*NIST Monograph 178*

# *Speed of Sound Data and Related Models for Mixtures of Natural Gas Constituents*

*B.A. Younglove, N.V. Frederick, and R.D. McCarty*



NIST
United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

The National Institute of Standards and Technology was established in 1988 by Congress to "assist industry in the development of technology . . . needed to improve product quality, to modernize manufacturing processes, to ensure product reliability . . . and to facilitate rapid commercialization . . . of products based on new scientific discoveries."

NIST, originally founded as the National Bureau of Standards in 1901, works to strengthen U.S. industry's competitiveness; advance science and engineering; and improve public health, safety, and the environment. One of the agency's basic functions is to develop, maintain, and retain custody of the national standards of measurement, and provide the means and methods for comparing standards used in science, engineering, manufacturing, commerce, industry, and education with the standards adopted or recognized by the Federal Government.

As an agency of the U.S. Commerce Department's Technology Administration, NIST conducts basic and applied research in the physical sciences and engineering and performs related services. The Institute does generic and precompetitive work on new and advanced technologies. NIST's research facilities are located at Gaithersburg, MD 20899, and at Boulder, CO 80303. Major technical operating units and their principal activities are listed below. For more information contact the Public Inquiries Desk, 301-975-3058.

---

### Technology Services
- Manufacturing Technology Centers Program
- Standards Services
- Technology Commercialization
- Measurement Services
- Technology Evaluation and Assessment
- Information Services

### Electronics and Electrical Engineering Laboratory
- Microelectronics
- Law Enforcement Standards
- Electricity
- Semiconductor Electronics
- Electromagnetic Fields[1]
- Electromagnetic Technology[1]

### Chemical Science and Technology Laboratory
- Biotechnology
- Chemical Engineering[1]
- Chemical Kinetics and Thermodynamics
- Inorganic Analytical Research
- Organic Analytical Research
- Process Measurements
- Surface and Microanalysis Science
- Thermophysics[2]

### Physics Laboratory
- Electron and Optical Physics
- Atomic Physics
- Molecular Physics
- Radiometric Physics
- Quantum Metrology
- Ionizing Radiation
- Time and Frequency[1]
- Quantum Physics[1]

### Manufacturing Engineering Laboratory
- Precision Engineering
- Automated Production Technology
- Robot Systems
- Factory Automation
- Fabrication Technology

### Materials Science and Engineering Laboratory
- Intelligent Processing of Materials
- Ceramics
- Materials Reliability[1]
- Polymers
- Metallurgy
- Reactor Radiation

### Building and Fire Research Laboratory
- Structures
- Building Materials
- Building Environment
- Fire Science and Engineering
- Fire Measurement and Research

### Computer Systems Laboratory
- Information Systems Engineering
- Systems and Software Technology
- Computer Security
- Systems and Network Architecture
- Advanced Systems

### Computing and Applied Mathematics Laboratory
- Applied and Computational Mathematics[2]
- Statistical Engineering[2]
- Scientific Computing Environments[2]
- Computer Services[2]
- Computer Systems and Communications[2]
- Information Systems

---

[1]At Boulder, CO 80303.
[2]Some elements at Boulder, CO 80303.

*NIST Monograph 178*

# *Speed of Sound Data and Related Models for Mixtures of Natural Gas Constituents*

B.A. Younglove
N.V. Frederick
R.D. McCarty

Thermophysics Division
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
Boulder, Colorado 80303-3328

Sponsored by

The Gas Research Institute
Physical Sciences Department

January 1993

U.S. DEPARTMENT OF COMMERCE, Barbara Hackman Franklin, Secretary
TECHNOLOGY ADMINISTRATION, Robert M. White, Under Secretary for Technology
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, John W. Lyons, Director

National Institute of Standards and Technology
Natl. Inst. Stand. Technol., Mono. 178, 97 pages (Jan. 1993)
CODEN:NIMOEZ

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1993

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325

## CONTENTS

## List of Tables

## List of Figures

# Speed of Sound Data and Related Models for Mixtures of Natural Gas Constituents

**B.A. Younglove, N.V. Frederick, and R.D. McCarty**

**Thermophysics Division**
**National Institute of Standards and Technology**
**325 Broadway**
**Boulder, Colorado 80303-3328**

Sound speed data have been obtained for thirteen binary mixtures and four multicomponent mixtures of natural gas components using a cylindrical cavity. These data cover a temperature range from 250 to 350 K at pressures to 10 MPa. The uncertainty in the data is approximately 0.05 percent. The binary mixtures are primarily methane-rich, with ethane, nitrogen, carbon dioxide, or propane as the second component. The multicomponent mixtures are representative of commercially available compositions in the United States and Europe. The data were used to develop and test mathematical models for prediction of the sound speed of natural gas mixtures, within an average uncertainty of 0.1 percent, over the ranges of pressure, temperature, and composition that encompass the major region of custody transfer for natural gas. The research program was managed and sponsored by the Gas Research Institute's Physical Sciences Department.

Key words: binary mixtures; carbon dioxide; ethane; gas; isotherm; methane; multicomponent mixtures; natural gas; nitrogen; propane; sound speed

## 1. Introduction

This report summarizes the results of a project focusing on obtaining sound speed data for primarily binary mixtures of natural gas components. It represents the first comprehensive measurement program of sound speed data for natural gas mixtures. The program was managed and sponsored by the Gas Research Institute (GRI), Physical Sciences Department.

Orifice plates and turbine meters are widely used to determine the mass flow rate of natural gas. Calibration of a flow meter can be accurately accomplished by measuring the mass flow rate with a sonic nozzle placed in series with the meter. The sonic nozzle is operated at maximum flow rate which is obtained at the speed of sound of the system, at a given temperature, pressure, and composition.

We can compute the mass flow rate [1,2] using

$$\mathbf{m} = \mathbf{C}\ \mathbf{A}\ \rho\ \mathbf{W}, \tag{1}$$

where **m** is the mass flow rate, **A** is the cross-sectional area of the nozzle at the throat, ρ is the density, **W** is the sound speed, and **C** is a calibration constant for the nozzle and depends on geometrical imperfections and energy losses of the nozzle. The ideal value for **C** is unity, for a lossless system. The temperature, pressure, and composition are used to compute the density and sound speed from an appropriate equation of state.

In the present study, sound speed data have been obtained for mixtures of natural gas components. The major objective of this work has been to provide the natural gas industry with experimental data that can then be correlated by an equation of state:

$$\mathbf{W} = \mathbf{W}(\mathbf{P},\mathbf{T},\mathbf{x}_i). \tag{2}$$

Speed of sound data on methane and its binary mixtures are used in the development of the model. Data have been obtained for thirteen binary mixtures. These are primarily methane-rich with either propane, carbon dioxide, or nitrogen as the second component. Sound speed results for methane have been measured at 273.15 K and compared with Gammon and Douslin's wide-range data [3], used in the development of the model. The data on four multicomponent mixtures (Gulf Coast, Amarillo, Statoil* dry gas, and Statoil* Statvordgass) have been obtained to test the predictions of speed of sound models. All of these mixtures were prepared gravimetrically using a high-precision balance. Measurements were taken on five isotherms, at 250, 275, 300, 325, and 350 K, at pressures to 10 MPa. This range of temperature and pressure encompasses the major region involved in custody transfer. All of the experimental measurements at NIST were made using a cylindrical resonant cavity with a fixed path length. The data of Gammon and Douslin [3] for pure methane were obtained using an interferometer of variable path length.

This monograph reports all of the new experimental sound speed data obtained in this study. Details of a new model developed at NIST, called NGAS [4], for predictions of sound speed and density of natural gas mixtures are presented. Comparisons of this model, the AGA 8 (American Gas Association) model [5,6], and the traditional approach of Johnson [7] are made with the comprehensive set of experimental data for natural gas mixtures and the

---

*Certain commercial materials, equipment, or instruments are identified in this paper in order to adequately specify the experimental results. Such identification does not imply endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment that are identified are necessarily the best available for the purpose.

pure methane data [8].

## 2. Experimental Method, Procedures, and Uncertainties

The details of the experimental procedure are given in [9]. The measurements were made using a cylindrical resonant cavity operating at frequencies between 10 and 70 kHz. Longitudinal resonances were measured, and the frequencies were corrected for shifts arising from viscous losses at the walls and for thermal conduction losses at the walls and end surfaces. Uncertainty in sound speed measurements is less than 0.05 percent. Temperatures were measured on the IPTS-68 temperature scale with a capsule platinum resistance thermometer. The sample temperature was regulated within 3 mK. The total uncertainty in the temperature measurement is approximately 0.02 K at 250 K and 0.03 K at 350 K. These temperatures may be converted to the ITS-90 scale using procedures described by H. Preston-Thomas [10]. Pressures were measured with a high-quality quartz-spiral bourdon gauge. The uncertainty in pressure measurement is estimated to be 0.001 MPa. The samples were prepared in clean aluminum cylinders which were heated and pumped to a high vacuum. Mixtures were prepared by weighing using a 25-kg, high-precision double pan balance. The maximum uncertainty in mole fraction is estimated to be 0.006 percent.

## 3. Experimental Results

Table 1 gives the compositions, in mole percent, of the thirteen binary and four multicomponent mixtures. The sound speed data are given in tables 2 through 18. The table entries are experimental sound speed in meters per second, temperature in kelvins, and pressure in megapascals or in pounds per square inch absolute. The experimental sound speed data are seen in figures 1 through 20, as a function of pressure along isotherms.

## 4. Predictive Models

### 4.1 NIST Model, NGAS

The functional form of the NIST model, NGAS [4], is given below in eq (3). $A_r$ is the real gas contribution to the Helmholtz energy. The pressure and temperature ranges of the equation of state are 0 to 10 MPa and 250 K to 350 K.

$$
\begin{aligned}
A_r = {} & RTz \sum_i \sum_j [N_1 + N_2 t_{ij}^{1.5}(G3)_{ij} + N_3 t_{ij}^{2.5} + N_4 t_{ij}^{2} + N_5 t_{ij}^{3.5}(G3)_{ij}] x_i x_j \\
& + (N_6 + N_7 \tau^{0.5} + N_8 \tau^2 + N_9 \tau^{2.5} + N_{16}/\tau^{0.5} \quad N_{17}\tau^{1.5}) RTz^2 (G3) \\
& + (N_{10}\tau^{0.5} + N_{11}\tau + N_{12}\tau^{1.5} + N_{18}) RTz^3 (G4) \\
& + (N_{14}\tau^3 + N_{22}\tau^{3.5} + N_{23}\tau^{5.5}) RTz^2 (G5) e^{-z^2} \\
& + (N_{13} z^2 \tau + N_{24}\tau^3 e^{-z^2}) RTz^3 (G6) \qquad (3) \\
& + (N_{19} z^4 + N_{15}\tau^3 z^2 e^{-z^2} + N_{26}\tau^{22} e^{-z^2}) RTz^2 (G7) \\
& + (N_{20} z^4 \tau^2 + N_{27}\tau^{18} e^{-z^4}) RTz^3 (G8) \\
& + [N_{21} z^4 \tau^2 + (N_{28}\tau^{11} + N_{29}\tau^{23}) e^{-z^4}] RTz^4 (G9) \\
& + N_{30} z^5 \tau^{18} e^{-z^4} (G10) + N_{25} z^{10} \tau^{5.5} e^{-z^2} (G11),
\end{aligned}
$$

where

$$t_{ij} = e_{ij}/T, \qquad (4)$$

$$e_{ij} = w_{ij} (\varepsilon_i \, \varepsilon_j)^{0.5}, \qquad (5)$$

$$z = \rho \sigma^3, \qquad (6)$$

$$\sigma^6 = \sum_i \sum_j x_i x_j \, \sigma_{ij}^6, \qquad (7)$$

$$\sigma_{ij}^3 = v_{ij} (\sigma_i^3 \sigma_j^3)^{0.5}, \qquad (8)$$

$$\tau = \varepsilon/T, \qquad (9)$$

$$\varepsilon = \sigma^{-6} \sum_i \sum_j x_i x_j \, \sigma_{ij}^6 \, \varepsilon_{ij}, \qquad (10)$$

$$\varepsilon_{ij} = u_{ij} (\varepsilon_i \varepsilon_j)^{0.5}, \qquad (11)$$

$$(Gk) = \sum_i \sum_j x_i x_j (Gk)_{ij} \quad k = 1, 2, \ldots 11, \qquad (12)$$

$$(Gk)_{ij} = (Gk_i + Gk_j)/2. \qquad (13)$$

$A_r$ is the real gas contribution to the Helmholtz energy. $R = 8.31434$ is the gas constant, **T** is the temperature in kelvins, and $\rho$ is the density in moles per liter. The $N_i$ for eq (3) were obtained by a least squares fit to the experimental sound speed data of Gammon and Douslin [3] and of Sivaraman and Gammon [8] simultaneously with the PVT results of Friend and Ely [11], and are given in table 19. The allowable pure components are the same as for the AGA Report No. 8 equation of state [5,6], with the exclusion of $H_2S$ and $H_2O$. See the listing in table 19. The $\sigma^3$, $\varepsilon_i$, $Gk_i$, $u_{ij}$, $v_{ij}$, and $w_{ij}$ were obtained by least squares fits to the binary sound speed data simultaneously with PVT results from [12,13] and are given in table 19. The total Helmholtz energy is given by

$$A = A_r + A^\circ, \tag{14}$$

where $A^\circ$ is the ideal gas contribution to the Helmholtz energy. The pressure derived from this expression is

$$p = \rho^2(\partial A/\partial \rho)_T. \tag{15}$$

The Helmholtz energy for the ideal gas is

$$A^\circ = H^\circ - RT - TS^\circ, \tag{16}$$

where $H^\circ$ and $S^\circ$ are the ideal gas enthalpy and entropy, and $T$ is the absolute temperature. To insure consistency, $H^\circ$ and $S^\circ$ from Starling [12] were used here, and the remainder of the thermodynamic properties were obtained from the appropriate derivatives of the Helmholtz energy from the new model reported here.

In addition to the restricted pressure and temperature ranges mentioned above, the equation of state is valid only for mixtures containing at least 60 percent methane, no more than 5 percent nitrogen or carbon dioxide, and no more than 1 percent total of $C_4$ and above. The predicted speeds of sound from eq (3) have been compared to the experimental data. In figures 1, 1a, and 1b deviations are shown on selected isotherms for the pure methane data of Gammon and Douslin [3] and of Sivaraman and Gammon [8]. Figure 2 shows the deviation for one isotherm of pure methane at 298.15 K taken with the cylindrical resonator. The deviation plots show that both models are generally within 0.1 percent of the experimental sound speeds from 223 to 348 K. Comparisons to the binary and multicomponent data are given in figures 21 through 37. These comparisons are made relative to the stated composition restrictions of the NGAS and AGA 8 equations of state. These deviation plots show that both eq (3) and AGA 8 predict sound speeds of the multicomponent gas mixtures within 0.1 percent for the mixtures that are within the equation limits, with the exception of the lowest temperature (250 K) for pressures above 5 MPa. In the low temperature, higher pressure regime, neither model agrees with the experimental data very well, but the deviation pattern of each model is different. Although the equations do not predict sound speeds to the desired 0.1 percent in this extreme temperature and pressure range, it is of little importance in the application to sonic metering since the pressure in the throat of the nozzle will always be less than 5 MPa if the upstream pressure is within the specified range of the equation of state. A computer program using eq (3) has been developed to calculate the thermodynamic properties of natural gas. In addition to the standard thermodynamic properties, the program also calculates the mass flow rate and the critical flow factor for a sonic meter. The program requires pressure, temperature, and composition as input. Copies of the NGAS program may be obtained from the Gas Research Institute. Computer programs using the AGA Report No. 8 model are available through the American Gas Association or the Gas Research Institute.

### 4.2 AGA 8 Model

Recently, work sponsored by the Gas Research Institute and the American Gas Association at the Universities of Oklahoma and Idaho has produced an improved equation of state, called in this work the AGA 8 model [5,6]. The speed of sound data obtained under GRI's program and reported here were used in the development of the new AGA 8 model. This model also incorporates the speed of sound data for methane of Sivaraman and Gammon [8]. Other data used in its development include pure component compressibility data, compressibility data for certain binary mixtures, and GERG (Groupe Européen de Recherches Gazeriès) compressibility data [14].

Figures 21 through 37, mentioned in the previous section, also present limited deviations between values calculated from the AGA 8 model and measured sound speeds. Some comparisons are made outside of the stated limits of the AGA 8 model. The comparison between the NGAS model and the AGA 8 model provided by these deviation plots indicates very little difference between the two models except at the lower temperatures for pressures above 5 MPa. In this low-temperature higher pressure regime neither model agrees with the experimental data very well, but the deviation pattern of each model is different. The NGAS model is probably somewhat better in this difficult region. Figures 38 through 41 give a comparison of densities calculated by means of the two models at the pressure and temperature of some of the measured sound speeds. Since there are no measured densities for these pressures and temperatures, no conclusions as to the accuracy of either of these models may be drawn from the deviation plots. The comparison does, however, indicate some interesting behavior. The densities calculated from either model are quite similar except in the low temperature, higher pressure region where the two models do not perform well in the prediction of sound speed, and for the Statoil Statvordgass mixture where there is about a 0.2 percent offset between the two models. Another interesting feature of the density deviation plots is an abrupt change in the deviation pattern of some of the isotherms at a pressure of 1 MPa for each of the mixtures, with the single exception of the Statoil dry gas mixture.

### 4.3 Johnson Model, Mass Flow Rate

The mass flow rates for a variety of compositions and plenum conditions have been calculated from the critical flow equations shown below and the equation of state presented here. A sonic nozzle operates at maximum mass flow. The mass flow speed at the throat of the nozzle is the speed of sound. This condition allows the calculation of the mass flow rate, ṁ, which is given in eq (1). Under the assumption that the fluid flow is one dimensional and that the entropy $S_t$ of the fluid in the nozzle throat is the same as the entropy $S_p$ of the fluid on the up-stream side or plenum of the nozzle,

$$S_p - S_t = 0, \tag{17}$$

$$U_t^2 = 2( H_p - H_t ), \tag{18}$$

where H is the enthalpy of the fluid and U is the mass flow rate in the nozzle, and the flow in the nozzle is sonic,

$$U_t^2 = w_t^2. \tag{19}$$

The conditions described by eqs (1) and (17) through (19) provide the basis for computation of mass flow rates for the sonic nozzle. Figures 42 through 49 compare these flow rates with those predicted by Johnson [7].

The deviations illustrated by figures 42 through 49 indicate a degraded performance of the Johnson model at higher pressures and lower temperatures. The deviation plots also indicate that the Johnson model is less reliable for mixtures containing significant amounts of components other than methane.

## 5. Summary of Results

The speed of sound measurements are given in this report for thirteen binary mixtures and four multicomponent mixtures of natural gas components. The accuracy of the experimental speed of sound data is estimated to be within 0.05 percent. The experimental data and the deviations from the predictive models, NGAS and AGA 8, are given in the form of graphs and tables. Both NGAS and AGA 8 were developed using the speed of sound data contained in this report as part of their correlation database. The functional form of NGAS is presented. Deviation plots for NGAS and AGA 8 from the pure methane data of Sivaraman and Gammon are also given. A comparison of the densities as predicted by NGAS and AGA 8 is given for the four multicomponent mixtures. The mass flow rates as computed from NGAS are compared to those from the Johnson formulation [13].

Deviations of the experimental sound speed from the values computed using NGAS and AGA 8 are given for each isotherm. In some cases AGA 8 deviations are shown beyond the limits for AGA 8 to allow comparisons with NGAS. Generally the values of sound speed computed from the equations of state are within ± 0.1 percent of the experimental data for the 273, 300, 325, and 350 K isotherms. The largest deviations are seen for data taken at 250 K.

This work was carried out at the National Institute of Standards and Technology under the sponsorship of the Gas Research Institute, Physical Sciences Department, Thermodynamics Program, Program Manager, Jeffrey L. Savidge.

## 6. References


[1] Miller, R.W., "Flow Measurement Engineering Handbook," *2nd. ed., McGraw Hill (1989).*

[2] Arnberg, B.T., "Review of Critical Flow Meters for Gas FLow Measurements," *J. Basic Eng.* *D84, 447-460 (1962).*

[3] Gammon, B.E., and Douslin, D.R., "The velocity of sound and heat capacity in methane from near-critical to subcritical conditions and equation-of-state implications," *J. Chem. Phys. 64, 203-218, (1976).*

[4] McCarty, R.D., "A Model for the Speed of Sound of Natural Gas Mixtures," *Proceedings of the International Symposium on Fluid Flow Measurement, June 6-8, 1990, published by American Gas Association, Arlington VA, Catalog No. XQ9010, p. 155-169 (1990).*

[5] Starling, K.E., and Savidge, J.L., "Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases," *American Gas Association Transmission Measurement Committee Report No. 8, American Gas Association, Arlington VA, Catalog No. XQ9212, (1992).*

[6] Starling, K.E., and Savidge, J.L., "GRI High Accuracy Natural gas Equation of State for Gas Measurement Applications," *Annual Report to American Gas Association Transmission Measurement Committee, Supercompressibility Factor Steering Committee, GRI-91/0184, (1991).*

[7] Johnson, R.C., "Calculations of the Flow of Natural Gas Through Critical Flow Nozzles," *Transactions of the ASME, p. 580 (September 1970).*

[8] Sivaraman, A., and Gammon, B.E., "Speed-of-Sound Measurements in Natural Gas Fluids," *Gas Research Institute Report 86-0043 (1986).*

[9] Younglove, B.A., and Frederick, N.V., "Sound Speed Measurements on Gas Mixtures of Natural Gas Components Using a Cylindrical Resonator," *Intl. J. Thermophys., 11, 897-909 (1990).*

[10] Preston-Thomas, H., "The International Temperature Scale of 1990 (ITS-90)," *Metrologia,* ***27****, 3-10 (1990).*

[11] Friend, D.G., and Ely, J.F., "Thermophysical Properties of Methane," *J. Phys. Chem. Ref. Data, 18, No. 2, 583-638 (1986).*

[12] Starling, K.E., Mannan, M., Savidge, J.L., Sadasivan S., Reid, T.B. Jr., Gangadhar, K., and Drass M.A., *Appendix C, Final Report, October 1984 - September 1987, Prepared for Gas Research Institute, Contract No. 5084-260-1010 (September 1987)*, University of Oklahoma, Norman, Oklahoma.

