Alternate Energy Systems, Inc.

A Corporation devoted to Energy-Oriented Needs

Technical Data for Propane, Butane, and LPG Mixtures

The following definitions, conversion factors, tables, and other information for and about propane, butane and propane/butane mixtures are compiled from commonly available sources and are reproduced for convenience only. While we exercised great caution during the compilation, we can not guarantee accuracy and urge everybody to verify the accuracy of the data before using them. Also, we would appreciate it if you alert us of any errors you find.

THEORETICAL COMPATIBLE PROPANE/AIR MIXTURES

Table below shows Propane/Air mixtures, compatible with natural gas with several different specific gravities and calorific values.
All figures are approximate and are given for Propane with specific gravity of 1.53 and calorific value of 2516 BTU/cuft.

Natural Gas		Propane / Air Mixture			
SGU	BTU/cuft	% LPG	% Air	SGU	BTU/cuft
0.56	800	47.54	52.46	1.252	1196
	850	50.87	49.13	1.270	1280
	900	54.24	45.76	1.287	1365
	950	57.65	42.35	1.306	1450
	1000	61.11	38.89	1.324	1538
	1050	64.62	35.38	1.342	1626
	1100	68.16	31.84	1.361	1715
	1150	71.76	28.24	1.380	1805
	1200	75.40	24.60	1.400	1897
0.58	800	46.62	53.38	1.247	1173
	850	49.88	50.12	1.264	1254
	900	53.18	46.82	1.282	1338
	950	56.52	43.48	1.300	1422
	1000	59.90	40.10	1.317	1507
	1050	63.33	36.67	1.336	1593
	1100	66.80	33.20	1.354	1681
	1150	70.32	29.68	1.373	1769
	1200	73.88	26.12	1.392	1869
0.60	800	45.76	54.26	1.243	1151
	850	48.95	51.05	1.259	1232
	900	52.18	47.82	1.276	1313
	950	55.45	44.55	1.294	1395
	1000	58.76	41.24	1.311	1478
	1050	62.12	37.88	1.329	1563
	1100	65.51	34.49	1.347	1648
	1150	68.95	31.05	1.365	1735
	1200	72.43	27.57	1.384	1822

Natural Gas		Propane / Air Mixture			
SGU	BTU/cuft	% LPG	% Air	SGU	BTU/cuft
0.62	800	44.93	55.07	1.238	1130
	850	48.06	51.94	1.255	1209
	900	51.23	48.77	1.272	1289
	950	54.43	45.57	1.288	1369
	1000	57.68	42.32	1.306	1451
	1050	60.97	39.03	1.323	1534
	1100	64.29	35.71	1.341	1618
	1150	67.66	32.34	1.359	1702
	1200	71.07	28.93	1.377	1788
0.64	800	44.15	55.85	1.234	1111
	850	47.22	52.78	1.250	1188
	900	50.32	49.68	1.267	1266
	950	53.47	46.53	1.283	1345
	1000	56.65	43.35	1.300	1425
	1050	59.87	40.13	1.317	1506
	1100	63.13	36.87	1.335	1588
	1150	66.44	33.56	1.352	1672
	1200	69.78	30.22	1.370	1756
0.66	800	43.41	56.59	1.230	1092
	850	46.42	53.58	1.246	1168
	900	49.47	50.53	1.262	1245
	950	52.55	47.45	1.262	1322
	1000	55.68	44.32	1.295	1401
	1050	58.84	41.16	1.312	1480
	1100	62.04	37.96	1.329	1561
	1150	65.27	34.73	1.346	1642
	1200	68.55	31.45	1.363	1725

