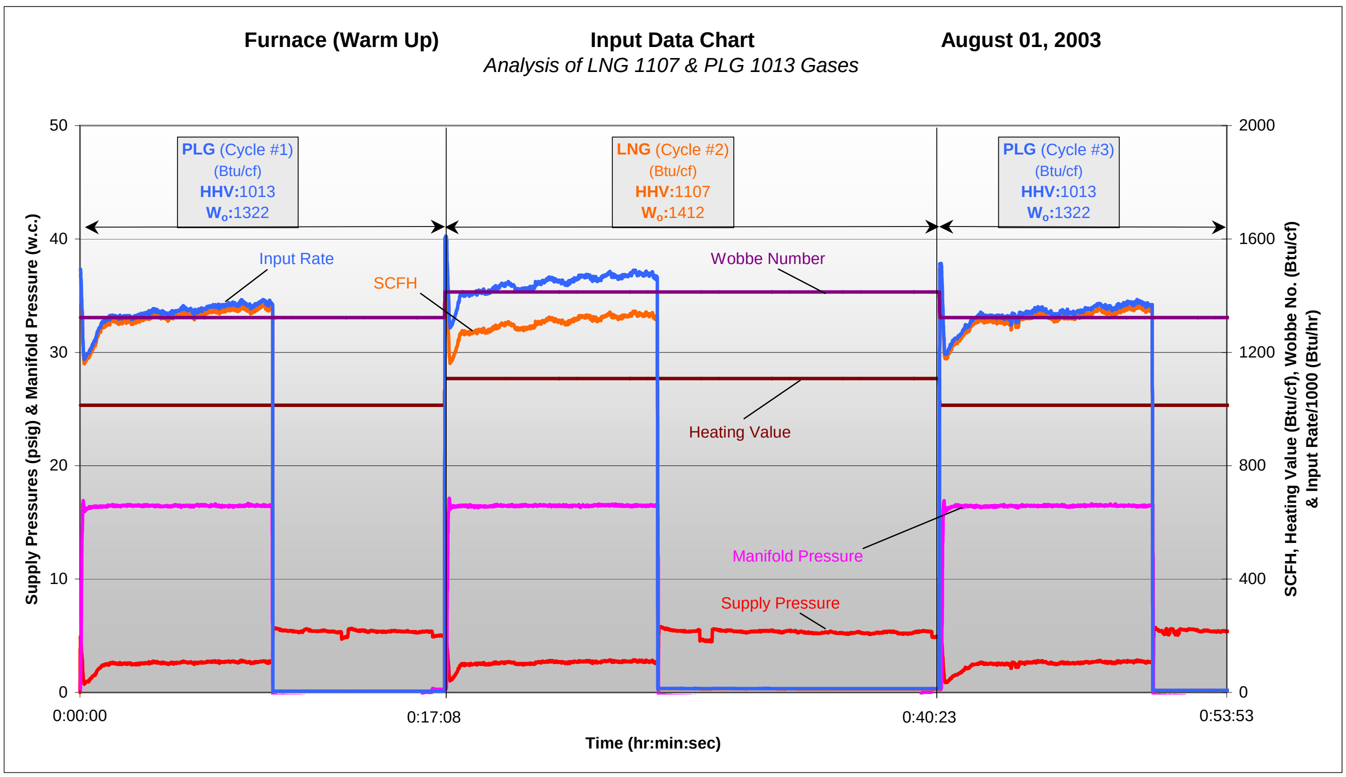

Figure 3

August 04, 2003[1] - Warm up (Run A)

Emissions Data

During the warm up, CO emissions values went out of the range of the instrument (20,000) when LNG was introduced. The other emissions constituents fluctuated as follows: The HC emissions values increased from 1 to 40, CO_2 emissions values increased from 8.9 to 11.4, NO_x emissions values decreased from 52 to 29 and O_2 emissions values decreased from 5.7 to 0.2. All emissions above are averages per cycle. After switching back to PLG 1013, the NOx and HC emissions came back close to the same levels as the first PLG 1013 cycle. CO emissions also came back but they were about 49 higher that in the first PLG 1013 cycle. The O_2 and CO_2 emissions remained at the same levels as during the LNG 1107 cycle. Figure 4 (warm-up) depicts the emissions results for PLG 1013 and LNG 1107.

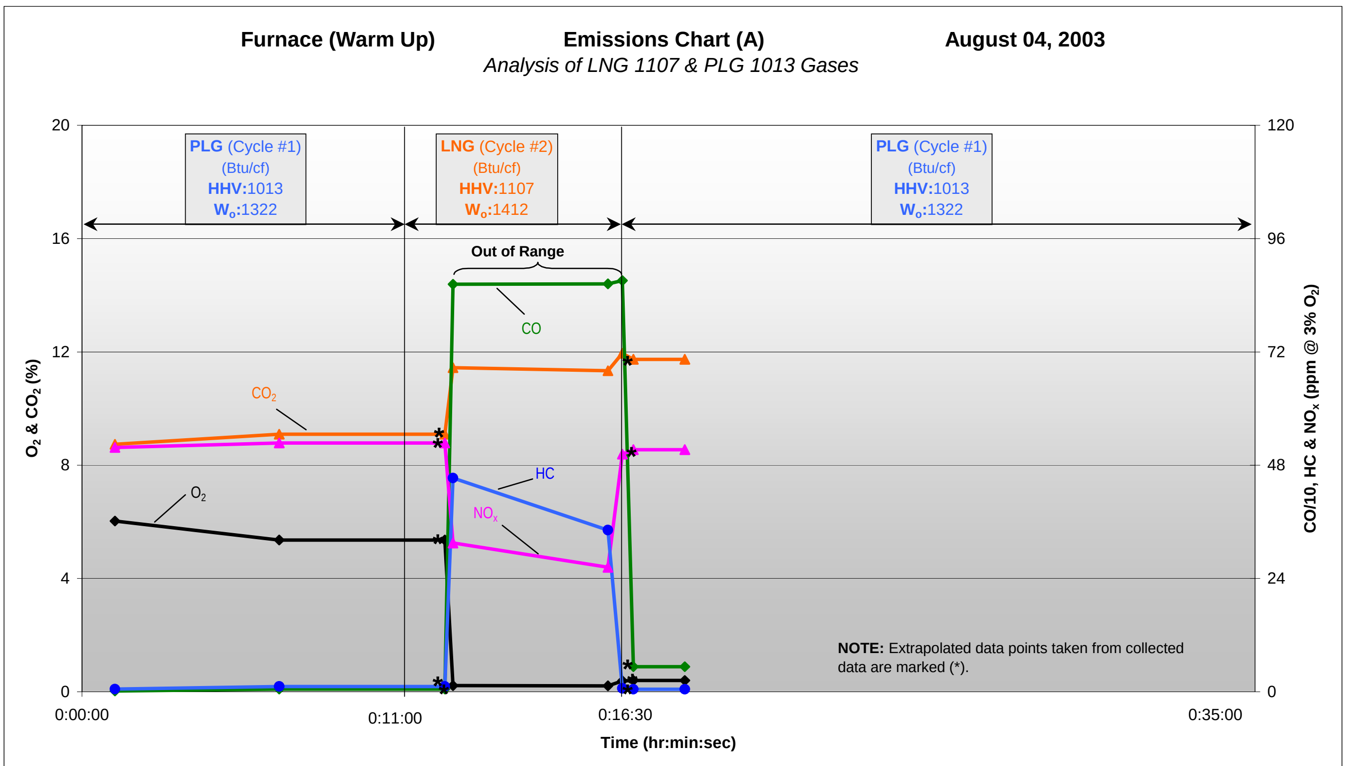

Figure 4

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[1] On August 4, 2003, due to technical difficulties with data logger, emissions data was only collected by hand.