[13] Starling, K.E., and Fitz, C., GRI computer program, *private communication*, University of Oklahoma, Norman, Oklahoma.

[14] Jaeschke, M., Audibert, S., van Caneghem, P., Humpreys, A.E., Jansen van Rosmalen, R., and Pellei, Q., "High Accuracy Compressibility Factor Calculation for Natural Gases and Similar Mixtures by Use of a Truncated Virial Equation," *GERG Technical Monograph 2 (1988).*

Table 1. Compositions in mole fraction for binary and multicomponent mixtures.

Compositions in mole fractions for the binary mixtures.

| | |
|---|---|
| 0.84992 methane | 0.15008 ethane |
| 0.68526 methane | 0.31474 ethane |
| 0.50217 methane | 0.49783 ethane |
| 0.34524 methane | 0.65476 ethane |
| 0.90016 methane | 0.09984 propane |
| 0.95114 methane | 0.04886 nitrogen |
| 0.85130 methane | 0.14870 nitrogen |
| 0.71373 methane | 0.28627 nitrogen |
| 0.94979 methane | 0.05021 carbon dioxide |
| 0.85026 methane | 0.14974 carbon dioxide |
| 0.69944 methane | 0.30056 carbon dioxide |
| 0.49593 nitrogen | 0.50407 carbon dioxide |

Compositions in mole fractions for the multicomponent mixtures.

| | Gulf Coast | Amarillo | Statoil Dry Gas | Statoil Statvordgass |
|---|---|---|---|---|
| methane | 0.965 61 | 0.907 08 | 0.839 80 | 0.743 48 |
| ethane | 0.018 29 | 0.044 91 | 0.134 75 | 0.120 05 |
| propane | 0.004 10 | 0.008 15 | 0.009 43 | 0.082 51 |
| normal butane | 0.000 98 | 0.001 41 | 0.000 67 | 0.030 26 |
| isobutane | 0.000 98 | 0.001 06 | 0.000 40 | -- |
| normal pentane | 0.000 32 | 0.000 65 | 0.000 08 | 0.005 75 |
| isopentane | 0.000 46 | 0.000 27 | 0.000 13 | -- |
| normal hexane | 0.000 67 | 0.000 34 | -- | 0.002 30 |
| nitrogen | 0.002 62 | 0.031 13 | 0.007 18 | 0.005 37 |
| carbon dioxide | 0.005 97 | 0.005 00 | 0.007 56 | 0.010 28 |

Table 2. Speed of sound data for the mixture $0.94985\ CH_4 + 0.05015\ C_2H_6$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 377.77 | 250.000 | 9.864 | 1430.6 |
| 377.11 | 250.000 | 9.800 | 1421.3 |
| 370.94 | 250.001 | 9.050 | 1312.5 |
| 367.57 | 250.000 | 8.401 | 1218.4 |
| 365.72 | 250.000 | 7.685 | 1114.6 |
| 365.60 | 250.000 | 7.520 | 1090.7 |
| 365.65 | 250.000 | 6.913 | 1002.6 |
| 366.96 | 250.000 | 6.193 | 898.2 |
| 369.26 | 250.000 | 5.496 | 797.1 |
| 373.92 | 250.000 | 4.493 | 651.7 |
| 380.02 | 250.000 | 3.428 | 497.1 |
| 386.97 | 250.000 | 2.356 | 341.7 |
| 394.64 | 250.000 | 1.253 | 181.7 |
| 397.00 | 250.000 | 0.915 | 132.7 |
| 397.97 | 250.000 | 0.777 | 112.7 |
| 407.39 | 275.000 | 10.588 | 1535.7 |
| 404.48 | 275.000 | 10.059 | 1458.9 |
| 400.79 | 275.000 | 9.152 | 1327.3 |
| 398.69 | 275.000 | 8.297 | 1203.4 |
| 397.85 | 275.000 | 7.522 | 1091.0 |
| 398.01 | 275.000 | 6.677 | 968.4 |
| 399.27 | 275.000 | 5.735 | 831.8 |
| 401.26 | 275.000 | 4.872 | 706.6 |
| 404.78 | 275.000 | 3.754 | 544.5 |
| 408.25 | 275.000 | 2.868 | 416.0 |
| 408.62 | 275.000 | 2.795 | 405.4 |
| 411.87 | 275.000 | 2.041 | 296.0 |
| 417.03 | 275.000 | 0.960 | 139.2 |
| 418.60 | 275.000 | 0.646 | 93.8 |
| 431.00 | 300.002 | 10.437 | 1513.8 |
| 429.28 | 300.000 | 9.952 | 1443.4 |
| 426.69 | 300.000 | 8.995 | 1304.6 |
| 424.96 | 300.000 | 7.952 | 1153.3 |
| 424.31 | 300.000 | 6.954 | 1008.6 |
| 424.77 | 300.000 | 5.650 | 819.5 |
| 426.09 | 300.000 | 4.603 | 667.6 |
| 428.22 | 300.000 | 3.495 | 506.8 |
| 431.15 | 300.000 | 2.360 | 342.2 |
| 434.27 | 300.000 | 1.341 | 194.5 |
| 435.38 | 300.000 | 1.019 | 147.8 |
| 436.70 | 300.000 | 0.624 | 90.5 |

Table 2. Speed of sound data for the mixture
$0.94985\ CH_4 + 0.05015\ C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 453.33 | 325.000 | 10.402 | 1508.7 |
| 451.77 | 325.002 | 9.892 | 1434.7 |
| 449.61 | 325.000 | 8.983 | 1302.9 |
| 448.22 | 325.000 | 8.281 | 1201.1 |
| 447.43 | 325.000 | 7.590 | 1100.9 |
| 446.42 | 324.999 | 6.205 | 899.9 |
| 446.51 | 325.002 | 5.521 | 800.8 |
| 446.80 | 325.000 | 4.821 | 699.3 |
| 447.37 | 325.000 | 4.124 | 598.1 |
| 448.05 | 324.999 | 3.447 | 500.0 |
| 449.15 | 325.000 | 2.668 | 387.0 |
| 450.20 | 325.000 | 2.058 | 298.6 |
| 451.55 | 325.000 | 1.411 | 204.6 |
| 452.01 | 325.001 | 1.247 | 180.9 |
| 452.42 | 325.000 | 1.086 | 157.5 |
| 452.75 | 325.001 | 0.937 | 136.0 |
| 453.06 | 325.001 | 0.804 | 116.6 |
| 453.39 | 325.000 | 0.660 | 95.8 |
| 453.78 | 325.000 | 0.496 | 71.9 |
| | | | |
| 473.74 | 350.000 | 10.521 | 1525.9 |
| 472.79 | 350.000 | 10.166 | 1474.4 |
| 472.74 | 350.000 | 10.164 | 1474.1 |
| 470.67 | 350.000 | 9.350 | 1356.1 |
| 468.95 | 350.000 | 8.528 | 1236.9 |
| 468.77 | 350.000 | 8.350 | 1211.0 |
| 467.57 | 350.000 | 7.558 | 1096.1 |
| 466.65 | 350.000 | 6.729 | 975.9 |
| 466.03 | 350.000 | 5.931 | 860.3 |
| 465.73 | 350.000 | 5.162 | 748.7 |
| 465.71 | 350.000 | 4.369 | 633.7 |
| 465.94 | 350.000 | 3.582 | 519.6 |
| 466.39 | 350.000 | 2.819 | 408.9 |
| 466.75 | 350.000 | 2.440 | 353.9 |
| 467.13 | 350.000 | 2.068 | 300.0 |
| 467.92 | 350.000 | 1.344 | 194.9 |
| 468.12 | 350.000 | 1.203 | 174.4 |
| 468.28 | 350.000 | 1.081 | 156.8 |
| 468.69 | 350.000 | 0.793 | 115.1 |
| 468.99 | 350.000 | 0.553 | 80.2 |

Table 3. Speed of sound data for the mixture $0.84992\ CH_4 + 0.15008\ C_2H_6$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 369.05 | 250.000 | 10.340 | 1499.7 |
| 355.92 | 250.000 | 9.717 | 1409.4 |
| 355.94 | 250.001 | 9.716 | 1409.2 |
| 343.80 | 250.000 | 8.941 | 1296.8 |
| 335.92 | 249.999 | 8.022 | 1163.5 |
| 334.13 | 250.000 | 6.989 | 1013.7 |
| 337.74 | 250.000 | 5.893 | 854.7 |
| 344.26 | 250.000 | 4.839 | 701.8 |
| 352.78 | 250.000 | 3.737 | 542.1 |
| 361.52 | 250.000 | 2.715 | 393.8 |
| 370.78 | 250.000 | 1.664 | 241.4 |
| 380.06 | 250.000 | 0.629 | 91.2 |
| 385.86 | 275.000 | 11.110 | 1611.4 |
| 379.69 | 275.000 | 10.424 | 1511.9 |
| 373.95 | 275.001 | 9.553 | 1385.5 |
| 369.96 | 275.001 | 8.480 | 1229.9 |
| 368.97 | 275.000 | 7.562 | 1096.8 |
| 369.90 | 275.000 | 6.566 | 952.4 |
| 372.66 | 275.000 | 5.527 | 801.6 |
| 377.06 | 275.000 | 4.433 | 642.9 |
| 384.06 | 275.000 | 3.060 | 443.8 |
| 390.34 | 275.000 | 1.984 | 287.8 |
| 390.34 | 275.000 | 1.984 | 287.8 |
| 396.48 | 275.000 | 0.994 | 144.2 |
| 399.50 | 275.000 | 0.525 | 76.2 |
| 403.77 | 300.004 | 10.641 | 1543.3 |
| 401.90 | 300.000 | 10.208 | 1480.5 |
| 398.93 | 300.000 | 9.269 | 1344.3 |
| 397.12 | 300.001 | 8.247 | 1196.1 |
| 396.68 | 300.000 | 7.258 | 1052.6 |
| 397.56 | 300.001 | 6.129 | 889.0 |
| 399.47 | 300.000 | 5.100 | 739.7 |
| 402.14 | 300.000 | 4.121 | 597.6 |
| 405.92 | 300.000 | 2.994 | 434.2 |
| 409.83 | 300.002 | 2.015 | 292.3 |
| 412.67 | 300.000 | 1.341 | 194.5 |
| 416.20 | 299.999 | 0.567 | 82.3 |

Table 3. Speed of sound data for the mixture 0.84992 $CH_4$ + 0.15008 $C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 431.85 | 325.000 | 0.661 | 95.8 |
| 431.71 | 325.000 | 0.682 | 98.9 |
| 431.25 | 325.000 | 0.811 | 117.7 |
| 430.76 | 325.000 | 0.968 | 140.3 |
| 430.30 | 325.000 | 1.105 | 160.3 |
| 429.84 | 325.000 | 1.238 | 179.5 |
| 429.43 | 325.000 | 1.361 | 197.3 |
| 421.24 | 325.000 | 4.833 | 701.0 |
| 420.58 | 325.000 | 5.506 | 798.6 |
| 420.02 | 325.000 | 6.283 | 911.3 |
| 419.73 | 325.000 | 7.040 | 1021.0 |
| 420.13 | 325.000 | 7.805 | 1132.0 |
| 421.04 | 325.000 | 8.636 | 1252.5 |
| 422.27 | 325.000 | 9.397 | 1362.9 |
| 424.26 | 325.000 | 10.145 | 1471.5 |
| 425.17 | 325.000 | 10.450 | 1515.6 |
| 445.49 | 350.000 | 10.457 | 1516.6 |
| 444.05 | 350.000 | 9.861 | 1430.2 |
| 441.61 | 350.000 | 8.549 | 1240.0 |
| 440.47 | 350.000 | 7.586 | 1100.3 |
| 440.49 | 350.000 | 7.585 | 1100.0 |
| 439.93 | 350.000 | 6.553 | 950.4 |
| 439.87 | 350.000 | 6.370 | 923.9 |
| 439.98 | 350.000 | 5.523 | 801.0 |
| 440.55 | 350.000 | 4.497 | 652.2 |
| 441.70 | 350.000 | 3.416 | 495.4 |
| 443.17 | 350.000 | 2.430 | 352.5 |
| 445.21 | 350.000 | 1.361 | 197.4 |
| 446.04 | 350.000 | 0.961 | 139.4 |
| 446.39 | 350.000 | 0.805 | 116.8 |

Table 4. Speed of sound data for the mixture $0.68526\ CH_4 + 0.31474\ C_2H_6$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 412.48 | 250.000 | 10.152 | 1472.4 |
| 389.29 | 250.000 | 9.680 | 1404.0 |
| 339.28 | 250.000 | 8.731 | 1266.3 |
| 291.56 | 250.000 | 7.718 | 1119.4 |
| 291.53 | 250.000 | 7.716 | 1119.1 |
| 276.29 | 250.000 | 7.007 | 1016.3 |
| 282.32 | 249.998 | 5.989 | 868.7 |
| 276.47 | 250.000 | 6.636 | 962.4 |
| 293.47 | 250.000 | 5.104 | 740.3 |
| 299.59 | 250.000 | 4.664 | 676.4 |
| 308.87 | 250.000 | 4.001 | 580.2 |
| 318.30 | 250.000 | 3.320 | 481.6 |
| 327.86 | 250.000 | 2.610 | 378.6 |
| 337.22 | 250.000 | 1.895 | 274.9 |
| 345.83 | 250.000 | 1.212 | 175.7 |
| 353.74 | 250.000 | 0.559 | 81.1 |
| 347.09 | 274.994 | 10.284 | 1491.6 |
| 342.73 | 275.000 | 10.030 | 1454.7 |
| 342.60 | 275.000 | 10.023 | 1453.7 |
| 333.67 | 275.000 | 9.389 | 1361.7 |
| 325.67 | 275.000 | 8.467 | 1228.0 |
| 323.15 | 275.001 | 7.617 | 1104.7 |
| 324.33 | 275.000 | 6.739 | 977.4 |
| 328.94 | 275.000 | 5.732 | 831.3 |
| 335.63 | 275.000 | 4.732 | 686.4 |
| 343.74 | 275.000 | 3.699 | 536.5 |
| 351.77 | 275.000 | 2.758 | 400.0 |
| 360.95 | 275.000 | 1.715 | 248.7 |
| 363.90 | 275.000 | 1.381 | 200.3 |
| 367.35 | 275.000 | 0.995 | 144.4 |
| 370.63 | 275.000 | 0.630 | 91.3 |
| 363.87 | 300.000 | 10.662 | 1546.4 |
| 361.40 | 300.000 | 10.310 | 1495.3 |
| 358.06 | 300.000 | 9.707 | 1407.9 |
| 355.33 | 300.000 | 8.915 | 1293.1 |
| 354.22 | 300.000 | 8.294 | 1203.0 |
| 354.63 | 300.000 | 7.062 | 1024.3 |
| 356.67 | 300.000 | 6.198 | 899.0 |
| 359.74 | 300.000 | 5.335 | 773.8 |
| 364.49 | 300.005 | 4.308 | 624.8 |
| 369.14 | 300.000 | 3.442 | 499.2 |

Table 4. Speed of sound data for the mixture $0.68526\ CH_4 + 0.31474\ C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 371.54 | 299.871 | 3.016 | 437.5 |
| 374.33 | 300.000 | 2.563 | 371.7 |
| 375.30 | 299.866 | 2.392 | 347.0 |
| 379.82 | 300.000 | 1.688 | 244.8 |
| 379.55 | 299.865 | 1.719 | 249.4 |
| 384.02 | 299.865 | 1.032 | 149.7 |
| 384.66 | 300.000 | 0.943 | 136.8 |
| 388.57 | 299.857 | 0.340 | 49.3 |
| 384.49 | 325.000 | 10.635 | 1542.5 |
| 384.38 | 325.000 | 10.622 | 1540.6 |
| 384.06 | 325.000 | 10.530 | 1527.3 |
| 383.27 | 325.000 | 10.335 | 1498.9 |
| 381.43 | 325.000 | 9.693 | 1405.9 |
| 379.96 | 325.000 | 8.940 | 1296.7 |
| 379.29 | 325.000 | 8.289 | 1202.2 |
| 379.21 | 325.000 | 7.605 | 1103.1 |
| 379.74 | 325.000 | 6.940 | 1006.5 |
| 380.70 | 325.000 | 6.248 | 906.1 |
| 382.24 | 325.000 | 5.551 | 805.0 |
| 384.17 | 325.000 | 4.829 | 700.4 |
| 386.42 | 325.000 | 4.138 | 600.2 |
| 388.94 | 325.000 | 3.439 | 498.8 |
| 391.75 | 325.000 | 2.747 | 398.4 |
| 395.11 | 325.000 | 2.009 | 291.4 |
| 397.99 | 325.000 | 1.379 | 200.0 |
| 398.77 | 325.000 | 1.237 | 179.5 |
| 400.16 | 325.000 | 0.954 | 138.4 |
| 401.49 | 325.000 | 0.687 | 99.6 |
| 389.36 | 324.952 | 3.331 | 483.1 |
| 392.59 | 324.961 | 2.558 | 371.0 |
| 395.76 | 324.948 | 1.852 | 268.6 |
| 399.66 | 324.944 | 1.032 | 149.7 |
| 403.09 | 324.943 | 0.345 | 50.0 |
| 404.96 | 350.000 | 10.680 | 1549.0 |
| 403.23 | 350.000 | 9.992 | 1449.1 |
| 401.75 | 350.000 | 9.130 | 1324.2 |

Table 4. Speed of sound data for the mixture $0.68526\ CH_4 + 0.31474\ C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 400.90 | 350.000 | 8.303 | 1204.3 |
| 400.72 | 350.000 | 7.522 | 1091.0 |
| 401.01 | 350.000 | 6.700 | 971.7 |
| 401.97 | 350.000 | 5.727 | 830.6 |
| 403.52 | 350.000 | 4.794 | 695.3 |
| 405.96 | 350.000 | 3.695 | 535.9 |
| 408.49 | 350.000 | 2.773 | 402.1 |
| 408.51 | 350.001 | 2.753 | 399.3 |
| 408.61 | 349.998 | 2.722 | 394.8 |
| 411.56 | 350.003 | 1.799 | 260.9 |
| 411.85 | 350.000 | 1.729 | 250.8 |
| 418.16 | 349.994 | 1.220 | 176.9 |
| 414.21 | 350.005 | 1.044 | 151.4 |
| 414.60 | 350.000 | 0.948 | 137.5 |
| 416.19 | 349.996 | 0.518 | 75.1 |
| 416.20 | 349.995 | 0.515 | 74.7 |
| 416.23 | 349.994 | 0.506 | 73.4 |
| 416.82 | 350.005 | 0.347 | 50.3 |

Table 5. Speed of sound data for the mixture
$0.50217\ CH_4 + 0.49783\ C_2H_6$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 285.33 | 250.000 | 2.890 | 419.1 |
| 289.35 | 250.000 | 2.703 | 392.0 |
| 297.52 | 250.000 | 2.310 | 335.0 |
| 305.52 | 250.000 | 1.898 | 275.3 |
| 314.39 | 250.000 | 1.404 | 203.7 |
| 323.69 | 250.000 | 0.849 | 123.2 |
| 329.23 | 250.000 | 0.504 | 73.2 |
| 311.01 | 274.998 | 8.730 | 1266.3 |
| 296.67 | 275.000 | 8.345 | 1210.3 |
| 288.52 | 274.999 | 8.083 | 1172.4 |
| 288.50 | 274.999 | 8.087 | 1172.9 |
| 278.42 | 274.999 | 7.654 | 1110.2 |
| 273.70 | 275.001 | 7.259 | 1052.8 |
| 272.57 | 275.000 | 6.921 | 1003.8 |
| 273.59 | 275.000 | 6.566 | 952.4 |
| 276.67 | 275.001 | 6.123 | 888.1 |
| 285.78 | 275.000 | 5.285 | 766.6 |
| 296.59 | 275.000 | 4.438 | 643.7 |
| 307.79 | 275.001 | 3.594 | 521.3 |
| 317.06 | 275.001 | 2.874 | 416.9 |
| 322.32 | 275.001 | 2.459 | 356.7 |
| 327.30 | 274.999 | 2.063 | 299.2 |
| 331.05 | 275.000 | 1.756 | 254.6 |
| 336.81 | 275.000 | 1.261 | 182.9 |
| 338.45 | 275.000 | 1.112 | 161.3 |
| 322.42 | 300.000 | 9.809 | 1422.7 |
| 319.74 | 300.000 | 9.588 | 1390.7 |
| 318.06 | 300.000 | 9.427 | 1367.3 |
| 314.51 | 300.000 | 9.029 | 1309.6 |
| 314.54 | 300.000 | 9.034 | 1310.2 |
| 310.63 | 299.997 | 8.328 | 1207.9 |
| 309.66 | 300.000 | 7.634 | 1107.3 |
| 311.26 | 300.000 | 6.831 | 990.8 |
| 315.40 | 300.000 | 5.960 | 864.4 |
| 320.81 | 300.000 | 5.142 | 745.8 |
| 325.53 | 300.000 | 4.520 | 655.5 |
| 333.02 | 299.999 | 3.606 | 522.9 |
| 340.62 | 299.996 | 2.749 | 398.8 |
| 344.04 | 300.000 | 2.368 | 343.5 |
| 347.17 | 299.999 | 2.021 | 293.1 |