Properties of		Natural Gas	Propane	Butane
Chemical formula		CH_4	C_3H_8	C_4H_{10}
Boiling point of liquid at atmospheric pressure	°F	-258.7	-44	32
Specific Gravity of vapor (Air = 1)		0.6	1.53	2.00
Specific Gravity of liquid (Water = 1)		0.6	0.51	0.58
Calorific value @ 60 °F	BTU/cuft	1012	2516	3280
	BTU/gal		91,690	102,032
	BTU/lb		21,591	21,221
Latent heat of vaporization	BTU/gal	712	785.0	808.0
Liquid weight	lbs/gal	2.5	4.24	4.81
Vapor volume from 1 gallon of liquid at 60 °F	cuft		36.39	31.26
Vapor volume from 1 lb. of liquid at 60 °F	cuft		8.547	6.506
Combustible limits	% of gas in air	5 - 15	2.4 - 9.6	1.9 - 8.6
Amount of air required to burn 1 cuft. of gas	cuft	9.53	23.86	31.02
Ignition temperature in air	°F	1200	920 - 1020	900 - 1000
Maximum flame temperature in air	°F	3568	3595	3615
Octane Number		100	Over 100	92
All data is approximate. For actual properties of any particular batch, contact your fuel supplier.				

Temperature Conversion Table	
°F	°C
- 50	- 45.6
- 40	- 40.0
- 30	- 34.1
- 20	- 28.9
- 10	- 23.3
0	- 17.8
+ 10	- 12.2
20	- 6.7
30	- 1.1
32	0
40	+ 4.4
50	10.0
60	15.6
70	21.1
80	26.7
90	32.2
100	37.8
110	43.3
120	48.9
130	54.4
140	60.0
150	65.6
160	71.1
170	76.7
180	82.2
190	87.8
200	93.3
212	100

Formula:

Degrees C = (°F - 32) x 5/9

Degrees F = 9/5 x °C + 32

Approximate Vapor Pressure in psig									
Temperature		Propane → To → Butane							
° F	° C	100%	95/5*	80/20	60/40	50/50	40/60	20/80	100%
-40	-40.0	3.6	1.3						
-30	-34.4	8	5.5	4.5					
-20	-28.9	14	11	9.2	4.9	1.9			
-10	-23.3	20	17	16	9	6	3.5		
0	-17.8	28	24	22	15	11	7.3		
10	-12.2	37	32	29	20	17	13	3.4	
20	-6.7	47	41	36	28	23	18	7.4	
30	-1.1	58	52	45	35	29	24	13	
40	4.4	72	63	58	44	37	32	18	3
50	10.0	86	77	69	53	46	40	24	6.9
60	15.6	102	93	80	65	56	49	30	12
70	21.1	127	109	95	78	68	59	38	17
80	26.7	140	128	125	90	80	70	46	23
90	32.2	165	149	140	112	95	82	56	29
100	37.8	196	172	168	137	123	100	69	36
110	43.3	220	197	185	165	148	130	80	45
* HD5, Commercial Grade Propane									

BTU content of common fuels		
	Per Pound	Per Gallon
Propane	21,591	91,690
Butane	21,221	102,032
Gasoline	20,930	110,250
Fuel Oil #1	16,960	135,425
Diesel	18,500	142,800

General Information	
1 Lb. Steam	970 BTU
1 Boiler HP (per hr)	33,475 BTU
1 Kilowatt Hour	3,412 BTU
1 Gallon, Water	8.337 lbs
1 Cubic Foot, Water	7.481 gallons
1 Cubic Foot	1,728 cubic inches
1 Gallon	231 cubic inches

Butane Equivalents						
Unit of Measure	BTU	Pound	Therm	Decitherm	Cuft.	Gallon
1 Pound =	21,221	1	0.212	2.12	6.50	0.208
1 Therm =	100,000	4.714	1	10	30.64	0.98
1 Decitherm =	10,000	0.4714	0.1	1	3.06	0.098
1 Cuft. =	3,280	0.1537	0.032	0.32	1	0.03199
1 Gallon =	102,032	4.81	1.02	10.20	31.26	1

