



Designation: ~~D3984-93 (Reapproved 2003)~~ Designation: D 3984 - 08

Standard Specification for Ethane Thermophysical Property Tables¹

This standard is issued under the fixed designation D 3984; 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 ethane thermophysical property tables 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 90 and 600 K at pressures to 70 MPa. These tables were developed by the National Institute of Standards and Technology (formerly the National Bureau of Standards) upon culmination of four years of effort in acquiring available physical properties data, in performing experimental measurements, and in formulating these tables for use in thermal computations:~~

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. 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. Sponsorship

~~2.1 The preparation of the tables and supporting work was done by the National Institute of Standards and Technology (NIST) under the sponsorship of the Gas Research Institute, the American Gas Association, and the Standard Reference Data Program of NIST.~~

3. Applicability

~~3.1 These tables apply directly only to pure gaseous and liquid ethane. However, it is expected that they will find substantial use in mathematical models and tables for the thermophysical properties of mixtures containing ethane, such as natural gas.~~

4.3. Tables standards.iteh.ai/catalog/standards/sist/218a4b11-049a-48c9-93f4-19ba0a776b25/astm-d3984-08

~~4.1 These thermophysical property tables are:~~

~~4.1.1~~

3.1 These thermophysical property tables are:

3.1.1 *Thermophysical Properties of Coexisting Gaseous and Liquid Ethane*, in SI units (Table in Appendix F, pp. 642–643).

4.1.2 *Thermophysical Properties of Ethane*, along isobars, in SI units (Table in Appendix F, pp. 645–684).³

~~4.2 These tables were produced by equations from a computer package, “NIST Thermophysical Properties of Fluids Database 12” (also designated MIPROPS) of the Standard Reference Data Program of NIST. A wide selection of units (SI units, engineering units, chemical units) is available with this program.~~

5. in SI units. See Table 1.

3.1.2 *Thermophysical Properties of Ethane 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 ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

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 May 10, 2003. Published May 2003. Originally approved in 1982. Last previous edition approved in 1998 as D3984-93 (1998).

Current edition approved Dec. 1, 2008. Published January 2009. Originally approved in 1982. Last previous edition approved in 2003 as D 3984 - 93 (2003).