Table 5. Sound of speed data for the mixture
$0.50217\ CH_4 + 0.49783\ C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 346.99 | 300.000 | 2.044 | 296.5 |
| 350.40 | 300.000 | 1.663 | 241.2 |
| 353.53 | 299.998 | 1.312 | 190.4 |
| 356.71 | 300.000 | 0.954 | 138.3 |
| 356.63 | 300.000 | 0.970 | 140.7 |
| 360.00 | 300.000 | 0.585 | 84.8 |
| | | | |
| 343.74 | 325.000 | 10.399 | 1508.2 |
| 341.49 | 325.000 | 10.004 | 1450.9 |
| 338.08 | 325.000 | 9.003 | 1305.8 |
| 337.31 | 325.000 | 8.262 | 1198.2 |
| 337.87 | 324.999 | 7.464 | 1082.6 |
| 339.61 | 325.000 | 6.700 | 971.7 |
| 342.26 | 325.000 | 5.938 | 861.2 |
| 345.64 | 325.000 | 5.165 | 749.1 |
| 349.49 | 325.000 | 4.414 | 640.1 |
| 353.86 | 325.000 | 3.657 | 530.4 |
| 358.65 | 325.000 | 2.882 | 418.0 |
| 363.52 | 325.000 | 2.135 | 309.6 |
| 368.69 | 325.000 | 1.370 | 198.6 |
| 370.02 | 325.000 | 1.181 | 171.2 |
| 371.05 | 325.000 | 1.032 | 149.6 |
| 372.03 | 325.000 | 0.890 | 129.1 |
| 373.14 | 325.000 | 0.730 | 105.9 |
| 374.52 | 325.000 | 0.529 | 76.7 |
| | | | |
| 361.18 | 350.000 | 9.009 | 1306.6 |
| 360.83 | 350.000 | 8.273 | 1199.8 |
| 361.24 | 350.000 | 7.569 | 1097.8 |
| 362.34 | 350.000 | 6.772 | 982.2 |
| 364.17 | 350.000 | 5.966 | 865.2 |
| 366.74 | 350.000 | 5.104 | 740.3 |
| 369.92 | 350.000 | 4.236 | 614.4 |
| 373.38 | 350.000 | 3.410 | 494.6 |
| 377.15 | 350.000 | 2.590 | 375.6 |
| 381.74 | 350.000 | 1.660 | 240.8 |
| 386.55 | 350.000 | 0.747 | 108.3 |
| 383.89 | 350.000 | 1.246 | 180.8 |
| 385.78 | 350.000 | 0.893 | 129.5 |
| 387.33 | 350.000 | 0.601 | 87.2 |

Table 6. Speed of sound data for the mixture $0.34524\ CH_4 + 0.65476\ C_2H_6$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 273.84 | 250.000 | 2.099 | 304.4 |
| 278.96 | 250.000 | 1.911 | 277.1 |
| 285.53 | 250.000 | 1.655 | 240.0 |
| 291.18 | 250.000 | 1.416 | 205.4 |
| 295.23 | 250.000 | 1.241 | 180.0 |
| 297.12 | 250.000 | 1.155 | 167.5 |
| 298.11 | 250.000 | 1.107 | 160.5 |
| 304.40 | 250.000 | 0.810 | 117.5 |
| 310.82 | 250.000 | 0.488 | 70.8 |
| 315.36 | 250.000 | 0.250 | 36.3 |
| 258.68 | 275.000 | 4.212 | 610.9 |
| 279.11 | 275.000 | 3.293 | 477.6 |
| 280.09 | 275.000 | 3.239 | 469.8 |
| 288.55 | 275.000 | 2.804 | 406.7 |
| 297.10 | 275.000 | 2.339 | 339.3 |
| 304.68 | 275.000 | 1.899 | 275.4 |
| 313.18 | 275.000 | 1.379 | 200.0 |
| 317.52 | 275.000 | 1.107 | 160.5 |
| 319.49 | 275.000 | 0.973 | 141.2 |
| 326.05 | 275.000 | 0.536 | 77.7 |
| 272.93 | 300.010 | 6.454 | 936.1 |
| 273.28 | 299.998 | 6.402 | 928.5 |
| 276.06 | 300.001 | 6.041 | 876.2 |
| 282.80 | 299.999 | 5.368 | 778.5 |
| 290.83 | 300.000 | 4.676 | 678.3 |
| 299.08 | 300.001 | 4.005 | 580.8 |
| 307.09 | 300.001 | 3.363 | 487.8 |
| 315.60 | 300.001 | 2.671 | 387.5 |
| 319.53 | 300.001 | 2.346 | 340.3 |
| 323.00 | 300.001 | 2.060 | 298.7 |
| 326.21 | 300.000 | 1.795 | 260.3 |
| 330.46 | 299.997 | 1.437 | 208.4 |
| 331.99 | 300.000 | 1.303 | 188.9 |
| 334.42 | 300.002 | 1.091 | 158.2 |
| 335.37 | 299.999 | 1.011 | 146.7 |
| 337.59 | 299.997 | 0.810 | 117.5 |
| 338.68 | 300.000 | 0.718 | 104.1 |
| 339.23 | 299.997 | 0.664 | 96.4 |
| 340.55 | 299.999 | 0.549 | 79.6 |
| 341.04 | 300.004 | 0.502 | 72.9 |

Table 6. Speed of sound data for the mixture
$0.34524\ CH_4 + 0.65476\ C_2H_6$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 317.37 | 325.000 | 10.368 | 1503.8 |
| 313.97 | 325.000 | 10.091 | 1463.6 |
| 309.96 | 325.000 | 9.702 | 1407.1 |
| 304.61 | 325.000 | 8.930 | 1295.2 |
| 302.50 | 325.000 | 8.174 | 1185.5 |
| 305.38 | 325.000 | 6.709 | 973.1 |
| 309.35 | 325.000 | 5.948 | 862.6 |
| 315.04 | 325.000 | 5.105 | 740.5 |
| 321.07 | 325.000 | 4.322 | 626.8 |
| 327.74 | 325.000 | 3.524 | 511.1 |
| 334.33 | 325.000 | 2.761 | 400.4 |
| 340.59 | 325.000 | 2.059 | 298.6 |
| 346.97 | 325.000 | 1.342 | 194.6 |
| 348.52 | 325.000 | 1.169 | 169.5 |
| 350.90 | 325.000 | 0.906 | 131.4 |
| 352.46 | 325.000 | 0.730 | 105.9 |
| 352.69 | 325.000 | 0.701 | 101.7 |
| 333.67 | 350.000 | 10.567 | 1532.7 |
| 329.23 | 350.000 | 9.388 | 1361.7 |
| 328.19 | 350.000 | 8.496 | 1232.3 |
| 328.95 | 350.000 | 7.607 | 1103.3 |
| 331.04 | 350.000 | 6.747 | 978.6 |
| 333.85 | 350.000 | 5.974 | 866.5 |
| 334.83 | 350.000 | 5.752 | 834.2 |
| 339.31 | 350.000 | 4.835 | 701.3 |
| 344.92 | 350.000 | 3.849 | 558.2 |
| 350.96 | 350.000 | 2.881 | 417.9 |
| 357.35 | 350.000 | 1.923 | 278.9 |
| 361.27 | 350.000 | 1.349 | 195.6 |
| 361.26 | 350.000 | 1.348 | 195.5 |
| 365.37 | 350.000 | 0.756 | 109.7 |
| 367.31 | 350.000 | 0.480 | 69.7 |

Table 7. Speed of sound data for the mixture $0.90016\ CH_4 + 0.09984\ C_3H_8$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 359.15 | 250.000 | 10.295 | 1493.2 |
| 347.73 | 250.000 | 9.779 | 1418.3 |
| 335.23 | 250.000 | 9.055 | 1313.3 |
| 327.15 | 250.000 | 8.307 | 1204.8 |
| 348.04 | 250.000 | 3.050 | 442.4 |
| 350.77 | 250.000 | 2.744 | 398.0 |
| 351.03 | 250.000 | 2.720 | 394.5 |
| 358.73 | 250.000 | 1.897 | 275.1 |
| 362.55 | 250.000 | 1.504 | 218.1 |
| 365.86 | 250.000 | 1.159 | 168.0 |
| 372.47 | 250.000 | 0.475 | 68.8 |
| 367.38 | 275.000 | 10.222 | 1482.5 |
| 363.76 | 275.000 | 9.718 | 1409.5 |
| 359.02 | 275.000 | 8.735 | 1266.9 |
| 357.11 | 275.000 | 7.657 | 1110.6 |
| 357.90 | 275.000 | 6.649 | 964.4 |
| 360.84 | 275.000 | 5.595 | 811.5 |
| 365.30 | 275.000 | 4.546 | 659.4 |
| 371.38 | 275.000 | 3.413 | 495.0 |
| 377.66 | 275.000 | 2.383 | 345.7 |
| 384.94 | 275.000 | 1.275 | 184.9 |
| 389.68 | 275.000 | 0.581 | 84.3 |
| 392.02 | 299.997 | 10.447 | 1515.2 |
| 391.70 | 299.999 | 10.366 | 1503.4 |
| 390.42 | 300.000 | 10.025 | 1454.0 |
| 387.01 | 300.000 | 8.978 | 1302.1 |
| 385.59 | 300.003 | 7.981 | 1157.5 |
| 385.54 | 300.002 | 6.947 | 1007.5 |
| 386.83 | 300.002 | 5.922 | 858.9 |
| 388.85 | 299.998 | 5.000 | 725.2 |
| 392.19 | 300.000 | 3.876 | 562.2 |
| 396.48 | 300.001 | 2.752 | 399.2 |
| 400.88 | 299.999 | 1.769 | 256.6 |
| 404.08 | 300.001 | 1.085 | 157.3 |
| 405.30 | 300.000 | 0.819 | 118.8 |
| 406.11 | 300.000 | 0.664 | 96.3 |
| 406.65 | 300.000 | 0.549 | 79.6 |

Table 7. Speed of sound data for the mixture
$0.90016\ CH_4 + 0.09984\ C_3H_8$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 422.44 | 325.000 | 0.481 | 69.8 |
| 422.26 | 325.000 | 0.524 | 76.0 |
| 422.29 | 325.000 | 0.533 | 77.3 |
| 421.67 | 325.000 | 0.683 | 99.1 |
| 421.06 | 325.000 | 0.857 | 124.4 |
| 420.39 | 325.000 | 1.035 | 150.1 |
| 419.72 | 325.000 | 1.224 | 177.6 |
| 418.95 | 325.000 | 1.432 | 207.7 |
| 416.95 | 325.000 | 2.062 | 299.1 |
| 414.48 | 325.000 | 2.951 | 428.0 |
| 414.46 | 325.000 | 2.954 | 428.5 |
| 414.45 | 325.000 | 2.956 | 428.7 |
| 413.18 | 325.000 | 3.451 | 500.5 |
| 411.50 | 325.000 | 4.122 | 597.9 |
| 410.32 | 325.000 | 4.827 | 700.1 |
| 409.33 | 325.000 | 5.503 | 798.1 |
| 408.71 | 325.000 | 6.199 | 899.1 |
| 408.35 | 325.000 | 6.889 | 999.2 |
| 408.50 | 325.000 | 7.585 | 1100.1 |
| 408.56 | 325.000 | 7.585 | 1100.1 |
| 409.02 | 325.000 | 8.254 | 1197.1 |
| 410.13 | 325.000 | 8.978 | 1302.1 |
| 411.52 | 325.000 | 9.660 | 1401.1 |
| 412.43 | 325.000 | 10.000 | 1450.4 |
| 413.74 | 325.000 | 10.409 | 1509.6 |
| 433.49 | 350.000 | 10.246 | 1486.1 |
| 433.00 | 350.000 | 10.079 | 1461.8 |
| 431.34 | 350.000 | 9.310 | 1350.3 |
| 429.65 | 350.000 | 8.285 | 1201.7 |
| 428.81 | 350.000 | 7.248 | 1051.2 |
| 428.48 | 350.000 | 6.211 | 900.9 |
| 428.81 | 350.000 | 5.172 | 750.1 |
| 429.77 | 350.000 | 4.162 | 603.7 |
| 431.24 | 350.000 | 3.104 | 450.2 |
| 433.17 | 350.000 | 2.057 | 298.4 |
| 434.77 | 350.000 | 1.345 | 195.1 |
| 435.17 | 350.000 | 1.160 | 168.2 |
| 436.00 | 350.000 | 0.821 | 119.0 |
| 436.51 | 350.000 | 0.617 | 89.5 |

Table 8. Speed of sound data for the mixture $0.95114\ CH_4 + 0.04886\ N_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 392.77 | 250.000 | 10.403 | 1508.8 |
| 389.33 | 250.000 | 9.980 | 1447.5 |
| 383.65 | 250.000 | 9.063 | 1314.5 |
| 380.41 | 250.000 | 8.191 | 1188.0 |
| 378.93 | 250.000 | 6.915 | 1003.0 |
| 380.06 | 250.000 | 5.873 | 851.8 |
| 382.80 | 250.000 | 4.837 | 701.5 |
| 387.10 | 250.000 | 3.696 | 536.1 |
| 392.26 | 250.000 | 2.596 | 376.6 |
| 397.99 | 250.000 | 1.518 | 220.2 |
| 402.66 | 250.000 | 0.700 | 101.5 |
| 404.60 | 250.000 | 0.377 | 54.7 |
| 417.79 | 275.000 | 10.460 | 1517.1 |
| 415.93 | 275.000 | 10.032 | 1454.9 |
| 412.22 | 275.000 | 9.009 | 1306.7 |
| 409.88 | 275.000 | 7.952 | 1153.3 |
| 408.93 | 275.000 | 6.949 | 1007.9 |
| 409.18 | 275.000 | 5.896 | 855.2 |
| 409.43 | 275.000 | 5.644 | 818.5 |
| 410.41 | 275.000 | 4.843 | 702.4 |
| 412.76 | 275.000 | 3.721 | 539.7 |
| 415.53 | 275.000 | 2.704 | 392.2 |
| 418.76 | 275.000 | 1.718 | 249.1 |
| 422.29 | 275.000 | 10.772 | 112.0 |
| 422.68 | 275.000 | 0.681 | 98.7 |
| 440.11 | 300.000 | 9.983 | 1448.0 |
| 438.29 | 300.000 | 9.399 | 1363.2 |
| 436.04 | 300.000 | 8.444 | 1224.7 |
| 434.63 | 300.000 | 7.583 | 1099.8 |
| 433.67 | 300.000 | 6.499 | 942.6 |
| 433.52 | 300.000 | 5.466 | 792.8 |
| 433.81 | 300.000 | 4.799 | 696.0 |
| 434.81 | 300.000 | 3.764 | 546.0 |
| 436.32 | 300.000 | 2.759 | 400.2 |
| 438.33 | 300.000 | 1.738 | 252.1 |
| 439.87 | 300.004 | 1.092 | 158.4 |
| 440.80 | 300.000 | 0.704 | 102.2 |

Table 8. Speed of sound data for the mixture $0.95114\ CH_4 + 0.04886\ N_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 454.54 | 324.998 | 4.264 | 1618.4 |
| 454.60 | 324.990 | 4.084 | 1592.3 |
| 454.59 | 325.000 | 4.084 | 1592.3 |
| 464.20 | 325.000 | 10.652 | 1544.9 |
| 463.12 | 324.998 | 10.343 | 1500.2 |
| 461.10 | 325.000 | 9.665 | 1401.8 |
| 459.34 | 325.000 | 8.969 | 1300.9 |
| 457.22 | 325.000 | 8.016 | 1162.7 |
| 456.42 | 325.000 | 7.431 | 1077.8 |
| 455.66 | 325.000 | 6.901 | 1000.8 |
| 455.11 | 325.000 | 6.211 | 900.8 |
| 454.70 | 325.000 | 5.524 | 801.3 |
| 454.42 | 324.997 | 4.842 | 702.3 |
| 454.40 | 325.000 | 4.140 | 600.4 |
| 454.69 | 325.000 | 3.447 | 500.0 |
| 455.24 | 325.000 | 2.753 | 399.2 |
| 455.86 | 325.000 | 2.065 | 299.6 |
| 456.59 | 325.000 | 1.507 | 218.5 |
| 456.82 | 325.000 | 1.380 | 200.2 |
| 457.02 | 325.000 | 1.237 | 179.4 |
| 457.20 | 325.000 | 1.102 | 159.8 |
| 457.41 | 325.000 | 0.966 | 140.1 |
| 457.65 | 325.000 | 0.801 | 116.2 |
| 457.88 | 325.000 | 0.670 | 97.2 |
| 482.89 | 350.000 | 10.433 | 1513.2 |
| 481.69 | 350.000 | 9.979 | 1447.4 |
| 481.68 | 350.000 | 9.976 | 1447.0 |
| 480.66 | 350.000 | 9.602 | 1392.7 |
| 478.21 | 350.000 | 8.623 | 1250.6 |
| 476.75 | 350.000 | 7.913 | 1147.7 |
| 476.34 | 350.000 | 7.711 | 1118.4 |
| 475.03 | 349.998 | 6.885 | 998.6 |
| 474.07 | 350.000 | 6.139 | 890.4 |
| 473.25 | 350.000 | 5.333 | 773.6 |
| 472.79 | 350.000 | 4.550 | 659.9 |
| 472.50 | 350.000 | 3.791 | 549.9 |
| 472.44 | 350.000 | 3.028 | 439.2 |
| 472.60 | 350.000 | 2.209 | 320.5 |
| 473.00 | 350.000 | 1.365 | 197.9 |

Table 8. Speed of sound data for the mixture $0.95114\ CH_4 + 0.04886\ N_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 473.07 | 350.000 | 1.363 | 197.8 |
| 473.11 | 350.000 | 1.184 | 171.8 |
| 473.23 | 350.000 | 1.000 | 145.1 |
| 473.40 | 350.000 | 0.781 | 113.3 |
| 473.71 | 350.000 | 0.523 | 75.9 |
| 392.61 | 249.998 | 0.281 | 40.7 |
| 391.91 | 250.002 | 0.419 | 60.8 |
| 391.22 | 250.000 | 0.561 | 81.4 |
| 390.60 | 250.000 | 0.695 | 100.8 |
| 387.71 | 250.000 | 1.320 | 191.5 |
| 384.72 | 250.000 | 2.002 | 290.4 |
| 381.31 | 250.001 | 2.876 | 417.1 |
| 379.16 | 250.001 | 3.472 | 503.5 |
| 377.29 | 250.000 | 4.091 | 593.4 |
| 375.52 | 249.997 | 4.826 | 699.9 |
| 374.16 | 249.999 | 5.624 | 815.7 |
| 373.58 | 249.999 | 6.864 | 995.5 |
| 375.41 | 250.000 | 8.108 | 1176.0 |
| 378.39 | 249.998 | 8.983 | 1302.9 |
| 381.34 | 249.999 | 9.591 | 1391.0 |
| 383.50 | 250.001 | 9.952 | 1443.5 |
| 385.71 | 250.001 | 10.281 | 1491.1 |

Table 9. Speed of sound data for the mixture $0.85130\ CH_4 + 0.14870\ N_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 411.12 | 275.000 | 0.290 | 42.1 |
| 410.68 | 275.000 | 0.420 | 60.9 |
| 410.26 | 275.000 | 0.551 | 79.9 |
| 409.82 | 274.999 | 0.689 | 99.9 |
| 409.73 | 275.000 | 0.702 | 101.8 |
| 407.70 | 275.000 | 1.404 | 203.7 |
| 405.90 | 275.000 | 2.104 | 305.2 |
| 404.32 | 275.000 | 2.781 | 403.4 |
| 403.01 | 274.999 | 3.452 | 500.7 |
| 401.97 | 274.998 | 4.125 | 598.3 |
| 401.29 | 275.002 | 4.800 | 696.2 |
| 400.84 | 274.998 | 5.537 | 803.1 |
| 400.81 | 274.998 | 6.216 | 901.6 |
| 401.26 | 274.999 | 6.910 | 1002.2 |
| 402.20 | 275.002 | 7.659 | 1110.8 |
| 403.51 | 275.000 | 8.328 | 1207.9 |
| 405.23 | 274.999 | 8.983 | 1302.8 |
| 407.36 | 275.001 | 9.599 | 1392.3 |
| 410.61 | 275.002 | 10.393 | 1507.4 |
| 433.32 | 300.000 | 10.454 | 1516.2 |
| 429.49 | 300.000 | 9.324 | 1352.4 |
| 426.87 | 300.001 | 8.287 | 1202.0 |
| 424.87 | 300.000 | 7.222 | 1047.5 |
| 423.80 | 300.000 | 6.216 | 901.5 |
| 423.32 | 300.000 | 4.943 | 716.9 |
| 423.52 | 300.000 | 3.935 | 570.7 |
| 424.04 | 300.000 | 3.075 | 446.0 |
| 426.29 | 300.000 | 1.334 | 193.5 |
| 427.59 | 300.000 | 0.628 | 91.1 |
| 453.60 | 325.000 | 10.447 | 1515.2 |
| 453.60 | 325.000 | 10.444 | 1514.8 |
| 452.69 | 325.000 | 10.167 | 1474.6 |
| 450.31 | 325.000 | 9.388 | 1361.6 |
| 448.35 | 325.000 | 8.624 | 1250.8 |
| 446.68 | 325.000 | 7.879 | 1142.7 |
| 445.30 | 325.000 | 7.112 | 1031.6 |
| 445.30 | 325.000 | 7.112 | 1031.4 |
| 444.20 | 325.000 | 6.338 | 919.2 |
| 442.86 | 325.000 | 4.890 | 709.2 |