Temperature Data

During the warm up, the average exhaust and average chamber temperatures continued to increase at the same rate when LNG was introduced and there where not abrupt changes. The gas temperature changed due to the pressure drop in the two-stage regulator system. Temperature results for each run are shown below.

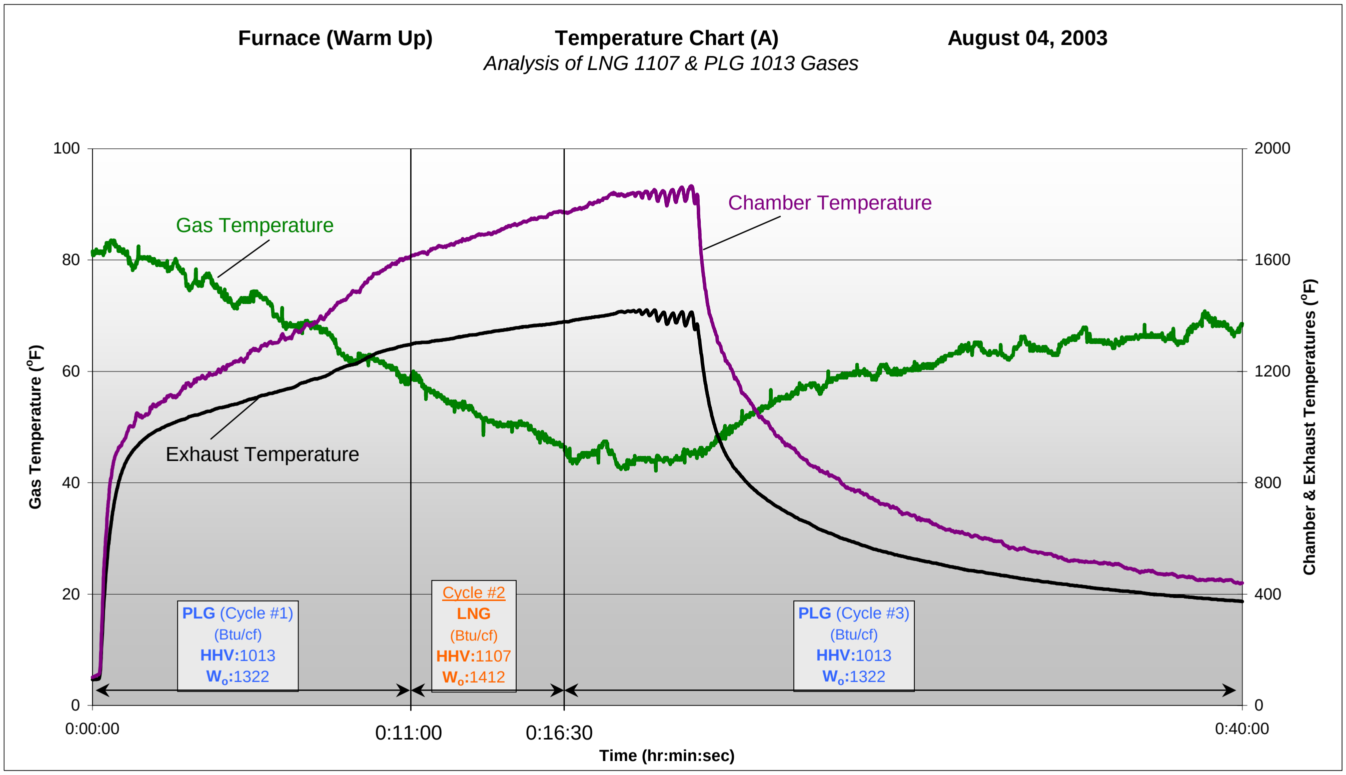

Figure 5

Input Data

During the warm up, the average input rate and SCFH increased by approximately 10.2% and 20.4% when LNG was introduced. Thus, creating an over-fired condition during this cycle with an averaging an input rate of 1,808,023 Btu/cf. In the first half of the 3rd cycle when PLG 1013 was reintroduced, the average input rate decreased to 1,608,924 Btu/cf – which is only slightly higher than the maximum input rate for the furnace (1,600,000 Btu/cf). In the second half of the 3rd cycle the furnace started to cycle "on" and "off" and the input rate increased momentarily every time the furnace came "on." Input results for each run are shown below.

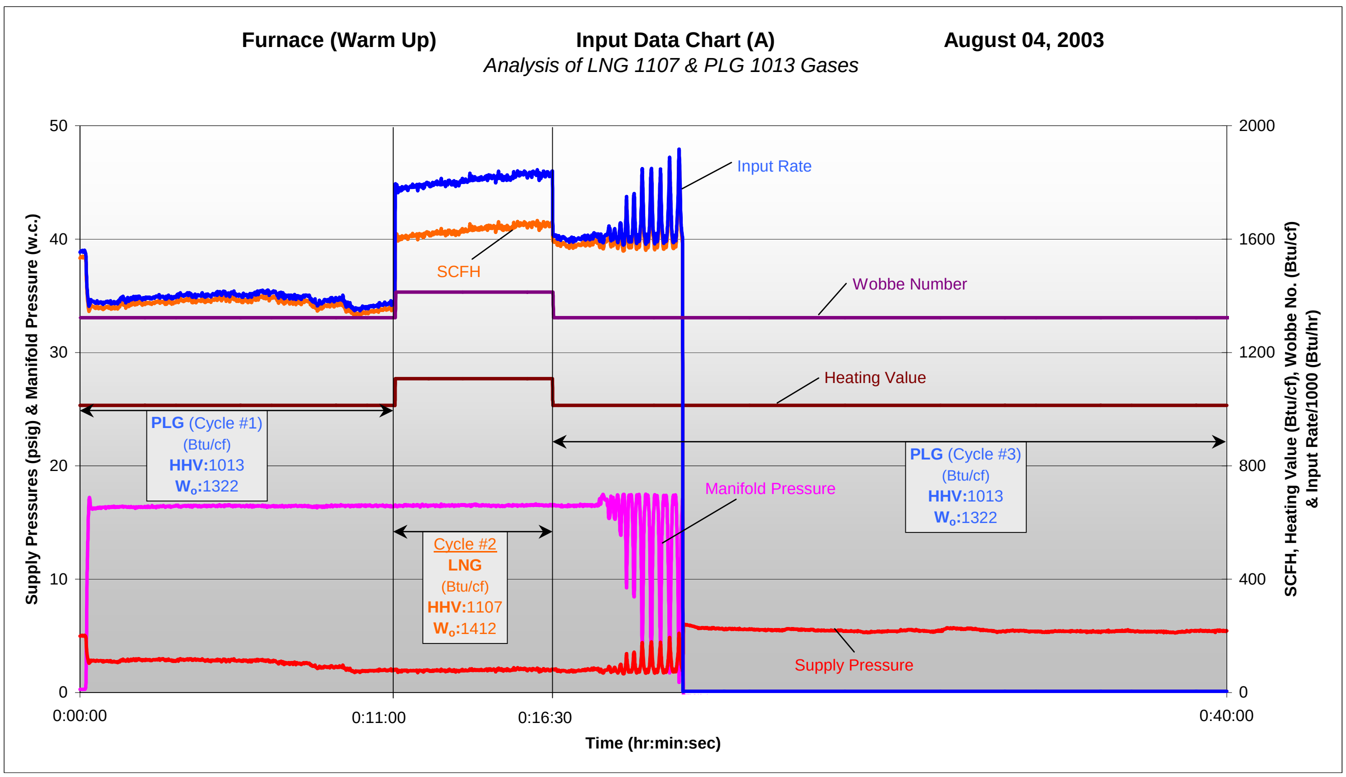

Figure 6

August 04, 2003[1] – High Fire (Run B)

