

CHAPTER 3 – GAS

PHYSICAL PROPERTIES OF COMMERCIAL FUEL GASES

No.	Gas	Constituents – % by Volume									Specific Gravity	Density, Lb per Cu Ft	Specific Volume Cu Ft/Lb
		CH ₄	C ₂ H ₆	C ₃ H ₈	C ₄ H ₁₀	CO	H ₂	CO ₂	O ₂	N ₂			
1	Acetylene	–	–	–	(100% C ₂ H ₂)	–	–	–	–	–	0.91	.07	14.4
2	Blast Furnace Gas	–	–	–	–	27.5	1	11.5	–	60	1.02	.078	12.8
3	Butane (natural gas)	–	–	7	93	–	–	–	–	–	1.95	.149	6.71
4	Butylene (Butene)	–	–	–	(100% C ₄ H ₈)	–	–	–	–	–	1.94	.148	6.74
5	Carbon Monoxide	–	–	–	–	100	–	–	–	–	0.97	.074	13.5
6	Carburetted Water Gas	10.2	(6.1% C ₂ H ₄ , 2.8% C ₆ H ₆)	–	–	34	40.5	3	0.5	2.9	0.63	.048	20.8
7	Coke Oven Gas	32.1	(3.5% C ₂ H ₄ , 0.5% C ₆ H ₆)	–	–	6.3	46.5	2.2	0.8	8.1	0.44	.034	29.7
8	Digester (Sewage) Gas	67	–	–	(8% H ₂ O)	–	–	25	–	–	0.80	.062	16.3
9	Ethane	–	100	–	–	–	–	–	–	–	1.05	.080	12.5
10	Hydrogen	–	–	–	–	–	100	–	–	–	0.07	.0054	186.9
11	Methane	100	–	–	–	–	–	–	–	–	0.55	.042	23.8
12	Natural (Birmingham, AL)	90	5	–	–	–	–	–	–	5	0.60	.046	21.8
13	Natural (Pittsburgh, PA)	83.4	15.8	–	–	–	–	–	–	0.8	0.61	.047	21.4
14	Natural (Los Angeles, CA)	77.5	16.0	–	–	–	–	6.5	–	–	0.70	.054	18.7
15	Natural (Kansas City, MO)	84.1	6.7	–	–	–	–	0.8	–	8.4	0.63	.048	20.8
16	Natural (Groningen, Netherlands)	81.3	2.9	0.4	0.1	–	–	0.9	–	14.4	0.64	.048	20.7
17	Natural (Midlands Grid, U.K.)	91.8	3.5	0.8	0.3	–	–	0.4	–	2.8	0.61	.046	21.8
18	Producer (Wellman-Galusha)	2.3	–	–	–	25	14.5	4.7	–	52.7	0.84	.065	15.4
19	Propane (natural gas)	–	–	100	–	–	–	–	–	–	1.52	.116	8.61
20	Propylene (Propene)	–	–	–	(100% C ₃ H ₆)	–	–	–	–	–	1.45	.111	9.02
21	Sasol (South Africa)	26	–	–	–	22	48	–	0.5	1	0.42	.032	31.3
22	Water Gas (bituminous)	4.6	(0.4% C ₂ H ₄ , 0.3% C ₆ H ₆)	–	–	28.2	32.5	5.5	0.9	27.6	0.71	.054	18.7

COMBUSTION PROPERTIES OF COMMERCIAL FUEL GASES

Air/Gas Ratio, Flammability Limits, Ignition Temperature & Flame Velocity

No.	Gas	Stoichiometric Air/Gas Ratio		Limits of Flammability % Gas in Air/Gas Mixture		Minimum Ignition Temperature in Air, °F	Maximum Flame Velocity in Air, Ft/Sec*
		Cu Ft Air/ Cu Ft Gas	Lb Air/ Lb Gas	Lean	Rich		
1	Acetylene	11.91	13.26	2.5	80	581	9.4
2	Blast Furnace Gas	0.68	0.67	45	72	–	–
3	Butane (natural gas)	30.47	15.63	1.86	8.41	826	2.8
4	Butylene (Butene)	28.59	14.77	1.7	9	829	3.2
5	Carbon Monoxide	2.38	2.46	12	74	1128	2.0
6	Carburetted Water Gas	4.60	7.36	4.2	42.9	–	–
7	Coke Oven Gas	4.99	11.27	4.5	31.5	–	–
8	Digester (Sewage) Gas	6.41	7.97	8	17	–	–
9	Ethane	16.68	15.98	3.15	12.8	882	2.8
10	Hydrogen	2.38	33.79	4	74.2	1065	16.0
11	Methane	9.53	17.23	5	15	1170	2.2
12	Natural (Birmingham, AL)	9.41	15.68	7.03	15.77	–	–
13	Natural (Pittsburgh, PA)	10.58	17.31	4.6	14.7	–	–
14	Natural (Los Angeles, CA)	10.05	14.26	4.9	15.6	–	–
15	Natural (Kansas City, MO)	9.13	14.59	5.4	16.3	–	–
16	Natural (Groningen, Netherlands)	8.41	13.45	6.1	15	1238	1.18
17	Natural (Midlands Grid, U.K.)	9.8	16.13	5	15	1300	0.98
18	Producer (Wellman-Galusha)	1.30	1.56	16.4	69.4	–	–
19	Propane (natural gas)	23.82	15.73	2.37	9.50	898	2.7
20	Propylene (Propene)	21.44	14.77	2	11.1	856	3.3
21	Sasol (South Africa)	4.13	9.84	5.3	37.4	–	–
22	Water Gas (bituminous)	2.01	2.86	8.9	61	–	–

*Uniform flame speed in a 1" diameter tube. Flame speeds increase in larger diameter tubes.

