Designation: D4651 – 14

Standard Specification for Isobutane Thermophysical Property Tables[1]

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.

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 Database (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 ($mol \cdot L^{-1}$)
H, molar enthalpy ($J \cdot mol^{-1}$)
S, molar entropy ($J \cdot K^{-1} \cdot mol^{-1}$)
C_v, constant volume molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
C_p, constant pressure molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
c, speed of sound ($m \cdot s^{-1}$)
η, viscosity (μPa·s)
λ, thermal conductivity ($mW \cdot m^{-1} \cdot K^{-1}$)

3.4 The tabulated thermophysical properties are:

ρ, molar density ($mol \cdot L^{-1}$)
H, molar enthalpy ($J \cdot mol^{-1}$)
S, molar entropy ($J \cdot K^{-1} \cdot mol^{-1}$)
C_v, constant volume molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
C_p, constant pressure molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
c, speed of sound ($m \cdot s^{-1}$)
η, viscosity (μPa·s)
λ, thermal conductivity ($mW \cdot m^{-1} \cdot K^{-1}$)

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, $H = 200$ J/g, and entropy, $S = 1$ J/(g·K), for the saturated liquid at 273.15K (0°C).

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

5. Keywords

5.1 isobutane; isobutane gas tables; natural gas; thermodynamic properties of isobutane; transport properties of isobutane; 2-methylpropane

[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 June 1, 2014. Published July 2014. Originally approved in 1987. Last previous edition approved in 2008 as D4651 – 08. DOI: 10.1520/D4651-14.