Emissions Data

During the 2nd and 4th cycles at high fire, CO emissions values also went out of range when LNG 1107 was introduced. The other major changes due to the introduction of LNG where that the HC emissions values increased from ~1 to ~14, O_2 emissions values decreased from ~0.7 to ~0.25 and the NO_x emissions decreased from ~53 to ~22. Figure 7 depicts the emissions results for PLG 1013 and LNG 1107.

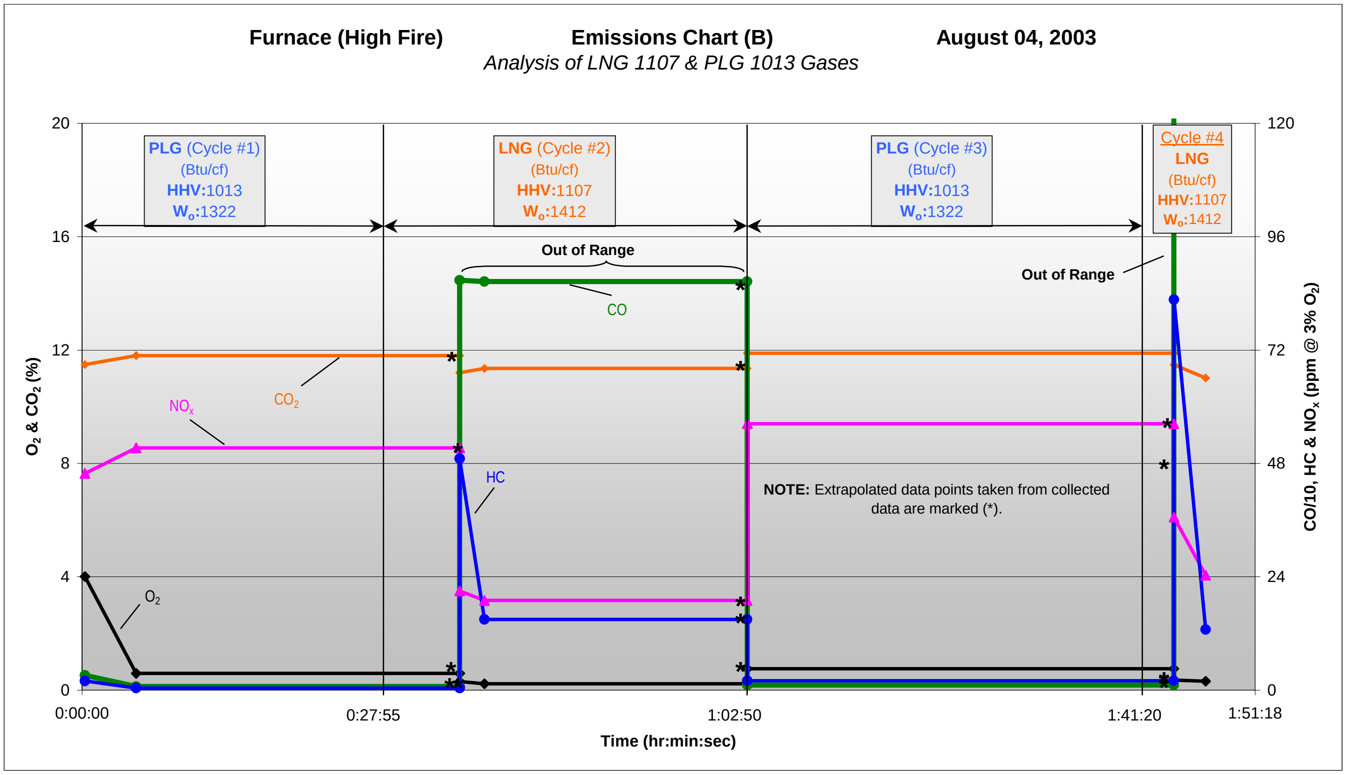

Figure 7

Temperature Data

For this run at high fire, the average exhaust, and chamber temperatures decreased by approximately 3.3% and 3.5%, respectively, when LNG was introduced in the 2nd and 4th cycles. Temperature data is depicted in the chart below.