Propane Equivalents						
Unit of Measure	BTU	Pound	Therm	Decitherm	Cuft.	Gallon
1 Pound =	21,591	1	0.216	2.16	8.58	0.239
1 Therm =	100,000	4.622	1	10	39.7	1.10
1 Decitherm =	10,000	0.4622	0.1	1	3.97	0.110
1 Cuft. =	2,516	0.1164	0.025	0.25	1	0.027
1 Gallon =	91,690	4.24	0.917	9.17	36.39	1

Specific Gravity and Heat Content by Volume of LP Gas-Air Mixtures

Propane - Air Mixtures

% Propane	% Air	Specific Gravity	Gross BTU/cuft	Wobbe Index
100	0	1.530	2516	2034
95	5	1.504	2390	1949
90	10	1.477	2264	1863
85	15	1.451	2139	1776
80	20	1.424	2013	1687
75	25	1.398	1887	1596
70	30	1.371	1761	1504
65	35	1.345	1635	1410
60	40	1.318	1510	1315
59	41	1.313	1484	1295
58	42	1.307	1459	1276
57	43	1.302	1434	1257
56	44	1.297	1409	1237
55	45	1.292	1384	1218
54	46	1.286	1359	1198
53	47	1.281	1333	1178
52	48	1.276	1308	1158
51	49	1.270	1283	1138
50	50	1.265	1258	1118
49	51	1.260	1233	1098
48	52	1.254	1208	1079
47	53	1.249	1183	1059
46	54	1.244	1157	1037
45	55	1.239	1132	1017
40	60	1.212	1006	914
35	65	1.186	881	809
30	70	1.159	755	701
25	75	1.133	629	591
20	80	1.106	503	478
15	85	1.080	377	363
10	90	1.053	252	246
5	95	1.027	126	124
0	100	1.000	0	0

Butane - Air Mixtures

% Butane	% Air	Specific Gravity	Gross BTU/cuft	Wobbe Index
100	0	2.000	3280	2319
95	5	1.950	3116	2231
90	10	1.900	2952	2142
85	15	1.850	2788	2050
80	20	1.800	2624	1956
75	25	1.750	2460	1860
70	30	1.700	2296	1761
65	35	1.650	2132	1660
60	40	1.600	1968	1556
59	41	1.590	1935	1535
58	42	1.580	1902	1513
57	43	1.570	1870	1492
56	44	1.560	1837	1471
55	45	1.550	1804	1449
54	46	1.540	1770	1426
53	47	1.530	1738	1405
52	48	1.520	1706	1384
51	49	1.510	1672	1361
50	50	1.500	1640	1339
49	51	1.490	1607	1317
48	52	1.480	1574	1294
47	53	1.470	1542	1272
46	54	1.460	1509	1249
45	55	1.450	1476	1226
40	60	1.400	1312	1109
35	65	1.350	1148	988
30	70	1.300	984	863
25	75	1.250	820	733
20	80	1.200	656	599
15	85	1.150	492	459
10	90	1.100	328	313
5	95	1.050	164	160
0	100	1.000	0	0

Propane (30%) Butane (70%) - Air Mixtures

% LPG	% Air	Specific Gravity	Gross BTU/cuft	Wobbe Index
100	0	1.859	3051	2238
95	5	1.816	2898	2151
90	10	1.773	2746	2062
85	15	1.730	2593	1971
80	20	1.687	2441	1879
75	25	1.644	2288	1784
70	30	1.601	2136	1688
65	35	1.559	1983	1588
60	40	1.515	1831	1488
59	41	1.507	1800	1466
58	42	1.498	1769	1445
57	43	1.490	1739	1425
56	44	1.481	1709	1404
55	45	1.473	1678	1383
54	46	1.464	1647	1361
53	47	1.455	1617	1341
52	48	1.447	1587	1319
51	49	1.438	1555	1297
50	50	1.430	1525	1275
49	51	1.421	1495	1254
48	52	1.412	1464	1232
47	53	1.404	1434	1210
46	54	1.395	1404	1189
45	55	1.387	1373	1166
40	60	1.344	1220	1052
35	65	1.301	1068	936
30	70	1.258	915	816
25	75	1.215	763	692
20	80	1.172	610	563
15	85	1.129	458	431
10	90	1.086	305	293
5	95	1.043	153	150
0	100	1	0	0

