



Designation: D4650 – 08

Standard Specification for Normal Butane Thermophysical Property Tables¹

This standard is issued under the fixed designation D4650; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The thermophysical property tables for normal butane are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of normal butane for process design and operations. Tables are provided for gaseous and liquid normal butane at temperatures between 136 and 560 K at pressures to 20 MPa. One table provides properties at the conditions of liquid-vapor equilibrium (saturation properties). The other table provides properties at selected T , p points for the equilibrium phase at those conditions. The tables were developed by the National Institute of Standards and Technology from a Standard Reference Database product REFPROP, version 8.0.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Applicability

2.1 These tables apply directly only to pure gaseous normal butane. However, it is expected that they may find substantial use in mathematical models and tables for the thermophysical properties of mixtures containing normal butane.

3. Tables

3.1 These thermophysical property tables are:

3.1.1 *Thermophysical Properties of Coexisting Gaseous and Liquid Normal Butane*, in SI units. See [Table 1](#).

3.1.2 *Thermophysical Properties of Normal Butane Along Isobars*, in SI units. See [Table 2](#).

3.2 The tabulated thermophysical properties are:

ρ , molar density ($\text{mol}\cdot\text{l}^{-1}$)

H , molar enthalpy ($\text{J}\cdot\text{mol}^{-1}$)

S , molar entropy ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

C_v , constant volume molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

C_p , constant pressure molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

c , speed of sound ($\text{m}\cdot\text{s}^{-1}$)

η , viscosity ($\mu\text{Pa}\cdot\text{s}$)

λ , thermal conductivity ($\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$)

3.3 These tables were produced by equations from a computer package, "NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version =8.0" A wide selection of units (SI units, engineering units, chemical units) is available with this program.²

4. Additional Information

4.1 Reference state properties are required to calculate certain of the thermodynamic properties (enthalpy, entropy, etc.) from an equation of state formulation. The reference state properties used to generate the tables in this specification are: enthalpy, H , and entropy, S , at 298.15 K and 0.101325 MPa ($H = 19275.7 \text{ J/mol}$ and $S = 309.909 \text{ J/(mol K)}$). The molar mass of normal butane is 58.122 g/mol.

5. Keywords

5.1 natural gas; normal butane gas tables; thermodynamic properties of normal butane; transport properties of normal

¹ This specification is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.08 on Thermophysical Properties.

Current edition approved Dec. 1, 2008. Published January 2009. Originally approved in 1987. Last previous edition approved in 2003 as D4650 – 93 (2003). DOI: 10.1520/D4650-08.

² Available from Standard Reference Data, National Institute of Standards and Technology (NIST), 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899.

butane

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TABLE 1 Thermophysical Properties of Coexisting Gaseous and Liquid Normal Butane

