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# Velocity of Sound in Liquid Propane*

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Sound velocity measurements on liquid propane from 90 to 300 K and for pressures to 34 MPa are reported. Also included are saturated liquid sound velocities from 90 to 290 K. The data were combined with $P\varrho T$ data to compute compressibility and specific heat ratio. Comparisons were made to computed values of sound velocity of Goodwin and to the data of Lacam.

Key words: Adiabatic compressibility; liquid; pressure; propane; sound; specific heat ratios; speed; temperature; velocity.

## 1. Introduction

Thermodynamic and transport properties of propane are valuable to the energy industry in the design calculations relating to the handling, transporting, and storage of liquefied natural gas. The data of this paper were obtained as part of a program to provide accurate thermodynamic properties data for propane to support the energy industry, especially the liquefied natural gas industry.

Measurements of sound velocity were made from 90 K to 290 K in the saturated liquid and from 90 K to 300 K and at pressures to 34 MPa in the compressed liquid.

Sound velocities, $W$, were related to the adiabatic compressibility, $k_s$ using

$$W = (\varrho k_s)^{-1/2} \qquad (1)$$

and to the specific heat ratio, $\gamma$, using

$$W = (\gamma \frac{\partial P}{\partial \varrho})_T)^{1/2}, \qquad (2)$$

where $P$, $\varrho$ and $T$ are pressure, density, and temperature respectively.

## 2. Experimental Procedure

Sound velocities were measured using a pulse superposition method. Pulses were generated with a 10 MHz quartz crystal and were allowed to reflect between a matched crystal mounted plane and parallel to the generating crystal. Pulses were generated at a rate such that the reflected pulses were superposed with the new pulses. This condition is detected with an oscilloscope by maximizing the resulting reinforced waveshape as seen by the receiving crystal. This technique, developed by Greenspan and Tschiegg [1],[1] has been used on hydrogen [2], oxygen [3], fluorine [4], methane [5], and ethane [6] in this laboratory and the apparatus is described in detail in the earlier publications. Uncertainty in the measured sound velocities is estimated to be 0.05 percent. Temperatures were measured using a platinum resistance thermometer calibrated by the National Bureau of Standards on the IPTS 1968. Uncertainty in temperature is estimated to be 0.005 K at the lower temperatures and increasing to 0.03 K at 300 K[6].

The sample propane was commercially available ultra high purity grade (99.97 mole percent propane).

## 3. Results

Experimental values of sound velocity and temperature for the saturated liquid are given in table I with the corresponding values of density, compressibility, and specific heat ratio. Table II gives the same quantities for the compressed liquid with the measured values of pressure on isotherms. Isotherms were at 10 K increments from 90 to 120 K and at 20 K increments from 120 to 300 K, and for pressures to 34 MPa. Densities, corresponding to the measured values of temperature and pressure were computed from the recent $P\varrho T$ surface of Goodwin [7,8]. These data are shown in figure 1.

Experimental uncertainty in compressibility of 0.3 percent is a result of the combined uncertainties in density and

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[1] Figures in brackets indicate literature references at the end of this paper.

sound velocity. The corresponding uncertainty for the specific heat ratio, $\gamma$, is 4 percent which is due to the uncertainty in the derivative $(\frac{\partial P}{\partial \varrho})_T$. Ethane has very low compressibility in the liquid phase, certainly so when compared with methane [5] and even with ethane [6]. The very rapid increase in pressure with respect to density puts considerable demands on the ability of the $P\varrho T$ surface to produce this derivative accurately since a small uncertainty in density corresponds to a very much larger uncertainty in pressure. The uncertainty in the density measurements on which the $P\varrho T$ is based will reflect in a much larger uncertainty in a calculated pressure and even more uncertainty in a calculated value of the derivative $(\frac{\partial P}{\partial \varrho})_T$.

Lacam [9] has measured sound velocities at 298.15 K (25 °C) and at 25 K increments to 498.15 K (225 °C) for pressures to 101 MPa. Figure 2 shows a comparison of his 25 C isotherm to the 280 K and 300 K isotherms of this report, where Goodwin's [8] computed sound velocities were used to make the comparison. It can be seen that there is about 0.2 to 0.3 percent difference in the two sets of measurements, which is within the combined uncertainties of the measurements Lacam estimated his uncertainties at 0.3 percent in sound velocity exclusive of temperature and pressure uncertainty contributions.