TABLE 1 Thermophysical Properties of Coexisting Gaseous and Liquid Ethane

| 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 | 1.15E-06 | 21.667 | -14794 | 69.195 | 48.26 | 69.93 | 2008.5 | 255.6 | 1279 |
| 90.4 | 1.15E-06 | 1.53E-06 | 3089.2 | 267.02 | 26.81 | 35.13 | 180.97 | 2.910 | 3.044 |
| 92 | 1.74E-06 | 21.608 | -14682 | 70.419 | 47.85 | 69.60 | 1996.7 | 254.3 | 1193 |
| 92 | 1.74E-06 | 2.28E-06 | 3145.5 | 264.2 | 26.90 | 35.22 | 182.48 | 3.000 | 3.089 |
| 94 | 2.86E-06 | 21.535 | -14543 | 71.912 | 47.39 | 69.27 | 1982.1 | 252.8 | 1097 |
| 94 | 2.86E-06 | 3.65E-06 | 3216 | 260.84 | 27.02 | 35.34 | 184.36 | 3.113 | 3.145 |
| 96 | 4.58E-06 | 21.462 | -14405 | 73.368 | 46.99 | 69.01 | 1967.5 | 251.1 | 1013 |
| 96 | 4.58E-06 | 5.74E-06 | 3286.8 | 257.66 | 27.14 | 35.46 | 186.22 | 3.227 | 3.202 |
| 98 | 7.2E-06 | 21.389 | -14267 | 74.788 | 46.64 | 68.80 | 1952.9 | 249.5 | 939.1 |
| 98 | 7.2E-06 | 8.83E-06 | 3357.8 | 254.64 | 27.26 | 35.58 | 188.05 | 3.341 | 3.259 |
| 100 | 1.11E-05 | 21.316 | -14130 | 76.176 | 46.32 | 68.64 | 1938.4 | 247.8 | 873.2 |
| 100 | 1.11E-05 | 1.33E-05 | 3429.1 | 251.77 | 27.38 | 35.70 | 189.86 | 3.456 | 3.316 |
| 102 | 1.68E-05 | 21.243 | -13993 | 77.534 | 46.04 | 68.52 | 1924 | 246.1 | 814.5 |
| 102 | 1.68E-05 | 1.98E-05 | 3500.6 | 249.04 | 27.50 | 35.82 | 191.65 | 3.572 | 3.373 |
| 104 | 2.49E-05 | 21.17 | -13856 | 78.864 | 45.79 | 68.44 | 1909.5 | 244.4 | 761.9 |
| 104 | 2.49E-05 | 2.88E-05 | 3572.3 | 246.44 | 27.63 | 35.94 | 193.42 | 3.689 | 3.430 |
| 106 | 3.64E-05 | 21.097 | -13719 | 80.167 | 45.56 | 68.38 | 1895.1 | 242.7 | 714.6 |
| 106 | 3.64E-05 | 4.13E-05 | 3644.2 | 243.97 | 27.75 | 36.07 | 195.17 | 3.807 | 3.488 |
| 108 | 5.24E-05 | 21.024 | -13582 | 81.445 | 45.36 | 68.36 | 1880.8 | 240.9 | 672.0 |
| 108 | 5.24E-05 | 5.83E-05 | 3716.4 | 241.62 | 27.87 | 36.19 | 196.9 | 3.925 | 3.545 |
| 110 | 7.43E-05 | 20.951 | -13446 | 82.699 | 45.17 | 68.35 | 1866.4 | 239.1 | 633.4 |
| 110 | 7.43E-05 | 8.12E-05 | 3788.7 | 239.37 | 28.00 | 36.32 | 198.61 | 4.045 | 3.603 |
| 112 | 0.000104 | 20.878 | -13309 | 83.931 | 45.00 | 68.36 | 1852 | 237.3 | 598.3 |
| 112 | 0.000104 | 0.000112 | 3861.3 | 237.24 | 28.12 | 36.45 | 200.3 | 4.165 | 3.662 |
| 114 | 0.000144 | 20.805 | -13172 | 85.141 | 44.85 | 68.39 | 1837.6 | 235.5 | 566.3 |
| 114 | 0.000144 | 0.000152 | 3934.1 | 235.2 | 28.25 | 36.58 | 201.98 | 4.286 | 3.720 |
| 116 | 0.000196 | 20.731 | -13035 | 86.331 | 44.71 | 68.43 | 1823.2 | 233.6 | 537.1 |
| 116 | 0.000196 | 0.000203 | 4007.0 | 233.25 | 28.38 | 36.71 | 203.63 | 4.409 | 3.778 |
| 118 | 0.000264 | 20.658 | -12898 | 87.501 | 44.57 | 68.48 | 1808.8 | 231.8 | 510.4 |
| 118 | 0.000264 | 0.000269 | 4080.2 | 231.39 | 28.52 | 36.85 | 205.27 | 4.532 | 3.837 |
| 120 | 0.000352 | 20.584 | -12761 | 88.653 | 44.45 | 68.54 | 1794.4 | 229.9 | 485.8 |
| 120 | 0.000352 | 0.000353 | 4153.5 | 229.61 | 28.65 | 36.99 | 206.89 | 4.657 | 3.896 |
| 122 | 0.000465 | 20.511 | -12624 | 89.786 | 44.34 | 68.61 | 1780 | 228.0 | 463.1 |
| 122 | 0.000465 | 0.000459 | 4227.0 | 227.91 | 28.79 | 37.14 | 208.49 | 4.782 | 3.955 |
| 124 | 0.000608 | 20.437 | -12487 | 90.903 | 44.24 | 68.69 | 1765.5 | 226.1 | 442.2 |
| 124 | 0.000608 | 0.00059 | 4300.6 | 226.29 | 28.93 | 37.29 | 210.07 | 4.909 | 4.015 |
| 126 | 0.000787 | 20.363 | -12349 | 92.002 | 44.14 | 68.78 | 1751 | 224.2 | 422.8 |
| 126 | 0.000787 | 0.000752 | 4374.4 | 224.73 | 29.08 | 37.45 | 211.63 | 5.037 | 4.074 |
| 128 | 0.001009 | 20.289 | -12212 | 93.086 | 44.05 | 68.86 | 1736.5 | 222.3 | 404.9 |
| 128 | 0.001009 | 0.000949 | 4448.3 | 223.24 | 29.23 | 37.61 | 213.17 | 5.166 | 4.134 |
| 130 | 0.001284 | 20.214 | -12074 | 94.154 | 43.96 | 68.96 | 1722 | 220.4 | 388.2 |
| 130 | 0.001284 | 0.001189 | 4522.3 | 221.82 | 29.38 | 37.77 | 214.69 | 5.296 | 4.194 |
| 132 | 0.00162 | 20.14 | -11936 | 95.208 | 43.88 | 69.06 | 1707.5 | 218.4 | 372.6 |
| 132 | 0.00162 | 0.001478 | 4596.4 | 220.45 | 29.53 | 37.94 | 216.19 | 5.427 | 4.254 |
| 134 | 0.002028 | 20.065 | -11798 | 96.247 | 43.81 | 69.16 | 1692.9 | 216.4 | 358.1 |
| 134 | 0.002028 | 0.001824 | 4670.6 | 219.14 | 29.69 | 38.11 | 217.68 | 5.560 | 4.314 |
| 136 | 0.002521 | 19.991 | -11659 | 97.273 | 43.74 | 69.27 | 1678.3 | 214.5 | 344.5 |
| 136 | 0.002521 | 0.002234 | 4744.8 | 217.89 | 29.84 | 38.28 | 219.14 | 5.694 | 4.374 |