Table 9. Speed of sound data for the mixture $0.85130\ CH_4 + 0.14870\ N_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 442.53 | 325.000 | 4.132 | 599.2 |
| 442.43 | 325.000 | 3.367 | 488.3 |
| 442.59 | 325.000 | 2.584 | 374.8 |
| 443.01 | 325.000 | 1.792 | 259.9 |
| 443.32 | 325.000 | 1.313 | 190.4 |
| 443.35 | 325.000 | 1.313 | 190.4 |
| 443.57 | 325.000 | 1.046 | 151.8 |
| 443.79 | 325.000 | 0.787 | 114.2 |
| 444.01 | 325.000 | 0.615 | 89.2 |
| 472.33 | 350.000 | 10.465 | 1517.9 |
| 472.20 | 350.000 | 10.463 | 1517.5 |
| 472.20 | 350.000 | 10.429 | 1512.6 |
| 471.15 | 350.000 | 10.100 | 1464.9 |
| 468.48 | 350.000 | 9.166 | 1329.4 |
| 466.20 | 350.000 | 8.239 | 1195.0 |
| 464.34 | 350.000 | 7.370 | 1068.9 |
| 462.75 | 350.000 | 6.499 | 942.6 |
| 461.49 | 350.000 | 5.650 | 819.4 |
| 460.52 | 350.000 | 4.824 | 699.6 |
| 459.76 | 350.000 | 3.923 | 569.0 |
| 459.33 | 350.000 | 3.233 | 468.9 |
| 459.36 | 350.000 | 3.185 | 461.9 |
| 459.11 | 350.000 | 2.406 | 349.0 |
| 459.07 | 350.000 | 1.582 | 229.4 |
| 459.08 | 350.000 | 1.355 | 196.5 |
| 459.10 | 350.000 | 1.152 | 167.1 |
| 459.16 | 350.000 | 0.999 | 144.8 |
| 459.18 | 350.000 | 0.646 | 93.7 |
| 459.21 | 350.000 | 0.640 | 92.9 |
| 459.20 | 350.000 | 0.632 | 91.6 |
| 459.33 | 350.000 | 0.542 | 78.7 |

Table 10. Speed of sound data for the mixture 0.71373 $CH_4$ + 0.28627 $N_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 377.04 | 250.000 | 10.065 | 1459.8 |
| 376.80 | 250.006 | 10.039 | 1456.0 |
| 373.22 | 250.014 | 9.322 | 1352.0 |
| 369.05 | 250.001 | 8.255 | 1197.3 |
| 366.40 | 249.993 | 6.977 | 1011.9 |
| 365.70 | 249.994 | 5.692 | 825.6 |
| 365.90 | 250.017 | 4.985 | 723.0 |
| 366.24 | 250.007 | 4.735 | 686.7 |
| 368.14 | 249.999 | 3.450 | 500.4 |
| 371.21 | 250.004 | 2.139 | 310.3 |
| 371.23 | 250.001 | 2.105 | 305.3 |
| 373.72 | 249.998 | 1.269 | 184.1 |
| 376.53 | 249.994 | 0.436 | 63.3 |
| 377.07 | 250.000 | 0.313 | 45.4 |
| 377.79 | 250.000 | 0.144 | 20.9 |
| 377.80 | 250.000 | 0.139 | 20.2 |
| 378.19 | 250.000 | 0.085 | 12.3 |
| 399.50 | 275.013 | 9.922 | 1439.0 |
| 396.10 | 274.998 | 8.945 | 1297.3 |
| 394.43 | 275.001 | 8.301 | 1204.0 |
| 392.15 | 274.996 | 7.430 | 1077.6 |
| 390.53 | 274.999 | 6.258 | 907.7 |
| 389.98 | 274.998 | 5.597 | 811.8 |
| 389.83 | 275.044 | 5.158 | 748.2 |
| 389.75 | 275.001 | 4.188 | 607.4 |
| 390.15 | 275.000 | 3.450 | 500.3 |
| 390.22 | 275.029 | 3.427 | 497.1 |
| 390.58 | 274.997 | 3.038 | 440.6 |
| 391.12 | 275.001 | 2.564 | 371.8 |
| 391.27 | 274.998 | 2.446 | 354.7 |
| 391.77 | 274.997 | 2.045 | 296.6 |
| 392.90 | 275.000 | 1.345 | 195.1 |
| 394.07 | 274.999 | 0.738 | 107.1 |
| 394.91 | 275.004 | 0.347 | 50.3 |
| 422.85 | 301.207 | 10.260 | 1488.1 |
| 420.79 | 301.234 | 9.662 | 1401.3 |
| 416.82 | 301.200 | 8.332 | 1208.5 |
| 413.99 | 301.177 | 7.013 | 1017.2 |
| 411.78 | 301.144 | 5.567 | 807.4 |
| 410.81 | 299.998 | 5.479 | 794.7 |

Table 10. Speed of sound data for the mixture $0.71373\ CH_4 + 0.28627\ N_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 409.87 | 299.999 | 4.156 | 602.7 |
| 409.85 | 300.098 | 3.029 | 439.3 |
| 410.14 | 300.077 | 2.073 | 300.6 |
| 410.57 | 300.077 | 1.398 | 202.8 |
| 411.17 | 300.051 | 0.713 | 103.5 |
| 411.39 | 300.005 | 0.476 | 69.0 |
| 411.39 | 300.005 | 0.476 | 69.0 |
| 411.44 | 299.994 | 0.354 | 51.3 |
| 411.43 | 300.001 | 0.363 | 52.6 |
| 411.55 | 299.998 | 0.275 | 39.9 |
| 411.64 | 299.999 | 0.209 | 30.3 |
| 411.82 | 299.999 | 0.146 | 21.2 |
| 411.97 | 299.986 | 0.103 | 15.0 |
| 440.07 | 325.000 | 10.007 | 1451.5 |
| 437.90 | 325.000 | 9.286 | 1346.8 |
| 435.95 | 325.000 | 8.631 | 1251.9 |
| 433.68 | 325.000 | 7.730 | 1121.1 |
| 431.84 | 325.000 | 6.922 | 1003.9 |
| 430.63 | 325.000 | 6.207 | 900.3 |
| 429.54 | 325.000 | 5.511 | 799.4 |
| 429.17 | 325.000 | 5.090 | 738.2 |
| 428.79 | 325.000 | 4.800 | 696.2 |
| 428.49 | 325.000 | 4.661 | 676.1 |
| 427.96 | 325.000 | 4.000 | 580.2 |
| 427.76 | 325.000 | 3.752 | 544.2 |
| 427.60 | 325.000 | 3.430 | 497.5 |
| 427.34 | 325.000 | 3.047 | 442.0 |
| 427.25 | 325.000 | 3.047 | 441.9 |
| 427.27 | 325.000 | 2.752 | 399.1 |
| 427.13 | 325.000 | 2.651 | 384.6 |
| 427.02 | 325.000 | 2.404 | 348.7 |
| 426.95 | 325.000 | 2.067 | 299.8 |
| 427.03 | 325.000 | 1.723 | 249.9 |
| 426.89 | 324.999 | 1.713 | 248.4 |
| 427.02 | 325.000 | 1.378 | 199.9 |
| 427.08 | 325.000 | 1.341 | 194.5 |
| 427.08 | 325.000 | 1.208 | 175.3 |
| 427.15 | 325.000 | 0.938 | 136.0 |
| 427.20 | 325.000 | 0.733 | 106.3 |
| 427.11 | 325.001 | 0.693 | 100.5 |
| 427.22 | 325.000 | 0.554 | 80.3 |
| 427.32 | 325.000 | 0.546 | 79.2 |

Table 10. Speed of sound data for the mixture $0.71373\ CH_4 + 0.28627\ N_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 459.14 | 350.000 | 10.469 | 1518.3 |
| 459.15 | 350.000 | 10.466 | 1518.0 |
| 455.52 | 350.000 | 9.320 | 1351.7 |
| 452.64 | 350.000 | 8.277 | 1200.5 |
| 450.14 | 350.000 | 7.236 | 1049.5 |
| 447.95 | 350.000 | 6.219 | 902.0 |
| 446.19 | 350.000 | 5.170 | 749.9 |
| 445.63 | 350.000 | 4.827 | 700.1 |
| 444.26 | 350.000 | 3.786 | 549.1 |
| 443.21 | 350.000 | 2.759 | 400.2 |
| 442.51 | 350.000 | 1.712 | 248.3 |
| 442.28 | 350.000 | 1.343 | 194.8 |
| 442.18 | 350.000 | 0.977 | 141.7 |
| 442.18 | 350.000 | 0.933 | 135.4 |
| 442.21 | 350.000 | 0.932 | 135.2 |

Table 11. Speed of sound data for the mixture
$0.94979\ CH_4 + 0.05021\ CO_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 378.77 | 249.999 | 10.517 | 1525.4 |
| 372.08 | 249.998 | 9.832 | 1426.0 |
| 372.05 | 249.998 | 9.826 | 1425.1 |
| 366.28 | 249.998 | 8.955 | 1298.8 |
| 363.41 | 249.998 | 8.186 | 1187.3 |
| 362.53 | 250.002 | 7.176 | 1040.8 |
| 362.61 | 250.000 | 7.106 | 1030.7 |
| 363.67 | 250.001 | 6.313 | 915.6 |
| 365.83 | 250.000 | 5.545 | 804.2 |
| 368.98 | 250.001 | 4.734 | 686.6 |
| 372.63 | 249.999 | 3.965 | 575.1 |
| 376.95 | 249.999 | 3.164 | 458.9 |
| 383.13 | 250.000 | 2.112 | 306.4 |
| 387.48 | 249.999 | 1.413 | 204.9 |
| 389.63 | 250.000 | 1.080 | 156.7 |
| 391.20 | 250.000 | 0.833 | 120.9 |
| 391.15 | 249.999 | 0.842 | 122.2 |
| 392.04 | 250.001 | 0.703 | 102.0 |
| 392.87 | 249.999 | 0.575 | 83.4 |
| 401.67 | 275.000 | 10.496 | 1522.3 |
| 398.56 | 275.000 | 9.804 | 1421.9 |
| 395.59 | 275.000 | 8.863 | 1285.5 |
| 393.95 | 275.001 | 7.837 | 1136.6 |
| 393.70 | 275.001 | 6.917 | 1003.2 |
| 394.88 | 275.001 | 5.692 | 825.6 |
| 396.88 | 275.000 | 4.717 | 684.2 |
| 400.07 | 275.000 | 3.607 | 523.2 |
| 403.45 | 275.000 | 2.647 | 383.9 |
| 407.25 | 275.000 | 1.685 | 244.4 |
| 410.48 | 275.000 | 0.938 | 136.1 |
| 412.73 | 275.000 | 0.447 | 64.9 |
| 426.09 | 300.003 | 10.604 | 1537.9 |
| 423.55 | 300.000 | 9.842 | 1427.4 |
| 421.42 | 300.000 | 8.978 | 1302.2 |
| 420.03 | 299.999 | 8.163 | 1184.0 |
| 419.09 | 300.000 | 7.119 | 1032.6 |
| 419.05 | 300.000 | 6.194 | 898.4 |
| 419.66 | 300.000 | 5.171 | 750.0 |
| 421.01 | 300.000 | 4.132 | 599.3 |
| 422.99 | 300.000 | 3.089 | 448.0 |
| 425.39 | 300.000 | 2.064 | 299.4 |

Table 11. Speed of sound data for the mixture 0.94979 $CH_4$ + 0.05021 $CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 428.33 | 300.000 | 1.022 | 148.2 |
| 429.98 | 300.000 | 0.489 | 71.0 |
| | | | |
| 446.04 | 325.000 | 0.599 | 86.9 |
| 445.99 | 325.000 | 0.599 | 86.9 |
| 445.66 | 325.000 | 0.763 | 110.7 |
| 445.27 | 325.001 | 0.957 | 138.8 |
| 444.76 | 325.002 | 1.234 | 179.0 |
| 444.54 | 325.001 | 1.356 | 196.7 |
| 444.18 | 325.000 | 1.499 | 217.5 |
| 443.26 | 325.000 | 2.066 | 299.6 |
| 442.38 | 325.000 | 2.746 | 398.3 |
| 441.56 | 325.000 | 3.446 | 499.8 |
| 440.93 | 325.002 | 4.134 | 599.5 |
| 440.58 | 325.000 | 4.813 | 698.1 |
| 440.44 | 325.000 | 5.518 | 800.3 |
| 440.32 | 325.001 | 5.518 | 800.3 |
| 440.39 | 325.000 | 5.535 | 802.8 |
| 440.40 | 325.000 | 5.538 | 803.2 |
| 440.47 | 325.002 | 6.203 | 899.7 |
| 440.81 | 325.000 | 6.892 | 999.6 |
| 440.79 | 325.000 | 6.934 | 1005.7 |
| 441.09 | 325.000 | 7.251 | 1051.7 |
| 441.31 | 325.000 | 7.580 | 1099.4 |
| 441.83 | 325.000 | 7.935 | 1150.9 |
| 442.38 | 325.000 | 8.288 | 1202.1 |
| 442.42 | 325.000 | 8.310 | 1205.3 |
| 443.52 | 325.000 | 8.975 | 1301.7 |
| 445.01 | 325.000 | 9.609 | 1393.7 |
| 445.97 | 325.000 | 10.011 | 1452.0 |
| 447.10 | 325.000 | 10.384 | 1506.0 |

Table 11. Speed of sound data for the mixture $0.94979\ CH_4 + 0.05021\ CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 461.72 | 350.000 | 8.011 | 1162.0 |
| 460.32 | 350.000 | 6.956 | 1008.9 |
| 459.41 | 350.000 | 5.896 | 855.2 |
| 458.91 | 350.000 | 4.809 | 697.4 |
| 458.88 | 350.000 | 3.783 | 548.7 |
| 459.28 | 350.000 | 2.759 | 400.1 |
| 460.06 | 350.000 | 1.697 | 246.1 |
| 460.42 | 350.000 | 1.319 | 191.4 |
| 461.10 | 350.000 | 0.688 | 99.8 |

Table 12. Speed of sound data for the mixture
$0.85026\ CH_4 + 0.14974\ CO_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 345.16 | 250.002 | 10.357 | 1502.1 |
| 337.33 | 250.000 | 9.628 | 1396.4 |
| 332.00 | 249.998 | 8.867 | 1286.0 |
| 329.32 | 249.999 | 8.096 | 1174.3 |
| 328.99 | 249.999 | 7.303 | 1059.2 |
| 330.33 | 249.999 | 6.536 | 948.0 |
| 333.12 | 249.999 | 5.704 | 827.3 |
| 336.76 | 250.000 | 4.933 | 715.4 |
| 341.28 | 249.999 | 4.099 | 594.6 |
| 346.48 | 249.999 | 3.246 | 470.7 |
| 351.17 | 249.999 | 2.523 | 366.0 |
| 354.47 | 249.999 | 2.025 | 293.7 |
| 356.42 | 250.001 | 1.733 | 251.3 |
| 358.79 | 249.999 | 1.384 | 200.7 |
| 360.63 | 249.999 | 1.114 | 161.5 |
| 362.59 | 250.000 | 0.831 | 120.6 |
| 362.53 | 249.999 | 0.836 | 121.2 |
| 363.55 | 249.998 | 0.684 | 99.2 |
| 364.33 | 250.000 | 0.564 | 81.8 |
| 366.00 | 275.000 | 10.289 | 1492.4 |
| 363.49 | 275.000 | 9.676 | 1403.4 |
| 360.95 | 275.000 | 8.675 | 1258.2 |
| 360.33 | 275.000 | 7.046 | 1021.9 |
| 361.50 | 275.000 | 6.130 | 889.0 |
| 363.79 | 275.000 | 5.137 | 745.0 |
| 366.99 | 275.000 | 4.099 | 594.5 |
| 370.76 | 275.000 | 3.094 | 448.8 |
| 375.32 | 275.000 | 2.022 | 293.3 |
| 379.87 | 275.000 | 1.038 | 150.5 |
| 382.61 | 275.000 | 0.475 | 68.8 |
| 391.10 | 300.000 | 10.772 | 1562.3 |
| 389.22 | 300.000 | 10.180 | 1476.5 |
| 386.88 | 300.000 | 9.197 | 1333.9 |
| 385.61 | 300.000 | 8.268 | 1199.2 |
| 385.11 | 300.000 | 7.255 | 1052.2 |
| 385.47 | 300.000 | 6.218 | 901.9 |
| 386.73 | 300.000 | 5.149 | 746.8 |
| 388.48 | 300.000 | 4.114 | 596.7 |

Table 12. Speed of sound data for the mixture $0.85026\ CH_4 + 0.14974\ CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 390.91 | 300.000 | 3.073 | 445.7 |
| 393.76 | 300.000 | 2.039 | 295.7 |
| 396.96 | 300.000 | 1.029 | 149.2 |
| 398.52 | 300.000 | 0.550 | 79.8 |
| | | | |
| 411.82 | 325.000 | 10.757 | 1560.2 |
| 409.63 | 325.000 | 9.853 | 1429.0 |
| 407.71 | 325.000 | 8.817 | 1278.8 |
| 406.55 | 325.008 | 7.788 | 1129.6 |
| 406.03 | 325.000 | 6.789 | 984.6 |
| 406.11 | 325.000 | 5.712 | 828.4 |
| 406.76 | 325.000 | 4.677 | 678.4 |
| 407.88 | 325.000 | 3.637 | 527.5 |
| 409.41 | 325.000 | 2.599 | 376.9 |
| 411.47 | 325.000 | 1.513 | 219.4 |
| 413.24 | 325.000 | 0.696 | 101.0 |
| | | | |
| 430.77 | 350.000 | 10.726 | 1555.6 |
| 429.50 | 350.000 | 10.173 | 1475.5 |
| 427.84 | 350.000 | 9.340 | 1354.6 |
| 426.17 | 350.000 | 8.274 | 1200.1 |
| 425.38 | 350.000 | 7.524 | 1091.2 |
| 424.77 | 350.000 | 6.760 | 980.5 |
| 424.39 | 350.000 | 5.799 | 841.1 |
| 424.34 | 350.000 | 4.993 | 724.1 |
| 424.28 | 350.000 | 4.900 | 710.7 |
| 424.51 | 350.000 | 4.203 | 609.5 |
| 424.52 | 350.000 | 4.201 | 609.3 |
| 424.47 | 350.000 | 4.131 | 599.2 |
| 424.82 | 350.000 | 3.435 | 498.2 |
| 424.94 | 350.000 | 3.367 | 488.4 |
| 425.43 | 350.000 | 2.725 | 395.2 |
| 425.64 | 350.000 | 2.488 | 360.8 |
| 426.09 | 350.000 | 2.069 | 300.1 |
| 426.46 | 350.000 | 1.698 | 246.2 |

Table 13. Speed of sound data for the mixture
$0.69944\ CH_4 + 0.30056\ CO_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 329.92 | 249.999 | 0.627 | 90.9 |
| 329.44 | 249.999 | 0.691 | 100.3 |
| 328.81 | 249.999 | 0.778 | 112.8 |
| 328.41 | 250.000 | 0.819 | 118.8 |
| 328.10 | 249.999 | 0.867 | 125.7 |
| 326.60 | 250.000 | 1.053 | 152.7 |
| 321.88 | 250.000 | 1.668 | 242.0 |
| 315.51 | 250.000 | 2.480 | 359.7 |
| 310.62 | 249.998 | 3.086 | 447.6 |
| 308.81 | 250.000 | 3.333 | 483.4 |
| 305.11 | 250.000 | 3.804 | 551.7 |
| 302.32 | 250.000 | 4.162 | 603.6 |
| 296.09 | 250.000 | 4.972 | 721.1 |
| 290.34 | 250.000 | 5.802 | 841.6 |
| 285.70 | 249.999 | 6.654 | 965.0 |
| 282.96 | 249.999 | 7.483 | 1085.3 |
| 283.70 | 250.001 | 8.316 | 1206.1 |
| 289.25 | 250.000 | 9.086 | 1317.8 |
| 301.65 | 249.999 | 9.900 | 1435.9 |
| 312.22 | 249.999 | 10.401 | 1508.5 |
| 318.55 | 250.001 | 10.663 | 1546.6 |
| 323.06 | 275.003 | 10.401 | 1508.6 |
| 320.02 | 274.998 | 9.729 | 1411.1 |
| 317.80 | 274.999 | 8.863 | 1285.4 |
| 317.34 | 274.998 | 8.103 | 1175.2 |
| 318.04 | 275.000 | 7.291 | 1057.4 |
| 319.67 | 274.999 | 6.527 | 946.7 |
| 322.11 | 274.999 | 5.706 | 827.5 |
| 324.99 | 275.000 | 4.944 | 717.1 |
| 328.62 | 275.001 | 4.100 | 594.6 |
| 332.22 | 274.999 | 3.352 | 486.2 |
| 336.22 | 275.001 | 2.565 | 372.0 |
| 341.01 | 275.000 | 1.664 | 241.4 |
| 342.51 | 275.001 | 1.377 | 199.7 |
| 344.08 | 274.999 | 1.084 | 157.3 |
| 345.45 | 275.000 | 0.833 | 120.8 |
| 346.18 | 274.999 | 0.699 | 101.4 |
| 346.92 | 275.000 | 0.560 | 81.2 |