T K	p MPa	ρ mol·l ⁻¹	H J·mol ⁻¹	S J·mol ⁻¹ ·K ⁻¹	C_v J·mol ⁻¹ ·K ⁻¹	C_p J·mol ⁻¹ ·K ⁻¹	c m·s ⁻¹	η μPa·s	λ mW·m ⁻¹ ·K ⁻¹
136	8.201E-07	12.627	-22292	134.96	83.79	114.72	1819.4	2201	176.2
136	8.201E-07	7.252E-07	6477.2	346.50	56.23	64.54	149.44	3.349	4.905
140	1.692E-06	12.563	-21832	138.29	83.80	114.92	1793.1	1887	174.8
140	1.692E-06	1.454E-06	6737.0	342.36	57.05	65.36	151.48	3.452	5.091
144	3.338E-06	12.499	-21372	141.53	83.81	115.12	1767.4	1645	173.4
144	3.338E-06	2.788E-06	7000.1	338.56	57.85	66.16	153.49	3.555	5.283
148	6.32E-06	12.435	-20911	144.69	83.82	115.33	1742.2	1452	172.0
148	6.32E-06	5.136E-06	7266.2	335.08	58.62	66.94	155.48	3.658	5.479
152	1.152E-05	12.371	-20450	147.76	83.84	115.55	1717.5	1295	170.4
152	1.152E-05	9.118E-06	7535.4	331.88	59.38	67.70	157.44	3.760	5.681
156	2.029E-05	12.307	-19987	150.77	83.87	115.79	1693.2	1165	168.8
156	2.029E-05	1.565E-05	7807.5	328.94	60.13	68.44	159.37	3.863	5.888
160	3.461E-05	12.243	-19523	153.70	83.92	116.05	1669.2	1055	167.2
160	3.461E-05	2.602E-05	8082.6	326.24	60.86	69.18	161.28	3.965	6.099
164	5.732E-05	12.178	-19059	156.57	83.98	116.32	1645.4	961.7	165.6
164	5.732E-05	4.205E-05	8360.5	323.76	61.59	69.91	163.17	4.067	6.316
168	9.238E-05	12.114	-18593	159.38	84.07	116.62	1621.8	881.0	163.9
168	9.238E-05	6.615E-05	8641.1	321.49	62.31	70.63	165.02	4.170	6.538
172	0.0001452	12.050	-18126	162.13	84.17	116.93	1598.4	810.7	162.1
172	0.0001452	0.0001016	8924.5	319.40	63.03	71.36	166.85	4.271	6.766
176	0.0002229	11.986	-17657	164.82	84.30	117.27	1575.2	749.1	160.4
176	0.0002229	0.0001524	9210.6	317.48	63.75	72.09	168.66	4.373	6.998
180	0.0003348	11.921	-17187	167.46	84.46	117.64	1552.1	694.6	158.6
180	0.0003348	0.0002238	9499.3	315.72	64.48	72.82	170.43	4.475	7.235
184	0.0004928	11.856	-16716	170.05	84.64	118.03	1529.2	646.1	156.8
184	0.0004928	0.0003223	9790.6	314.11	65.21	73.56	172.18	4.576	7.478
188	0.0007118	11.792	-16243	172.59	84.85	118.44	1506.3	602.7	154.9
188	0.0007118	0.0004558	10084	312.63	65.95	74.31	173.90	4.677	7.725
192	0.0010102	11.727	-15768	175.09	85.08	118.89	1483.5	563.7	153.1
192	0.0010102	0.0006337	10381	311.28	66.70	75.07	175.59	4.778	7.977
196	0.0014104	11.661	-15292	177.55	85.34	119.36	1460.8	528.5	151.2
196	0.0014104	0.000867	10680	310.05	67.46	75.85	177.25	4.879	8.235
200	0.001939	11.596	-14814	179.96	85.63	119.86	1438.2	496.5	149.4
200	0.001939	0.0011686	10981	308.93	68.23	76.64	178.87	4.979	8.497
204	0.0026276	11.531	-14333	182.34	85.94	120.38	1415.7	467.4	147.5
204	0.0026276	0.0015535	11284	307.92	69.01	77.45	180.46	5.079	8.765
208	0.003513	11.465	-13850	184.68	86.29	120.94	1393.2	440.8	145.6
208	0.003513	0.0020385	11590	306.99	69.81	78.28	182.01	5.179	9.037
212	0.0046377	11.399	-13365	186.99	86.65	121.53	1370.8	416.5	143.7
212	0.0046377	0.0026425	11898	306.16	70.63	79.13	183.53	5.279	9.315
216	0.00605	11.332	-12878	189.27	87.05	122.15	1348.5	394.1	141.8
216	0.00605	0.0033866	12208	305.41	71.46	80.01	185.00	5.378	9.597
220	0.0078045	11.265	-12388	191.52	87.47	122.80	1326.2	373.4	139.9
220	0.0078045	0.0042942	12520	304.74	72.32	80.91	186.44	5.477	9.884
224	0.0099624	11.198	-11895	193.73	87.92	123.48	1304.0	354.4	138.0
224	0.0099624	0.0053905	12835	304.14	73.18	81.83	187.82	5.575	10.176
228	0.012592	11.131	-11400	195.93	88.40	124.19	1281.8	336.7	136.1
228	0.012592	0.0067034	13151	303.60	74.07	82.78	189.16	5.674	10.47
232	0.015766	11.063	-10901	198.09	88.89	124.93	1259.7	320.3	134.2