[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

TABLE 1 *Continued*

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}
268	0.13025	10.090	10944	55.617	91.175	131.10	990.63	210.70	100.66
270	0.14017	10.051	11207	56.592	91.592	131.70	979.29	205.87	99.867
272	0.15066	10.012	11472	57.564	92.012	132.32	967.96	201.19	99.082
274	0.16174	9.9721	11738	58.534	92.436	132.94	956.65	196.65	98.301
276	0.17344	9.9324	12005	59.501	92.864	133.57	945.35	192.25	97.524
278	0.18577	9.8925	12273	60.465	93.294	134.21	934.06	187.98	96.753
280	0.19876	9.8523	12543	61.427	93.728	134.86	922.77	183.83	95.986
282	0.21243	9.8118	12813	62.386	94.165	135.52	911.50	179.81	95.224
284	0.22681	9.7710	13086	63.343	94.606	136.19	900.23	175.89	94.467
286	0.24192	9.7300	13359	64.298	95.050	136.87	888.97	172.09	93.715
288	0.25777	9.6887	13635	65.250	95.496	137.56	877.72	168.40	92.969
290	0.27440	9.6470	13911	66.201	95.946	138.26	866.47	164.80	92.227
292	0.29183	9.6051	14189	67.150	96.400	138.97	855.22	161.31	91.491
294	0.31008	9.5628	14468	68.096	96.856	139.70	843.98	157.91	90.761
296	0.32917	9.5202	14749	69.042	97.315	140.43	832.74	154.59	90.036
298	0.34914	9.4773	15031	69.985	97.778	141.18	821.50	151.37	89.316
300	0.37000	9.4339	15315	70.927	98.243	141.94	810.25	148.22	88.602
302	0.39177	9.3902	15600	71.867	98.711	142.72	799.01	145.16	87.894
304	0.41450	9.3462	15887	72.806	99.183	143.51	787.76	142.17	87.191
306	0.43819	9.3017	16176	73.743	99.657	144.32	776.50	139.26	86.494
308	0.46288	9.2568	16466	74.680	100.13	145.14	765.24	136.41	85.803
310	0.48858	9.2114	16758	75.615	100.62	145.98	753.97	133.64	85.118
312	0.51534	9.1657	17051	76.549	101.10	146.84	742.69	130.92	84.439
314	0.54317	9.1194	17346	77.482	101.59	147.71	731.40	128.27	83.765
316	0.57209	9.0727	17643	78.414	102.07	148.61	720.10	125.68	83.098
318	0.60215	9.0255	17942	79.346	102.57	149.52	708.78	123.15	82.437
320	0.63335	8.9777	18242	80.276	103.06	150.46	697.45	120.67	81.781
322	0.66573	8.9295	18544	81.207	103.56	151.42	686.10	118.24	81.132
324	0.69932	8.8806	18848	82.137	104.06	152.40	674.72	115.86	80.489
326	0.73415	8.8312	19154	83.066	104.57	153.41	663.33	113.53	79.851
328	0.77023	8.7811	19462	83.995	105.08	154.45	651.91	111.25	79.220
330	0.80761	8.7304	19772	84.925	105.59	155.52	640.46	109.01	78.595
332	0.84630	8.6790	20084	85.854	106.11	156.62	628.99	106.81	77.976
334	0.88635	8.6270	20398	86.783	106.63	157.75	617.48	104.65	77.363
336	0.92776	8.5741	20715	87.713	107.15	158.92	605.94	102.53	76.757
338	0.97059	8.5206	21033	88.643	107.68	160.13	594.36	100.45	76.156
340	1.0148	8.4662	21354	89.574	108.21	161.39	582.74	98.394	75.561
342	1.0606	8.4109	21677	90.505	108.74	162.69	571.08	96.375	74.973
344	1.1078	8.3548	22002	91.438	109.28	164.04	559.37	94.387	74.390
346	1.1565	8.2977	22330	92.371	109.83	165.44	547.62	92.427	73.814
348	1.2068	8.2396	22661	93.306	110.38	166.91	535.81	90.495	73.243
350	1.2587	8.1805	22994	94.242	110.93	168.44	523.94	88.587	72.679
352	1.3123	8.1202	23330	95.180	111.49	170.04	512.02	86.704	72.120
354	1.3674	8.0588	23668	96.120	112.06	171.73	500.02	84.842	71.567
356	1.4243	7.9961	24010	97.062	112.63	173.50	487.96	83.000	71.020
358	1.4829	7.9321	24354	98.007	113.21	175.38	475.82	81.177	70.479
360	1.5433	7.8666	24702	98.954	113.80	177.37	463.60	79.371	69.944
362	1.6054	7.7996	25053	99.904	114.39	179.48	451.29	77.580	69.415
364	1.6694	7.7310	25408	100.86	114.99	181.74	438.89	75.802	68.891
366	1.7352	7.6606	25766	101.82	115.60	184.15	426.38	74.034	68.374
368	1.8030	7.5883	26128	102.78	116.22	186.76	413.76	72.277	67.862
370	1.8727	7.5139	26494	103.75	116.86	189.58	401.01	70.526	67.356
372	1.9444	7.4372	26864	104.72	117.50	192.66	388.14	68.779	66.856
374	2.0181	7.3580	27239	105.7	118.17	196.03	375.12	67.036	66.363
376	2.0939	7.2762	27619	106.68	118.84	199.74	361.94	65.292	65.877
378	2.1718	7.1913	28005	107.68	119.54	203.88	348.59	63.544	65.398
380	2.2519	7.1031	28396	108.68	120.26	208.53	335.05	61.791	64.926
382	2.3343	7.0111	28794	109.69	121.01	213.80	321.32	60.027	64.465
384	2.4189	6.9149	29198	110.72	121.79	219.85	307.36	58.248	64.014
386	2.5058	6.8138	29611	111.76	122.62	226.90	293.15	56.450	63.577
388	2.5951	6.7072	30032	112.81	123.49	235.25	278.69	54.626	63.158
390	2.6869	6.5941	30464	113.88	124.42	245.34	263.93	52.770	62.764
392	2.7812	6.4732	30907	114.98	125.42	257.82	248.86	50.870	62.403
394	2.8782	6.3430	31365	116.11	126.52	273.75	233.42	48.915	62.093
396	2.9778	6.2012	31840	117.27	127.74	294.88	217.58	46.887	61.861
398	3.0802	6.0444	32336	118.48	129.14	324.44	201.26	44.761	61.762
400	3.1856	5.8674	32862	119.75	130.78	369.01	184.38	42.498	61.898
402	3.2940	5.6611	33429	121.12	132.80	444.47	166.79	40.030	62.501
404	3.4057	5.4067	34065	122.65	135.47	601.19	148.23	37.215	64.151
406	3.5210	5.0501	34847	124.52	139.62	1125.7	128.12	33.651	68.999
407.81	3.6284	4.0403	36583	128.73	152.07	329210	106.84	25.500	348.88

