



Designation: D4651 – 14 (Reapproved 2020)

Standard Specification for Isobutane Thermophysical Property Tables¹

This standard is issued under the fixed designation D4651; 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 isobutane are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of isobutane for process design and operations. Two tables provide properties at the conditions of liquid-vapor equilibrium (saturation properties), one for liquid and one for vapor, at temperatures between 120 K and the critical point, 407.81 K. A third table provides properties at selected T , p points for the equilibrium phase at temperatures between 120 K and 570 K at pressures to 20 MPa. The tables were developed using the National Institute of Standards and Technology Standard Reference Database product REFPROP, version 9.1.

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

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Applicability

2.1 These tables apply directly only to pure isobutane. They may also be used in mathematical models and tables for the thermophysical properties of mixtures containing isobutane.

3. Tables

3.1 These tables were produced by equations from a computer package, “NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Data-

base (REFPROP): Version 9.1.”² A wide selection of units (SI units, engineering units, chemical units) and additional properties are available with this program.

3.2 These thermophysical property tables are:

3.2.1 *Thermophysical Properties of Isobutane Liquid at Vapor-Liquid Equilibrium*, in SI units. See [Table 1](#).

3.2.2 *Thermophysical Properties of Isobutane Vapor at Vapor-Liquid Equilibrium*, in SI units. See [Table 2](#).

3.2.3 *Thermophysical Properties of Isobutane Along Isobars*, in SI units. See [Table 3](#).

3.3 The symbols are:

T , temperature (K)

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 ($\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$)

3.4 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 ($\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$)

4. Additional Information

4.1 Reference state properties are required to calculate the thermodynamic properties enthalpy and entropy from an equation of state formulation. The reference state properties used are those specified by the International Institute of Refrigeration (IIR): enthalpy, $H = 200 \text{ J/g}$, and entropy, $S = 1 \text{ J/(g}\cdot\text{K)}$, for the saturated liquid at 273.15K (0 °C).

4.2 The molar mass of isobutane is 58.122 g/mol.

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 April 1, 2020. Published May 2020. Originally approved in 1987. Last previous edition approved in 2014 as D4651 – 14. DOI: 10.1520/D4651-14R20.

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

TABLE 1 Thermophysical Properties of Isobutane Liquid at Vapor-Liquid Equilibrium