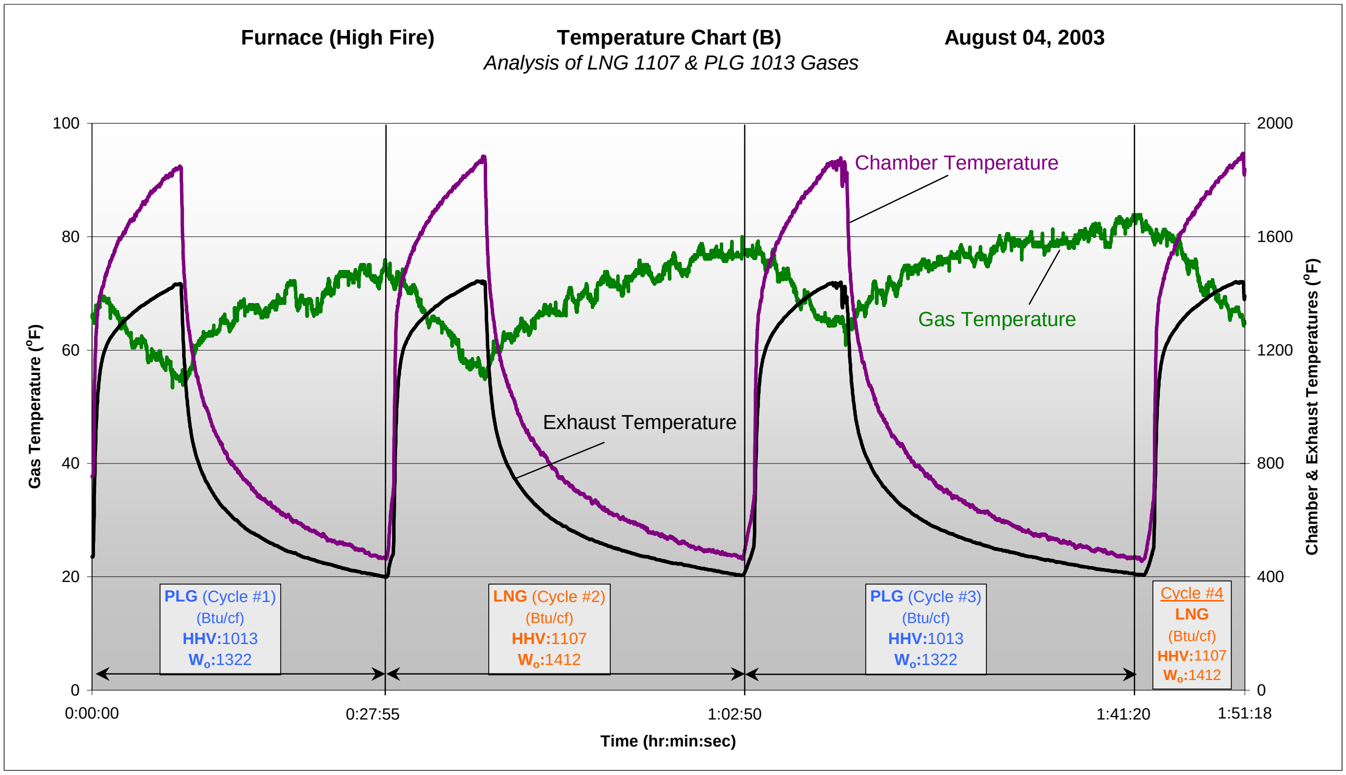

Figure 8

Input Data

During the 1st and 2nd cycles, the maximum input rates after the burner stabilized were up to 160,000 Btu/cf over the rated input. The average input rates for the industrial furnace in the 1st and 2nd cycles were 1,662,365 Btu/cf and 1,691,876 Btu/cf. In the 2nd cycle when LNG was introduced, the average SCFH decreased by 7.8% but the average input rate increased by 0.8%. During the 3rd and 4th cycles, the maximum input rates after the burner stabilized were up to 22,000 Btu/cf over the rated input. The average input rates for the industrial furnace in the 3rd and 4th cycles were 1,581,515 Btu/cf and 1,577,624 Btu/cf. Input data is depicted in the chart below.

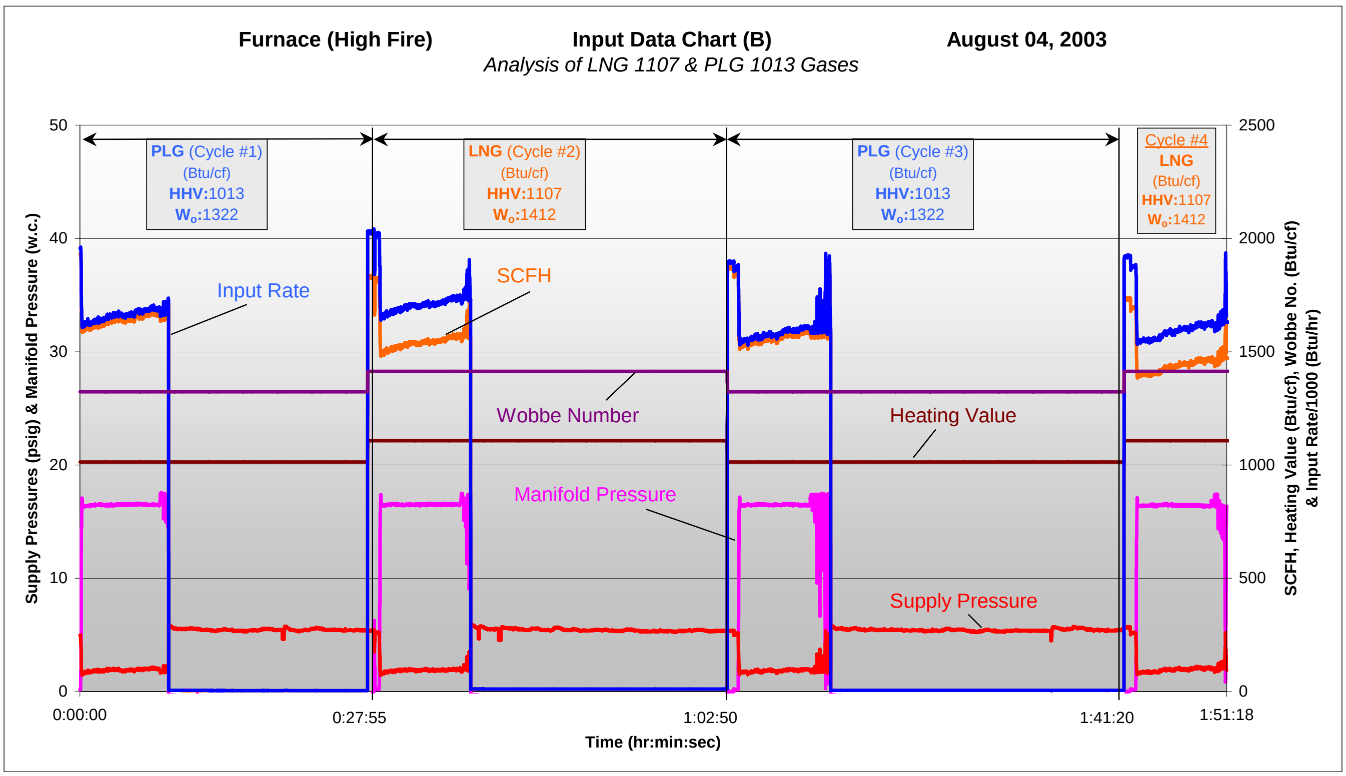

Figure 9

August 04, 2003[1] - High Fire (Run C)

Emissions Data

For this run, PLG 1132 and PLG 1002 were compared to PLG 1047. CO emissions values went out of range when PLG 1132 was introduced. The average O_2, CO_2, NO_x, and HC values were 0.5, 11.9, 44.3, and 2.1. On PLG 1047 the CO drop to 2.9 and the CO_2, NO_x and HC remained almost unchanged. When 1002 PLG was introduced NO_x and O_2 increased to 49.6 and 1.9 while the CO and HC decreased to 0.0 and 0.3. Emissions data is depicted in the charts below.