TABLE 1 *Continued*

| T K | p MPa | ρ mol ⁻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 |
|----------|------------|-----------------------------|----------------------------|---|---|---|--------------------------|-----------------|--|
| 138 | 0.003111 | 19.916 | -11520 | 98.285 | 43.67 | 69.38 | 1663.7 | 212.5 | 331.8 |
| 138 | 0.003111 | 0.002718 | 4819.2 | 216.69 | 30.00 | 38.45 | 220.58 | 5.829 | 4.435 |
| 140 | 0.003814 | 19.84 | -11382 | 99.284 | 43.61 | 69.50 | 1649.1 | 210.6 | 319.8 |
| 140 | 0.003814 | 0.003286 | 4893.6 | 215.53 | 30.15 | 38.62 | 222.01 | 5.966 | 4.496 |
| 142 | 0.004645 | 19.765 | -11242 | 100.27 | 43.55 | 69.62 | 1634.4 | 208.6 | 308.5 |
| 142 | 0.004645 | 0.003947 | 4968.0 | 214.43 | 30.31 | 38.79 | 223.42 | 6.104 | 4.556 |
| 144 | 0.005623 | 19.689 | -11103 | 101.24 | 43.49 | 69.74 | 1619.7 | 206.6 | 297.9 |
| 144 | 0.005623 | 0.004714 | 5042.4 | 213.37 | 30.45 | 38.96 | 224.80 | 6.244 | 4.617 |
| 146 | 0.006766 | 19.613 | -10963 | 102.21 | 43.44 | 69.87 | 1605.0 | 204.7 | 287.9 |
| 146 | 0.006766 | 0.005599 | 5116.8 | 212.35 | 30.60 | 39.13 | 226.17 | 6.385 | 4.678 |
| 148 | 0.008097 | 19.537 | -10823 | 103.16 | 43.40 | 70.00 | 1590.3 | 202.7 | 278.5 |
| 148 | 0.008097 | 0.006614 | 5191.2 | 211.37 | 30.74 | 39.29 | 227.51 | 6.528 | 4.740 |
| 150 | 0.009638 | 19.461 | -10683 | 104.1 | 43.35 | 70.14 | 1575.5 | 200.7 | 269.6 |
| 150 | 0.009638 | 0.007773 | 5265.6 | 210.42 | 30.88 | 39.45 | 228.84 | 6.672 | 4.801 |
| 152 | 0.011413 | 19.384 | -10543 | 105.03 | 43.31 | 70.28 | 1560.7 | 198.7 | 261.1 |
| 152 | 0.011413 | 0.009091 | 5339.8 | 209.52 | 31.01 | 39.61 | 230.14 | 6.819 | 4.863 |
| 154 | 0.013448 | 19.307 | -10402 | 105.95 | 43.27 | 70.42 | 1545.9 | 196.8 | 253.0 |
| 154 | 0.013448 | 0.010582 | 5414.0 | 208.65 | 31.14 | 39.76 | 231.42 | 6.967 | 4.924 |
| 156 | 0.015772 | 19.23 | -10261 | 106.86 | 43.24 | 70.57 | 1531.1 | 194.8 | 245.4 |
| 156 | 0.015772 | 0.012264 | 5488.1 | 207.81 | 31.26 | 39.92 | 232.68 | 7.116 | 4.986 |
| 158 | 0.018414 | 19.152 | -10120 | 107.76 | 43.21 | 70.73 | 1516.2 | 192.8 | 238.1 |
| 158 | 0.018414 | 0.014151 | 5561.9 | 207.01 | 31.39 | 40.08 | 233.91 | 7.268 | 5.048 |
| 160 | 0.021405 | 19.074 | -9977.8 | 108.65 | 43.18 | 70.89 | 1501.3 | 190.8 | 231.2 |
