



Designation: D3984 – 24

Standard Specification for Ethane Thermophysical Property Tables¹

This standard is issued under the fixed designation D3984; 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 ethane are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of ethane for process design and operations. Tables are provided for gaseous and liquid ethane at temperatures between 92 and 600 K at pressures to 20 MPa. Two tables provide properties at the conditions of liquid-vapor equilibrium (saturation properties). A third 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 Standard Reference Database 23, REFPROP, version 10.0.

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

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. Referenced Documents

2.1 ASTM Standards:²

D4150 Terminology Relating to Gaseous Fuels

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.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 NIST Standards:³

NIST REFPROP Version 10.0 Lemmon, E.W., Bell, I.H., Huber, M.L., McLinden, M.O. NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties-REFPROP, Version 10.0

3. Terminology

3.1 Definitions:

3.1.1 For definitions of general terms used in D03 Gaseous Fuels standards, refer to Terminology D4150.

3.2 Symbols:

- 3.2.1 c —speed of sound ($\text{m}\cdot\text{s}^{-1}$)
- 3.2.2 C_v —constant volume molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)
- 3.2.3 C_p —constant pressure molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)
- 3.2.4 H —molar enthalpy ($\text{J}\cdot\text{mol}^{-1}$)
- 3.2.5 S —molar entropy ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)
- 3.2.6 T —temperature (K)
- 3.2.7 η —viscosity ($\mu\text{Pa}\cdot\text{s}$)
- 3.2.8 λ —thermal conductivity ($\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$)
- 3.2.9 ρ —molar density ($\text{mol}\cdot\text{l}^{-1}$)

4. Applicability

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

5. Tables

5.1 These tables were produced by equations from a computer package, “NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version 10.0.” A wide selection of units (SI units, engineering units, chemical units) and additional properties are available with this program.⁴

5.2 These thermophysical property tables are:

³ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

⁴ Available from Standard Reference Data, National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

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

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

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

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

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

6. Additional Information

6.1 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 the Normal Boiling Point; 184.57 K and 0.10133 MPa ($H = 14716 \text{ J/mol}$ and $S = 79.731 \text{ J/(mol K)}$). The molar mass of ethane is 30.069 g/mol.

7. Keywords

7.1 ethane gas tables; natural gas; thermodynamic properties of ethane; transport properties of ethane