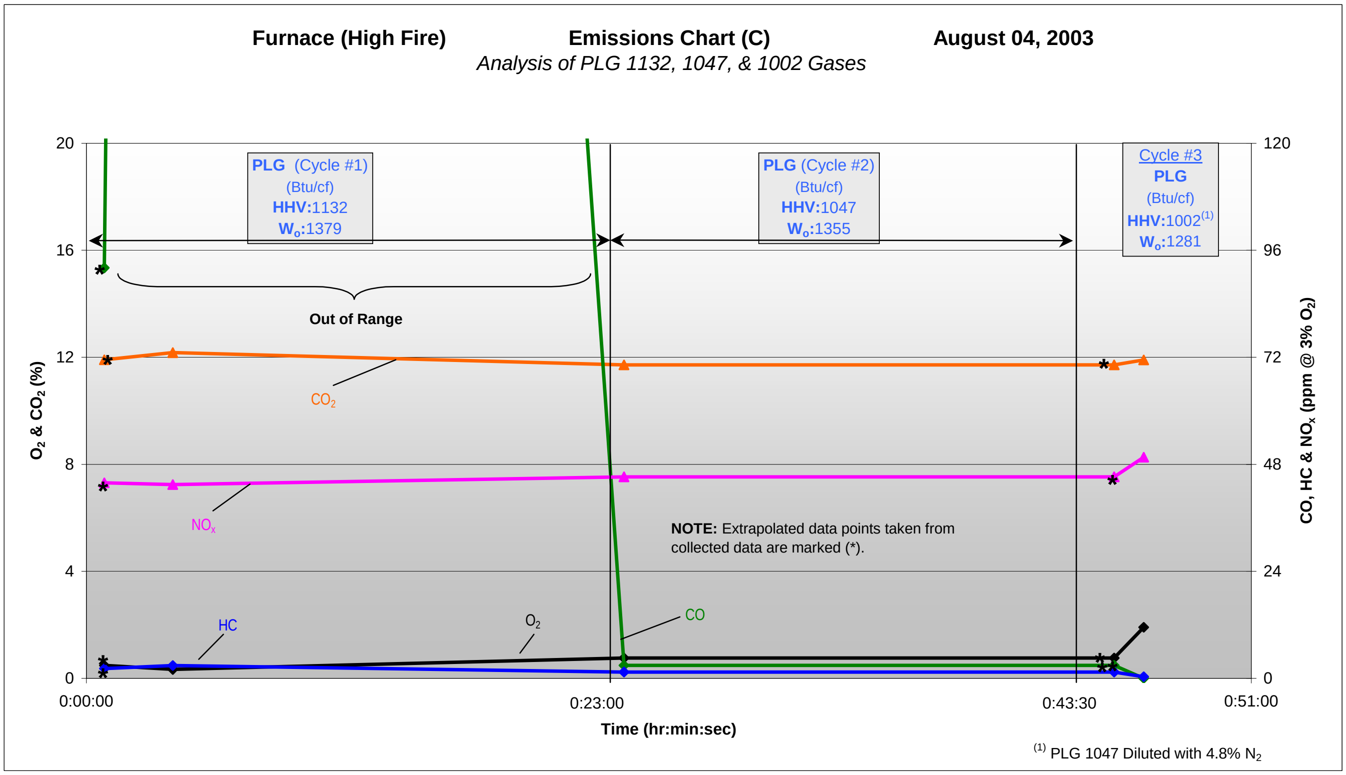

Figure 10

Temperature Data

During the 1st cycle, the average exhaust and chamber temperatures were approximately 6% and 7% higher than in the 2nd cycle. During the 3rd cycle the average exhaust and chamber temperatures were approximately 5.8% and 10.4% higher than in the 2nd cycle. Temperature data is depicted in the chart below.

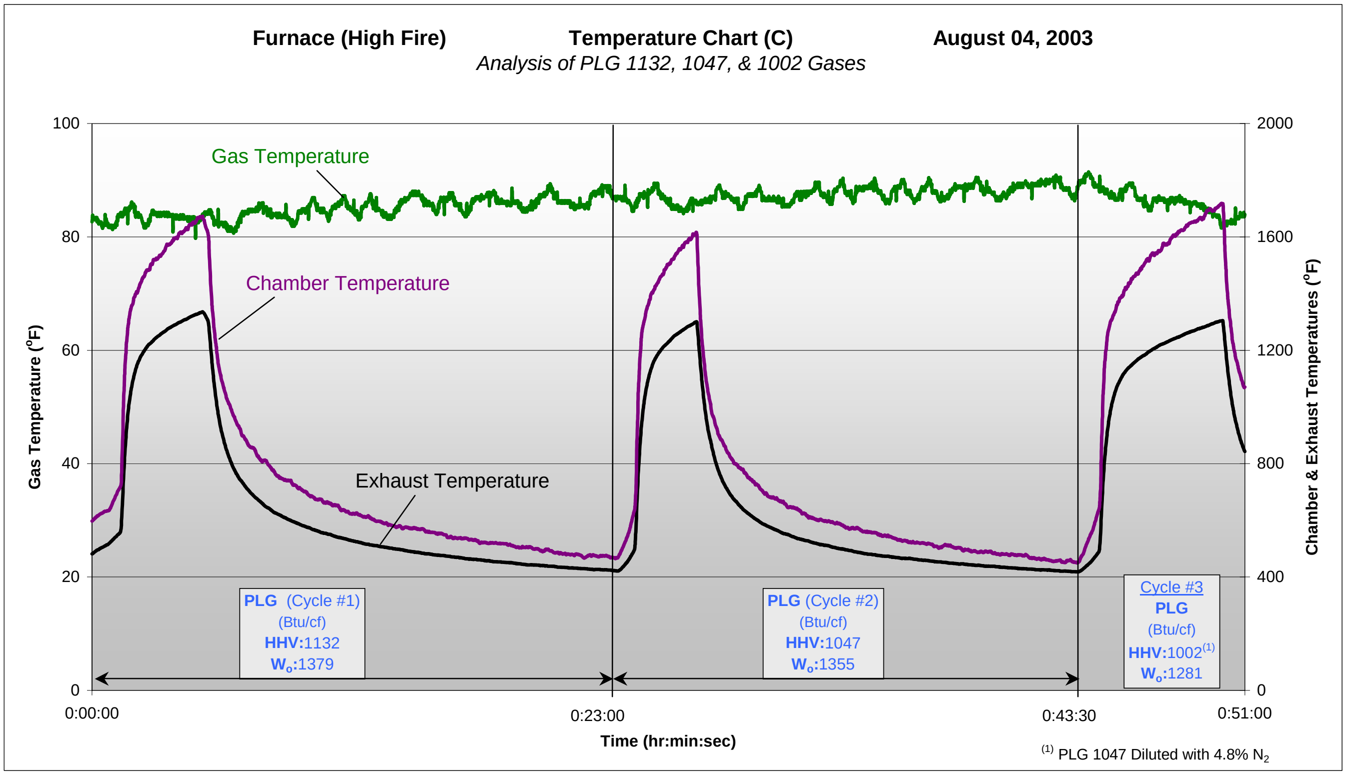

Figure 11

Input Data

During the 1st, 2nd and 3rd cycles, the average input rates after the burner stabilized were about 1,384,000 Btu/cf, 1,380,000 Btu/cf and 1,284,000 Btu/cf, which are all below the rated input. Input data is depicted in the chart below.