All data is based on the following assumptions: Propane Vapor SGU = 1.53 2516 BTU/cuft Butane Vapor SGU = 2.00 3280 BTU/cuft

Conversion Factors

Multiply		By	To Obtain	
Pressure				
Atmospheres	atm	1.0332	Kilogram per cm^2	Kg/cm^2
Atmospheres	atm	14.70	Pounds per square inch	psi
Atmospheres	atm	404.19	Inches of Water	inWC
Inches of Mercury	inHg	0.4912	Pounds per square inch	psi
Inches of Mercury	inHg	13.609	Inches of Water	inWC
Inches of Water	inWC	0.361	Pounds per square inch	psi
Inches of Water	inWC	0.0735	Inches of Mercury	inHg
Inches of Water	inWC	0.5775	Ounces per square inch	oz/in^2
Kilo Pascals	kPa	0.01	bar	bar
Kilogram per cm^2	kg/cm^2	14.22	Pounds per square inch	psi
Pounds per square inch	psi	0.0681	Atmospheres	atm
Pounds per square inch	psi	0.0704	Kilogram per cm^2	Kg/cm^2
Pounds per square inch	psi	6.895	KiloPascal	kPa
Pounds per square inch	psi	0.06895	bar	bar
Pounds per square inch	psi	2.036	Inches of Mercury	inHg
Pounds per square inch	psi	27.71	Inches of Water	inWC
Length				
Centimeters	cm	0.3937	Inches	in
Feet	ft	0.3048	Meters	n
Feet	ft	30.48	Centimeters	cm
Feet	ft	304.8	Millimeters	mm
Inches	in	2.54	Centimeters	cm
Inches	in	25.4	Millimeters	mm
Kilometers	km	0.6214	Miles	mls
Meters	m	1.094	Yards	yd
Meters	m	3.281	Feet	ft
Meters	m	39.37	Inches	in
Miles, nautical	mls	1853.0	Meters	m
Miles, statute	mls	1609.0	Meters	m
Yards	yd	0.9144	Meters	m
Yards	yd	91.44	Centimeters	cm

Multiply		By	To Obtain	
Area				
Square inches	sqin	6.4516	Square centimeter	cm^2
Square feet	sqft	929.0304	Square centimeter	cm^2
Square feet	sqft	0.0929	Square meter	m^2
Square centimeter	cm^2	0.155	Square inches	sqin
Square meter	m^2	10.76391	Square feet	**sqft**
Volume				
Cubic centimeter	cm^3	0.06103	Cubic inches	cuin
Cubic feet	cuft	7.48	Gallons (US)	gal
Cubic feet	cuft	28.316	Liters	l
Cubic feet	cuft	1728	Cubic inches	cuin
Cubic feet	cuft	0.76923	Cubic yards	cuyd
Cubic feet	cuft	0.02857	Cubic meters	m^3
Gallons (imperial)	gal	1.20095	Gallons (US)	gal
Gallons (US)	gal	0.1337	Cubic feet	cuft
Gallons (US)	gal	0.83267	Gallons (Imperial)	gal
Gallons (US)	gal	3.785	Liters	l
Gallons (US)	gal	231	Cubic inches	cuin
Liters	l	0.03531	Cubic feet	cuft
Liters	l	0.2642	Gallons (US)	gal
Liters	l	1.057	Quarts (US)	qt
Liters	l	2.113	Pints (US)	pt
Pints (US)	pt	0.4732	Liters	l
Miscellaneous				
BTU	BTU	252.0	Calories	cal
Kilo Calories	kcal	3.968	BTU	BTU
Kilogram	kg	2.205	Pounds	lb
Kilowatt Hour	kWh	3412	BTU	BTU
Ounces	oz	28.35	Grams	gr
Pounds	lb	0.4536	Kilograms	Kg
Pounds	lb	453.5924	Grams (metric)	g
Pounds	lb	21600	Propane BTU	BTU