Table 13. Speed of sound data for the mixture 0.69944 $CH_4$ + 0.30056 $CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 346.28 | 300.001 | 10.384 | 1506.0 |
| 344.55 | 300.002 | 9.598 | 1392.1 |
| 343.64 | 299.998 | 8.908 | 1291.9 |
| 343.22 | 299.999 | 8.100 | 1174.8 |
| 343.47 | 300.001 | 7.312 | 1060.5 |
| 344.28 | 299.999 | 6.538 | 948.2 |
| 345.70 | 299.998 | 5.685 | 824.5 |
| 347.33 | 299.997 | 4.941 | 716.7 |
| 349.43 | 299.999 | 4.151 | 602.0 |
| 351.82 | 300.000 | 3.357 | 486.9 |
| 354.80 | 299.999 | 2.464 | 357.4 |
| 356.08 | 300.000 | 2.108 | 305.8 |
| 357.43 | 299.999 | 1.733 | 251.3 |
| 358.73 | 300.000 | 1.383 | 200.6 |
| 359.71 | 299.999 | 1.127 | 163.5 |
| 360.81 | 299.999 | 0.830 | 120.4 |
| 361.36 | 300.000 | 0.693 | 100.5 |
| 375.61 | 325.000 | 0.575 | 83.4 |
| 375.12 | 325.000 | 0.748 | 108.5 |
| 374.58 | 325.000 | 0.949 | 137.7 |
| 374.17 | 325.000 | 1.104 | 160.1 |
| 373.78 | 325.000 | 1.241 | 179.9 |
| 373.42 | 325.000 | 1.361 | 197.4 |
| 372.56 | 325.000 | 1.645 | 238.7 |
| 370.92 | 325.000 | 2.340 | 339.4 |
| 369.24 | 325.000 | 3.101 | 449.8 |
| 367.69 | 325.000 | 3.865 | 560.6 |
| 366.82 | 325.000 | 4.389 | 636.6 |
| 366.47 | 325.000 | 4.617 | 669.7 |
| 365.22 | 325.000 | 5.387 | 781.3 |
| 364.63 | 325.000 | 6.183 | 896.7 |
| 364.19 | 325.000 | 6.953 | 1008.4 |
| 364.08 | 325.000 | 7.736 | 1122.0 |
| 364.36 | 325.000 | 8.507 | 1233.8 |
| 364.95 | 325.000 | 9.254 | 1342.2 |
| 366.07 | 325.000 | 10.007 | 1451.4 |
| 367.13 | 325.000 | 10.445 | 1514.9 |

Table 13. Speed of sound data for the mixture $0.69944\ CH_4 + 0.30056\ CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 385.53 | 350.000 | 10.372 | 1504.3 |
| 384.99 | 350.000 | 9.996 | 1449.8 |
| 384.25 | 350.000 | 9.415 | 1365.6 |
| 383.26 | 350.000 | 8.541 | 1238.8 |
| 382.55 | 350.000 | 7.602 | 1102.6 |
| 382.32 | 350.000 | 6.782 | 983.6 |
| 382.44 | 350.000 | 5.865 | 850.6 |
| 382.85 | 350.000 | 4.937 | 716.0 |
| 383.75 | 350.000 | 3.863 | 560.2 |
| 384.80 | 350.000 | 2.961 | 429.4 |
| 386.10 | 350.000 | 2.063 | 299.3 |
| 387.41 | 350.000 | 1.258 | 182.5 |
| 388.06 | 350.000 | 0.898 | 130.3 |
| 388.50 | 350.000 | 0.632 | 91.6 |
| 388.53 | 350.000 | 0.631 | 91.5 |

Table 14. Speed of sound data for mixture 0.49593 $N_2$ + 0.50407 $CO_2$.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 256.91 | 250.001 | 3.956 | 573.8 |
| 259.93 | 250.001 | 3.415 | 495.4 |
| 262.03 | 249.998 | 3.019 | 437.8 |
| 264.33 | 249.999 | 2.607 | 378.2 |
| 266.54 | 249.999 | 2.202 | 319.3 |
| 268.40 | 250.000 | 1.873 | 271.7 |
| 270.44 | 249.999 | 1.520 | 220.4 |
| 272.31 | 250.000 | 1.198 | 173.7 |
| 274.29 | 249.999 | 0.836 | 121.2 |
| 272.68 | 275.000 | 10.212 | 1481.1 |
| 271.26 | 275.000 | 9.363 | 1357.9 |
| 270.67 | 275.000 | 8.340 | 1209.6 |
| 271.20 | 275.000 | 7.293 | 1057.8 |
| 272.73 | 275.000 | 6.249 | 906.3 |
| 274.96 | 274.999 | 5.198 | 753.9 |
| 277.76 | 275.000 | 4.128 | 598.7 |
| 280.91 | 275.000 | 3.091 | 448.4 |
| 284.43 | 275.000 | 2.038 | 295.5 |
| 294.17 | 300.000 | 10.029 | 1454.6 |
| 293.69 | 300.000 | 9.685 | 1404.8 |
| 292.91 | 300.000 | 9.053 | 1313.0 |
| 292.31 | 300.000 | 8.270 | 1199.5 |
| 292.11 | 300.000 | 7.536 | 1093.1 |
| 292.38 | 300.000 | 6.554 | 950.6 |
| 293.15 | 300.000 | 5.518 | 800.4 |
| 294.39 | 300.000 | 4.480 | 649.8 |
| 296.07 | 300.000 | 3.443 | 499.4 |
| 298.13 | 300.000 | 2.391 | 346.8 |
| 300.57 | 300.000 | 1.329 | 192.8 |
| 311.93 | 325.000 | 10.015 | 1452.6 |
| 311.49 | 325.000 | 9.675 | 1403.3 |
| 311.46 | 325.000 | 9.674 | 1403.1 |
| 310.04 | 325.000 | 8.201 | 1189.4 |
| 310.12 | 325.000 | 8.169 | 1184.8 |
| 309.66 | 325.000 | 7.396 | 1072.7 |
| 309.46 | 325.000 | 6.633 | 962.1 |
| 309.47 | 325.000 | 5.870 | 851.3 |
| 309.64 | 325.000 | 5.115 | 741.9 |

Table 14. Speed of sound data for mixture $0.49593\ N_2 + 0.50407\ CO_2$ (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 309.99 | 325.000 | 4.355 | 631.6 |
| 310.52 | 325.000 | 3.583 | 519.7 |
| 310.54 | 325.000 | 3.584 | 519.8 |
| 311.18 | 325.000 | 2.837 | 411.4 |
| 312.06 | 325.000 | 2.063 | 299.2 |
| 312.99 | 325.000 | 1.383 | 200.6 |
| 313.29 | 325.000 | 1.206 | 174.9 |
| 313.56 | 325.000 | 1.030 | 149.3 |
| 313.87 | 325.000 | 0.852 | 123.5 |
| 314.44 | 325.000 | 0.519 | 75.3 |
| 328.45 | 350.000 | 10.344 | 1500.3 |
| 328.25 | 350.000 | 10.176 | 1475.9 |
| 327.31 | 350.000 | 9.607 | 1393.4 |
| 327.34 | 350.000 | 9.606 | 1393.2 |
| 326.22 | 350.000 | 8.787 | 1274.5 |
| 325.43 | 350.000 | 8.023 | 1163.7 |
| 325.31 | 350.000 | 7.890 | 1144.4 |
| 324.64 | 350.000 | 7.072 | 1025.7 |
| 324.65 | 350.000 | 7.059 | 1023.8 |
| 324.16 | 350.000 | 6.216 | 901.5 |
| 324.19 | 350.000 | 6.213 | 901.1 |
| 323.79 | 350.000 | 5.279 | 765.6 |
| 323.84 | 350.000 | 4.558 | 661.2 |
| 323.81 | 350.000 | 4.095 | 594.0 |
| 323.94 | 350.000 | 3.364 | 488.0 |
| 324.31 | 350.000 | 2.608 | 378.2 |
| 324.87 | 350.000 | 1.752 | 254.1 |

Table 15. Speed of sound data for Gulf Coast mixture.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 387.91 | 250.000 | 10.708 | 1553.1 |
| 387.86 | 250.000 | 10.700 | 1551.9 |
| 384.19 | 250.000 | 10.409 | 1509.7 |
| 380.41 | 250.000 | 10.065 | 1459.8 |
| 375.87 | 250.000 | 9.571 | 1388.2 |
| 370.18 | 250.000 | 8.672 | 1257.8 |
| 367.62 | 250.000 | 7.853 | 1139.0 |
| 367.24 | 250.000 | 6.923 | 1004.1 |
| 367.43 | 250.000 | 6.802 | 986.5 |
| 369.27 | 250.000 | 5.912 | 857.5 |
| 371.79 | 250.000 | 5.195 | 753.4 |
| 375.64 | 250.000 | 4.366 | 633.3 |
| 378.84 | 250.000 | 3.763 | 545.8 |
| 383.80 | 250.000 | 2.920 | 423.5 |
| 389.44 | 250.000 | 2.036 | 295.4 |
| 394.19 | 250.000 | 1.317 | 191.0 |
| 399.23 | 250.000 | 0.591 | 85.7 |
| 406.91 | 275.000 | 10.325 | 1497.5 |
| 404.02 | 275.000 | 9.715 | 1409.0 |
| 404.03 | 275.000 | 9.714 | 1409.0 |
| 401.33 | 275.000 | 8.935 | 1296.0 |
| 399.69 | 275.000 | 8.165 | 1184.2 |
| 399.00 | 275.000 | 7.369 | 1068.8 |
| 399.19 | 275.000 | 6.521 | 945.8 |
| 400.41 | 275.000 | 5.623 | 815.6 |
| 402.12 | 275.000 | 4.824 | 699.6 |
| 404.36 | 275.000 | 4.047 | 586.9 |
| 407.26 | 275.000 | 3.213 | 466.1 |
| 411.32 | 275.000 | 2.197 | 318.7 |
| 415.73 | 275.000 | 1.209 | 175.3 |
| 419.16 | 275.000 | 0.500 | 72.5 |
| 431.53 | 300.000 | 10.309 | 1495.2 |
| 429.40 | 300.000 | 9.652 | 1399.8 |
| 427.66 | 300.000 | 8.972 | 1301.2 |
| 426.29 | 300.000 | 8.233 | 1194.1 |
| 425.53 | 300.000 | 7.567 | 1097.5 |
| 425.19 | 300.025 | 6.842 | 992.4 |
| 425.25 | 300.004 | 6.053 | 877.9 |
| 425.94 | 300.003 | 5.150 | 746.9 |

Table 15. Speed of sound data for Gulf Coast mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 427.04 | 300.000 | 4.322 | 626.8 |
| 428.72 | 300.004 | 3.433 | 497.9 |
| 430.59 | 300.000 | 2.631 | 381.5 |
| 432.98 | 300.000 | 1.780 | 258.2 |
| 435.83 | 300.000 | 0.856 | 124.1 |
| 437.14 | 300.000 | 0.468 | 67.9 |
| | | | |
| 454.25 | 325.000 | 10.382 | 1505.8 |
| 452.89 | 325.000 | 9.986 | 1448.4 |
| 452.00 | 325.000 | 9.655 | 1400.4 |
| 450.31 | 325.000 | 8.969 | 1300.9 |
| 448.99 | 325.000 | 8.224 | 1192.8 |
| 448.18 | 325.000 | 7.575 | 1098.7 |
| 447.51 | 325.001 | 6.904 | 1001.3 |
| 447.22 | 325.001 | 6.213 | 901.1 |
| 447.08 | 325.000 | 5.535 | 802.8 |
| 447.34 | 325.000 | 4.839 | 701.9 |
| 447.37 | 325.000 | 4.838 | 701.7 |
| 447.85 | 325.000 | 4.103 | 595.2 |
| 448.48 | 325.000 | 3.453 | 500.8 |
| 449.22 | 325.000 | 2.759 | 400.1 |
| 450.42 | 325.000 | 2.065 | 299.6 |
| 451.54 | 325.000 | 1.469 | 213.1 |
| 451.79 | 325.000 | 1.360 | 197.2 |
| 452.11 | 325.000 | 1.201 | 174.3 |
| 453.46 | 325.000 | 0.554 | 80.4 |
| 453.53 | 325.000 | 0.542 | 78.6 |
| | | | |
| 474.04 | 350.000 | 10.395 | 1507.6 |
| 473.09 | 350.000 | 10.051 | 1457.8 |
| 471.82 | 350.000 | 9.559 | 1386.4 |
| 471.11 | 350.000 | 9.246 | 1341.0 |
| 469.54 | 350.000 | 8.481 | 1230.1 |
| 468.29 | 350.000 | 7.721 | 1119.8 |
| 468.07 | 350.000 | 7.544 | 1094.2 |
| 467.14 | 350.000 | 6.741 | 977.7 |
| 466.52 | 350.000 | 5.914 | 857.7 |
| 466.13 | 350.000 | 5.104 | 740.2 |
| 466.04 | 350.000 | 4.336 | 628.9 |
| 466.21 | 350.000 | 3.509 | 508.9 |

Table 15. Speed of sound data for Gulf Coast mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 466.65 | 350.000 | 2.692 | 390.4 |
| 467.33 | 350.000 | 1.875 | 271.9 |
| 468.16 | 350.000 | 1.101 | 159.7 |
| 468.36 | 350.000 | 0.959 | 139.0 |
| 468.56 | 350.000 | 0.820 | 118.9 |
| 468.79 | 350.000 | 0.633 | 91.8 |

Table 16. Speed of sound data for Amarillo mixture.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 381.37 | 250.000 | 10.875 | 1577.2 |
| 368.83 | 250.000 | 9.889 | 1434.2 |
| 361.41 | 250.000 | 9.024 | 1308.8 |
| 356.65 | 250.000 | 7.988 | 1158.5 |
| 355.87 | 250.000 | 6.933 | 1005.6 |
| 358.11 | 250.000 | 5.878 | 852.5 |
| 362.43 | 250.000 | 4.806 | 697.1 |
| 367.92 | 250.000 | 3.784 | 548.8 |
| 374.33 | 250.000 | 2.750 | 398.8 |
| 381.31 | 250.000 | 1.713 | 248.5 |
| 388.72 | 250.000 | 0.667 | 96.8 |
| | | | |
| 396.65 | 275.009 | 10.474 | 1519.1 |
| 392.67 | 275.000 | 9.699 | 1406.7 |
| 388.98 | 275.019 | 8.559 | 1241.4 |
| 387.62 | 275.000 | 7.606 | 1103.2 |
| 387.71 | 275.000 | 6.563 | 952.0 |
| 389.24 | 275.000 | 5.517 | 800.1 |
| 395.47 | 275.000 | 3.415 | 495.3 |
| 399.66 | 275.000 | 2.405 | 348.9 |
| 404.43 | 275.000 | 1.366 | 198.1 |
| 407.95 | 274.998 | 0.650 | 94.3 |
| | | | |
| 551.16 | 298.00 | 23.390 | 3392.4 |
| 519.41 | 298.00 | 21.030 | 3050.1 |
| 468.08 | 298.00 | 16.869 | 2446.6 |
| 431.20 | 298.00 | 12.806 | 1857.4 |
| 415.23 | 298.00 | 9.531 | 1382.4 |
| 411.40 | 298.00 | 6.888 | 999.0 |
| | | | |
| 420.09 | 300.000 | 10.433 | 1513.2 |
| 417.49 | 300.000 | 9.653 | 1400.0 |
| 414.82 | 300.000 | 8.524 | 1236.3 |
| 413.31 | 300.000 | 7.204 | 1044.8 |
| 413.36 | 300.003 | 6.191 | 897.9 |
| 414.17 | 300.003 | 5.174 | 750.4 |
| 415.84 | 300.001 | 4.095 | 593.9 |
| 418.31 | 300.000 | 2.992 | 433.9 |
| 421.06 | 300.000 | 2.000 | 290.1 |
| 424.29 | 300.000 | 0.986 | 143.0 |
| 425.77 | 300.000 | 0.557 | 80.8 |

Table 16. Speed of sound data for Amarillo mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 441.73 | 325.000 | 0.686 | 99.5 |
| 441.29 | 325.000 | 0.893 | 129.6 |
| 440.96 | 325.000 | 1.036 | 150.3 |
| 440.65 | 325.000 | 1.190 | 172.6 |
| 440.24 | 325.000 | 1.366 | 198.1 |
| 440.00 | 325.000 | 1.464 | 212.3 |
| 439.53 | 325.000 | 1.654 | 239.9 |
| 438.20 | 325.000 | 2.411 | 349.7 |
| 437.08 | 325.000 | 3.113 | 451.5 |
| 436.15 | 325.000 | 3.799 | 551.1 |
| 435.96 | 325.000 | 4.136 | 599.8 |
| 435.80 | 325.000 | 4.149 | 601.7 |
| 435.94 | 325.000 | 4.149 | 601.8 |
| 435.35 | 324.999 | 4.805 | 696.8 |
| 435.25 | 325.000 | 5.197 | 753.8 |
| 435.16 | 325.000 | 5.201 | 754.3 |
| 435.22 | 325.000 | 5.543 | 803.9 |
| 435.09 | 325.000 | 6.234 | 904.1 |
| 435.41 | 325.000 | 6.905 | 1001.4 |
| 435.99 | 325.000 | 7.590 | 1100.8 |
| 436.93 | 325.000 | 8.254 | 1197.1 |
| 438.12 | 325.000 | 8.975 | 1301.6 |
| 439.74 | 325.000 | 9.653 | 1400.1 |
| 440.74 | 325.000 | 10.002 | 1450.7 |
| 442.06 | 325.002 | 10.426 | 1512.2 |
| 462.27 | 350.000 | 10.642 | 1543.5 |
| 459.49 | 350.000 | 9.597 | 1391.9 |
| 456.82 | 350.000 | 8.331 | 1208.4 |
| 455.40 | 350.000 | 7.337 | 1064.2 |
| 454.28 | 350.000 | 6.185 | 897.1 |
| 453.90 | 350.000 | 5.343 | 775.0 |
| 453.84 | 350.000 | 5.185 | 752.0 |
| 453.85 | 350.000 | 4.116 | 597.0 |
| 454.13 | 350.000 | 3.435 | 498.2 |
| 454.30 | 350.000 | 3.100 | 449.6 |
| 455.17 | 350.000 | 2.052 | 297.6 |
| 455.16 | 350.000 | 2.052 | 297.6 |
| 455.97 | 350.000 | 1.338 | 194.1 |
| 456.11 | 350.000 | 1.212 | 175.9 |

Table 16. Speed of sound data for Amarillo mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 456.16 | 350.000 | 1.190 | 172.5 |
| 456.25 | 350.000 | 1.155 | 167.5 |
| 456.42 | 350.000 | 1.001 | 145.1 |
| 456.57 | 350.000 | 0.856 | 124.1 |
| 456.58 | 350.000 | 0.856 | 124.1 |

Table 17. Speed of sound data for the Statoil dry gas mixture.

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 365.54 | 249.999 | 10.337 | 1499.3 |
| 358.57 | 249.999 | 10.020 | 1453.3 |
| 352.92 | 249.999 | 9.740 | 1412.7 |
| 352.75 | 250.000 | 9.737 | 1412.3 |
| 340.94 | 249.999 | 9.043 | 1311.5 |
| 333.62 | 250.001 | 8.337 | 1209.3 |
| 330.15 | 250.000 | 7.630 | 1106.6 |
| 329.89 | 250.000 | 7.016 | 1017.6 |
| 331.76 | 249.999 | 6.200 | 899.2 |
| 335.47 | 250.000 | 5.531 | 802.2 |
| 339.81 | 250.000 | 4.846 | 702.9 |
| 345.05 | 249.999 | 4.152 | 602.2 |
| 350.65 | 250.000 | 3.477 | 504.3 |
| 356.77 | 250.000 | 2.756 | 399.8 |
| 362.76 | 250.000 | 2.086 | 302.5 |
| 369.42 | 250.000 | 1.325 | 192.2 |
| 370.23 | 249.999 | 1.237 | 179.3 |
| 371.35 | 250.000 | 1.109 | 160.8 |
| 372.47 | 250.000 | 0.976 | 141.5 |
| 374.09 | 250.001 | 0.799 | 115.8 |
| 375.14 | 275.000 | 10.419 | 1511.2 |
| 368.69 | 275.000 | 9.413 | 1365.3 |
| 364.99 | 275.000 | 8.300 | 1203.9 |
| 364.49 | 275.000 | 7.260 | 1052.9 |
| 365.93 | 275.000 | 6.240 | 905.1 |
| 369.37 | 275.000 | 5.155 | 747.7 |
| 373.94 | 275.000 | 4.112 | 596.4 |
| 379.43 | 275.000 | 3.060 | 443.8 |
| 385.81 | 275.000 | 1.963 | 284.7 |
| 392.19 | 275.000 | 0.953 | 138.2 |
| 394.95 | 275.000 | 0.520 | 75.4 |
| 398.02 | 299.999 | 10.385 | 1506.3 |
| 397.68 | 300.000 | 10.297 | 1493.4 |
| 394.17 | 300.000 | 9.209 | 1335.6 |
| 393.71 | 300.000 | 8.973 | 1301.4 |
| 392.40 | 300.000 | 8.121 | 1177.9 |
| 392.10 | 300.000 | 7.321 | 1061.8 |
| 392.51 | 299.999 | 6.486 | 940.6 |
| 393.68 | 300.000 | 5.699 | 826.6 |

Table 17. Speed of sound data for the Statoil dry gas mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 395.51 | 300.000 | 4.841 | 702.2 |
| 397.77 | 300.000 | 4.023 | 583.5 |
| 400.59 | 300.000 | 3.194 | 463.2 |
| 403.66 | 300.000 | 2.371 | 343.9 |
| 403.65 | 300.000 | 2.398 | 347.8 |
| 406.42 | 300.000 | 1.738 | 252.0 |
| 406.39 | 300.000 | 1.748 | 253.5 |
| 406.84 | 300.000 | 1.653 | 239.8 |
| 407.43 | 300.000 | 1.502 | 217.8 |
| 408.07 | 300.001 | 1.357 | 196.9 |
| 408.70 | 299.999 | 1.211 | 175.6 |
| 409.28 | 299.999 | 1.080 | 156.6 |
| 409.86 | 300.000 | 0.955 | 138.5 |
| 410.39 | 300.000 | 0.834 | 120.9 |
| 411.12 | 300.000 | 0.675 | 97.9 |
| 411.75 | 300.000 | 0.526 | 76.3 |
| 427.57 | 325.000 | 0.466 | 67.6 |
| 427.03 | 325.000 | 0.631 | 91.5 |
| 427.00 | 325.000 | 0.634 | 91.9 |
| 426.48 | 325.000 | 0.792 | 114.8 |
| 426.34 | 325.000 | 0.832 | 120.6 |
| 426.00 | 325.000 | 0.935 | 135.7 |
| 425.50 | 325.000 | 1.093 | 158.5 |
| 424.85 | 325.000 | 1.295 | 187.8 |
| 424.32 | 325.000 | 1.441 | 209.0 |
| 421.62 | 325.000 | 2.352 | 341.1 |
| 419.73 | 325.000 | 3.104 | 450.3 |
| 418.33 | 325.000 | 3.791 | 549.9 |
| 416.84 | 325.000 | 4.542 | 658.8 |
| 415.87 | 325.000 | 5.239 | 759.9 |
| 415.43 | 325.000 | 5.725 | 830.3 |
| 415.20 | 325.000 | 5.923 | 859.0 |
| 414.77 | 325.000 | 6.625 | 960.9 |
| 414.88 | 325.000 | 7.306 | 1059.6 |
| 415.31 | 325.000 | 8.025 | 1163.9 |
| 416.24 | 325.000 | 8.721 | 1264.9 |
| 417.42 | 325.000 | 9.426 | 1367.1 |
| 420.13 | 325.000 | 10.399 | 1508.3 |
| 420.28 | 325.000 | 10.402 | 1508.7 |

Table 17. Speed of sound data for the Statoil dry gas mixture (continued).