## 4. References


[1] Greenspan, M.; Tschiegg, C.E. Speed of sound in water by a direct method. 59(4): 249-254; 1957 October.

[2] Younglove, B. A. Speed of sound in fluid parahydrogen. J. Acoust. Soc. Am. 38: 433-438; (1965).

[3] Straty, G. C.; Younglove, B. A. Velocity of sound in saturated and compressed fluid oxygen. J. Chem. Thermo. 5: 305-312; (1973).

[4] Straty, G. C.; Younglove, B. A. Some sound velocity measurements on liquid fluorine. J. Chem. Phys. 58: 2191-2192; (1973).

[5] Straty, G. C. Velocity of sound in dense fluid methane. Cryogenics. 14: 367-370; (1974).

[6] Tsumura, R.; Straty, G. C. Speed of sound in saturated and compressed fluid ethane. Cryogenics. 17: 195-200; (1977).

[7] Goodwin, R. D. The nonanalytic equation of state for pure fluids applied to propane. Advances in Chemistry Series No. 182, The American Chemical Society, Publishers; pp. 345-64. (176th National Meeting of the American Chemical Society, Miami Beach, Florida, Sept. 10-15, 1978.)

[8] Goodwin, R. D. Provisional thermodynamic functions of propane, from 85 to 700 K at Pressures to 700 Bar, Nat. Bur. Stand. (U.S.), Interagency Report NBSIR 77-860.

[9] Lacam, A. Etude experimentale de la propagation des ultrasons dans les fluides. J. Recherches C.N.R.S. 34: 25-56; (1956).


*TABLE I. Experimental values of saturated liquid sound velocity, $W_E$, and temperature, T, with values of sound velocity, $W_c$, and density, $\varrho$, computed from the $P\varrho T$ surface [ref. 7, 8]. The adiabatic compressibility, $K_s$, and heat capacity ratio, $\gamma$, were computed from $W_E$ and $P\varrho T$ derived properties.*

| $T$ K | $W_E$ m/s | $W_c$ m/s | $\Delta$ % | $\varrho$ mol/L | $K_s$ GPa$^{-1}$ | $\gamma$ |
|---|---|---|---|---|---|---|
| 90.0 | 2106.2 | 2115.8 | 0.46 | 16.52 | 0.309 | 1.366 |
| 100.0 | 2037.6 | 2020.8 | −.82 | 16.29 | .335 | 1.418 |
| 110.0 | 1969.2 | 1932.5 | −1.86 | 16.06 | .364 | 1.462 |
| 120.0 | 1900.8 | 1849.7 | −2.69 | 15.83 | .396 | 1.500 |
| 130.0 | 1832.6 | 1771.3 | −3.34 | 15.61 | .433 | 1.531 |
| 140.0 | 1764.9 | 1696.6 | −3.87 | 15.37 | .474 | 1.557 |
| 150.0 | 1697.4 | 1625.1 | −4.26 | 15.14 | .520 | 1.578 |
| 160.0 | 1630.3 | 1556.1 | −4.55 | 14.91 | .572 | 1.594 |
| 170.0 | 1563.3 | 1489.3 | −4.74 | 14.68 | .632 | 1.606 |
| 180.0 | 1496.5 | 1424.3 | −4.82 | 14.44 | .701 | 1.615 |
| 190.0 | 1430.0 | 1360.9 | −4.83 | 14.20 | .781 | 1.620 |
| 200.0 | 1364.4 | 1298.7 | −4.81 | 13.95 | .873 | 1.625 |
| 210.0 | 1298.5 | 1237.6 | −4.69 | 13.71 | .981 | 1.626 |
| 230.0 | 1167.1 | 1117.6 | −4.25 | 13.20 | 1.261 | 1.623 |
| 250.0 | 1036.5 | 999.3 | −3.59 | 12.66 | 1.667 | 1.618 |
| 260.0 | 971.6 | 940.4 | −3.20 | 12.37 | 1.941 | 1.617 |
| 270.0 | 905.4 | 881.5 | −2.65 | 12.08 | 2.290 | 1.614 |
| 290.0 | 775.1 | 762.2 | −1.67 | 11.44 | 3.298 | 1.624 |