TABLE 1 Thermophysical Properties of Ethane 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
90.4	1.1518E-06	21.667	-6588.5	-49.729	48.255	69.928	2008.5	1290	255.42
92	1.7410E-06	21.608	-6476.9	-48.505	47.848	69.604	1996.7	1207.2	254.17
94	2.8559E-06	21.535	-6338	-47.012	47.394	69.271	1982.1	1114	252.59
96	4.5809E-06	21.462	-6199.7	-45.557	46.994	69.006	1967.5	1030.9	250.98
98	7.1951E-06	21.389	-6061.9	-44.136	46.639	68.798	1952.9	956.63	249.34
100	1.1081E-05	21.316	-5924.5	-42.748	46.324	68.639	1938.4	889.99	247.68
102	1.6752E-05	21.243	-5787.4	-41.39	46.043	68.521	1924	830.08	245.99
104	2.4891E-05	21.17	-5650.4	-40.06	45.791	68.438	1909.5	776.1	244.27
106	3.6383E-05	21.097	-5513.6	-38.757	45.564	68.385	1895.1	727.35	242.53
108	5.2368E-05	21.024	-5376.9	-37.479	45.358	68.357	1880.8	683.2	240.77
110	7.4287E-05	20.951	-5240.1	-36.225	45.172	68.351	1866.4	643.14	238.99
112	1.0394E-04	20.878	-5103.4	-34.993	45.003	68.363	1852	606.7	237.18
114	1.4357E-04	20.805	-4966.7	-33.783	44.848	68.39	1837.6	573.48	235.36
116	1.9587E-04	20.731	-4829.9	-32.593	44.706	68.431	1823.2	543.14	233.52
118	2.6414E-04	20.658	-4692.9	-31.423	44.574	68.482	1808.8	515.35	231.67
120	3.5230E-04	20.584	-4555.9	-30.271	44.453	68.544	1794.4	489.85	229.79
122	4.6500E-04	20.511	-4418.8	-29.138	44.341	68.614	1780	466.41	227.91
124	6.0768E-04	20.437	-4281.5	-28.022	44.236	68.691	1765.5	444.8	226.01
126	7.8667E-04	20.363	-4144	-26.922	44.138	68.775	1751	424.85	224.1
128	0.0010093	20.289	-4006.3	-25.838	44.047	68.864	1736.5	406.38	222.18
130	0.0012839	20.214	-3868.5	-24.77	43.962	68.959	1722	389.26	220.25
132	0.0016200	20.14	-3730.5	-23.716	43.882	69.058	1707.5	373.35	218.31
134	0.0020283	20.065	-3592.2	-22.677	43.806	69.162	1692.9	358.54	216.36
136	0.0025209	19.991	-3453.8	-21.652	43.736	69.271	1678.3	344.73	214.41
138	0.0031110	19.916	-3315.1	-20.64	43.669	69.383	1663.7	331.81	212.45
140	0.0038136	19.84	-3176.2	-19.64	43.607	69.499	1649.1	319.72	210.49
142	0.0046448	19.765	-3037.1	-18.654	43.548	69.619	1634.4	308.38	208.53
144	0.0056226	19.689	-2897.7	-17.679	43.494	69.743	1619.7	297.72	206.56
146	0.0067664	19.613	-2758	-16.717	43.443	69.871	1605	287.68	204.58
148	0.0080973	19.537	-2618.1	-15.765	43.395	70.003	1590.3	278.22	202.61
150	0.0096380	19.461	-2477.9	-14.825	43.351	70.139	1575.5	269.28	200.64
152	0.011413	19.384	-2337.4	-13.895	43.311	70.279	1560.7	260.82	198.66
154	0.013448	19.307	-2196.6	-12.976	43.273	70.424	1545.9	252.8	196.69
156	0.015772	19.23	-2055.5	-12.066	43.24	70.574	1531.1	245.18	194.72
158	0.018414	19.152	-1914.2	-11.167	43.209	70.728	1516.2	237.95	192.75
160	0.021405	19.074	-1772.4	-10.276	43.183	70.888	1501.3	231.06	190.78
162	0.024779	18.996	-1630.4	-9.3949	43.159	71.052	1486.3	224.49	188.81
164	0.028570	18.918	-1488	-8.5225	43.139	71.222	1471.4	218.21	186.85
166	0.032814	18.839	-1345.2	-7.6586	43.123	71.398	1456.4	212.22	184.89
168	0.037551	18.759	-1202.1	-6.803	43.11	71.58	1441.4	206.48	182.93
170	0.042819	18.68	-1058.5	-5.9553	43.1	71.768	1426.3	200.98	180.98
172	0.048660	18.6	-914.61	-5.1155	43.094	71.963	1411.2	195.7	179.03
174	0.055118	18.519	-770.26	-4.2831	43.092	72.164	1396.1	190.63	177.09
176	0.062235	18.438	-625.49	-3.4581	43.094	72.372	1380.9	185.76	175.15
178	0.070060	18.357	-480.27	-2.64	43.099	72.588	1365.7	181.06	173.22
180	0.078638	18.275	-334.59	-1.8288	43.108	72.812	1350.5	176.54	171.3
182	0.088019	18.193	-188.44	-1.0241	43.12	73.043	1335.2	172.18	169.38
184	0.098253	18.11	-41.785	-0.22582	43.137	73.283	1319.9	167.97	167.47
186	0.10939	18.026	105.38	0.56634	43.157	73.532	1304.5	163.9	165.56
188	0.12149	17.942	253.08	1.3526	43.181	73.789	1289.2	159.96	163.66
190	0.13459	17.858	401.33	2.1331	43.21	74.056	1273.7	156.15	161.77
192	0.14876	17.773	550.14	2.9081	43.242	74.333	1258.3	152.46	159.89
194	0.16405	17.687	699.55	3.6778	43.278	74.62	1242.8	148.88	158.01
196	0.18052	17.601	849.57	4.4423	43.318	74.918	1227.2	145.41	156.14
198	0.19823	17.514	1000.2	5.2019	43.363	75.227	1211.7	142.04	154.28
200	0.21723	17.426	1151.5	5.9569	43.411	75.548	1196	138.77	152.43
202	0.23759	17.337	1303.5	6.7072	43.464	75.881	1180.4	135.59	150.58
204	0.25936	17.248	1456.2	7.4532	43.52	76.226	1164.7	132.5	148.75
206	0.28261	17.158	1609.7	8.1951	43.582	76.585	1148.9	129.49	146.93
208	0.30740	17.068	1763.8	8.9329	43.647	76.958	1133.1	126.56	145.12
210	0.33380	16.976	1918.8	9.667	43.717	77.345	1117.3	123.7	143.31
212	0.36185	16.884	2074.6	10.397	43.791	77.748	1101.4	120.91	141.52
214	0.39164	16.79	2231.2	11.124	43.869	78.167	1085.4	118.2	139.73
216	0.42323	16.696	2388.7	11.848	43.952	78.603	1069.5	115.55	137.95
218	0.45667	16.601	2547.1	12.569	44.039	79.057	1053.4	112.96	136.19
220	0.49205	16.504	2706.4	13.287	44.131	79.529	1037.3	110.43	134.43
222	0.52941	16.407	2866.7	14.002	44.228	80.022	1021.2	107.96	132.68
224	0.56884	16.309	3028	14.714	44.329	80.537	1005	105.55	130.93
226	0.61040	16.209	3190.4	15.424	44.435	81.074	988.76	103.19	129.2
228	0.65416	16.108	3353.8	16.133	44.545	81.635	972.46	100.88	127.48
230	0.70018	16.006	3518.4	16.839	44.661	82.221	956.09	98.617	125.76
232	0.74854	15.903	3684.2	17.543	44.781	82.836	939.66	96.401	124.06
234	0.79931	15.798	3851.1	18.246	44.907	83.48	923.17	94.23	122.36
236	0.85256	15.692	4019.3	18.947	45.037	84.155	906.6	92.103	120.67