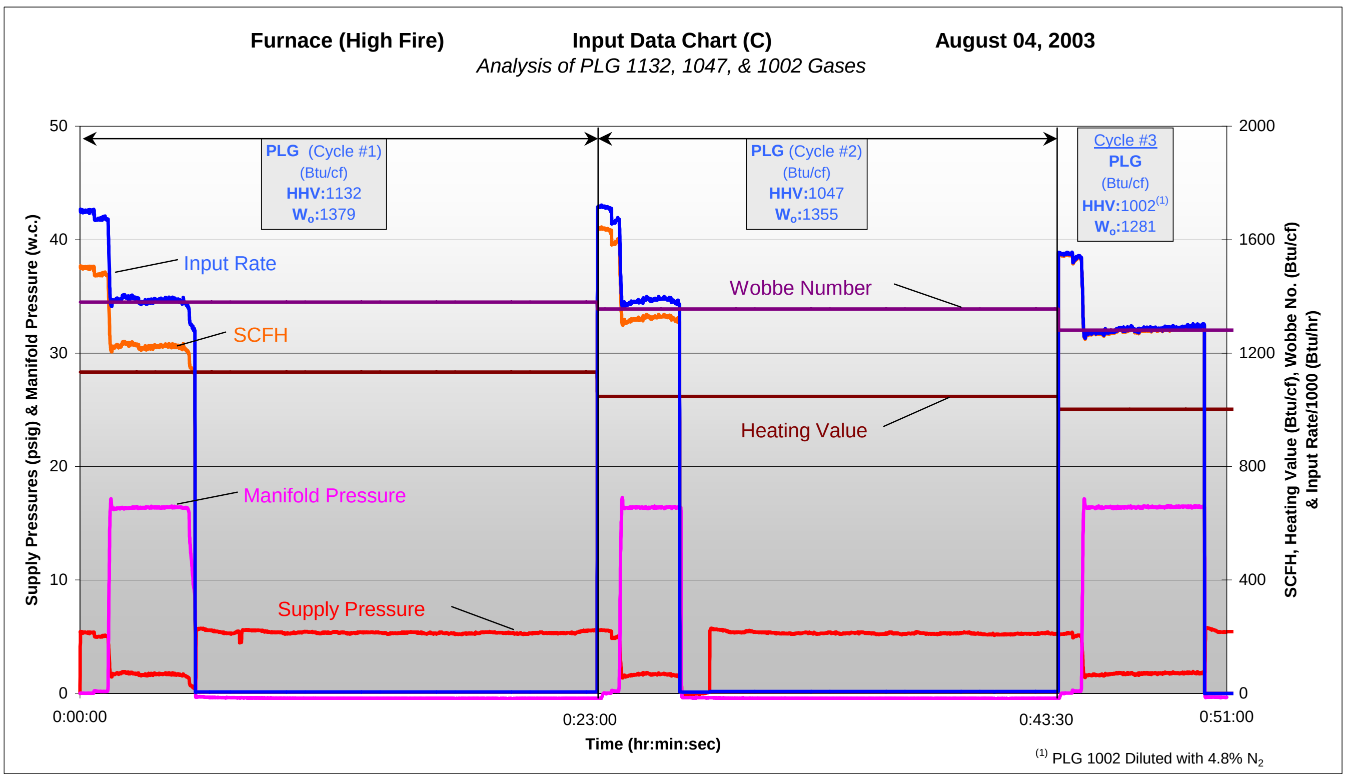

Figure 12

Test Equipment

Equipment utilized for testing adheres to industry standards for testing laboratories. The test rig is transportable and includes a data logger, emissions cart, gas chromatograph, gas meter, thermocouples and pressure transducers; plus, a gas regulation system that can take natural gas from 3,000 PSIG and deliver up to 2,000,000 SCFH at low pressure (~5 PSIG). The test rig is illustrated in Figure 13.

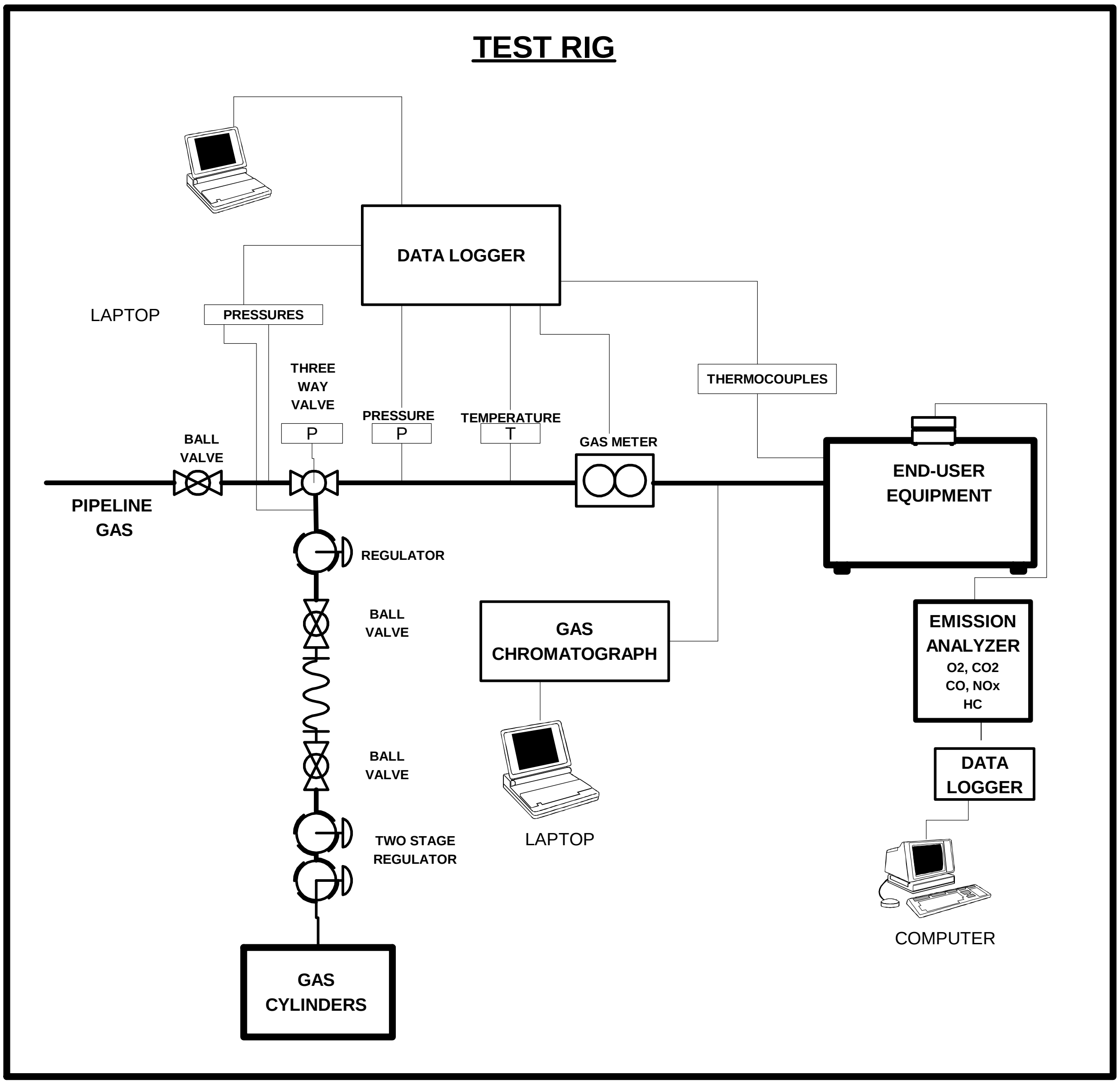

Figure 13

Emissions analyzers meet CARB and SCAQMD standards. Test gases are certified master class. Following is a list of the test equipment (Tables 1 & 2).

Emissions Analyzer				
Analyzer	**Manufacturer**	**Model**	**Type**	**Accuracy**
NO/NO_X	Thermo Environmental Instruments Inc.	10AR	Chemiluminescent	± 1% of full scale
CO	Thermo Environmental Instruments Inc.	48	Nondispersive infrared (NDIR) gas analyzer	± 1% of full scale
CO_2	Fuji	ZRH	Nondispersive infrared (NDIR) gas analyzer	± 1% of full scale
HC	California Analytical Instruments, Inc.	300 HFID	Flame ionization detector (FID)	± 1% of full scale
O_2	Teledyne	326RA	Electrochemical cell	± 1% of full scale
Portable	Horiba Instruments Inc.	PG-250A	Portable gas analyzer (Backup) - NO/NO_x, CO, CO_2, O_2	± 1% of full scale
Gas Delivery System				
Equipment	**Manufacturer**	**Model**	**Type**	**Accuracy**
3 Way Valve	Power Controls Inc.	SX4B-10-1VP	Variable speed 3 way valve	n/a
Controller	Fluke	743B	Documenting process calibrator	n/a
GC	Daniel Flow Products Inc.	2350A	Gas chromatograph	± 0.5 BTU/ cu ft
Datalogger	Logic Beach Inc.	4.61	Data logging system	n/a