TABLE II. *Experimental values of compressed liquid sound velocity,* $W_E$*, temperature* T*, and pressure,* P*. Sound velocity,* $W_c$*, and density,* ρ*, were computed from the* PρT *surface (ref. 7,8). Adiabatic compressibility,* $K_s$*, and specific heat ratio were computed from* $W_E$ *and properties derived from the* PρT *surface.*

| $W_E$ m/s | $W_c$ m/s | Δ % | P MPa | T K | ρ mol/L | $K_s$ GPa⁻¹ | γ |
|---|---|---|---|---|---|---|---|
| 2205.44 | 2337.55 | 5.99 | 34.83 | 90.00 | 16.739 | 0.279 | 1.218 |
| 2196.20 | 2316.63 | 5.48 | 31.43 | 90.00 | 16.719 | .281 | 1.231 |
| 2190.77 | 2304.92 | 5.21 | 29.54 | 90.00 | 16.708 | .283 | 1.237 |
| 2188.78 | 2299.81 | 5.07 | 28.71 | 90.00 | 16.703 | .283 | 1.241 |
| 2179.03 | 2277.51 | 4.52 | 25.13 | 90.00 | 16.682 | .286 | 1.254 |
| 2173.65 | 2266.16 | 4.26 | 23.32 | 90.00 | 16.671 | .288 | 1.261 |
| 2156.54 | 2227.63 | 3.30 | 17.22 | 90.00 | 16.633 | .293 | 1.286 |
| 2149.02 | 2210.83 | 2.88 | 14.58 | 90.00 | 16.616 | .296 | 1.298 |
| 2138.05 | 2190.05 | 2.45 | 11.42 | 90.00 | 16.595 | .299 | 1.310 |
| 2132.21 | 2173.98 | 1.96 | 8.86 | 90.00 | 16.578 | .301 | 1.324 |
| 2123.73 | 2155.66 | 1.50 | 6.05 | 90.00 | 16.559 | .304 | 1.336 |
| 2114.18 | 2134.37 | .95 | 2.80 | 90.00 | 16.537 | .307 | 1.352 |
| 2143.33 | 2239.98 | 4.51 | 34.57 | 100.00 | 16.533 | .299 | 1.266 |
| 2130.73 | 2212.04 | 3.82 | 29.99 | 100.00 | 16.504 | .303 | 1.284 |
| 2120.78 | 2191.23 | 3.32 | 26.61 | 100.00 | 16.482 | .306 | 1.297 |
| 2111.08 | 2170.90 | 2.83 | 23.34 | 100.00 | 16.460 | .309 | 1.310 |
| 2101.98 | 2151.91 | 2.38 | 20.31 | 100.00 | 16.439 | .312 | 1.324 |
| 2092.18 | 2131.84 | 1.90 | 17.12 | 100.00 | 16.417 | .316 | 1.337 |
| 2083.40 | 2113.72 | 1.46 | 14.27 | 100.00 | 16.397 | .319 | 1.349 |
| 2075.42 | 2097.28 | 1.05 | 11.70 | 100.00 | 16.379 | .321 | 1.361 |
| 2065.52 | 2077.08 | .56 | 8.57 | 100.00 | 16.356 | .325 | 1.375 |
| 2056.28 | 2058.59 | .11 | 5.73 | 100.00 | 16.334 | .328 | 1.390 |
| 2046.52 | 2040.08 | −.31 | 2.91 | 100.00 | 16.313 | .332 | 1.402 |
| 2082.37 | 2151.94 | 3.34 | 34.56 | 110.00 | 16.330 | .320 | 1.305 |
| 2073.64 | 2134.77 | 2.95 | 31.73 | 110.00 | 16.310 | .323 | 1.316 |
| 2064.95 | 2117.48 | 2.54 | 28.90 | 110.00 | 16.290 | .326 | 1.327 |
| 2056.27 | 2100.33 | 2.14 | 26.12 | 110.00 | 16.270 | .330 | 1.339 |
| 2053.58 | 2094.18 | 1.98 | 25.12 | 110.00 | 16.262 | .331 | 1.344 |
| 2049.41 | 2086.45 | 1.81 | 23.88 | 110.00 | 16.253 | .332 | 1.349 |
| 2038.65 | 2065.26 | 1.31 | 20.49 | 110.00 | 16.228 | .336 | 1.363 |
| 2028.89 | 2046.46 | .87 | 17.51 | 110.00 | 16.205 | .340 | 1.377 |
| 2018.84 | 2027.12 | .41 | 14.46 | 110.00 | 16.182 | .344 | 1.390 |
| 2009.49 | 2009.27 | −.01 | 11.68 | 110.00 | 16.160 | .348 | 1.403 |
| 1999.34 | 1989.62 | −.49 | 8.65 | 110.00 | 16.135 | .352 | 1.418 |
| 1989.58 | 1971.14 | −.93 | 5.82 | 110.00 | 16.112 | .356 | 1.432 |
| 1979.93 | 1952.74 | −1.37 | 3.03 | 110.00 | 16.089 | .360 | 1.446 |
| 2022.84 | 2071.43 | 2.40 | 34.73 | 120.00 | 16.128 | .344 | 1.338 |
| 2011.06 | 2048.79 | 1.88 | 31.00 | 120.00 | 16.099 | .348 | 1.354 |
| 2003.04 | 2034.46 | 1.57 | 28.66 | 120.00 | 16.081 | .351 | 1.363 |
| 1989.88 | 2011.17 | 1.07 | 24.90 | 120.00 | 16.051 | .357 | 1.378 |
| 1975.15 | 1983.23 | .41 | 20.44 | 120.00 | 16.015 | .363 | 1.398 |
| 1964.44 | 1963.68 | −.04 | 17.35 | 120.00 | 15.989 | .368 | 1.413 |
| 1953.21 | 1943.44 | −.50 | 14.19 | 120.00 | 15.963 | .372 | 1.426 |
| 1944.42 | 1927.68 | −.86 | 11.76 | 120.00 | 15.941 | .376 | 1.439 |
| 1933.20 | 1907.48 | −1.33 | 8.66 | 120.00 | 15.914 | .381 | 1.454 |
| 1921.82 | 1885.74 | −1.88 | 5.37 | 120.00 | 15.884 | .387 | 1.472 |
| 1912.43 | 1870.40 | −2.20 | 3.07 | 120.00 | 15.863 | .391 | 1.483 |
| 1905.10 | 1924.60 | 1.02 | 34.90 | 140.00 | 15.724 | .397 | 1.389 |
| 1895.45 | 1908.54 | .69 | 32.29 | 140.00 | 15.701 | .402 | 1.399 |
| 1882.90 | 1887.82 | .26 | 28.94 | 140.00 | 15.671 | .408 | 1.413 |
| 1873.05 | 1871.52 | −.08 | 26.34 | 140.00 | 15.647 | .413 | 1.424 |
| 1859.89 | 1849.90 | −.54 | 22.93 | 140.00 | 15.615 | .420 | 1.439 |
| 1850.14 | 1833.37 | −.91 | 20.35 | 140.00 | 15.590 | .425 | 1.451 |
| 1839.27 | 1816.03 | −1.26 | 17.66 | 140.00 | 15.563 | .431 | 1.464 |