| 160 | 0.021405 | 0.016263 | 5635.6 | 206.23 | 31.51 | 40.24 | 235.12 | 7.422 | 5.110 |
| 162 | 0.024779 | 18.996 | -9835.8 | 109.53 | 43.16 | 71.05 | 1486.3 | 188.9 | 224.5 |
| 162 | 0.024779 | 0.018617 | 5709.0 | 205.48 | 31.64 | 40.40 | 236.3 | 7.577 | 5.172 |
| 164 | 0.02857 | 18.918 | -9693.3 | 110.4 | 43.14 | 71.22 | 1471.4 | 186.9 | 218.2 |
| 164 | 0.02857 | 0.021232 | 5782.2 | 204.76 | 31.76 | 40.57 | 237.45 | 7.735 | 5.234 |
| 166 | 0.032814 | 18.839 | -9550.6 | 111.27 | 43.12 | 71.40 | 1456.4 | 184.9 | 212.2 |
| 166 | 0.032814 | 0.024127 | 5855.0 | 204.07 | 31.90 | 40.75 | 238.57 | 7.895 | 5.297 |
| 168 | 0.037551 | 18.759 | -9407.4 | 112.12 | 43.11 | 71.58 | 1441.4 | 183.0 | 206.4 |
| 168 | 0.037551 | 0.027324 | 5927.6 | 203.4 | 32.03 | 40.94 | 239.67 | 8.057 | 5.360 |
| 170 | 0.042819 | 18.68 | -9263.9 | 112.97 | 43.10 | 71.77 | 1426.3 | 181.0 | 200.8 |
| 170 | 0.042819 | 0.030843 | 5999.7 | 202.75 | 32.17 | 41.14 | 240.73 | 8.221 | 5.422 |
| 172 | 0.04866 | 18.6 | -9120.0 | 113.81 | 43.09 | 71.96 | 1411.2 | 179.1 | 195.5 |
| 172 | 0.04866 | 0.034706 | 6071.4 | 202.13 | 32.32 | 41.35 | 241.76 | 8.388 | 5.485 |
| 174 | 0.055118 | 18.519 | -8975.6 | 114.64 | 43.09 | 72.16 | 1396.1 | 177.1 | 190.4 |
| 174 | 0.055118 | 0.038935 | 6142.7 | 201.53 | 32.48 | 41.58 | 242.76 | 8.557 | 5.548 |
| 176 | 0.062235 | 18.438 | -8830.9 | 115.47 | 43.09 | 72.37 | 1380.9 | 175.2 | 185.5 |
| 176 | 0.062235 | 0.043553 | 6213.5 | 200.95 | 32.65 | 41.83 | 243.72 | 8.728 | 5.612 |
| 178 | 0.07006 | 18.357 | -8685.7 | 116.28 | 43.10 | 72.59 | 1365.7 | 173.3 | 180.7 |
| 178 | 0.07006 | 0.048584 | 6283.7 | 200.38 | 32.83 | 42.09 | 244.65 | 8.902 | 5.675 |
| 180 | 0.078638 | 18.275 | -8540.0 | 117.1 | 43.11 | 72.81 | 1350.5 | 171.3 | 176.2 |
| 180 | 0.078638 | 0.054053 | 6353.4 | 199.84 | 33.02 | 42.38 | 245.54 | 9.079 | 5.739 |
| 182 | 0.088019 | 18.193 | -8393.8 | 117.9 | 43.12 | 73.04 | 1335.2 | 169.4 | 171.8 |
| 182 | 0.088019 | 0.059985 | 6422.6 | 199.31 | 33.21 | 42.68 | 246.39 | 9.258 | 5.803 |
| 184 | 0.098253 | 18.11 | -8247.2 | 118.7 | 43.14 | 73.28 | 1319.9 | 167.5 | 167.6 |
| 184 | 0.098253 | 0.066405 | 6491.2 | 198.8 | 33.42 | 43.00 | 247.2 | 9.441 | 5.867 |
| 186 | 0.10939 | 18.026 | -8100.0 | 119.49 | 43.16 | 73.53 | 1304.5 | 165.6 | 163.5 |