Table 1

Gas Meter & Pulser				
Equipment	**Manufacturer**	**Model**	**Type**	**Accuracy**
3M	Roots Meter	3M175	Dry meter - 3000 cfh max	99.90%
Pulser	IMAC System Inc	n/a	50 pulses per 10 cu ft	n/a

Calibration & Test Gases			
Gas	**Manufacturer**	**Type**	**Accuracy**
NO/NO_X	Scott Specialty Gases	Certified Master Class - 18.95 ppm	± 2%
CO	Scott Specialty Gases	Certified Master Class - 79.3 ppm	± 2%
CO_2	Scott Specialty Gases	Certified Master Class -12.1%	± 2%
HC	Scott Specialty Gases	Certified Master Class - 0.5 ppm	± 2%
O_2	Scott Specialty Gases	Certified Master Class - 9.1%	± 2%
Zero	Scott Specialty Gases	Certified Master Class - 0%	± 2%
LNG	Matheson Tri Gas	Natural gas blend (HHV-1107, Wobbe-1412)	± 2%

Thermocouples			
Type	**Manufacturer**	**Model**	**Accuracy**
K	Omega Engineering Co.	KMQSS	2.2^{o}C or 0.75%
T	Omega Engineering Co.	TMQSS	2.2^{o}C or 0.75%

Table 2

Calculations

Emission Concentrations (Corrected to 3% O_2)

$$\text{CO, HC \& NO}_x \text{ concentrations (corrected to 3\% O}_2) = \text{ppm} \times \left[\frac{20.9 - \text{O}_2\,\text{Std.}}{20.9 - \%\text{O}_2} \right]$$

Where:

ppm ………. Measured CO, HC & NO_x concentrations, by volume

O_2 Std. …… Oxygen Standard/Correction value (%)

% O_2 ……… Measured O_2 concentration

SCFH

$$\text{SCFH} = \text{ACFH} \times \left[\frac{(\text{Fuel Press.} + 14.60)}{14.735} \right] \times \left[\frac{519.67}{(\text{Gas Temp} + 459.67)} \right]$$

Where:

SCFH ……. Standard cubic feet per hour (cf/hr.)

ACFH ……. Actual cubic feet per hour (cf/hr.)

Fuel Press. …Fuel Pressure (psig)

Gas Temp. …Gas temperature (°F)

Input Rate (Btu/cf)

$$\text{Input Rate} = \text{SCFH} \times \text{HHV}$$

Where:

SCFH ……. Standard cubic feet per hour (cf/hr.)

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

Attachment A

Emissions Log

Manually Recorded Emissions Data											
LNG Testing			Equipment Tested: Industrial Furnace								
Date: August 04, 2003											
			Raw Emissions					Corrected Emissions			
Test	Time	Type of Gas	O_2 (%)	CO (ppm)	CO_2 (%)	HC (ppm)	NO_X (ppm)	CO (ppm)	NO_X (ppm)	HC (ppm)
A	11:05 AM	PLG 1010	6.03	1.59	8.74	0.51	43.01	1.91	8.10	0.75
	11:09 AM		5.36	5.16	9.10	0.97	45.78	5.94	10.35	1.47
	11:15 AM	LNG 1107	0.22	997.56	11.44	52.30	36.41	863.46	31.00	43.00
	11:20 AM		0.21	999.00	11.34	39.62	30.48	864.29	-0.21	74.18
	11:20 AM	PLG 1010	0.39	998.00	11.95	0.85	57.67	25.43	53.48	0.51
	11:22 AM		0.40	61.10	11.74	0.63	58.73	53.35	-5.23	1.23
	11:25 AM		2.47	20.62	2.75	479.65	7.36	20.03	175.80	473.04
B	11:47 AM	PLG 1010	4.01	29.50	11.49	0.85	49.78	8.43	45.87	1.97
	11:52 AM		0.59	8.89	11.81	0.24	57.97	8.58	51.28	0.45
	12:23 PM	LNG 1107	0.30	999.00	11.20	45.00	26.00	866.00	21.00	49.00
	12:25 PM		0.23	999.00	11.35	24.00	23.00	866.00	19.00	15.00
	12:50 PM	PLG 1010	0.76	12.25	11.89	0.63	64.23	10.06	56.40	2.01
	1:30 PM	LNG 1107	0.36	36560.00	11.48	101.65	43.08	869.00	36.64	82.70
	1:33 PM		0.32	25509.00	11.02	14.74	28.61	866.00	24.32	12.85
C	2:15 PM	PLG 1132	0.33	37070.00	12.17	3.30	49.94	9.66	43.42	2.65
	2:35 PM	PLG 1047	0.76	3.26	11.71	1.59	50.81	4.37	45.01	0.40
	2:58 PM	PLG 1002	1.91	0.00	11.90	0.35	52.60	0.00	49.91	0.88

Gases

PLG 1013

- Compressed and bottled at the Engineering Analysis Center (EAC) in Pico Rivera, CA.
- **HHV:** 1013 Btu/cf; **Wobbe Number:** 1332 Btu/cf.

PLG Analysis				
HC GC LAB stream 1 on 8/5/03 11:29 AM	**MolPct**	**Gal/1000**	**BTUGross**	**RelDens**
C6 + 57/28/14	0.0494	N/A	N/A	N/A
NITROGEN	0.8080	N/A	N/A	N/A
METHANE	95.6415	N/A	N/A	N/A
CARBON DIOXIDE	1.4791	N/A	N/A	N/A
ETHANE	1.5498	N/A	N/A	N/A
PROPANE	0.3095	N/A	N/A	N/A
i-BUTANE	0.0535	N/A	N/A	N/A
n-BUTANE	0.0581	N/A	N/A	N/A
NEOPENTANE	0.0000	N/A	N/A	N/A
i-PENTANE	0.0183	N/A	N/A	N/A
n-PENTANE	0.0159	N/A	N/A	N/A
TOTAL	**99.9831**	**0**	**0.00**	**0**
Compressibility Factor	0.9976			
Heating Value Gross BTU Dry	1013.477			
Heating Value Gross BTU Sat.	913.093			
Relative Density Gas Corr.	0.5871			
Gallons/1000 SCF C2+	N/A			
Gallons/1000 SCF C3+	N/A			
Gallons/1000 SCF C4+	N/A			
Gallons/1000 SCF C5+	N/A			
Gallons/1000 SCF C6+	N/A			
Total Unnormalized Conc.	N/A			
WOBBE Index	1322.697			

PLG 1132

- Compressed and bottled from a producer located in Seal Beach, CA.
- **HHV:** 1133 Btu/cf; **Wobbe Number:** 1380 Btu/cf

PLG Analysis				
100479-2 stream 1 on 6/25/03 12:56 PM	MolPct	Gal/1000	BTUGross	RelDens
C6 + 57/28/14	0.0386	0.0170	2.01	0.0013
NITROGEN	0.3151	0.0000	0.00	0.0030
METHANE	86.1878	0.0000	872.48	0.4774
CARBON DIOXIDE	2.4683	0.0000	0.00	0.0375
ETHANE	4.8506	1.2965	86.04	0.0504
PROPANE	4.4187	1.2166	111.44	0.0673
i-BUTANE	0.6257	0.2047	20.39	0.0126
n-BUTANE	0.9064	0.2857	29.64	0.0182
NEOPENTANE	0.0000	0.0000	0.00	0.0000
i-PENTANE	0.1167	0.0427	4.68	0.0029
n-PENTANE	0.0721	0.0261	2.90	0.0018
TOTAL	**100.0000**	**3.0893**	**1129.58**	**0.6724**