TABLE II. *Experimental values of compressed liquid sound velocity,* $W_E$, *temperature* T, *and pressure,* P. *Sound velocity,* $W_c$, *and density,* ρ, *were computed from the* PρT *surface (ref. 7,8). Adiabatic compressibility,* $K_s$, *and specific heat ratio were computed from* $W_E$ *and properties derived from the* PρT *surface.*—Continued.

| $W_E$ m/s | $W_c$ m/s | Δ % | $P$ MPa | $T$ K | ρ mol/L | $K_s$ GPa$^{-1}$ | γ |
|---|---|---|---|---|---|---|---|
| 1825.05 | 1793.00 | −1.76 | 14.15 | 140.00 | 15.528 | .438 | 1.480 |
| 1813.01 | 1773.54 | −2.18 | 11.22 | 140.00 | 15.498 | .445 | 1.495 |
| 1801.58 | 1754.90 | −2.59 | 8.44 | 140.00 | 15.468 | .452 | 1.510 |
| 1790.56 | 1737.34 | −2.97 | 5.86 | 140.00 | 15.441 | .458 | 1.523 |
| 1779.49 | 1719.92 | −3.35 | 3.33 | 140.00 | 15.413 | .465 | 1.537 |
| 1788.31 | 1790.01 | .10 | 34.57 | 160.00 | 15.319 | .463 | 1.422 |
| 1777.79 | 1773.82 | −.22 | 31.99 | 160.00 | 15.292 | .469 | 1.433 |
| 1764.69 | 1753.94 | −.61 | 28.86 | 160.00 | 15.259 | .477 | 1.446 |
| 1753.72 | 1737.38 | −.93 | 26.28 | 160.00 | 15.232 | .484 | 1.457 |
| 1739.54 | 1716.50 | −1.32 | 23.07 | 160.00 | 15.196 | .493 | 1.471 |
| 1726.90 | 1697.22 | −1.72 | 20.15 | 160.00 | 15.163 | .501 | 1.485 |
| 1715.11 | 1679.69 | −2.07 | 17.53 | 160.00 | 15.133 | .509 | 1.497 |
| 1700.99 | 1659.01 | −2.47 | 14.48 | 160.00 | 15.097 | .519 | 1.512 |
| 1673.66 | 1618.90 | −3.27 | 8.70 | 160.00 | 15.025 | .539 | 1.544 |
| 1645.12 | 1577.88 | −4.09 | 2.97 | 160.00 | 14.951 | .560 | 1.575 |
| 1674.66 | 1665.96 | −.52 | 34.08 | 180.00 | 14.912 | .542 | 1.443 |
| 1664.70 | 1652.11 | −.76 | 31.94 | 180.00 | 14.887 | .550 | 1.451 |
| 1651.34 | 1633.30 | −1.09 | 29.07 | 180.00 | 14.852 | .560 | 1.463 |
| 1638.39 | 1615.25 | −1.41 | 26.36 | 180.00 | 14.818 | .570 | 1.475 |
| 1623.96 | 1595.72 | −1.74 | 23.46 | 180.00 | 14.781 | .582 | 1.488 |
| 1608.47 | 1574.39 | −2.12 | 20.35 | 180.00 | 14.740 | .595 | 1.502 |
| 1593.23 | 1553.09 | −2.52 | 17.30 | 180.00 | 14.699 | .608 | 1.517 |
| 1579.41 | 1534.12 | −2.87 | 14.62 | 180.00 | 14.662 | .620 | 1.531 |
| 1562.04 | 1510.98 | −3.27 | 11.42 | 180.00 | 14.616 | .636 | 1.547 |