TABLE 2 Thermophysical Properties of Isobutane Vapor 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	1.0657E-07	21733	196.17	44.496	52.811	142.74	3.0131	2.6257
122	1.6734E-07	1.6497E-07	21840	193.27	45.023	53.338	143.79	3.0658	2.7408
124	2.5915E-07	2.5136E-07	21947	190.51	45.546	53.861	144.83	3.1185	2.8569
126	3.9524E-07	3.7727E-07	22055	187.87	46.064	54.379	145.87	3.1711	2.9740
128	5.9407E-07	5.5821E-07	22164	185.34	46.578	54.892	146.90	3.2237	3.0922
130	8.8064E-07	8.1474E-07	22275	182.92	47.087	55.402	147.92	3.2763	3.2114
132	1.2883E-06	1.1738E-06	22386	180.61	47.592	55.907	148.93	3.3288	3.3317
134	1.8611E-06	1.6704E-06	22498	178.39	48.094	56.409	149.94	3.3813	3.4530
136	2.6564E-06	2.3492E-06	22611	176.27	48.591	56.906	150.94	3.4337	3.5753
138	3.7483E-06	3.2669E-06	22726	174.24	49.085	57.400	151.94	3.4860	3.6987
140	5.2314E-06	4.4943E-06	22841	172.30	49.575	57.891	152.92	3.5384	3.8231
142	7.2252E-06	6.1198E-06	22957	170.44	50.062	58.378	153.90	3.5906	3.9485
144	9.8793E-06	8.2517E-06	23074	168.66	50.546	58.862	154.88	3.6429	4.0750
146	1.3379E-05	1.1022E-05	23193	166.95	51.028	59.344	155.84	3.6950	4.2025
148	1.7953E-05	1.4591E-05	23312	165.32	51.506	59.823	156.80	3.7472	4.3310
150	2.3880E-05	1.9149E-05	23432	163.75	51.982	60.300	157.76	3.7992	4.4606
152	3.1496E-05	2.4924E-05	23553	162.25	52.456	60.774	158.71	3.8513	4.5912
154	4.1206E-05	3.2185E-05	23675	160.82	52.928	61.247	159.65	3.9032	4.7228
156	5.3493E-05	4.1247E-05	23798	159.44	53.397	61.717	160.58	3.9551	4.8555
158	6.8925E-05	5.2475E-05	23921	158.12	53.866	62.187	161.51	4.0070	4.9892
160	8.8176E-05	6.6294E-05	24046	156.86	54.332	62.655	162.43	4.0588	5.1239
162	0.00011203	8.3191E-05	24171	155.65	54.798	63.122	163.35	4.1105	5.2596
164	0.00014139	0.00010372	24298	154.49	55.262	63.589	164.26	4.1622	5.3964
166	0.00017732	0.00012852	24425	153.38	55.726	64.054	165.16	4.2138	5.5342
168	0.00022101	0.00015829	24553	152.31	56.188	64.520	166.06	4.2654	5.6729
170	0.00027386	0.00019384	24682	151.29	56.651	64.985	166.95	4.3168	5.8127
172	0.00033740	0.00023606	24812	150.32	57.113	65.451	167.83	4.3682	5.9535
174	0.00041343	0.00028595	24943	149.39	57.575	65.917	168.70	4.4196	6.0953
176	0.00050391	0.00034461	25075	148.49	58.037	66.384	169.57	4.4708	6.2381
178	0.00061107	0.00041325	25207	147.64	58.500	66.852	170.43	4.5220	6.3819
180	0.00073738	0.00049321	25340	146.82	58.963	67.320	171.29	4.5732	6.5267
182	0.00088560	0.00058593	25474	146.04	59.426	67.791	172.13	4.6242	6.6725
184	0.0010588	0.00069300	25609	145.30	59.891	68.262	172.97	4.6751	6.8192
186	0.0012602	0.00081613	25745	144.58	60.356	68.736	173.80	4.7260	6.9669
188	0.0014935	0.00095718	25881	143.90	60.823	69.212	174.63	4.7768	7.1156
190	0.0017628	0.0011181	26018	143.25	61.291	69.690	175.44	4.8275	7.2652