COMBUSTION PROPERTIES OF COMMERCIAL FUEL GASES

Heating Value, Heat Release & Flame Temperature

No.	Gas	Heating Value				Heat release, Btu		Theoretical Flame Temperature °F
		Btu/cu ft		Btu/lb		Per Cu Ft Air	Per Lb Air	
		Gross	Net	Gross	Net			
1	Acetylene	1498	1447	21,569	20,837	125.8	1677	4250
2	Blast Furnace Gas	92	92	1178	1178	135.3	1804	2650
3	Butane (natural gas)	3225	2977	21,640	19,976	105.8	1411	3640
4	Butylene (Butene)	3077	2876	20,780	19,420	107.6	1435	3810
5	Carbon Monoxide	323	323	4368	4368	135.7	1809	3960
6	Carburetted Water Gas	550	508	11,440	10,566	119.6	1595	3725
7	Coke Oven Gas	574	514	17,048	15,266	115.0	1533	3610
8	Digester (Sewage) Gas	690	621	11,316	10,184	107.6	1407	3550
9	Ethane	1783	1630	22,198	20,295	106.9	1425	3710
10	Hydrogen	325	275	61,084	51,628	136.6	1821	3960
11	Methane	1011	910	23,811	21,433	106.1	1415	3640
12	Natural (Birmingham, AL)	1002	904	21,844	19,707	106.5	1420	3565
13	Natural (Pittsburgh, PA)	1129	1021	24,161	21,849	106.7	1423	3562
14	Natural (Los Angeles, CA)	1073	971	20,065	18,158	106.8	1424	3550
15	Natural (Kansas City, MO)	974	879	20,259	18,283	106.7	1423	3535
16	Natural (Groningen, Netherlands)	941	849	19,599	17,678	111.9	1492	3380
17	Natural (Midlands Grid, U.K.)	1035	902	22,500	19,609	105.6	1408	3450
18	Producer (Wellman-Galusha)	167	156	2650	2476	128.5	1713	3200
19	Propane (natural gas)	2572	2365	21,500	19,770	108	1440	3660
20	Propylene (Propene)	2322	2181	20,990	19,630	108.8	1451	3830
21	Sasol (South Africa)	500	443	14,550	13,016	116.3	1551	3452
22	Water Gas (bituminous)	261	239	4881	4469	129.9	1732	3510

COMBUSTION PROPERTIES OF COMMERCIAL FUEL GASES

Combustion Products & %CO₂

No.	Gas	Combustion Products, Cu Ft/Cu Ft Gas				Combustion Products, Lb/Lb Gas				Ultimate CO ₂ %*
		CO ₂	H ₂ O	N ₂	Total	CO ₂	H ₂ O	N ₂	Total	
1	Acetylene	2.00	1.00	9.41	12.41	3.38	0.69	10.19	14.26	17.5
2	Blast Furnace Gas	0.39	0.02	1.14	1.54	.59	—	1.08	1.67	25.5
3	Butane (natural gas)	3.93	4.93	24.07	32.93	3.09	1.59	11.95	16.63	14.0
4	Butylene (Butene)	4.00	4.00	22.59	30.59	3.14	1.29	11.34	15.77	15.0
5	Carbon Monoxide	1.00	—	1.88	2.88	1.57	—	1.89	3.46	34.7
6	Carburetted Water Gas	0.76	0.87	3.66	5.29	1.85	0.87	5.64	8.36	17.2
7	Coke Oven Gas	0.51	1.25	4.02	5.78	1.76	1.76	8.75	12.27	11.2
8	Digester (Sewage) Gas	0.92	1.42	5.44	7.78	1.74	1.10	6.53	9.37	14.5
9	Ethane	2.00	3.00	13.18	18.18	2.93	1.8	12.25	16.98	13.2]
10	Hydrogen	—	1.00	1.88	2.88	—	8.89	25.90	34.79	0
11	Methane	1.00	2.00	7.53	10.53	2.75	2.25	13.23	18.23	11.7
12	Natural (Birmingham, AL)	1.00	2.02	7.48	10.50	2.54	2.11	12.03	16.68	11.8
13	Natural (Pittsburgh, PA)	1.15	2.22	8.37	11.73	2.86	2.27	13.18	18.31	12.1
14	Natural (Los Angeles, CA)	1.16	2.10	7.94	11.20	2.51	1.87	10.88	15.26	12.7
15	Natural (Kansas City, MO)	0.98	1.95	7.30	10.23	2.39	1.95	11.25	15.59	11.9
16	Natural (Groningen, Netherlands)	0.89	1.73	6.74	9.36	2.17	1.73	10.45	14.35	11.7
17	Natural (Midlands Grid, U.K.)	1.05	2.19	7.94	11.78	2.67	2.29	12.84	17.80	11.7
18	Producer (Wellman-Galusha)	0.34	0.17	1.59	2.11	0.61	0.13	1.82	2.56	17.6
19	Propane (natural gas)	3.00	4.17	18.82	25.99	3.00	1.70	12.03	16.73	13.7
20	Propylene (Propene)	3.00	3.00	16.94	22.94	3.14	1.29	11.34	15.77	15.0
21	Sasol (South Africa)	0.48	1.00	3.28	4.76	1.76	1.50	7.63	10.89	12.8
22	Water Gas (bituminous)	0.41	0.47	1.86	2.74	0.89	0.42	2.55	3.86	18.0

*In dry flue gas sample