| 1546.24 | 1490.19 | −3.63 | 8.60 | 180.00 | 14.574 | .651 | 1.563 |
| 1531.56 | 1469.95 | −4.02 | 5.90 | 180.00 | 14.533 | .665 | 1.579 |
| 1514.50 | 1447.56 | −4.42 | 2.98 | 180.00 | 14.487 | .682 | 1.596 |
| 1568.77 | 1557.99 | −.69 | 34.67 | 200.00 | 14.520 | .635 | 1.446 |
| 1569.08 | 1556.74 | −.79 | 34.48 | 200.00 | 14.518 | .634 | 1.448 |
| 1554.50 | 1537.57 | −1.09 | 31.63 | 200.00 | 14.478 | .648 | 1.461 |
| 1542.61 | 1522.11 | −1.33 | 29.36 | 200.00 | 14.447 | .660 | 1.469 |
| 1524.37 | 1498.35 | −1.71 | 25.94 | 200.00 | 14.397 | .678 | 1.485 |
| 1513.91 | 1484.70 | −1.93 | 24.00 | 200.00 | 14.368 | .689 | 1.494 |
| 1493.44 | 1458.35 | −2.35 | 20.33 | 200.00 | 14.312 | .710 | 1.511 |
| 1475.66 | 1436.01 | −2.69 | 17.29 | 200.00 | 14.264 | .730 | 1.525 |
| 1458.18 | 1413.81 | −3.04 | 14.33 | 200.00 | 14.216 | .750 | 1.540 |
| 1440.66 | 1391.79 | −3.93 | 11.45 | 200.00 | 14.167 | .771 | 1.556 |
| 1420.44 | 1366.69 | −3.78 | 8.26 | 200.00 | 14.111 | .796 | 1.574 |
| 1400.22 | 1341.84 | −4.17 | 5.18 | 200.00 | 14.055 | .823 | 1.592 |
| 1380.82 | 1317.96 | −4.55 | 2.29 | 200.00 | 14.000 | .850 | 1.611 |
| 1468.01 | 1455.94 | −.82 | 35.01 | 220.00 | 14.126 | .745 | 1.445 |
| 1452.62 | 1437.01 | −1.07 | 32.30 | 220.00 | 14.084 | .763 | 1.455 |
| 1434.94 | 1415.24 | −1.37 | 29.24 | 220.00 | 14.035 | .785 | 1.467 |
| 1417.61 | 1394.05 | −1.66 | 26.33 | 220.00 | 13.986 | .807 | 1.480 |
| 1399.99 | 1372.70 | −1.95 | 23.45 | 220.00 | 13.937 | .830 | 1.492 |
| 1380.17 | 1348.72 | −2.28 | 20.29 | 220.00 | 13.880 | .858 | 1.508 |
| 1361.07 | 1325.71 | −2.60 | 17.34 | 220.00 | 13.826 | .885 | 1.522 |
| 1341.26 | 1302.34 | −2.90 | 14.42 | 220.00 | 13.769 | .916 | 1.537 |
| 1319.31 | 1276.56 | −3.24 | 11.28 | 220.00 | 13.706 | .951 | 1.554 |
| 1297.42 | 1251.03 | −3.58 | 8.26 | 220.00 | 13.643 | .987 | 1.572 |
| 1274.40 | 1224.42 | −3.92 | 5.22 | 220.00 | 13.576 | 1.029 | 1.591 |
| 1252.92 | 1199.96 | −4.23 | 2.50 | 220.00 | 13.514 | 1.069 | 1.608 |
| 1366.78 | 1356.03 | −.79 | 34.75 | 240.00 | 13.722 | .885 | 1.438 |
| 1354.79 | 1341.71 | −.97 | 32.79 | 240.00 | 13.687 | .903 | 1.445 |
| 1331.98 | 1314.77 | −1.29 | 29.19 | 240.00 | 13.621 | .938 | 1.460 |