192	0.0020724	0.0013012	26156	142.63	61.760	70.170	176.25	4.8781	7.4158
194	0.0024270	0.0015085	26295	142.04	62.231	70.653	177.05	4.9286	7.5673
196	0.0028316	0.0017426	26434	141.48	62.704	71.140	177.83	4.9790	7.7198
198	0.0032918	0.0020061	26574	140.94	63.179	71.629	178.61	5.0294	7.8732
200	0.0038135	0.0023017	26715	140.43	63.656	72.122	179.38	5.0796	8.0275
202	0.0044031	0.0026324	26857	139.94	64.135	72.618	180.14	5.1297	8.1827
204	0.0050671	0.0030011	26999	139.48	64.617	73.118	180.89	5.1797	8.3389
206	0.0058130	0.0034111	27142	139.04	65.101	73.623	181.63	5.2297	8.4959
208	0.0066482	0.0038658	27285	138.62	65.587	74.131	182.36	5.2795	8.6539
210	0.0075808	0.0043687	27429	138.23	66.077	74.644	183.08	5.3292	8.8127
212	0.0086196	0.0049235	27574	137.85	66.569	75.161	183.78	5.3789	8.9724
214	0.0097734	0.0055342	27720	137.50	67.064	75.684	184.48	5.4284	9.1330
216	0.011052	0.0062046	27866	137.16	67.561	76.211	185.16	5.4778	9.2945
218	0.012465	0.0069390	28012	136.85	68.062	76.743	185.83	5.5271	9.4569
220	0.014023	0.0077418	28159	136.55	68.567	77.281	186.48	5.5763	9.6201
222	0.015736	0.0086174	28307	136.27	69.074	77.824	187.12	5.6254	9.7842
224	0.017618	0.0095704	28455	136.01	69.585	78.373	187.75	5.6744	9.9492
226	0.019678	0.010606	28604	135.76	70.099	78.928	188.37	5.7234	10.115
228	0.021930	0.011728	28753	135.53	70.616	79.488	188.97	5.7722	10.282
230	0.024387	0.012943	28903	135.31	71.137	80.055	189.56	5.8209	10.449
232	0.027061	0.014256	29053	135.11	71.662	80.629	190.13	5.8696	10.618
234	0.029967	0.015671	29204	134.92	72.190	81.208	190.68	5.9182	10.787
236	0.033118	0.017195	29355	134.75	72.722	81.795	191.22	5.9666	10.957
238	0.036530	0.018834	29506	134.59	73.257	82.388	191.75	6.0151	11.128
240	0.040218	0.020593	29658	134.44	73.796	82.988	192.25	6.0634	11.300
242	0.044196	0.022477	29810	134.30	74.339	83.595	192.74	6.1117	11.473
244	0.048482	0.024495	29963	134.18	74.886	84.210	193.22	6.1600	11.647
246	0.053092	0.026651	30116	134.07	75.436	84.832	193.67	6.2082	11.822
248	0.058042	0.028952	30269	133.97	75.990	85.462	194.11	6.2564	11.997
250	0.063350	0.031405	30423	133.88	76.548	86.099	194.52	6.3045	12.174
252	0.069033	0.034017	30577	133.80	77.110	86.744	194.92	6.3527	12.352
254	0.075109	0.036794	30731	133.73	77.676	87.398	195.30	6.4008	12.530
256	0.081597	0.039744	30886	133.67	78.245	88.060	195.66	6.4489	12.710
258	0.088516	0.042874	31041	133.62	78.819	88.730	196.00	6.4971	12.891
260	0.095885	0.046192	31196	133.58	79.396	89.409	196.32	6.5453	13.073
262	0.10372	0.049705	31351	133.55	79.977	90.097	196.62	6.5935	13.256
264	0.11205	0.053421	31506	133.53	80.561	90.793	196.89	6.6419	13.440
266	0.12089	0.057348	31662	133.51	81.150	91.499	197.15	6.6903	13.625