TABLE 1 *Continued*

| T K | ρ MPa | ρ mol·l ⁻¹ | H J·mol ⁻¹ | S J·mol ⁻¹ ·K ⁻¹ | C_p 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 |
|----------|---------------|-------------------------------|----------------------------|---|---|---|--------------------------|-----------------|--|
| 186 | 0.10939 | 0.07334 | 6559.1 | 198.3 | 33.65 | 43.34 | 247.98 | 9.626 | 5.931 |
| 188 | 0.12149 | 17.942 | -7952.3 | 120.28 | 43.18 | 73.79 | 1289.2 | 163.7 | 159.5 |
| 188 | 0.12149 | 0.080817 | 6626.4 | 197.82 | 33.88 | 43.69 | 248.71 | 9.814 | 5.996 |
| 190 | 0.13459 | 17.858 | -7804.1 | 121.06 | 43.21 | 74.06 | 1273.7 | 161.8 | 155.7 |
| 190 | 0.13459 | 0.088865 | 6693.0 | 197.36 | 34.12 | 44.07 | 249.41 | 10.00 | 6.061 |
| 192 | 0.14876 | 17.773 | -7655.2 | 121.83 | 43.24 | 74.33 | 1258.3 | 156.0 | 152.0 |
| 192 | 0.14876 | 0.097512 | 6758.9 | 196.91 | 34.37 | 44.46 | 250.06 | 10.20 | 6.126 |
| 194 | 0.16405 | 17.687 | -7505.8 | 122.6 | 43.28 | 74.62 | 1242.8 | 158.1 | 148.4 |
| 194 | 0.16405 | 0.10679 | 6824.1 | 196.47 | 34.63 | 44.89 | 250.67 | 10.40 | 6.192 |
| 196 | 0.18052 | 17.601 | -7355.8 | 123.37 | 43.32 | 74.92 | 1227.2 | 156.2 | 144.9 |
| 196 | 0.18052 | 0.11672 | 6888.6 | 196.04 | 34.90 | 45.31 | 251.24 | 10.60 | 6.258 |
| 198 | 0.19823 | 17.514 | -7205.1 | 124.13 | 43.36 | 75.23 | 1211.7 | 154.4 | 141.5 |
| 198 | 0.19823 | 0.12735 | 6952.3 | 195.63 | 35.18 | 45.76 | 251.77 | 10.80 | 6.324 |
| 200 | 0.21723 | 17.426 | -7053.8 | 124.88 | 43.41 | 75.55 | 1196.0 | 152.6 | 138.3 |
| 200 | 0.21723 | 0.1387 | 7015.2 | 195.23 | 35.46 | 46.22 | 252.26 | 11.01 | 6.391 |
| 202 | 0.23759 | 17.337 | -6901.8 | 125.63 | 43.46 | 75.88 | 1180.4 | 150.7 | 135.1 |
| 202 | 0.23759 | 0.1508 | 7077.3 | 194.84 | 35.74 | 46.70 | 252.70 | 11.22 | 6.458 |
| 204 | 0.25936 | 17.248 | -6749.1 | 126.38 | 43.52 | 76.23 | 1164.7 | 148.9 | 132.0 |
| 204 | 0.25936 | 0.1637 | 7138.6 | 194.45 | 36.04 | 47.19 | 253.10 | 11.44 | 6.526 |
| 206 | 0.28261 | 17.158 | -6595.7 | 127.12 | 43.58 | 76.58 | 1148.9 | 147.1 | 129.0 |
| 206 | 0.28261 | 0.17742 | 7199.0 | 194.08 | 36.33 | 47.70 | 253.45 | 11.66 | 6.594 |
| 208 | 0.3074 | 17.068 | -6441.5 | 127.86 | 43.65 | 76.96 | 1133.1 | 145.3 | 126.1 |
| 208 | 0.3074 | 0.192 | 7258.5 | 193.72 | 36.63 | 48.23 | 253.76 | 11.88 | 6.663 |