TABLE II. *Experimental values of compressed liquid sound velocity, $W_E$, temperature T, and pressure, P. Sound velocity, $W_c$, and density, ϱ, were computed from the PϱT surface (ref. 7,8). Adiabatic compressibility, $K_s$, and specific heat ratio were computed from $W_E$ and properties derived from the PϱT surface.*—Continued.

| $W_E$ m/s | $W_c$ m/s | Δ % | P MPa | T K | ϱ mol/L | $K_s$ GPa⁻¹ | γ |
|---|---|---|---|---|---|---|---|
| 1315.98 | 1296.06 | −1.51 | 26.74 | 240.00 | 13.574 | .965 | 1.470 |
| 1295.35 | 1272.20 | −1.79 | 23.70 | 240.00 | 13.513 | 1.000 | 1.484 |
| 1273.86 | 1247.34 | −2.08 | 20.62 | 240.00 | 13.449 | 1.039 | 1.499 |
| 1255.72 | 1226.66 | −2.31 | 18.13 | 240.00 | 13.395 | 1.074 | 1.511 |
| 1227.37 | 1194.90 | −2.65 | 14.42 | 240.00 | 13.311 | 1.131 | 1.530 |
| 1205.33 | 1169.98 | −2.93 | 11.61 | 240.00 | 13.244 | 1.179 | 1.546 |
| 1175.71 | 1137.32 | −3.27 | 8.06 | 240.00 | 13.155 | 1.247 | 1.567 |
| 1149.59 | 1108.82 | −3.55 | 5.10 | 240.00 | 13.075 | 1.312 | 1.587 |
| 1123.73 | 1081.19 | −3.79 | 2.35 | 240.00 | 12.997 | 1.382 | 1.606 |
| 1273.83 | 1265.36 | −.66 | 35.00 | 260.00 | 13.326 | 1.049 | 1.425 |
| 1254.47 | 1243.15 | −.90 | 32.12 | 260.00 | 13.267 | 1.086 | 1.436 |
| 1235.06 | 1221.13 | −1.13 | 29.34 | 260.00 | 13.207 | 1.126 | 1.448 |
| 1215.65 | 1199.46 | −1.33 | 26.68 | 260.00 | 13.148 | 1.167 | 1.459 |
| 1212.25 | 1195.70 | −1.37 | 26.22 | 260.00 | 13.137 | 1.175 | 1.462 |
| 1193.35 | 1174.68 | −1.56 | 23.71 | 260.00 | 13.079 | 1.218 | 1.472 |
| 1166.47 | 1145.01 | −1.84 | 20.29 | 260.00 | 12.995 | 1.283 | 1.489 |
| 1142.69 | 1118.92 | −2.08 | 17.38 | 260.00 | 12.920 | 1.344 | 1.505 |
| 1120.08 | 1094.75 | −2.26 | 14.79 | 260.00 | 12.850 | 1.407 | 1.518 |
| 1091.48 | 1063.69 | −2.55 | 11.58 | 260.00 | 12.758 | 1.492 | 1.538 |
| 1034.53 | 1004.14 | −2.94 | 5.84 | 260.00 | 12.576 | 1.685 | 1.576 |
| 1001.40 | 970.76 | −3.06 | 2.87 | 260.00 | 12.472 | 1.813 | 1.595 |
| 1181.52 | 1174.36 | −.61 | 34.56 | 280.00 | 12.911 | 1.258 | 1.416 |
| 1163.44 | 1154.56 | −.76 | 32.14 | 280.00 | 12.853 | 1.303 | 1.425 |