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
238	0.90836	15.584	4188.9	19.648	45.173	84.865	889.97	90.016	118.99
240	0.96679	15.475	4359.8	20.347	45.314	85.612	873.25	87.968	117.32
242	1.0279	15.364	4532.2	21.046	45.461	86.398	856.45	85.958	115.66
244	1.0918	15.251	4706.1	21.744	45.614	87.229	839.57	83.984	114
246	1.1585	15.136	4881.5	22.442	45.772	88.107	822.59	82.045	112.35
248	1.2282	15.019	5058.6	23.141	45.937	89.037	805.51	80.138	110.71
250	1.3008	14.901	5237.4	23.839	46.109	90.024	788.33	78.262	109.08
252	1.3766	14.779	5418	24.538	46.287	91.075	771.03	76.415	107.46
254	1.4555	14.656	5600.5	25.239	46.472	92.195	753.6	74.597	105.84
256	1.5376	14.53	5785	25.94	46.665	93.393	736.05	72.805	104.23
258	1.6230	14.401	5971.7	26.643	46.866	94.677	718.36	71.038	102.62
260	1.7118	14.27	6160.6	27.349	47.076	96.059	700.52	69.294	101.02
262	1.8041	14.135	6351.8	28.057	47.294	97.55	682.53	67.571	99.424
264	1.9000	13.997	6545.6	28.768	47.523	99.166	664.38	65.868	97.833
266	1.9996	13.855	6742.1	29.482	47.761	100.93	646.06	64.183	96.247
268	2.1029	13.709	6941.4	30.201	48.01	102.85	627.58	62.514	94.664
270	2.2100	13.559	7143.8	30.924	48.269	104.96	608.92	60.86	93.083
272	2.3210	13.405	7349.6	31.653	48.539	107.3	590.08	59.217	91.506
274	2.4361	13.245	7559	32.388	48.82	109.9	571.04	57.583	89.929
276	2.5554	13.079	7772.4	33.131	49.113	112.82	551.77	55.956	88.354
278	2.6789	12.907	7990	33.882	49.419	116.12	532.23	54.333	86.778
280	2.8067	12.728	8212.4	34.644	49.743	119.89	512.38	52.71	85.203
282	2.9391	12.541	8440.2	35.417	50.09	124.26	492.15	51.083	83.626
284	3.0760	12.345	8673.9	36.204	50.469	129.38	471.46	49.448	82.05
286	3.2177	12.138	8914.4	37.007	50.89	135.48	450.22	47.797	80.475
288	3.3643	11.918	9162.8	37.83	51.369	142.91	428.34	46.125	78.904
290	3.5159	11.684	9420.4	38.677	51.927	152.19	405.7	44.421	77.344
292	3.6728	11.431	9689.1	39.554	52.59	164.16	382.18	42.673	75.81
294	3.8351	11.155	9971.6	40.469	53.394	180.25	357.64	40.863	74.329
296	4.0031	10.849	10272	41.435	54.396	203.18	331.84	38.964	72.96
298	4.1770	10.502	10597	42.473	55.695	238.66	304.47	36.934	71.84
300	4.3573	10.094	10957	43.62	57.488	301.37	274.91	34.698	71.306
302	4.5442	9.5785	11379	44.958	60.283	443.32	241.95	32.091	72.342
304	4.7387	8.8094	11945	46.758	66.07	1064	202.16	28.585	79.577
305	4.8392	8.0469	12448	48.37	74.262	4934.1	175.12	25.666	106.59