| 210 | 0.3338 | 16.976 | -6286.6 | 128.59 | 43.72 | 77.34 | 1117.3 | 143.5 | 123.2 |
| 210 | 0.3338 | 0.20749 | 7317.1 | 193.37 | 36.94 | 48.77 | 254.02 | 12.11 | 6.732 |
| 212 | 0.36185 | 16.884 | -6130.8 | 129.32 | 43.79 | 77.75 | 1101.4 | 141.7 | 120.5 |
| 212 | 0.36185 | 0.22392 | 7374.8 | 193.03 | 37.24 | 49.33 | 254.24 | 12.34 | 6.802 |
| 214 | 0.39164 | 16.79 | -5974.2 | 130.05 | 43.87 | 78.17 | 1085.4 | 139.9 | 117.8 |
| 214 | 0.39164 | 0.24133 | 7431.5 | 192.69 | 37.55 | 49.90 | 254.41 | 12.58 | 6.872 |
| 216 | 0.42323 | 16.696 | -5816.7 | 130.77 | 43.95 | 78.60 | 1069.5 | 138.1 | 115.1 |
| 216 | 0.42323 | 0.25976 | 7487.1 | 192.36 | 37.86 | 50.49 | 254.54 | 12.82 | 6.944 |
| 218 | 0.45667 | 16.601 | -5658.3 | 131.49 | 44.04 | 79.06 | 1053.4 | 136.4 | 112.6 |
| 218 | 0.45667 | 0.27927 | 7541.7 | 192.04 | 38.17 | 51.09 | 254.62 | 13.07 | 7.016 |
| 220 | 0.49205 | 16.504 | -5498.9 | 132.21 | 44.13 | 79.53 | 1037.3 | 134.6 | 110.0 |
| 220 | 0.49205 | 0.29989 | 7595.2 | 191.73 | 38.49 | 51.72 | 254.65 | 13.32 | 7.089 |
| 222 | 0.52941 | 16.407 | -5338.6 | 132.93 | 44.23 | 80.02 | 1021.2 | 132.8 | 107.6 |
| 222 | 0.52941 | 0.32168 | 7647.6 | 191.42 | 38.80 | 52.36 | 254.63 | 13.58 | 7.163 |
| 224 | 0.56884 | 16.309 | -5177.3 | 133.64 | 44.33 | 80.54 | 1005.0 | 131.1 | 105.2 |
| 224 | 0.56884 | 0.34468 | 7698.8 | 191.12 | 39.12 | 53.03 | 254.56 | 13.84 | 7.238 |
| 226 | 0.6104 | 16.209 | -5015.0 | 134.35 | 44.44 | 81.07 | 988.76 | 129.4 | 102.9 |
| 226 | 0.6104 | 0.36896 | 7748.7 | 190.83 | 39.43 | 53.72 | 254.44 | 14.11 | 7.313 |
| 228 | 0.65416 | 16.108 | -4851.5 | 135.06 | 44.54 | 81.64 | 972.46 | 127.7 | 100.6 |
| 228 | 0.65416 | 0.39457 | 7797.4 | 190.53 | 39.76 | 54.43 | 254.27 | 14.38 | 7.390 |
| 230 | 0.70018 | 16.006 | -4687.0 | 135.76 | 44.66 | 82.22 | 956.09 | 126.0 | 98.34 |
| 230 | 0.70018 | 0.42157 | 7844.7 | 190.25 | 40.08 | 55.18 | 254.05 | 14.66 | 7.469 |
| 232 | 0.74854 | 15.903 | -4521.2 | 136.47 | 44.78 | 82.84 | 939.66 | 124.2 | 96.15 |
| 232 | 0.74854 | 0.45003 | 7890.6 | 189.97 | 40.40 | 55.95 | 253.78 | 14.95 | 7.548 |
| 236 | 0.85256 | 15.692 | -4186.0 | 137.87 | 45.04 | 84.16 | 906.6 | 120.9 | 91.89 |
| 236 | 0.85256 | 0.51158 | 7977.9 | 189.41 | 41.06 | 57.60 | 253.07 | 15.55 | 7.712 |