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 440.17 | 350.000 | 10.412 | 1510.1 |
| 439.19 | 350.000 | 10.028 | 1454.4 |
| 437.10 | 350.000 | 8.969 | 1300.8 |
| 435.62 | 350.000 | 7.902 | 1146.1 |
| 434.89 | 350.000 | 6.885 | 998.6 |
| 434.74 | 350.000 | 5.864 | 850.4 |
| 434.79 | 350.000 | 5.665 | 821.6 |
| 434.89 | 350.000 | 5.589 | 810.6 |
| 435.18 | 350.000 | 4.823 | 699.5 |
| 436.13 | 350.000 | 3.783 | 548.7 |
| 437.56 | 350.000 | 2.753 | 399.3 |
| 439.35 | 350.000 | 1.715 | 248.8 |
| 440.36 | 350.000 | 1.241 | 180.0 |

Table 18. **Speed of sound data for the Statoil Statvordgass mixture.**

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 340.98 | 300.000 | 10.379 | 1505.3 |
| 340.94 | 300.001 | 10.369 | 1503.9 |
| 336.19 | 300.000 | 9.662 | 1401.4 |
| 332.90 | 300.000 | 8.893 | 1289.8 |
| 331.49 | 300.000 | 8.201 | 1189.4 |
| 331.44 | 300.000 | 7.462 | 1082.2 |
| 332.72 | 300.000 | 6.704 | 972.4 |
| 335.14 | 300.000 | 5.940 | 861.5 |
| 338.38 | 300.000 | 5.196 | 753.6 |
| 342.80 | 300.000 | 4.369 | 633.6 |
| 347.60 | 300.000 | 3.576 | 518.6 |
| 352.73 | 300.000 | 2.803 | 406.6 |
| 359.32 | 300.000 | 1.863 | 270.2 |
| 360.09 | 325.000 | 9.895 | 1435.2 |
| 358.24 | 325.000 | 9.207 | 1335.3 |
| 357.89 | 325.000 | 9.047 | 1312.2 |
| 356.97 | 325.000 | 8.281 | 1201.1 |
| 357.10 | 325.000 | 7.291 | 1057.4 |
| 358.12 | 325.000 | 6.496 | 942.2 |
| 359.94 | 325.000 | 5.710 | 828.2 |
| 362.66 | 325.000 | 4.837 | 701.6 |
| 365.89 | 325.000 | 3.999 | 580.1 |
| 369.72 | 325.000 | 3.132 | 454.2 |
| 374.08 | 325.000 | 2.246 | 325.8 |
| 378.67 | 325.000 | 1.380 | 200.2 |
| 381.90 | 325.000 | 0.799 | 115.8 |
| 384.01 | 325.000 | 0.421 | 61.1 |
| 382.53 | 350.000 | 10.436 | 1513.7 |
| 381.64 | 350.000 | 10.110 | 1466.4 |
| 381.64 | 350.000 | 10.111 | 1466.4 |
| 379.81 | 350.000 | 9.217 | 1336.9 |
| 378.86 | 350.000 | 8.336 | 1209.0 |
| 378.69 | 350.000 | 7.922 | 1149.0 |
| 378.68 | 350.000 | 7.497 | 1087.3 |
| 379.11 | 350.000 | 6.711 | 973.4 |
| 379.86 | 350.000 | 6.054 | 878.1 |
| 381.03 | 350.000 | 5.335 | 773.8 |
| 382.84 | 350.000 | 4.535 | 657.8 |
| 384.94 | 350.000 | 3.767 | 546.3 |

Table 18. **Speed of sound data for the Statoil Statvordgass mixture (continued).**

| $W_{exp}$ m/s | TEMP K | PRES MPa | PRES psia |
|---|---|---|---|
| 387.41 | 350.000 | 2.993 | 434.0 |
| 390.55 | 350.000 | 2.120 | 307.4 |
| 394.04 | 350.000 | 1.232 | 178.7 |
| 395.40 | 350.000 | 0.901 | 130.7 |
| 396.46 | 350.000 | 0.641 | 92.9 |

**Table 19**

**Coefficients for NGAS, Equation (3).**

| | |
|---|---|
| N1 = 0.402 802 616 852 552 3 | N16 = -1.653 616 778 945 739 |
| N2 = 1.330 664 037 447 985 | N17 = -0.839 778 394 352 348 2 |
| N3 = -0.421 496 580 014 783 | N18 = -2.974 276 333 189 398 |
| N4 = 5.103 260 154 147 587 | N19 = 8.677 270 045 092 660 |
| N5 = -2.129 821 889 124 908 | N20 = -2.240 332 292 886 185 |
| N6 = 3.564 066 437 091 546 | N21 = -2.052 230 326 096 707 |
| N7 = 0.009 443 037 461 497 888 | N22 = -0.013 318 230 108 264 99 |
| N8 = 0.025 420 666 751 205 73 | N23 = 0.545 603 758 634 985 |
| N9 = -8.750 142 463 225 309 | N24 = 0.522 791 316 318 536 9 |
| N10 = -0.001 743 056 843 897 025 | N25 = 0.013 649 770 526 603 93 |
| N11 = -0.005 437 139 298 301 518 | N26 = -0.125 968 548 596 810 4 |
| N12 = -0.055 033 896 057 606 47 | N27 = 0.054 487 059 711 882 84 |
| N13 = 0.003 230 999 234 097 726 | N28 = -0.003 685 997 072 874 476 |
| N14 = 0.028 416 721 702 783 82 | N29 = -0.028 400 005 339 353 36 |
| N15 = -0.031 141 966 393 105 62 | N30 = 0.024 763 720 856 701 82 |

| **Component** | **Crit Temp** $\varepsilon_i$ | **Crit Dens** $\sigma^3$ | **Mol Wt** |
|---|---|---|---|
| 1 = nitrogen | 126.26 | 0.416 8 | 28.013 4 |
| 2 = carbon dioxide | 304.212 | 0.455 23 | 44.01 |
| 3 = methane | 190.555 | 0.098 629 | 16.043 |
| 4 = ethane | 305.334 | 0.145 45 | 30.07 |
| 5 = propane | 369.85 | 0.584 8 | 44.097 |
| 6 = normal butane | 425.16 | 0.634 22 | 58.123 |
| 7 = isobutane | 407.85 | 0.637 48 | 58.123 |
| 8 = normal pentane | 469.7 | 0.63 | 72.15 |
| 9 = isopentane | 460.4 | 0.63 | 72.15 |
| 10 = normal hexane | 507.3 | 0.68 | 86.177 |
| 11 = normal neptane | 538.4 | 0.7 | 100.204 |
| 12 = octane | 567.5 | 0.7 | 114.231 |
| 13 = normal nonane | 594.54 | 0.77 | 128.285 |
| 14 = normal decane | 615.5 | 0.8 | 142.285 |

**Values of Gk:**

| Component | G3 | G4 | G5 |
|---|---|---|---|
| 1 | -0.137 968 025 4 | -6.489 193 563 | -11.821 117 21 |
| 2 | 1.343 746 237 | -0.437 444 557 6 | -6.275 691 346 |
| 3 | 1.0 | 1.0 | 1.0 |
| 4 | 0.995 464 878 9 | 0.998 410 425 3 | 1.112 432 39 |
| 5 | 1.444 150 683 | 2.443 230 19 | 2.815 679 962 |
| 6 | 2.262 240 243 | 2.543 607 824 | -8.337 742 816 |
| 7 | 1.929 806 053 | 1.750 437 195 | 0.368 657 474 7 |
| 8 | 2.145 918 50 | 3.775 088 823 | -3.658 214 800 |
| 9 | 1.889 485 197 | 1.324 890 237 | 0.147 434 342 1 |
| 10 | 2.042 454 505 | 2.535 866 056 | 3.265 853 765 |
| 11 | 2.301 477 499 | 1.660 952 157 | -0.859 520 051 5 |
| 12 | 2.361 724 346 | 1.842 959 663 | -0.601 284 957 9 |
| 13 | 2.507 809 96 | 1.579 803 181 | -0.838 160 165 2 |
| 14 | 2.611 495 198 | 2.471 380 059 | -1.157 843 638 |

| Component | G6 | G7 | G8 |
|---|---|---|---|
| 1 | -5.214 016 927 | -55.258 917 45 | -24.103 518 73 |
| 2 | -8.398 770 437 | -21.656 427 66 | -0.749 299 015 6 |
| 3 | 1.0 | 1.0 | 1.0 |
| 4 | 1.492 840 378 | 5.777 994 243 | 0.940 203 752 0 |
| 5 | -3.374 892 231 | -8.420 869 082 | 0.704 187 325 2 |
| 6 | -17.778 943 53 | 45.678 470 97 | 0.836 955 587 5 |
| 7 | 0.850 533 049 1 | 1.168 709 277 | -4.044 894 166 |
| 8 | -3.227 381 796 | 29.533 373 76 | -18.665 857 85 |
| 9 | -0.422 901 659 1 | -15.254 980 97 | 1.095 166 830 |
| 10 | -4.798 074 499 | -11.055 176 74 | 6.640 963 739 |
| 11 | -0.392 209 174 1 | -0.384 657 523 8 | -0.677 523 957 1 |
| 12 | 0.808 767 609 5 | 14.227 964 25 | -6.860 930 093 |
| 13 | 0.706 119 756 8 | 7.888 704 149 | -3.737 466 433 |
| 14 | 0.132 269 481 7 | -1.002 974 962 | -2.279 161 978 |

| Component | G9 | G10 | G11 |
|---|---|---|---|
| 1 | 19.956 846 43 | -1602.900 815 | 957.611 275 9 |
| 2 | 0.260 185 607 6 | 52.022 136 397 | 12.681 015 96 |
| 3 | 1.0 | 1.0 | 1.0 |
| 4 | -0.299 588 602 6 | -82.221 595 66 | -4.544 856 988 |
| 5 | 0.887 344 687 8 | -0.245 723 414 5 | 5.463 328 055 |
| 6 | -12.320 901 54 | 1829.107 816 | -174.362 987 9 |
| 7 | 6.015 133 981 | -868.647 739 9 | 655.023 323 6 |
| 8 | 19.738 469 26 | -2616.867 323 | 2767.027 867 |
| 9 | 1.181 912 388 | -111.583 511 5 | 118.902 562 9 |
| 10 | -0.663 735 712 7 | -66.819 069 52 | 103.669 204 0 |
| 11 | 1.371 781 956 | -128.668 298 6 | 120.707 850 3 |
| 12 | 4.627 715 335 | -942.094 744 4 | 429.349 425 9 |
| 13 | 2.959 502 580 | -517.916 625 5 | 268.311 302 7 |
| 14 | -4.102 453 851 | -187.913 734 2 | 63.292 692 08 |

**Values of interaction parameters, $u_{ij}$:**
All $u_{ij} = u_{ji}$, and all $u_{ij}$ not specified are 1.0.

| | | |
|---|---|---|
| $u_{1,2} = 0.5$ | $u_{1,3} = 0.559\ 847\ 933$ | $u_{1,4} = 0.805\ 299\ 176$ |
| $u_{2,3} = 0.852\ 645\ 207\ 8$ | $u_{2,4} = 0.991\ 4$ | $u_{2,5} = 0.995\ 7$ |
| ($u_{3,j}$ , j = 4 to 14) | | |
| 0.775 434 442 977 | 0.597 093 668 50 | 1.049 730 857 |
| 1.075 883 14 | 1.182 9545 69 | 0.646 902 552 6 |
| 0.667 278 229 4 | 0.647 5447 996 | 0.657 629 840 4 |
| 0.658 869 170 9 | 0.646 7821 411 | |
| $u_{4,5} = 0.322\ 671\ 221$ | $u_{4,6} = -0.354\ 556$ | |

**Values of interaction parameters, $v_{ij}$:**
All $v_{ij} = v_{ji}$, and all $v_{ij}$ not specified are 1.0.

| | | |
|---|---|---|
| $v_{1,2} = 0.5$ | $v_{1,3} = 0.878\ 785\ 412$ | $v_{1,4} = 1.086\ 425\ 59$ |
| $v_{2,3} = 0.756\ 436\ 767\ 2$ | | |
| ($v_{3,j}$ , j = 4 to 14) | | |
| 1.020 561 377 7 | 0.608 362 646 2 | 0.765 777 222 5 |
| 0.769 880 679 1 | 0.787 958 978 3 | 0.840 454 662 8 |
| 0.852 892 451 2 | 0.868 651 146 0 | 0.903 663 781 |
| 0.895 462 954 0 | 0.928 291 547 20 | |
| $v_{4,5} = 0.816\ 674\ 999$ | $v_{4,6} = 0.850\ 877\ 0$ | |

**Values of interaction parameters, $w_{ij}$:**
All $w_{ij} = w_{ji}$, and all $w_{ij}$ not specified are 1.0.

| | | |
|---|---|---|
| ($w_{1,j}$ , j = 3 to 14) | | |
| 2.176 228 546 | 0.780 643 916 7 | 0.941 6 |
| 0.929 7 | 0.927 4 | 0.916 1 |
| 0.915 5 | 0.898 1 | 0.880 6 |
| 0.865 6 | 0.849 9 | 0.833 5 |
| ($w_{2,j}$ , j = 3 to 14) | | |
| 0.864 789 644 4 | 0.919 9 | 0.894 4 |
| 0.851 7 | 0.845 4 | 0.813 1 |
| 0.811 5 | 0.762 | 0.712 4 |
| 0.669 8 | 0.625 2 | 0.578 6 |
| ($w_{3,j}$ , j = 4 to 14) | | |
| 0.997 137 756 393 | 0.921 957 626 6 | 0.916 822 318 6 |
| 0.867 979 518 10 | 0.903 797 490 3 | 0.854 582 195 7 |
| 0.867 365 612 4 | 0.847 498 050 9 | 0.843 680 648 6 |
| 0.844 752 460 8 | 0.834 925 903 7 | |
| $w_{4,5} = 0.553\ 542\ 574$ | $w_{4,6} = 0.374\ 035\ 5$ | |

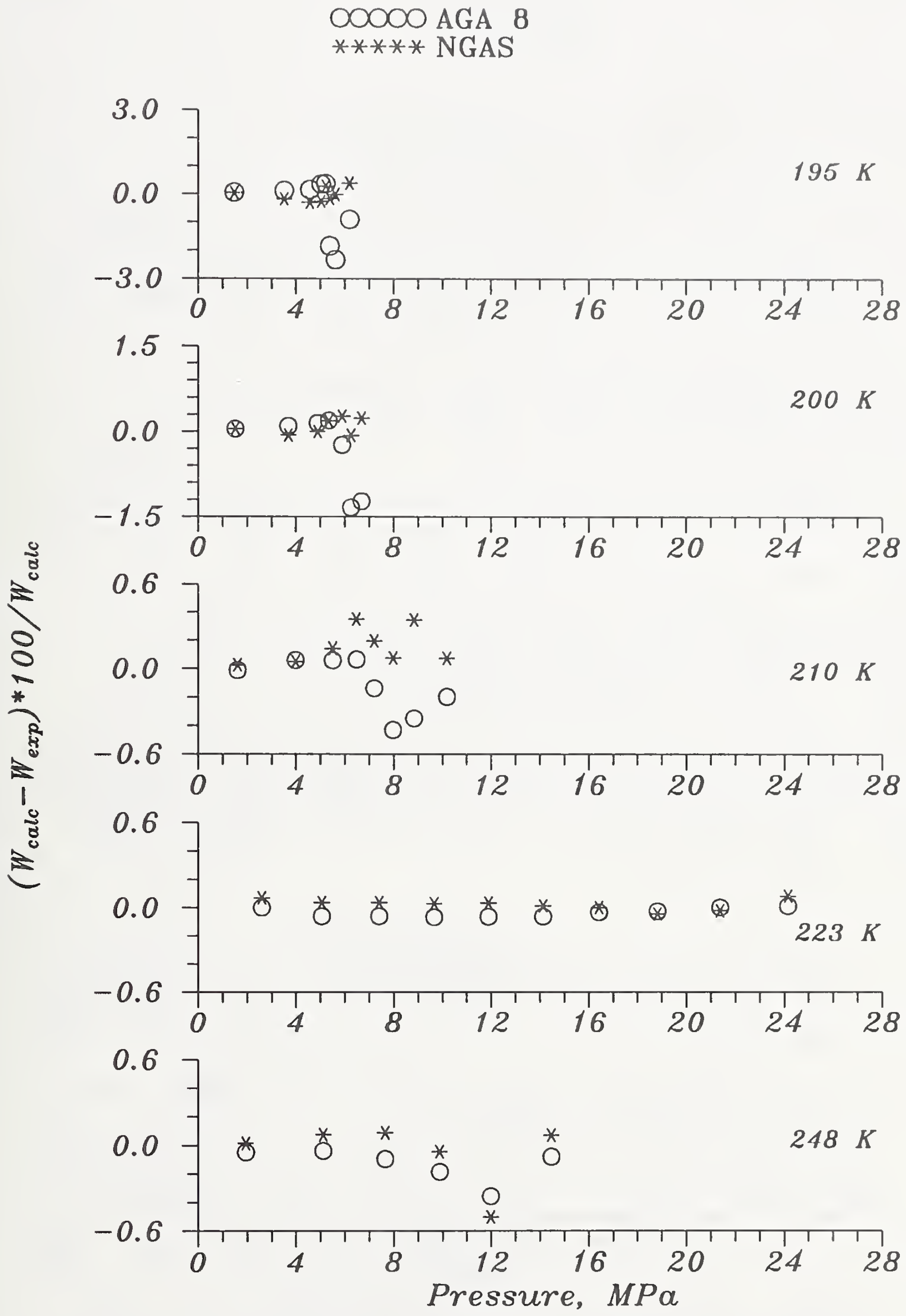


*Figure 1a. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the pure methane data of Sivaraman and Gammon [8].*