TABLE 2 *Continued*

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}
268	0.13025	0.061495	31818	133.50	81.742	92.215	197.38	6.7387	13.812
270	0.14017	0.065869	31974	133.50	82.338	92.940	197.59	6.7873	14.000
272	0.15066	0.070480	32130	133.51	82.938	93.675	197.78	6.8361	14.189
274	0.16174	0.075336	32286	133.53	83.542	94.421	197.94	6.8850	14.380
276	0.17344	0.080446	32442	133.55	84.149	95.177	198.08	6.9340	14.572
278	0.18577	0.085821	32598	133.58	84.760	95.944	198.20	6.9833	14.766
280	0.19876	0.091469	32754	133.61	85.375	96.722	198.29	7.0328	14.961
282	0.21243	0.097400	32911	133.65	85.993	97.511	198.35	7.0825	15.159
284	0.22681	0.10362	33067	133.70	86.615	98.312	198.39	7.1325	15.357
286	0.24192	0.11015	33223	133.75	87.241	99.126	198.41	7.1828	15.558
288	0.25777	0.11700	33379	133.81	87.870	99.952	198.39	7.2334	15.761
290	0.27440	0.12417	33535	133.87	88.503	100.79	198.35	7.2844	15.966
292	0.29183	0.13168	33691	133.94	89.140	101.64	198.29	7.3357	16.173
294	0.31008	0.13954	33847	134.01	89.780	102.51	198.19	7.3875	16.382
296	0.32917	0.14776	34003	134.09	90.423	103.39	198.07	7.4397	16.593
298	0.34914	0.15635	34158	134.17	91.070	104.29	197.92	7.4925	16.807
300	0.37000	0.16534	34314	134.26	91.721	105.20	197.74	7.5457	17.024
302	0.39177	0.17472	34469	134.34	92.375	106.13	197.52	7.5996	17.243
304	0.41450	0.18452	34623	134.44	93.033	107.08	197.28	7.6541	17.465
306	0.43819	0.19476	34778	134.53	93.695	108.04	197.01	7.7092	17.691
308	0.46288	0.20544	34932	134.63	94.361	109.02	196.70	7.7650	17.919
310	0.48858	0.21659	35086	134.74	95.030	110.03	196.37	7.8217	18.151
312	0.51534	0.22822	35239	134.84	95.703	111.05	196.00	7.8791	18.387
314	0.54317	0.24034	35392	134.95	96.380	112.10	195.59	7.9375	18.627
316	0.57209	0.25298	35544	135.06	97.061	113.17	195.15	7.9967	18.870
318	0.60215	0.26617	35696	135.18	97.746	114.27	194.68	8.0570	19.118
320	0.63335	0.27991	35847	135.29	98.434	115.39	194.17	8.1184	19.370
322	0.66573	0.29422	35997	135.41	99.125	116.54	193.62	8.1810	19.627
324	0.69932	0.30915	36147	135.53	99.819	117.72	193.04	8.2448	19.889
326	0.73415	0.32470	36296	135.65	100.51	118.93	192.41	8.3100	20.156
328	0.77023	0.34090	36444	135.77	101.21	120.17	191.75	8.3766	20.429
330	0.80761	0.35779	36592	135.89	101.91	121.44	191.05	8.4448	20.708
332	0.84630	0.37539	36738	136.02	102.61	122.75	190.31	8.5146	20.994
334	0.88635	0.39372	36884	136.14	103.31	124.10	189.52	8.5861	21.286
336	0.92776	0.41284	37028	136.26	104.01	125.49	188.69	8.6596	21.585