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
120	1.0633E-07	12.636	-5912.6	-34.216	69.001	99.308	1945.4	6055.8	156.73
122	1.6734E-07	12.603	-5713.6	-32.571	69.251	99.681	1928.5	5441.0	156.30
124	2.5915E-07	12.571	-5513.9	-30.948	69.501	100.06	1911.9	4910.8	155.85
126	3.9524E-07	12.538	-5313.4	-29.344	69.752	100.43	1895.5	4450.9	155.38
128	5.9407E-07	12.506	-5112.1	-27.759	70.004	100.81	1879.3	4049.9	154.89
130	8.8064E-07	12.473	-4910.1	-26.193	70.255	101.18	1863.4	3698.4	154.39
132	1.2883E-06	12.441	-4707.4	-24.646	70.505	101.56	1847.7	3389.0	153.86
134	1.8611E-06	12.408	-4503.9	-23.116	70.754	101.93	1832.2	3115.4	153.32
136	2.6564E-06	12.376	-4299.7	-21.603	71.003	102.30	1816.9	2872.5	152.76
138	3.7483E-06	12.343	-4094.7	-20.107	71.250	102.68	1801.7	2656.0	152.19
140	5.2314E-06	12.311	-3889.0	-18.627	71.497	103.05	1786.8	2462.5	151.60
142	7.2252E-06	12.278	-3682.5	-17.162	71.743	103.42	1772.0	2288.8	150.99
144	9.8793E-06	12.245	-3475.3	-15.713	71.988	103.79	1757.4	2132.5	150.37
146	1.3379E-05	12.213	-3267.4	-14.279	72.233	104.16	1742.9	1991.3	149.74
148	1.7953E-05	12.180	-3058.7	-12.859	72.477	104.53	1728.6	1863.6	149.09
150	2.3880E-05	12.147	-2849.3	-11.454	72.720	104.89	1714.4	1747.6	148.43
152	3.1496E-05	12.115	-2639.1	-10.062	72.964	105.26	1700.3	1642.0	147.75
154	4.1206E-05	12.082	-2428.2	-8.6838	73.207	105.63	1686.4	1545.6	147.07
156	5.3493E-05	12.049	-2216.6	-7.3185	73.451	106.00	1672.6	1457.5	146.37
158	6.8925E-05	12.016	-2004.2	-5.9659	73.695	106.36	1658.9	1376.7	145.67
160	8.8176E-05	11.984	-1791.1	-4.6257	73.940	106.73	1645.3	1302.4	144.95
162	0.00011203	11.951	-1577.3	-3.2975	74.186	107.10	1631.8	1234.1	144.22
164	0.00014139	11.918	-1362.8	-1.9812	74.432	107.47	1618.3	1171.0	143.48
166	0.00017732	11.885	-1147.5	-0.67634	74.679	107.83	1605.0	1112.6	142.74
168	0.00022101	11.852	-931.41	0.61730	74.928	108.20	1591.8	1058.6	141.98
170	0.00027386	11.819	-714.63	1.9000	75.178	108.57	1578.6	1008.4	141.22
172	0.00033740	11.786	-497.11	3.1721	75.430	108.95	1565.6	961.80	140.45
174	0.00041343	11.752	-278.84	4.4337	75.684	109.32	1552.6	918.37	139.67
176	0.00050391	11.719	-59.816	5.6852	75.939	109.69	1539.6	877.85	138.88
178	0.00061107	11.686	159.96	6.9268	76.197	110.07	1526.8	839.98	138.09
180	0.00073738	11.653	380.48	8.1588	76.456	110.45	1514.0	804.54	137.30
182	0.00088560	11.619	601.77	9.3813	76.718	110.83	1501.3	771.33	136.49
184	0.0010588	11.586	823.82	10.595	76.983	111.21	1488.6	740.15	135.68
186	0.0012602	11.552	1046.6	11.799	77.250	111.60	1476.0	710.84	134.87
188	0.0014935	11.519	1270.2	12.995	77.519	111.98	1463.4	683.26	134.05
190	0.0017628	11.485	1494.6	14.182	77.792	112.37	1450.9	657.25	133.23
192	0.0020724	11.451	1719.8	15.360	78.067	112.77	1438.5	632.72	132.40
194	0.0024270	11.418	1945.7	16.531	78.345	113.16	1426.1	609.54	131.57
196	0.0028316	11.384	2172.5	17.694	78.627	113.56	1413.7	587.61	130.73
198	0.0032918	11.350	2400.0	18.849	78.911	113.96	1401.4	566.84	129.90
200	0.0038135	11.316	2628.4	19.996	79.199	114.37	1389.1	547.15	129.06
202	0.0044031	11.282	2857.6	21.136	79.490	114.78	1376.9	528.46	128.21
204	0.0050671	11.248	3087.6	22.269	79.785	115.19	1364.7	510.71	127.37
206	0.0058130	11.213	3318.5	23.394	80.082	115.61	1352.6	493.83	126.52
208	0.0066482	11.179	3550.1	24.513	80.384	116.03	1340.5	477.76	125.67
210	0.0075808	11.145	3782.7	25.626	80.689	116.46	1328.4	462.45	124.82
212	0.0086196	11.110	4016.1	26.731	80.998	116.88	1316.3	447.85	123.97
214	0.0097734	11.075	4250.4	27.831	81.310	117.32	1304.4	433.92	123.12
216	0.011052	11.041	4485.5	28.924	81.626	117.76	1292.4	420.62	122.27
218	0.012465	11.006	4721.5	30.011	81.946	118.20	1280.5	407.90	121.41
220	0.014023	10.971	4958.5	31.092	82.269	118.65	1268.6	395.73	120.56
222	0.015736	10.936	5196.3	32.168	82.596	119.10	1256.7	384.08	119.71
224	0.017618	10.901	5435.1	33.238	82.927	119.55	1244.9	372.92	118.86
226	0.019678	10.865	5674.8	34.302	83.262	120.02	1233.0	362.23	118.02
228	0.021930	10.830	5915.4	35.361	83.601	120.48	1221.3	351.97	117.17
230	0.024387	10.794	6157.0	36.415	83.944	120.96	1209.5	342.12	116.32
232	0.027061	10.759	6399.5	37.464	84.290	121.43	1197.8	332.66	115.47
234	0.029967	10.723	6643.0	38.508	84.640	121.92	1186.1	323.57	114.63
236	0.033118	10.687	6887.5	39.547	84.995	122.41	1174.4	314.83	113.79
238	0.036530	10.651	7133.0	40.582	85.353	122.90	1162.8	306.42	112.94
240	0.040218	10.615	7379.5	41.612	85.714	123.40	1151.2	298.32	112.10
242	0.044196	10.578	7627.1	42.637	86.080	123.91	1139.6	290.53	111.27
244	0.048482	10.542	7875.6	43.658	86.450	124.42	1128.0	283.01	110.43
246	0.053092	10.505	8125.2	44.675	86.823	124.94	1116.4	275.77	109.60
248	0.058042	10.468	8375.9	45.688	87.200	125.46	1104.9	268.78	108.77
250	0.063350	10.431	8627.7	46.697	87.581	126.00	1093.4	262.04	107.94
252	0.069033	10.394	8880.5	47.703	87.966	126.54	1081.9	255.54	107.12
254	0.075109	10.357	9134.4	48.704	88.354	127.08	1070.4	249.25	106.30
256	0.081597	10.319	9389.5	49.702	88.746	127.63	1059.0	243.18	105.48
258	0.088516	10.281	9645.6	50.696	89.142	128.19	1047.5	237.31	104.67
260	0.095885	10.243	9903.0	51.687	89.541	128.76	1036.1	231.63	103.86
262	0.10372	10.205	10161	52.674	89.944	129.33	1024.7	226.14	103.05
264	0.11205	10.167	10421	53.658	90.351	129.91	1013.3	220.83	102.25
266	0.12089	10.128	10682	54.639	90.761	130.50	1002.0	215.68	101.45