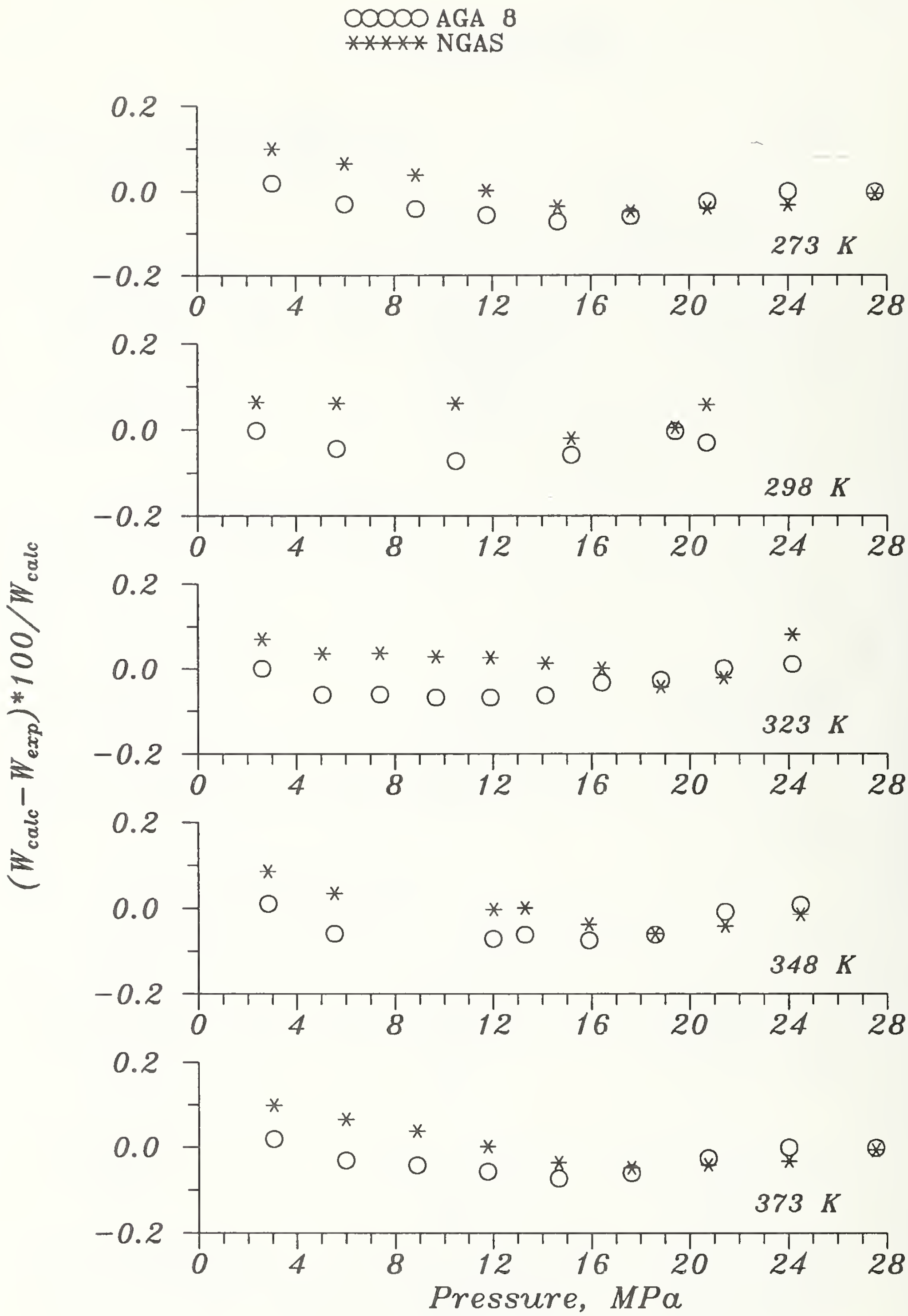


*Figure 1b. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the pure methane data of Sivaraman and Gammon [8].*

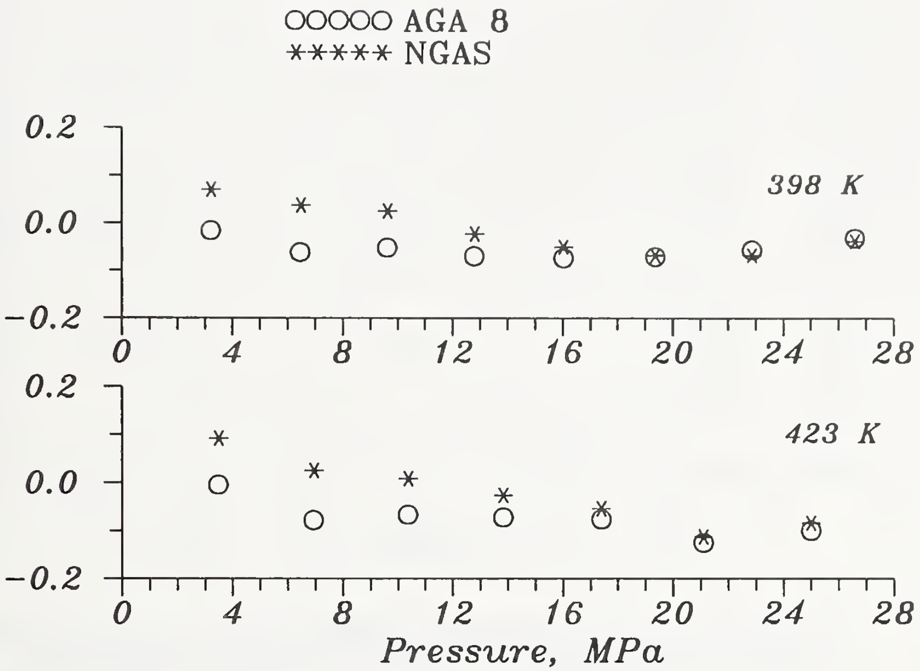


*Figure 1c. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the pure methane data of Sivaraman and Gammon [8].*

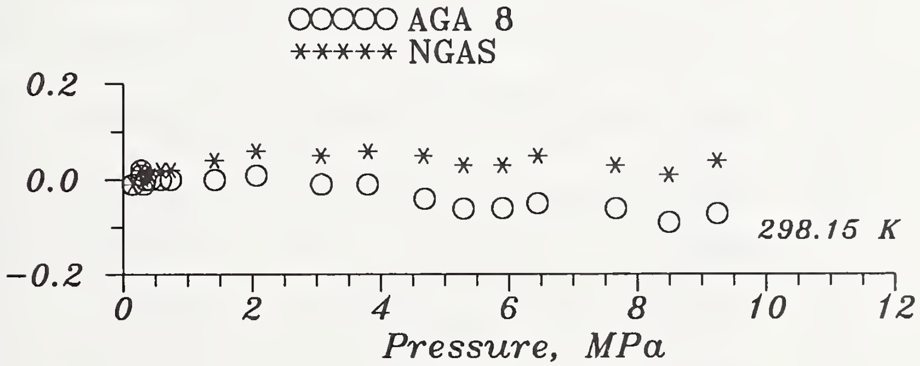


*Figure 2. Deviations of speed of sound computed by AGA 8 and NGAS from the NIST experimental values for pure methane.*

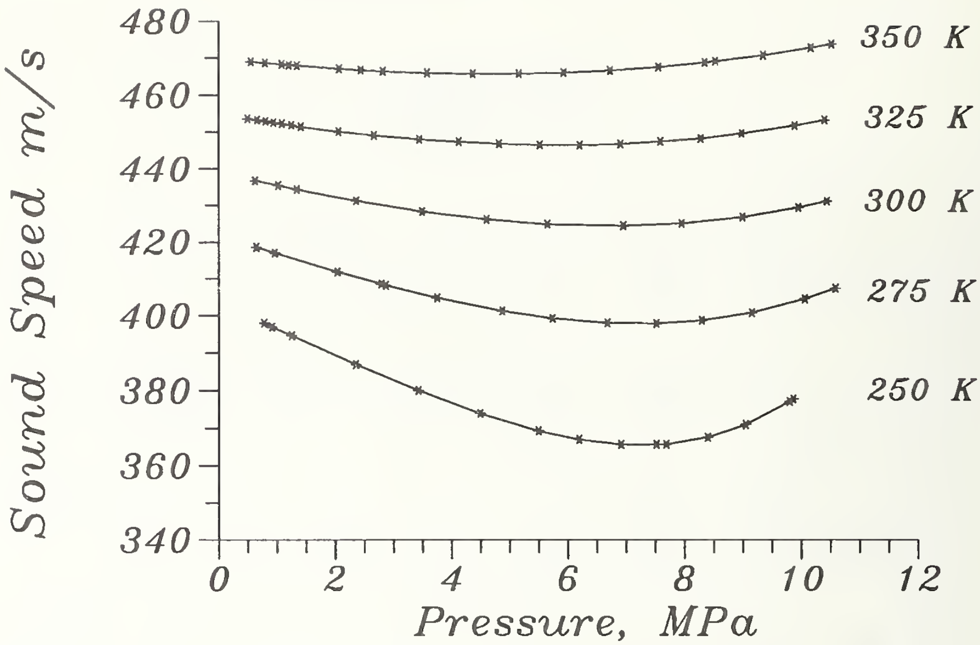


*Figure 3. Experimental speed of sound for the binary mixture methane 0.95 – ethane 0.05.*

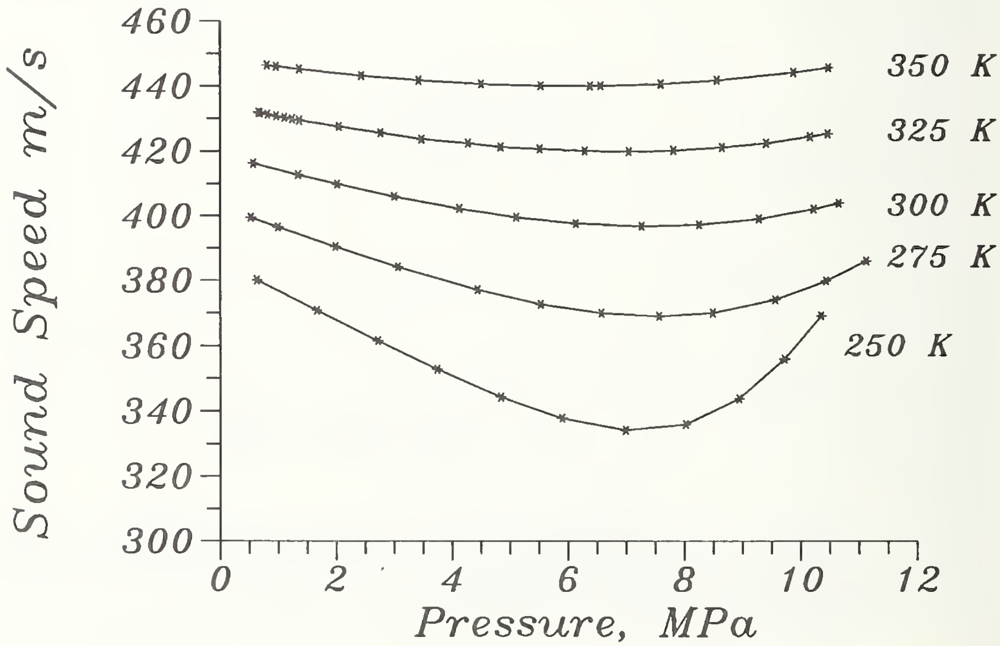


*Figure 4. Experimental speed of sound for the binary mixture methane 0.85 – ethane 0.15.*

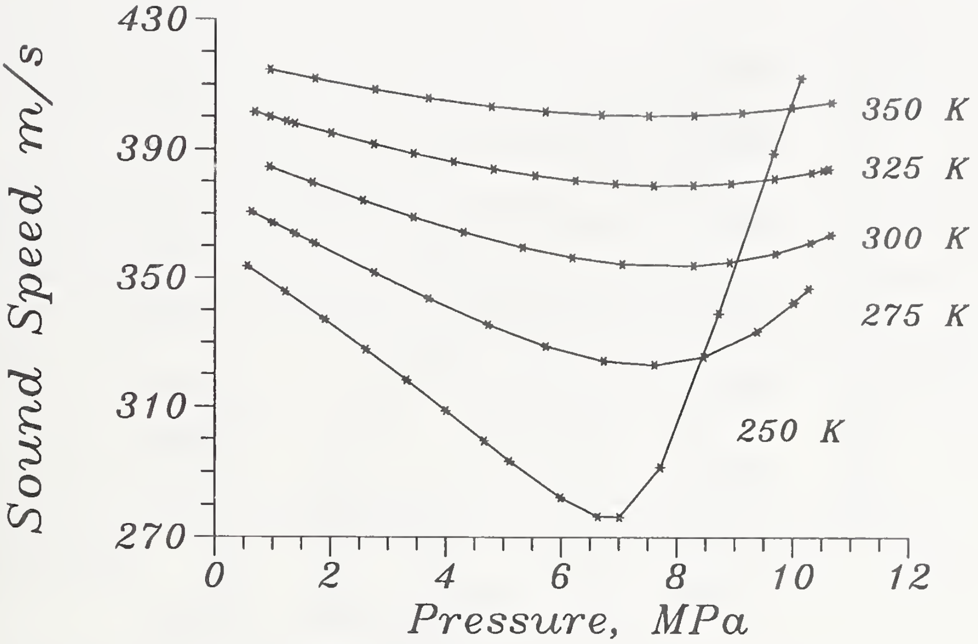


*Figure 5. Experimental speed of sound for the binary mixture methane 0.69 – ethane 0.31.*

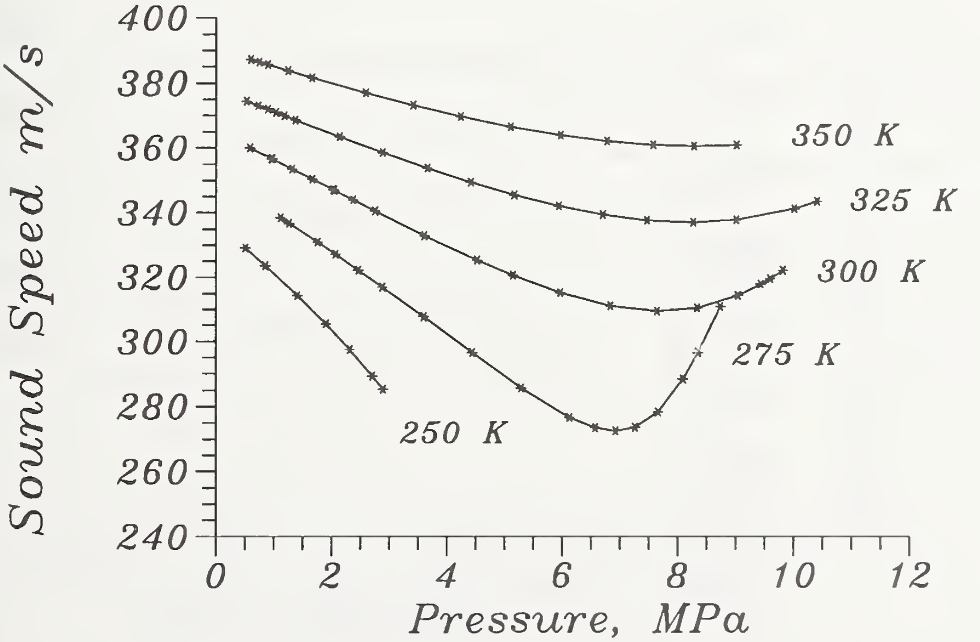


*Figure 6. Experimental speed of sound for the binary mixture methane 0.50 – ethane 0.50.*

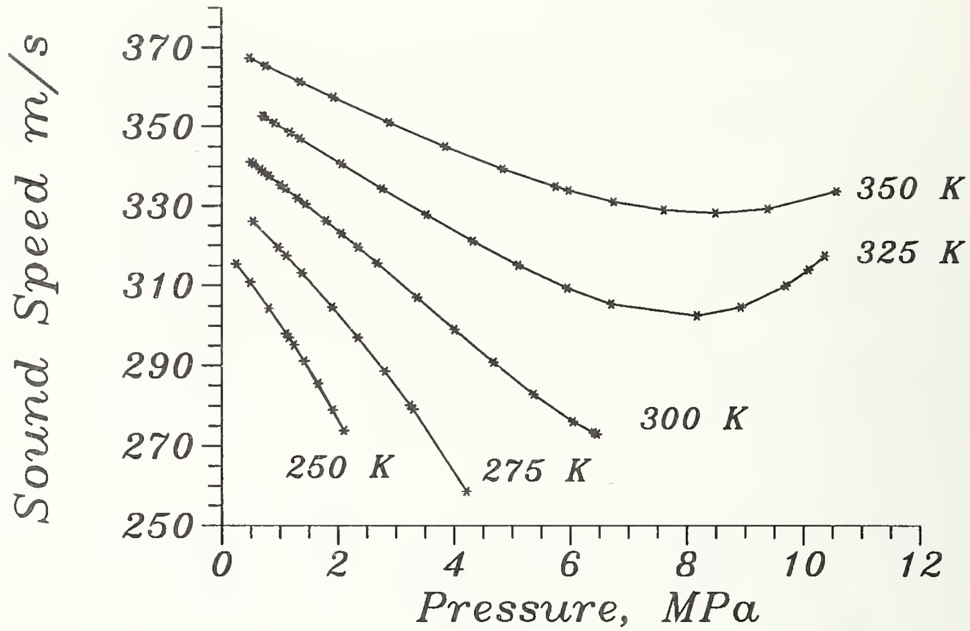


*Figure 7. Experimental speed of sound for the binary mixture methane 0.35 – ethane 0.65.*

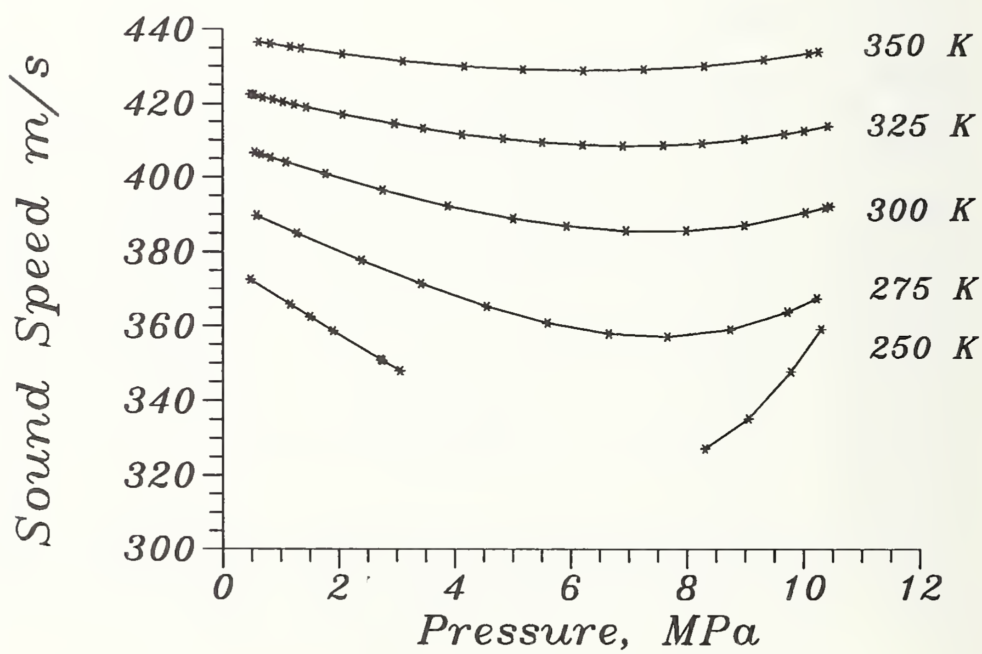


*Figure 8. Experimental speed of sound for the binary mixture methane 0.90 – propane 0.10.*

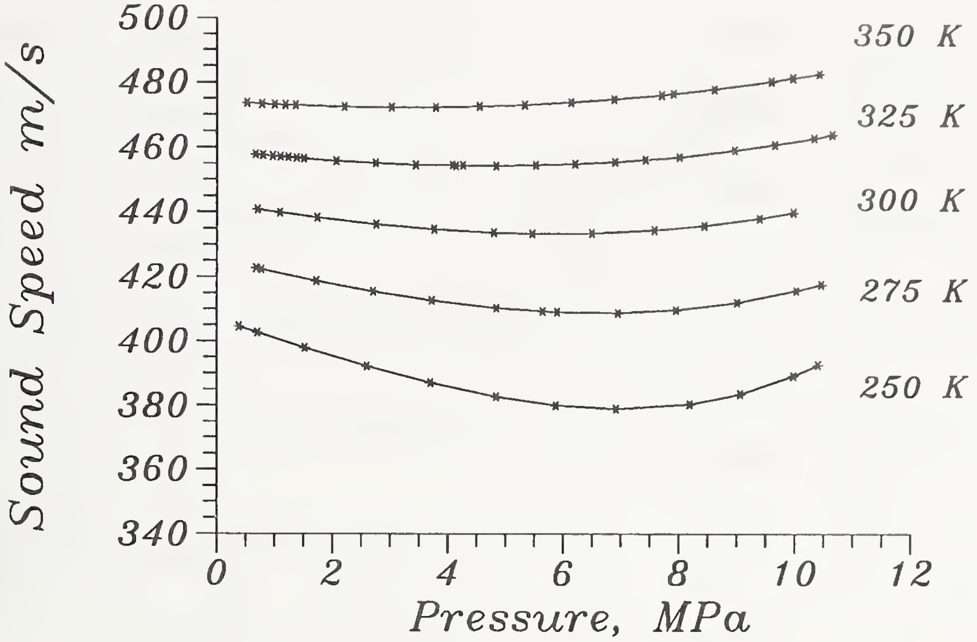


*Figure 9. Experimental speed of sound for the binary mixture methane 0.95 – nitrogen 0.05.*

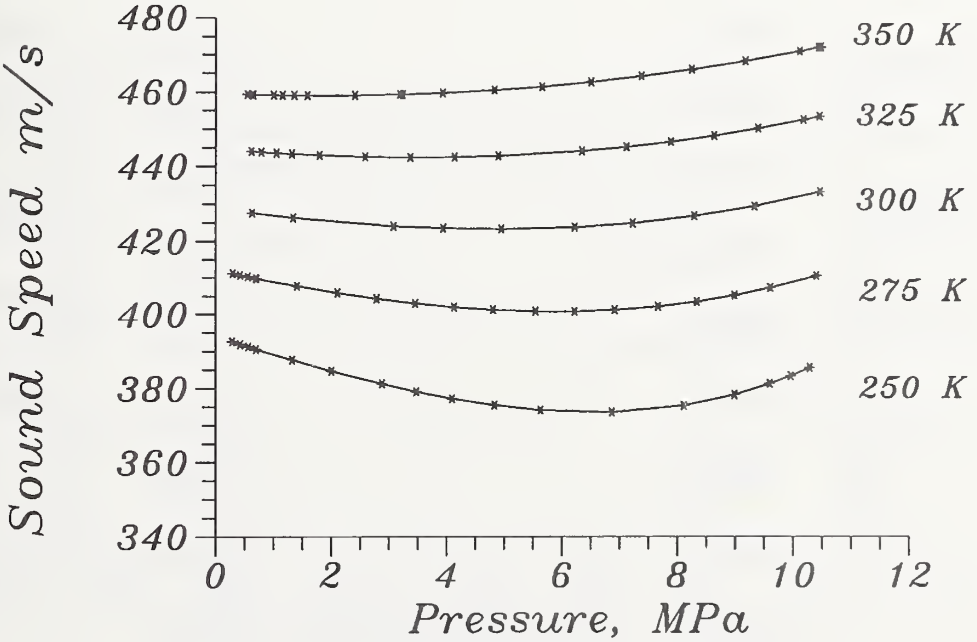


*Figure 10. Experimental speed of sound for the binary mixture methane 0.85 – nitrogen 0.15.*