338	0.97059	0.43277	37171	136.39	104.71	126.93	187.82	8.7352	21.892
340	1.0148	0.45354	37313	136.51	105.41	128.42	186.90	8.8129	22.207
342	1.0606	0.47521	37453	136.64	106.11	129.97	185.94	8.8930	22.531
344	1.1078	0.49781	37592	136.76	106.81	131.58	184.92	8.9757	22.865
346	1.1565	0.52140	37729	136.88	107.52	133.26	183.86	9.0611	23.208
348	1.2068	0.54602	37865	137.00	108.23	135.03	182.75	9.1495	23.562
350	1.2587	0.57173	37998	137.11	108.95	136.89	181.59	9.2411	23.928
352	1.3123	0.59860	38130	137.23	109.67	138.86	180.38	9.3362	24.306
354	1.3674	0.62668	38259	137.34	110.41	140.94	179.11	9.4350	24.698
356	1.4243	0.65606	38386	137.45	111.16	143.17	177.78	9.5379	25.105
358	1.4829	0.68681	38510	137.55	111.93	145.55	176.40	9.6453	25.528
360	1.5433	0.71903	38632	137.65	112.72	148.11	174.96	9.7575	25.968
362	1.6054	0.75280	38751	137.74	113.53	150.87	173.45	9.8750	26.427
364	1.6694	0.78824	38866	137.83	114.37	153.86	171.89	9.9982	26.908
366	1.7352	0.82548	38978	137.92	115.23	157.11	170.25	10.128	27.411
368	1.8030	0.86464	39086	137.99	116.11	160.66	168.55	10.264	27.941
370	1.8727	0.90588	39190	138.06	117.03	164.55	166.77	10.409	28.498
372	1.9444	0.94937	39290	138.12	117.98	168.84	164.92	10.561	29.088
374	2.0181	0.99533	39385	138.17	118.96	173.60	163.00	10.723	29.713
376	2.0939	1.0440	39474	138.21	119.97	178.92	160.99	10.896	30.378
378	2.1718	1.0956	39558	138.24	121.02	184.89	158.90	11.081	31.089
380	2.2519	1.1505	39635	138.25	122.11	191.67	156.73	11.278	31.853
382	2.3343	1.2090	39704	138.25	123.23	199.43	154.46	11.491	32.677
384	2.4189	1.2716	39765	138.24	124.41	208.42	152.10	11.721	33.572
386	2.5058	1.3389	39817	138.20	125.63	218.98	149.63	11.972	34.551
388	2.5951	1.4115	39858	138.13	126.92	231.58	147.06	12.245	35.630
390	2.6869	1.4904	39886	138.04	128.27	246.92	144.37	12.546	36.832
392	2.7812	1.5766	39899	137.92	129.70	266.03	141.57	12.881	38.187
394	2.8782	1.6716	39894	137.75	131.24	290.57	138.63	13.256	39.738
396	2.9778	1.7777	39866	137.54	132.91	323.33	135.56	13.682	41.551
398	3.0802	1.8978	39809	137.25	134.75	369.40	132.32	14.175	43.728
400	3.1856	2.0369	39712	136.88	136.83	439.11	128.90	14.761	46.452
402	3.2940	2.2035	39559	136.37	139.26	557.25	125.27	15.484	50.083
404	3.4057	2.4155	39312	135.63	142.29	801.43	121.33	16.437	55.527
406	3.5210	2.7246	38868	134.43	146.50	1601.4	116.78	17.902	66.347
407.81	3.6284	3.7092	37136	130.09	153.85	409210	107.93	23.329	402.21