| 1142.60 | 1131.55 | −.97 | 29.40 | 280.00 | 12.786 | 1.359 | 1.436 |
| 1117.30 | 1104.02 | −1.19 | 26.23 | 280.00 | 12.703 | 1.430 | 1.451 |
| 1095.25 | 1080.16 | −1.38 | 23.57 | 280.00 | 12.631 | 1.497 | 1.463 |
| 1070.45 | 1053.86 | −1.55 | 20.75 | 280.00 | 12.550 | 1.577 | 1.476 |
| 1042.41 | 1024.19 | −1.75 | 17.70 | 280.00 | 12.456 | 1.675 | 1.493 |
| 1002.42 | 982.81 | −1.96 | 13.67 | 280.00 | 12.323 | 1.831 | 1.516 |
| 977.47 | 957.07 | −2.09 | 11.30 | 280.00 | 12.238 | 1.939 | 1.532 |
| 946.83 | 926.01 | −2.20 | 8.58 | 280.00 | 12.134 | 2.085 | 1.551 |
| 909.95 | 889.29 | −2.27 | 5.56 | 280.00 | 12.008 | 2.281 | 1.574 |
| 860.05 | 841.19 | −2.19 | 1.92 | 280.00 | 11.839 | 2.590 | 1.603 |
| 1098.21 | 1093.27 | −.45 | 34.75 | 300.00 | 12.506 | 1.503 | 1.401 |
| 1071.17 | 1063.71 | −.70 | 31.35 | 300.00 | 12.412 | 1.592 | 1.417 |
| 1055.73 | 1047.03 | −.82 | 29.49 | 300.00 | 12.358 | 1.646 | 1.425 |
| 1048.97 | 1040.11 | −.84 | 28.73 | 300.00 | 12.336 | 1.671 | 1.428 |
| 1017.21 | 1006.15 | −1.09 | 25.12 | 300.00 | 12.224 | 1.793 | 1.446 |
| 1010.40 | 999.13 | −1.12 | 24.40 | 300.00 | 12.201 | 1.821 | 1.449 |
| 989.11 | 976.70 | −1.25 | 22.14 | 300.00 | 12.125 | 1.912 | 1.461 |
| 976.05 | 963.07 | −1.33 | 20.80 | 300.00 | 12.079 | 1.971 | 1.468 |
| 965.74 | 952.41 | −1.38 | 19.78 | 300.00 | 12.042 | 2.019 | 1.474 |
| 944.24 | 930.41 | −1.46 | 17.73 | 300.00 | 11.966 | 2.126 | 1.485 |
| 942.26 | 928.64 | −1.45 | 17.57 | 300.00 | 11.959 | 2.136 | 1.487 |
| 908.52 | 894.37 | −1.56 | 14.54 | 300.00 | 11.838 | 2.321 | 1.505 |
| 904.05 | 889.83 | −1.57 | 14.15 | 300.00 | 11.821 | 2.347 | 1.509 |
| 876.16 | 861.82 | −1.64 | 11.83 | 300.00 | 11.720 | 2.521 | 1.525 |
| 868.38 | 853.89 | −1.67 | 11.20 | 300.00 | 11.690 | 2.572 | 1.531 |
| 847.35 | 833.36 | −1.65 | 9.61 | 300.00 | 11.614 | 2.719 | 1.543 |
| 827.58 | 813.96 | −1.65 | 8.17 | 300.00 | 11.541 | 2.869 | 1.555 |
| 792.52 | 780.58 | −1.51 | 5.83 | 300.00 | 11.413 | 3.164 | 1.575 |
| 787.49 | 775.71 | −1.50 | 5.50 | 300.00 | 11.394 | 3.209 | 1.579 |
| 748.57 | 739.26 | −1.24 | 3.19 | 300.00 | 11.250 | 3.597 | 1.603 |