TABLE 1 *Continued*

| T K | p MPa | ρ mol ⁻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 | -4016.5 | 138.57 | 45.17 | 84.86 | 889.97 | 119.2 | 89.82 |
| 238 | 0.90836 | 0.54482 | 8019.2 | 189.14 | 41.40 | 58.49 | 252.64 | 15.86 | 7.796 |
| 240 | 0.96679 | 15.475 | -3845.6 | 139.27 | 45.31 | 85.61 | 873.25 | 117.5 | 87.80 |
| 240 | 0.96679 | 0.57983 | 8058.7 | 188.87 | 41.74 | 59.42 | 252.14 | 16.18 | 7.881 |
| 242 | 1.0279 | 15.364 | -3673.2 | 139.97 | 45.46 | 86.40 | 856.45 | 115.8 | 85.81 |
| 242 | 1.0279 | 0.61668 | 8096.6 | 188.61 | 42.09 | 60.40 | 251.59 | 16.51 | 7.969 |
| 244 | 1.0918 | 15.251 | -3499.3 | 140.67 | 45.61 | 87.23 | 839.57 | 114.2 | 83.86 |
| 244 | 1.0918 | 0.65547 | 8132.5 | 188.34 | 42.44 | 61.44 | 250.98 | 16.85 | 8.059 |
| 246 | 1.1585 | 15.136 | -3323.9 | 141.37 | 45.77 | 88.11 | 822.59 | 112.6 | 81.94 |
| 246 | 1.1585 | 0.6963 | 8166.5 | 188.08 | 42.80 | 62.54 | 250.31 | 17.20 | 8.151 |
| 248 | 1.2282 | 15.019 | -3146.8 | 142.06 | 45.94 | 89.04 | 805.51 | 110.9 | 80.05 |
| 248 | 1.2282 | 0.73929 | 8198.5 | 187.81 | 43.17 | 63.71 | 249.58 | 17.56 | 8.245 |
| 250 | 1.3008 | 14.901 | -2968.0 | 142.76 | 46.11 | 90.02 | 788.33 | 109.3 | 78.19 |
| 250 | 1.3008 | 0.78456 | 8228.2 | 187.55 | 43.55 | 64.96 | 248.79 | 17.93 | 8.342 |
| 252 | 1.3766 | 14.779 | -2787.4 | 143.46 | 46.29 | 91.08 | 771.03 | 107.7 | 76.36 |
| 252 | 1.3766 | 0.83224 | 8255.7 | 187.28 | 43.93 | 66.29 | 247.93 | 18.32 | 8.442 |
| 254 | 1.4555 | 14.656 | -2604.9 | 144.16 | 46.47 | 92.20 | 753.60 | 106.0 | 74.56 |
| 254 | 1.4555 | 0.88247 | 8280.8 | 187.02 | 44.33 | 67.72 | 247.00 | 18.72 | 8.545 |
| 256 | 1.5376 | 14.53 | -2420.3 | 144.86 | 46.66 | 93.39 | 736.05 | 104.4 | 72.78 |
| 256 | 1.5376 | 0.93543 | 8303.3 | 186.75 | 44.74 | 69.26 | 246.01 | 19.14 | 8.652 |
| 258 | 1.623 | 14.401 | -2233.7 | 145.57 | 46.87 | 94.68 | 718.36 | 102.8 | 71.03 |
| 258 | 1.623 | 0.99127 | 8323.0 | 186.49 | 45.16 | 70.91 | 244.95 | 19.57 | 8.762 |
| 260 | 1.7118 | 14.27 | -2044.8 | 146.27 | 47.08 | 96.06 | 700.52 | 101.2 | 69.30 |
| 260 | 1.7118 | 1.0502 | 8339.9 | 186.21 | 45.59 | 72.71 | 243.81 | 20.02 | 8.876 |
| 262 | 1.8041 | 14.135 | -1853.6 | 146.98 | 47.29 | 97.55 | 682.53 | 99.64 | 67.60 |
| 262 | 1.8041 | 1.1124 | 8353.6 | 185.94 | 46.03 | 74.67 | 242.61 | 20.50 | 8.995 |
| 264 | 1.9 | 13.997 | -1659.8 | 147.69 | 47.52 | 99.17 | 664.38 | 98.05 | 65.91 |
| 264 | 1.9 | 1.1782 | 8364.0 | 185.66 | 46.49 | 76.80 | 241.33 | 21.00 | 9.119 |
| 266 | 1.9996 | 13.855 | -1463.3 | 148.41 | 47.76 | 100.93 | 646.06 | 96.47 | 64.24 |
| 266 | 1.9996 | 1.2478 | 8370.9 | 185.38 | 46.96 | 79.15 | 239.97 | 21.52 | 9.248 |
| 268 | 2.1029 | 13.709 | -1264 | 149.12 | 48.01 | 102.8 | 627.58 | 94.89 | 62.58 |
| 268 | 2.1029 | 1.3215 | 8373.9 | 185.09 | 47.46 | 81.75 | 238.54 | 22.08 | 9.384 |
| 270 | 2.21 | 13.559 | -1061.5 | 149.85 | 48.27 | 105.0 | 608.92 | 93.31 | 60.94 |
| 270 | 2.21 | 1.3998 | 8372.7 | 184.79 | 47.97 | 84.63 | 237.02 | 22.67 | 9.526 |
| 272 | 2.321 | 13.405 | -855.75 | 150.58 | 48.54 | 107.3 | 590.08 | 91.73 | 59.30 |
| 272 | 2.321 | 1.4829 | 8367.0 | 184.48 | 48.51 | 87.86 | 235.42 | 23.29 | 9.676 |
| 274 | 2.4361 | 13.245 | -646.35 | 151.31 | 48.82 | 109.9 | 571.04 | 90.16 | 57.68 |
| 274 | 2.4361 | 1.5713 | 8356.4 | 184.17 | 49.08 | 91.51 | 233.73 | 23.97 | 9.834 |
| 276 | 2.5554 | 13.079 | -433.02 | 152.06 | 49.11 | 112.8 | 551.77 | 88.58 | 56.06 |
| 276 | 2.5554 | 1.6657 | 8340.3 | 183.84 | 49.68 | 95.65 | 231.95 | 24.69 | 10.00 |
| 278 | 2.6789 | 12.907 | -215.36 | 152.81 | 49.42 | 116.1 | 532.23 | 87.01 | 54.45 |
| 278 | 2.6789 | 1.7666 | 8318.2 | 183.5 | 50.31 | 100.4 | 230.07 | 25.47 | 10.18 |
| 280 | 2.8067 | 12.728 | 7.0624 | 153.57 | 49.74 | 119.9 | 512.38 | 85.43 | 52.84 |
| 280 | 2.8067 | 1.8748 | 8289.5 | 183.15 | 50.99 | 105.9 | 228.1 | 26.33 | 10.37 |
| 282 | 2.9391 | 12.541 | 234.80 | 154.34 | 50.09 | 124.3 | 492.15 | 83.86 | 51.22 |
| 282 | 2.9391 | 1.9913 | 8253.3 | 182.78 | 51.70 | 112.4 | 226.01 | 27.26 | 10.58 |
| 284 | 3.076 | 12.345 | 468.51 | 155.13 | 50.47 | 129.4 | 471.46 | 82.28 | 49.60 |
| 284 | 3.076 | 2.1172 | 8208.7 | 182.38 | 52.47 | 120.0 | 223.82 | 28.31 | 10.80 |