TABLE 3 Thermophysical Properties of Isobutane Along Isobars

T K	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}
Pressure = 0.1 MPa								
120	12.636	-5905.9	-34.226	69.010	99.305	1945.6	6062.7	156.74
130	12.474	-4903.5	-26.204	70.263	101.18	1863.7	3702.4	154.41
140	12.311	-3882.4	-18.637	71.505	103.04	1787.1	2465.0	151.62
150	12.148	-2842.7	-11.465	72.728	104.89	1714.8	1749.3	148.46
160	11.985	-1784.6	-4.6371	73.948	106.72	1645.7	1303.7	144.98
170	11.820	-708.20	1.8882	75.186	108.57	1579.1	1009.4	141.25
180	11.654	386.81	8.1466	76.463	110.44	1514.5	805.33	137.33
190	11.486	1500.8	14.169	77.799	112.37	1451.5	657.90	133.26
200	11.317	2634.3	19.983	79.206	114.36	1389.7	547.68	129.10
210	11.146	3788.3	25.613	80.695	116.44	1329.0	462.89	124.86
220	10.972	4963.6	31.080	82.275	118.63	1269.2	396.09	120.60
230	10.796	6161.3	36.404	83.949	120.94	1210.1	342.40	116.36
240	10.616	7382.9	41.602	85.718	123.39	1151.6	298.53	112.14
250	10.432	8629.6	46.691	87.584	125.99	1093.7	262.16	107.96
260	10.244	9903.2	51.686	89.542	128.76	1036.2	231.65	103.86
261.07	10.223	10040	52.213	89.756	129.06	1030.1	228.69	103.43
261.07	0.048038	31278	133.56	79.705	89.774	196.48	6.5710	13.170
270	0.046232	32089	136.62	81.849	91.688	200.26	6.7970	14.034
280	0.044385	33017	139.99	84.328	93.959	204.32	7.0478	15.025
290	0.042696	33968	143.33	86.874	96.336	208.25	7.2966	16.041
300	0.041143	34944	146.64	89.474	98.798	212.04	7.5436	17.082
310	0.039709	35945	149.92	92.116	101.32	215.73	7.7888	18.148
320	0.038379	36971	153.17	94.788	103.90	219.32	8.0324	19.239
330	0.037141	38023	156.41	97.481	106.51	222.83	8.2743	20.355
340	0.035985	39101	159.63	100.19	109.15	226.26	8.5148	21.497
350	0.034902	40206	162.83	102.90	111.80	229.61	8.7539	22.664
360	0.033886	41337	166.02	105.61	114.45	232.90	8.9915	23.856
370	0.032930	42495	169.19	108.31	117.11	236.13	9.2279	25.074
380	0.032029	43679	172.35	111.00	119.76	239.30	9.4629	26.317
390	0.031178	44890	175.49	113.66	122.39	242.43	9.6967	27.585
400	0.030372	46127	178.63	116.31	125.01	245.50	9.9294	28.880
410	0.029608	47390	181.75	118.93	127.60	248.53	10.161	30.199
420	0.028882	48679	184.85	121.52	130.16	251.51	10.391	31.545
430	0.028193	49993	187.94	124.08	132.70	254.46	10.620	32.916
440	0.027536	51333	191.02	126.61	135.21	257.36	10.848	34.313
450	0.026910	52697	194.09	129.10	137.68	260.23	11.075	35.735
460	0.026312	54086	197.14	131.56	140.12	263.07	11.301	37.183
470	0.025741	55499	200.18	133.98	142.53	265.87	11.526	38.657
480	0.025194	56937	203.21	136.36	144.89	268.64	11.750	40.156
490	0.024671	58397	206.22	138.70	147.23	271.38	11.973	41.681
500	0.024169	59881	209.22	141.01	149.52	274.09	12.195	43.232
510	0.023688	61388	212.20	143.28	151.78	276.77	12.416	44.809
520	0.023225	62916	215.17	145.51	154.00	279.42	12.637	46.411
530	0.022781	64467	218.12	147.71	156.19	282.05	12.856	48.039
540	0.022353	66040	221.06	149.87	158.34	284.65	13.074	49.693
550	0.021942	67634	223.99	151.99	160.46	287.23	13.292	51.373
560	0.021545	69249	226.90	154.08	162.54	289.78	13.508	53.079
570	0.021163	70885	229.79	156.13	164.58	292.31	13.724	54.810
Pressure = 1 MPa								
120	12.642	-5845.6	-34.318	69.091	99.277	1947.8	6124.6	156.91
130	12.480	-4843.5	-26.297	70.340	101.14	1866.3	3738.2	154.60
140	12.318	-3822.8	-18.734	71.579	103.00	1790.1	2488.1	151.84
150	12.156	-2783.5	-11.564	72.799	104.84	1718.1	1765.3	148.70
160	11.993	-1726.0	-4.7397	74.016	106.67	1649.4	1315.4	145.25
170	11.829	-650.14	1.7820	75.252	108.50	1583.2	1018.4	141.55
180	11.663	444.19	8.0365	76.528	110.37	1519.0	812.47	137.65
190	11.497	1557.4	14.055	77.862	112.28	1456.3	663.77	133.61
200	11.329	2690.0	19.864	79.268	114.26	1395.0	552.65	129.47
210	11.158	3842.9	25.488	80.757	116.33	1334.7	467.20	125.27
220	10.986	5016.9	30.950	82.335	118.50	1275.4	399.90	121.03
230	10.811	6213.2	36.267	84.008	120.78	1216.8	345.82	116.82
240	10.632	7433.0	41.458	85.777	123.20	1158.9	301.65	112.62
250	10.450	8677.6	46.538	87.641	125.76	1101.6	265.05	108.48
260	10.264	9948.7	51.523	89.598	128.48	1044.7	234.36	104.41
270	10.073	11248	56.426	91.643	131.39	988.22	208.33	100.42
280	9.8753	12577	61.260	93.773	134.50	931.89	186.03	96.536
290	9.6707	13939	66.038	95.984	137.85	875.56	166.74	92.757
300	9.4575	15335	70.771	98.270	141.50	819.00	149.88	89.092
310	9.2336	16770	75.475	100.63	145.51	761.91	134.98	85.544
320	8.9965	18247	80.165	103.07	150.01	703.88	121.64	82.110
330	8.7422	19772	84.858	105.59	155.19	644.33	109.54	78.783
339.34	8.4843	21247	89.265	108.03	160.97	586.60	99.071	75.758
339.34	0.44655	37266	136.47	105.18	127.92	187.21	8.7869	22.102