TABLE 1 *Continued*

<i>T</i> K	<i>p</i> MPa	ρ mol·l ⁻¹	<i>H</i> J·mol ⁻¹	<i>S</i> J·mol ⁻¹ ·K ⁻¹	<i>C_v</i> J·mol ⁻¹ ·K ⁻¹	<i>C_p</i> J·mol ⁻¹ ·K ⁻¹	<i>c</i> m·s ⁻¹	η μPa·s	λ mW·m ⁻¹ ·K ⁻¹
232	0.015766	0.0082627	13469	303.13	74.98	83.75	190.45	5.772	10.78
236	0.019568	10.995	-10400	200.23	89.42	125.70	1237.6	305.1	132.3
236	0.019568	0.0101	13788	302.73	75.90	84.76	191.69	5.869	11.08
240	0.024086	10.926	-9895.3	202.35	89.96	126.50	1215.6	290.9	130.4
240	0.024086	0.012251	14109	302.37	76.84	85.79	192.87	5.966	11.40
244	0.029415	10.857	-9387.3	204.45	90.53	127.33	1193.7	277.6	128.6
244	0.029415	0.01475	14432	302.07	77.80	86.85	194.00	6.064	11.71
248	0.035656	10.787	-8875.9	206.53	91.13	128.20	1171.8	265.2	126.7
248	0.035656	0.017637	14756	301.82	78.78	87.94	195.06	6.160	12.03
252	0.042919	10.717	-8360.9	208.58	91.74	129.10	1149.9	253.5	124.8
252	0.042919	0.020952	15082	301.61	79.78	89.06	196.06	6.257	12.36
256	0.051319	10.646	-7842.3	210.62	92.37	130.02	1128.1	242.6	123.0
256	0.051319	0.024739	15408	301.44	80.80	90.22	197.00	6.354	12.70
260	0.060978	10.575	-7319.7	212.64	93.03	130.98	1106.4	232.3	121.19
260	0.060978	0.029042	15736	301.32	81.84	91.40	197.86	6.450	13.03
264	0.072022	10.503	-6793.2	214.65	93.70	131.98	1084.7	222.6	119.4
264	0.072022	0.033908	16065	301.23	82.89	92.62	198.66	6.547	13.38
268	0.084586	10.430	-6262.7	216.64	94.39	133.00	1063.0	213.5	117.6
268	0.084586	0.039388	16394	301.18	83.96	93.88	199.38	6.644	13.73
272	0.098809	10.357	-5727.8	218.62	95.10	134.06	1041.4	204.9	115.8
272	0.098809	0.045533	16725	301.16	85.05	95.16	200.03	6.740	14.08
276	0.11484	10.283	-5188.6	220.58	95.83	135.15	1019.8	196.7	114.1
276	0.11484	0.052397	17055	301.17	86.15	96.49	200.59	6.838	14.45
280	0.13282	10.208	-4644.9	222.53	96.57	136.28	998.26	189.0	112.3
280	0.13282	0.060039	17387	301.21	87.27	97.85	201.08	6.935	14.82
284	0.15291	10.132	-4096.6	224.46	97.33	137.44	976.74	181.6	110.6
284	0.15291	0.068517	17719	301.28	88.41	99.25	201.47	7.034	15.20
288	0.17526	10.055	-3543.4	226.39	98.10	138.64	955.24	174.6	108.9
288	0.17526	0.077896	18051	301.37	89.56	100.69	201.78	7.133	15.58
292	0.20005	9.9773	-2985.3	228.31	98.89	139.88	933.77	168.0	107.2
292	0.20005	0.088241	18383	301.48	90.72	102.17	202.00	7.233	15.97
296	0.22744	9.8985	-2422.1	230.21	99.70	141.15	912.32	161.7	105.6
296	0.22744	0.099622	18714	301.62	91.90	103.70	202.13	7.334	16.37
300	0.2576	9.8186	-1853.7	232.11	100.51	142.47	890.88	155.6	103.9
300	0.2576	0.11212	19046	301.78	93.10	105.27	202.15	7.436	16.78
304	0.2907	9.7376	-1279.9	234.00	101.34	143.83	869.44	149.9	102.3
304	0.2907	0.12580	19377	301.95	94.31	106.89	202.08	7.540	17.20
308	0.32694	9.6553	-700.5	235.88	102.18	145.24	848.01	144.3	100.7
308	0.32694	0.14075	19707	302.14	95.53	108.56	201.89	7.646	17.64
312	0.36648	9.5717	-115.4	237.75	103.03	146.69	826.57	139.0	99.16
312	0.36648	0.15707	20037	302.35	96.76	110.29	201.61	7.754	18.08
316	0.40952	9.4867	475.7	239.62	103.90	148.20	805.11	134.0	97.62
316	0.40952	0.17485	20365	302.56	98.01	112.08	201.2	7.865	18.53
320	0.45624	9.4002	1072.8	241.48	104.78	149.76	783.62	129.1	96.10
320	0.45624	0.19420	20693	302.80	99.27	113.94	200.69	7.978	18.90
324	0.50684	9.3122	1676.3	243.34	105.66	151.38	762.10	124.4	94.61
324	0.50684	0.21521	21018	303.04	100.55	115.87	200.05	8.095	19.48
328	0.56152	9.2224	2286.3	245.20	106.56	153.07	740.53	119.9	93.14
328	0.56152	0.23803	21342	303.29	101.84	117.87	199.28	8.215	19.98