Definitions of Flame Velocity and Color, Specific Gravity, Calorific Value, Wobbe Index Number

Several characteristics affect Liquified Petroleum Gas (LPG) as a replacement fuel. These include:

- Flame Velocity and Color
- Specific Gravity
- Calorific Value
- BTU Measurement (Wobbe Index)

1. Flame Velocity and Color

Because of the different number of carbon atoms in propane, propane-air mixtures produce a flame that is more yellow in color than that of natural gas. However, the yellow tips are not of any consequence and do not affect burner operation or efficiency. Flame velocities of LPG are near equal to that of natural gas. Therefore, there is no significant flame lift difference between natural gas and propane-air mixtures.

2. Specific Gravity

The density of gas, relative to air, is called specific gravity. The specific gravity of air is defined as 1. Since propane gas has a specific gravity of 1.5, propane-air mixtures have a specific gravity of greater than 1. The chart on the right indicates heat value in BTU per cubic foot, kcal per cubic meter, and the specific gravities of various propane-air mixtures.

Different heat values result primarily from differences in specific gravity. The higher the specific gravity, the heavier the gas. Since burner orifices, flow meters, regulators, etc. have fixed openings, they allow less flow of heavier gas and therefore must have a higher heat value to provide the same energy input as a lighter gas.

Most natural gas has an average heat value of approximately 1050 BTU/cuft (9350 kcal/m³) and a specific gravity of 0.6 (nominal). Compatible propane-air replacement should have a heat value of approximately 1450 BTU/cuft (12,467 kcal/m³) and a specific gravity of 1.297.

Propane - Air Mixtures

BTU/cuft Kcal/Nm^3	% Propane by Volume	% Air by Volume	% Oxygen by Volume	Specific Gravity of Mixture
1700 15,130	66.67	33.33	6.694	1.349
1650 14,685	64.70	35.30	7.378	1.338
1600 14,220	62.74	37.26	7.787	1.328
1550 13,795	60.78	39.22	8.197	1.318
1500 13,350	58.82	41.18	8.606	1.308
1450 12,950	56.86	43.14	9.016	1.297
1400 12,450	54.90	45.10	9.246	1.287
1350 12,015	52.94	47.06	9.835	1.277
1300 11,580	50.98	49.02	10.245	1.267
1250 11,135	49.02	50.98	10.654	1.257

3. Calorific Value

The calorific value is the measurement of the amount of heat or energy produced, and is measured either as gross calorific value or net calorific value. The difference being the latent heat of condensation of the water vapor produced during the combustion process. Gross calorific value assumes all water produced during the combustion process is fully condensed. Net calorific value assumes the water leaves with the combustion products without being fully condensed.

Since most gas burning appliances cannot utilize the heat content of the water vapor, gross calorific value is of little interest. Fuel should be compared based on the net calorific value. This is especially true for natural gas, since increased hydrogen content results in high water formation during combustion.

4. Wobbe Index

The Wobbe Index, a critical factor when analyzing Propane-Air plant requirements, is a function of gas quality and allows matching one gas (in this case, natural gas) to a replacement gas (in this case, Propane-Air). If the two different gases have an identical Wobbe Index, they will produce an equal amount of heat and combustion products and will require the same amount of combustion air. Burners, adjusted for a specific calorific value and fitted with a replacement orifice to match a lower Wobbe Index, result in minor combustion changes. Substituting a gas for one with a higher Wobbe Index, generally allows a narrow acceptance range. Flame characteristics determine the acceptance range for the replacement gas.

The Wobbe index is defined as:

Wobbe Index = Gross Heating Value / (Square root of Specific Gravity)

and is used to compare the energy input into an appliance with different composition fuel gases. If two fuels have identical Wobbe indices, then for a given burner pressure, the energy input will also be identical.

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