TABLE 1 *Continued*

| T K | ρ 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 |
|----------|---------------|-------------------------------|----------------------------|---|---|---|--------------------------|-----------------|--|
| 286 | 3.2177 | 12.138 | 709.01 | 155.93 | 50.89 | 135.5 | 450.22 | 80.71 | 47.96 |
| 286 | 3.2177 | 2.254 | 8154.3 | 181.96 | 53.30 | 129.3 | 221.51 | 29.47 | 11.05 |
| 288 | 3.3643 | 11.918 | 957.38 | 156.75 | 51.37 | 142.9 | 428.34 | 79.14 | 46.30 |
| 288 | 3.3643 | 2.4034 | 8088.7 | 181.52 | 54.20 | 140.8 | 219.07 | 30.80 | 11.32 |
| 290 | 3.5159 | 11.684 | 1215.0 | 157.6 | 51.93 | 152.2 | 405.7 | 77.57 | 44.60 |
| 290 | 3.5159 | 2.5679 | 8009.7 | 181.03 | 55.18 | 155.2 | 216.5 | 32.32 | 11.62 |
| 292 | 3.6728 | 11.431 | 1483.7 | 158.48 | 52.59 | 164.2 | 382.18 | 76.04 | 42.87 |
| 292 | 3.6728 | 2.7507 | 7914.6 | 180.5 | 56.27 | 174.1 | 213.78 | 34.11 | 11.95 |
| 294 | 3.8351 | 11.155 | 1766.3 | 159.39 | 53.39 | 180.2 | 357.64 | 74.55 | 41.07 |
| 294 | 3.8351 | 2.9566 | 7799.3 | 179.91 | 57.49 | 199.9 | 210.88 | 36.27 | 12.34 |
| 296 | 4.0031 | 10.849 | 2066.6 | 160.36 | 54.40 | 203.2 | 331.84 | 73.18 | 39.19 |
| 296 | 4.0031 | 3.1925 | 7658.2 | 179.25 | 58.92 | 237.1 | 207.77 | 38.95 | 12.79 |
| 298 | 4.177 | 10.502 | 2391.2 | 161.4 | 55.70 | 238.7 | 304.47 | 72.04 | 37.18 |
| 298 | 4.177 | 3.4695 | 7481.7 | 178.48 | 60.63 | 295.5 | 204.37 | 42.48 | 13.34 |
| 300 | 4.3573 | 10.094 | 2751.6 | 162.54 | 57.49 | 301.4 | 274.91 | 71.49 | 34.97 |
| 300 | 4.3573 | 3.8079 | 7253.0 | 177.55 | 62.82 | 399.9 | 200.51 | 47.46 | 14.02 |
| 302 | 4.5442 | 9.5785 | 3173.2 | 163.88 | 60.28 | 443.3 | 241.95 | 72.47 | 32.40 |
| 302 | 4.5442 | 4.2525 | 6935.7 | 176.34 | 65.96 | 637.9 | 195.74 | 55.66 | 14.97 |
| 304 | 4.7387 | 8.8094 | 3740.0 | 165.68 | 66.07 | 1064 | 202.16 | 79.53 | 28.94 |
| 304 | 4.7387 | 4.9503 | 6411.8 | 174.47 | 71.74 | 1657 | 188.14 | 75.46 | 16.57 |
| 305 | 4.8392 | 8.0469 | 4242.7 | 167.29 | 74.26 | 4934 | 175.12 | 106.3 | 25.90 |
| 305 | 4.8392 | 5.6788 | 5852.4 | 172.57 | 78.86 | 7441 | 178.83 | 122.1 | 18.40 |

$C_{v,m}$, constant volume molar heat capacity (J·K⁻¹·mol⁻¹)

$C_{p,m}$, constant pressure molar heat capacity (J·K⁻¹·mol⁻¹)

c , speed of sound (m·s⁻¹)

η , viscosity (μPa·s)

λ , thermal conductivity (mW·m⁻¹·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

5.1 These tables were originally published by the American Chemical Society and the American Institute of Physics for the National Institute of Standards and Technology in a comprehensive report titled “Thermophysical Properties of Fluids. II. Methane, Ethane, Propane, Isobutane and Normal Butane.” This report also contains the following:

5.1.1 Properties and uncertainties data.

5.1.2 Correlation equations for ethane.

5.1.3 Description of the research study culminating in the tables.

5.1.4 References to properties data.

5.1.5 Computational methods used.

6.

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 ($H = 11874.2$ J/mol and $S = 221.116$ J/(mol K)). The molar mass of ethane is 30.069 g/mol.

5. Keywords

6.1 natural gas tables

² Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D03-1005.

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