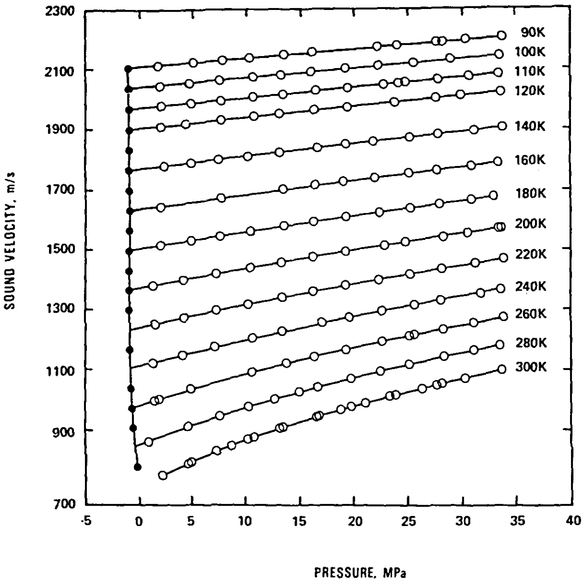


FIGURE 1. Sound velocity in compressed liquid propane as a function of pressure on isotherms. Closed circles are for saturated liquid.

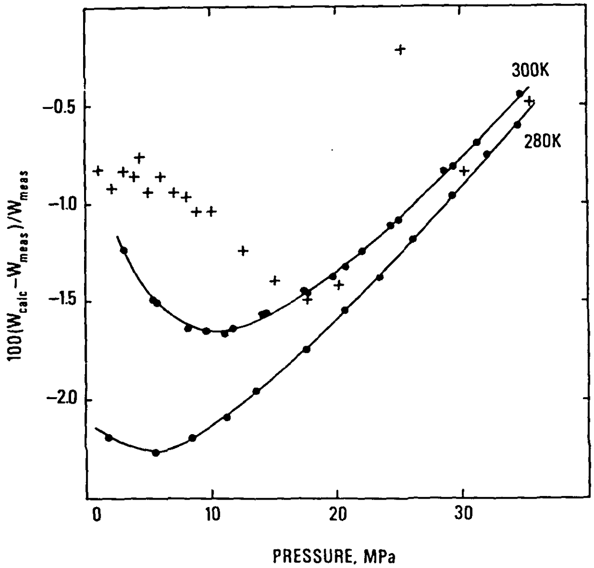


FIGURE 2. Deviation of Goodwin's calculated sound velocity relative to the data of Lacam for $T = 298.15$ K (+). For comparison, the deviation of Goodwin's calculated values relative to the measured values of this report are shown for $T = 280$ K and 300 K (•).