



Alternate Energy Systems, Inc.

A Corporation devoted to Energy Oriented Needs

Application Note

The Effect of Changes in the LPG Composition on the Interchangeability of LPG/Air Mixtures in SG-controlled Synthetic Natural Gas Plants.

Background

Synthetic Natural Gas Plants produce LPG/Air mixtures as replacement of, or supplement to, Natural Gas. The produced Synthetic Natural Gas (SNG) is considered compatible with Natural Gas (NG), if its Wobbe Index is close to the Wobbe Index of the NG (within +/- 10%).

The Wobbe Index is defined as the Gross Calorific Value (CV) divided by the Square Root of the Specific Gravity (SG).

$$\text{Wobbe Index} = \frac{\text{Calorific Value (CV)}}{\sqrt{\text{Specific Gravity (SG)}}}$$

The SG can relatively easily be determined with relatively high certainty at relatively low cost through on-line, real-time measurement, using a Gravitometer such as the GraviBlend™-3.

Measuring the other component of the equation, the Calorific Value, is typically considerably more complex and more expensive. Most Calorimeters require very well controlled ambient conditions, ongoing care and maintenance, and a sizable capital investment.

Alternate Energy Systems, Inc. has developed interactive electronic controls for the GraviBlend™-3, allowing the user to select an LPG feedstock (Propane/Butane) from a list of pre-defined mixtures, or to enter the known properties of "his" LPG.

Based on this information, the GraviBlend™-3 measures the SG of the SNG and calculates and displays its Calorific Value and its Wobbe Index. These results are then used in a control loop to maintain the properties (SG) of the SNG by adjusting the LPG/Air mixing ratio.

While the properties of the LPG feedstock in North America are considered to be consistent from batch to batch, users in other countries are very often facing deviations in the composition of the LPG from the specifications as published by the LPG manufacturer (refinery or importer).

The desired solution to compensate for these variations would be the use of a Calorimeter in combination with a Gravitometer. However, as shown in the following tables, the use of a GraviBlend™-3 alone will yield acceptable results, if the variations in the feedstock properties can be kept within certain limits.

Example

The to-be-replaced NG has a CV of 1020 BTU/cuft and a SG of 0.6, with a resulting Wobbe Index of 1317. The nominal feedstock composition is 50% Propane and 50% Butane (see Note 1). The LPG/Air mixture, which creates a close Wobbe Index of 1316, would consist of 54% LPG Vapor and 46% Air, with a resulting SG of 1.41.



If the produced SNG is kept at a constant SG of 1.41, the composition of the LPG feedstock could vary from 18% Propane and 82% Butane to 75% Propane and 25% Butane, and still have a Wobbe Index that would be within +/- 10% of the original 1317.

If the acceptable Wobbe Index variations are limited further, the LPG feedstock mixture could still vary between 37% Propane and 63% Butane to 65% Propane and 35% Butane, and still have a Wobbe Index that would be within +/- 5% of the original 1317.

Conclusion

Based on the above assumptions and calculations, controlling the SNG properties based on the measurement of the Specific Gravity alone is acceptable, if the Gravitometer is "intelligent" and allows user-input of the nominal LPG feedstock properties.

Tables

	Raw Feedstock				LPG Mixture		
	Propane	Butane	NG	Air	Propane	Butane	Total
					50%	50%	100%
CV	2516	3280	1020	0	1258	1640	2898
SG	1.53	2.00	0.60	1.00	0.765	1.000	1.765
Wobbe	2034	2319	1317				2181

$$\text{LPG\%} = \frac{1 - \text{SG}_{\text{LPG}}}{1 - \text{SG}_{\text{Mix}}}$$

Acceptable Limits	
90%	1185
100%	1317
110%	1448

Vapor	Air	SG	CV	Wobbe
53.7%	46.3%	1.41	1556	1310
53.8%	46.2%	1.41	1559	1312
53.9%	46.1%	1.41	1562	1314
54.0%	46.0%	1.41	1565	1316
54.05%	45.95%	1.41	1566	1317
54.1%	45.9%	1.41	1568	1319
54.2%	45.8%	1.41	1571	1321
54.3%	45.7%	1.42	1574	1323

Note 1:

The discussion in this paper assumes that the LPG composition only be Propane and Butane. In reality, other LPGs besides Propane and Butane may be present in the mixture.

However, most other LPGs have Calorific Values and Specific Gravities that are so close to Butane, that they can safely be included with the Butane content of the mixture, without substantially distorting the results of the calculations.



Propane	Butane	SG LPG	CV LPG	LPG%	Air%	Total CV	Total SG	Total Wobbe	Acceptable	
0%	100%	2.000	3280	41%	59%	1345	1.41	1133	NO	-14.00%
5%	95%	1.977	3242	42%	58%	1361	1.41	1146	NO	-12.95%
10%	90%	1.953	3204	43%	57%	1378	1.41	1161	NO	-11.86%
15%	85%	1.930	3165	44%	56%	1396	1.41	1176	NO	-10.70%
18%	82%	1.915	3142	45%	55%	1407	1.41	1185	YES	-9.99%
20%	80%	1.906	3127	45%	55%	1415	1.41	1192	YES	-9.49%
25%	75%	1.883	3089	46%	54%	1435	1.41	1209	YES	-8.22%
30%	70%	1.859	3051	48%	52%	1456	1.41	1226	YES	-6.87%
35%	65%	1.836	3013	49%	51%	1478	1.41	1245	YES	-5.45%
36%	64%	1.831	3005	49%	51%	1483	1.41	1249	YES	-5.16%
37%	63%	1.826	2997	50%	50%	1488	1.41	1253	YES	-4.86%
40%	60%	1.812	2974	50%	50%	1502	1.41	1265	YES	-3.95%
45%	55%	1.789	2936	52%	48%	1527	1.41	1286	YES	-2.36%
50%	50%	1.765	2898	54%	46%	1553	1.41	1308	YES	-0.67%
52%	48%	1.756	2883	54%	46%	1564	1.41	1317	YES	0.04%
55%	45%	1.742	2860	55%	45%	1581	1.41	1332	YES	1.13%
60%	40%	1.718	2822	57%	43%	1611	1.41	1357	YES	3.04%
65%	35%	1.695	2783	59%	41%	1643	1.41	1384	YES	5.09%
66%	34%	1.690	2776	59%	41%	1650	1.41	1389	YES	5.51%
70%	30%	1.671	2745	61%	39%	1677	1.41	1413	YES	7.28%
75%	25%	1.648	2707	63%	37%	1714	1.41	1444	YES	9.62%
76%	24%	1.643	2699	64%	36%	1722	1.41	1450	NO	10.11%
80%	20%	1.624	2669	66%	34%	1754	1.41	1477	NO	12.15%
85%	15%	1.601	2631	68%	32%	1796	1.41	1513	NO	14.87%
90%	10%	1.577	2592	71%	29%	1842	1.41	1551	NO	17.81%
95%	5%	1.554	2554	74%	26%	1892	1.41	1593	NO	21.00%
100%	0%	1.530	2516	77%	23%	1946	1.41	1639	NO	24.48%