Compressibility Factor	1.00286
Heating Value Gross BTU Dry	1132.8
Heating Value Gross BTU Sat.	1113.09
Relative Density Gas Corr.	0.674
Gallons/1000 SCF C2+	3.0894
Gallons/1000 SCF C3+	1.7928
Gallons/1000 SCF C4+	0.5762
Gallons/1000 SCF C5+	0.0858
Gallons/1000 SCF C6+	0.017
Total Unnormalized Conc.	100.266
WOBBE Index	1379.87

PLG 1047

- Compressed and bottled from a producer located in Seal Beach, CA
- **HHV:** 1047 Btu/cf, **Wobbe Number:** 1355 Btu/cf

PLG Analysis				
100479-2 stream 1 on 6/25/03 16:56 PM	**MolPct**	**Gal/1000**	**BTUGross**	**RelDens**
C6 + 57/28/14	0.0377	0.0166	1.96	0.0012
NITROGEN	0.6468	0.0000	0.00	0.0063
METHANE	93.4773	0.0000	946.27	0.5178
CARBON DIOXIDE	0.8816	0.0000	0.00	0.0134
ETHANE	4.0894	1.0931	72.54	0.0425
PROPANE	0.6352	0.1749	16.02	0.0097
i-BUTANE	0.0882	0.0288	2.87	0.0018
n-BUTANE	0.0952	0.0300	3.11	0.0019
NEOPENTANE	0.0000	0.0000	0.00	0.0000
i-PENTANE	0.0289	0.0106	1.16	0.0007
n-PENTANE	0.0197	0.0071	0.79	0.0005
TOTAL	**100.0000**	**1.3611**	**1044.72**	**0.5958**
Compressibility Factor	1.00225			
Heating Value Gross BTU Dry	1047.07			
Heating Value Gross BTU Sat.	1028.86			
Relative Density Gas Corr.	0.5968			
Gallons/1000 SCF C2+	1.3611			
Gallons/1000 SCF C3+	0.2681			
Gallons/1000 SCF C4+	0.0932			
Gallons/1000 SCF C5+	0.0343			
Gallons/1000 SCF C6+	0.0166			
Total Unnormalized Conc.	99.654			
WOBBE Index	1355.41			

PLG 1002

- Compressed and bottled at the Engineering Analysis Center (EAC) in Pico Rivera, CA (Diluted with 4.8% N_2)
- **HHV:** 1002 Btu/cf, **Wobbe Number:** 1281 Btu/cf

PLG Analysis				
100479-2 stream 1 on 6/25/03 14:20 PM	**MolPct**	**Gal/1000**	**BTUGross**	**RelDens**
C6 + 57/28/14	0.0366	0.0161	1.90	0.0012
NITROGEN	4.8474	0.0000	0.00	0.0469
METHANE	89.5371	0.0000	906.38	0.4960
CARBON DIOXIDE	0.8435	0.0000	0.00	0.0128
ETHANE	3.9038	1.0435	69.25	0.0405
PROPANE	0.6098	0.1679	15.38	0.0093
i-BUTANE	0.0839	0.0274	2.73	0.0017
n-BUTANE	0.0914	0.0288	2.99	0.0018
NEOPENTANE	0.0000	0.0000	0.00	0.0000
i-PENTANE	0.0271	0.0099	1.09	0.0007
n-PENTANE	0.0194	0.0070	0.78	0.0005
TOTAL	**100.0000**	**1.3006**	**1000.50**	**0.6114**

Compressibility Factor	1.00214
Heating Value Gross BTU Dry	1002.64
Heating Value Gross BTU Sat.	985.19
Relative Density Gas Corr.	0.6124
Gallons/1000 SCF C2+	1.3006
Gallons/1000 SCF C3+	0.2572
Gallons/1000 SCF C4+	0.0893
Gallons/1000 SCF C5+	0.033
Gallons/1000 SCF C6+	0.0161
Total Unnormalized Conc.	99.953
WOBBE Index	1281.22

LNG 1107

- Blended and bottled by Matheson Tri-Gases located in Joliet, IL.
- **HHV:** 1107 Btu/cf, **Wobbe Number:** 1413 Btu/cf.

LNG Analysis				
100479-2 stream 1 on 6/25/03 11:44AM	**MolPct**	**Gal/1000**	**BTUGross**	**RelDens**
C6 + 57/28/14	0.0000	0.0000	0.0000	0.0000
NITROGEN	0.0203	0.0000	0.0000	0.0002
METHANE	91.5808	0.0000	927.0700	0.5073
CARBON DIOXIDE	0.0000	0.0000	0.0000	0.0000
ETHANE	5.5813	1.4918	99.0000	0.0579
PROPANE	1.7779	0.4895	44.8400	0.0271
i-BUTANE	0.5207	0.1703	16.9700	0.0104
n-BUTANE	0.5190	0.1636	16.9700	0.0104
NEOPENTANE	0.0000	0.0000	0.0000	0.0000
i-PENTANE	0.0000	0.0000	0.0000	0.0000
n-PENTANE	0.0000	0.0000	0.0000	0.0000
TOTAL	**100.0000**	**2.3152**	**1104.8500**	**0.6133**

Compressibility Factor	1.0025
Heating Value Gross BTU Dry	1107.63
Heating Value Gross BTU Sat.	1088.38
Relative Density Gas Corr.	0.6146
Gallons/1000 SCF C2+	2.3153
Gallons/1000 SCF C3+	0.8235
Gallons/1000 SCF C4+	0.3339
Gallons/1000 SCF C5+	0.000
Gallons/1000 SCF C6+	0.000
Total Unnormalized Conc.	100.163
WOBBE Index	1412.8

Zero & Span Averages

- August 1, 2003

08/01/2003 11:14:48 AM Data file name: C:\Das\Cart Das\Logfiles\eac032103_average.csv							
			Raw Emissions				
	Time	Avg. Time (min)	O_2	CO_2	CO (ppm)	HC (ppm)	NO_x (ppm)
Zero (Start)	11:14:48	2	0.24%	0.02%	-1.09	-0.88	0.14
Span (Start)	11:30:28	2	1.05%	12.02%	78.93	434.42	18.47
Span (end)	14:44:09	2	4.12%	12.20%	77.55	393.56	18.29
Zero (end)	14:40:20	2	0.22%	0.15%	-3.38	0.3	0.36
* Corrected to 3% O_2							

- August 4, 2003

08/04/2003 10:03:36 AM Data file name: C:\Das\Cart Das\Logfiles\eac032103_average.csv							
			Raw Emissions				
	Time	Avg. Time (min)	O_2	CO_2	CO (ppm)	HC (ppm)	NO_x (ppm)
Zero (Start)	10:03:36	2	0.17%	0.03%	-0.42	-0.67	-0.05
Span (Start)	10:16:29	2	1.05%	12.04%	80.35	433.58	18.57
Span (end)	15:28:50	2	1.51%	12.32%	77.9	459.79	20.56
Zero (end)	15:17:27	2	0.19%	0.22%	-2.31	-1.67	2.1
* Corrected to 3% O_2							