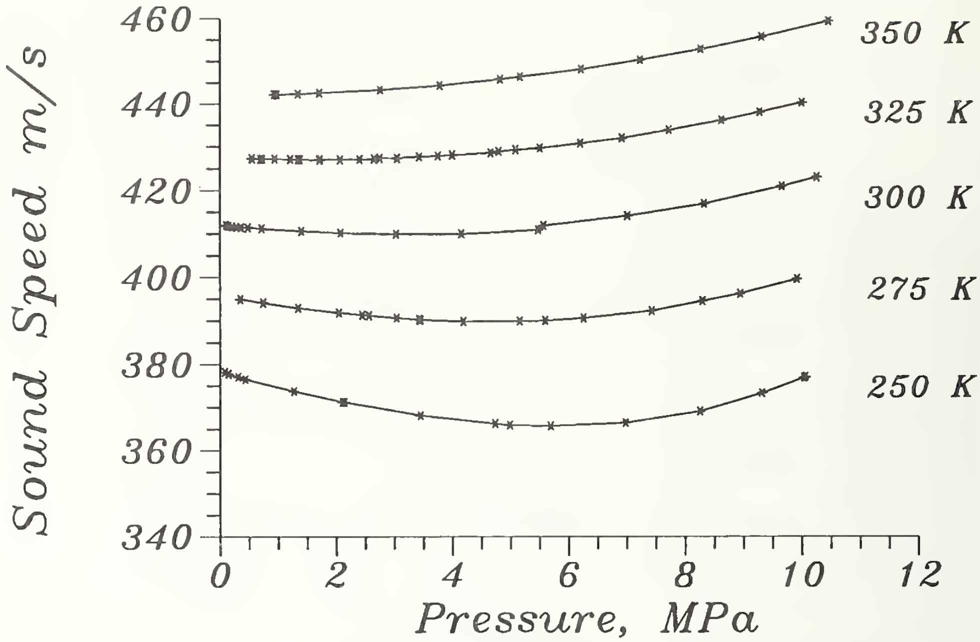


*Figure 11. Experimental speed of sound for the binary mixture methane 0.71 – nitrogen 0.29.*

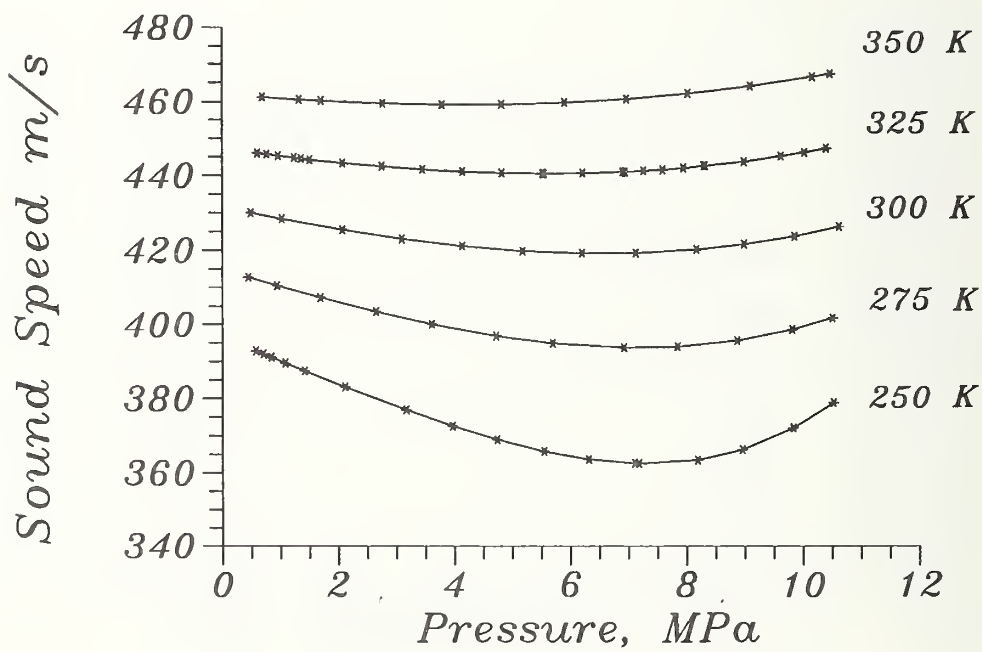


*Figure 12. Experimental speed of sound for the binary mixture methane 0.95 – carbon dioxide 0.05.*

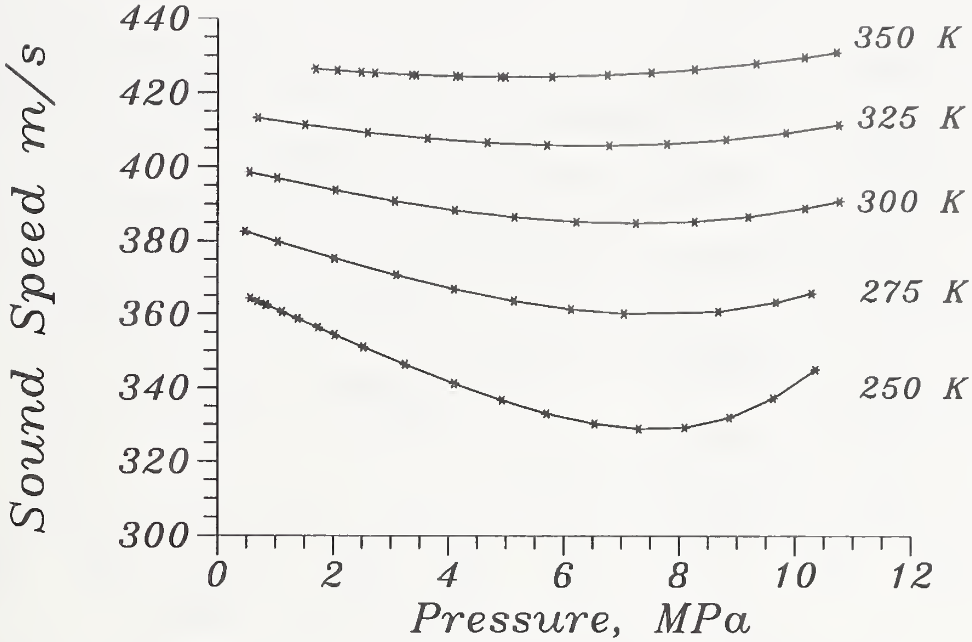


*Figure 13. Experimental speed of sound for the binary mixture methane 0.85 – carbon dioxide 0.15.*

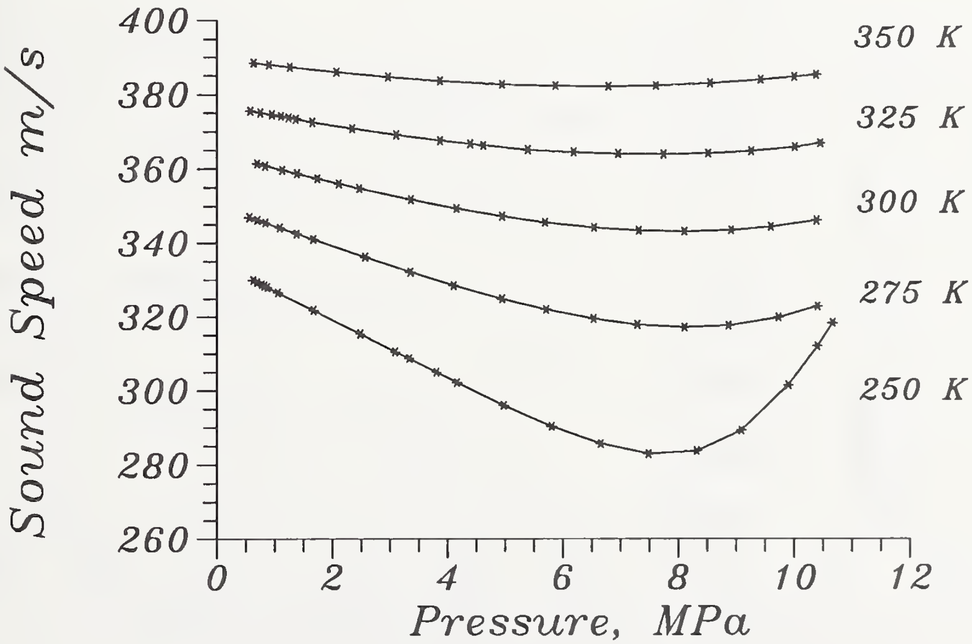


*Figure 14. Experimental speed of sound for the binary mixture methane 0.70 – carbon dioxide 0.30.*

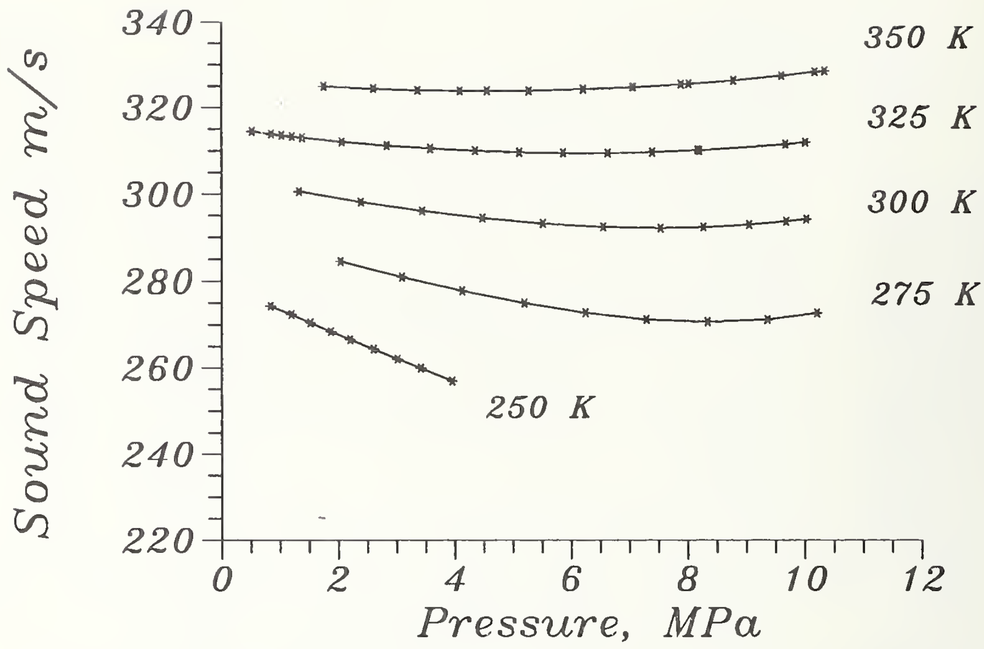


*Figure 15. Experimental speed of sound for the binary mixture nitrogen 0.50 – carbon dioxide 0.50.*

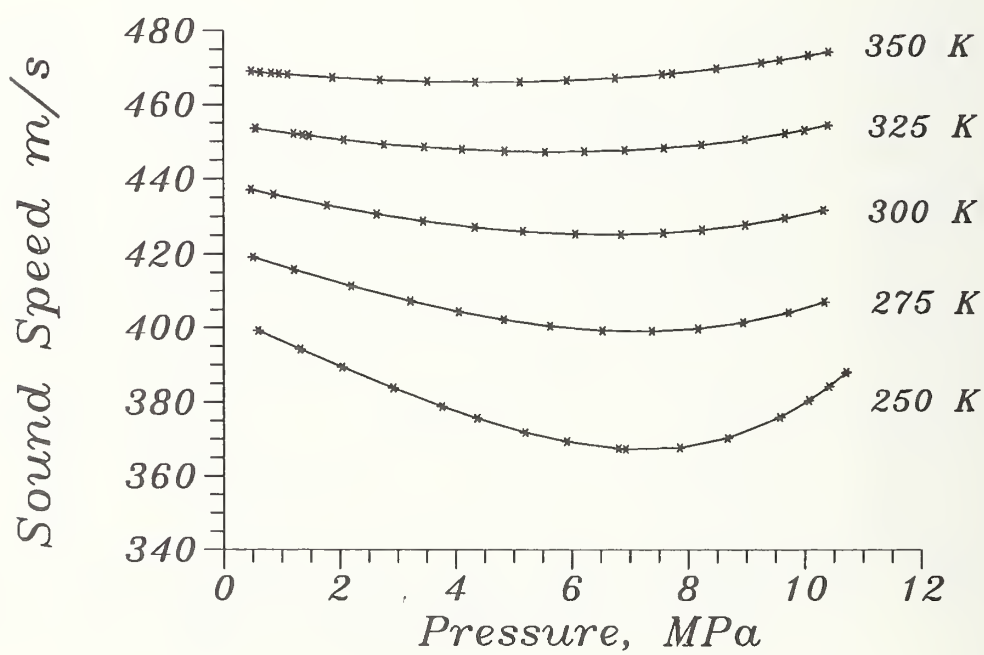


*Figure 16. Experimental speed of sound for the Gulf Coast mixture.*

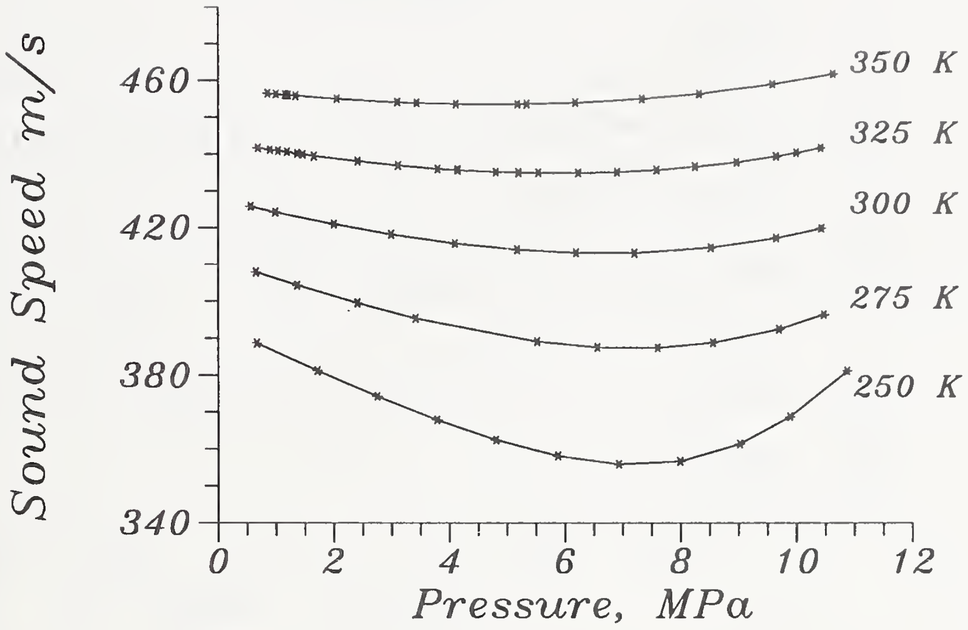


*Figure 17. Experimental speed of sound for the Amarillo mixture.*

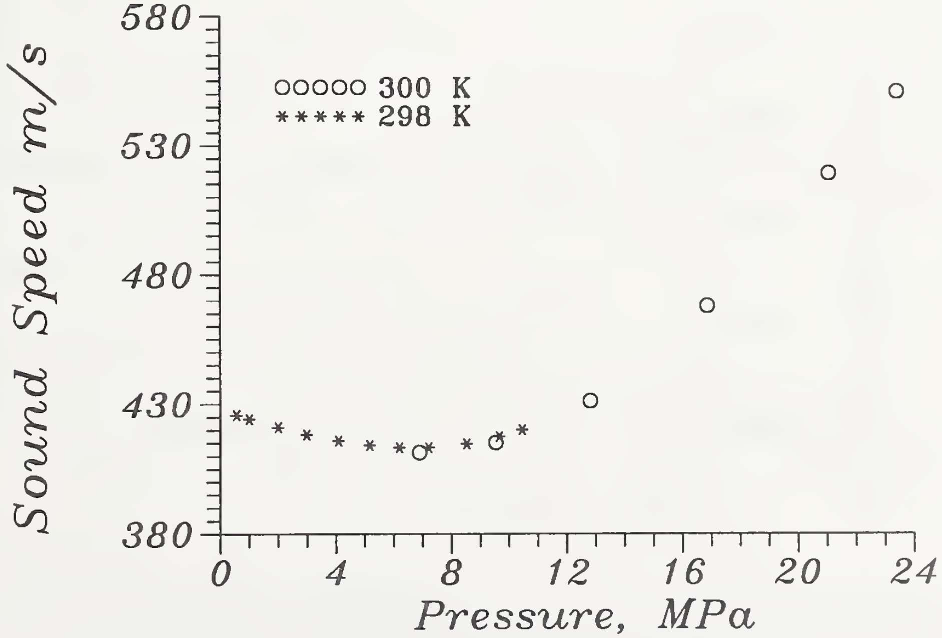


*Figure 18. Experimental speed of sound for the Amarillo mixture. Comparing the 300 K run to the high pressure isotherm at 298 K.*

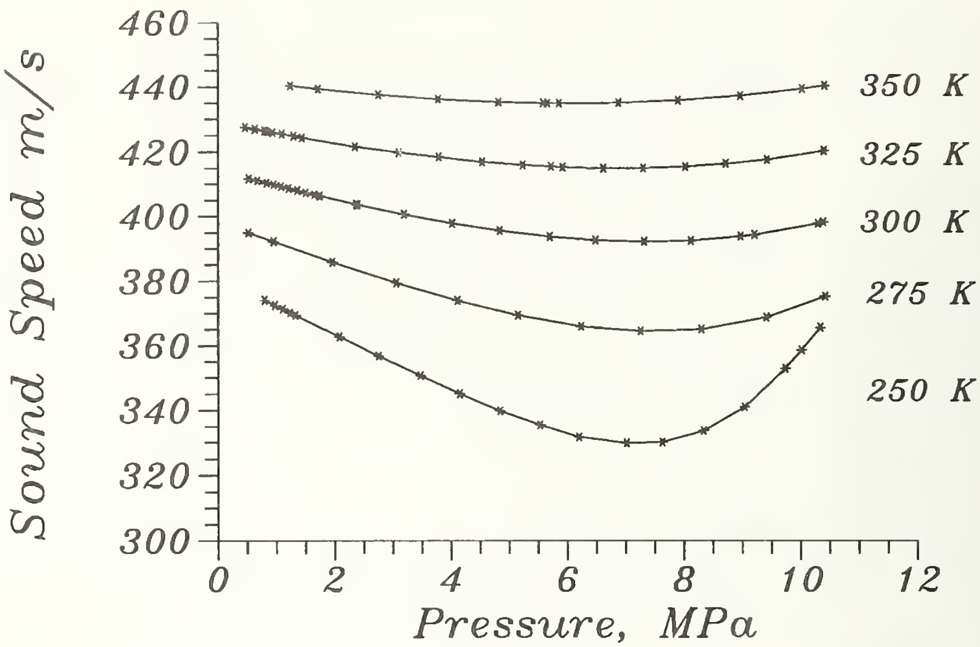


*Figure 19. Experimental speed of sound for the Statoil dry gas mixture.*

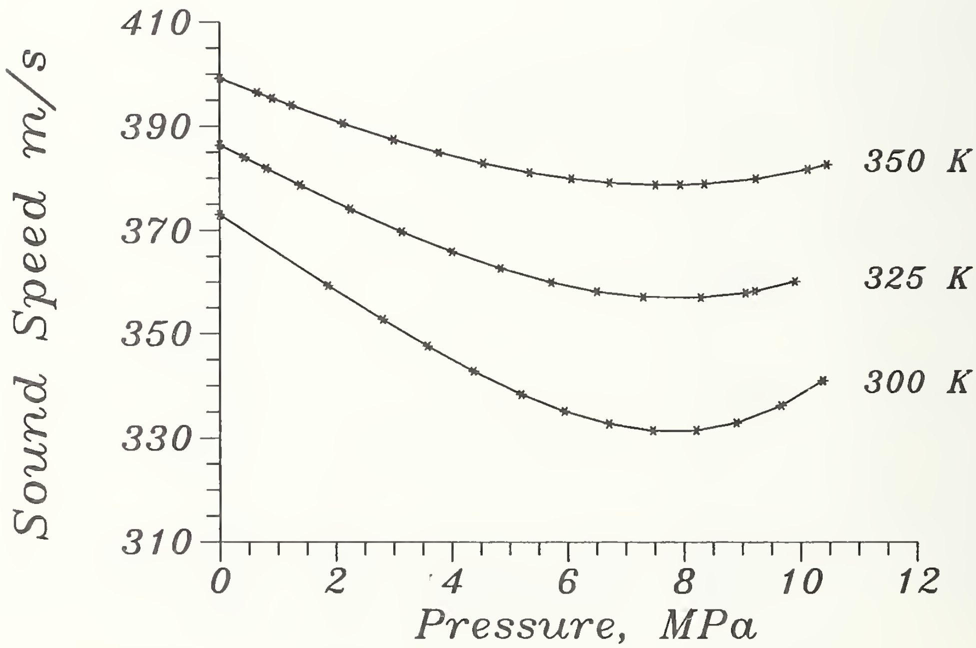


*Figure 20. Experimental speed of sound for the Statoil Statvordgass mixture.*

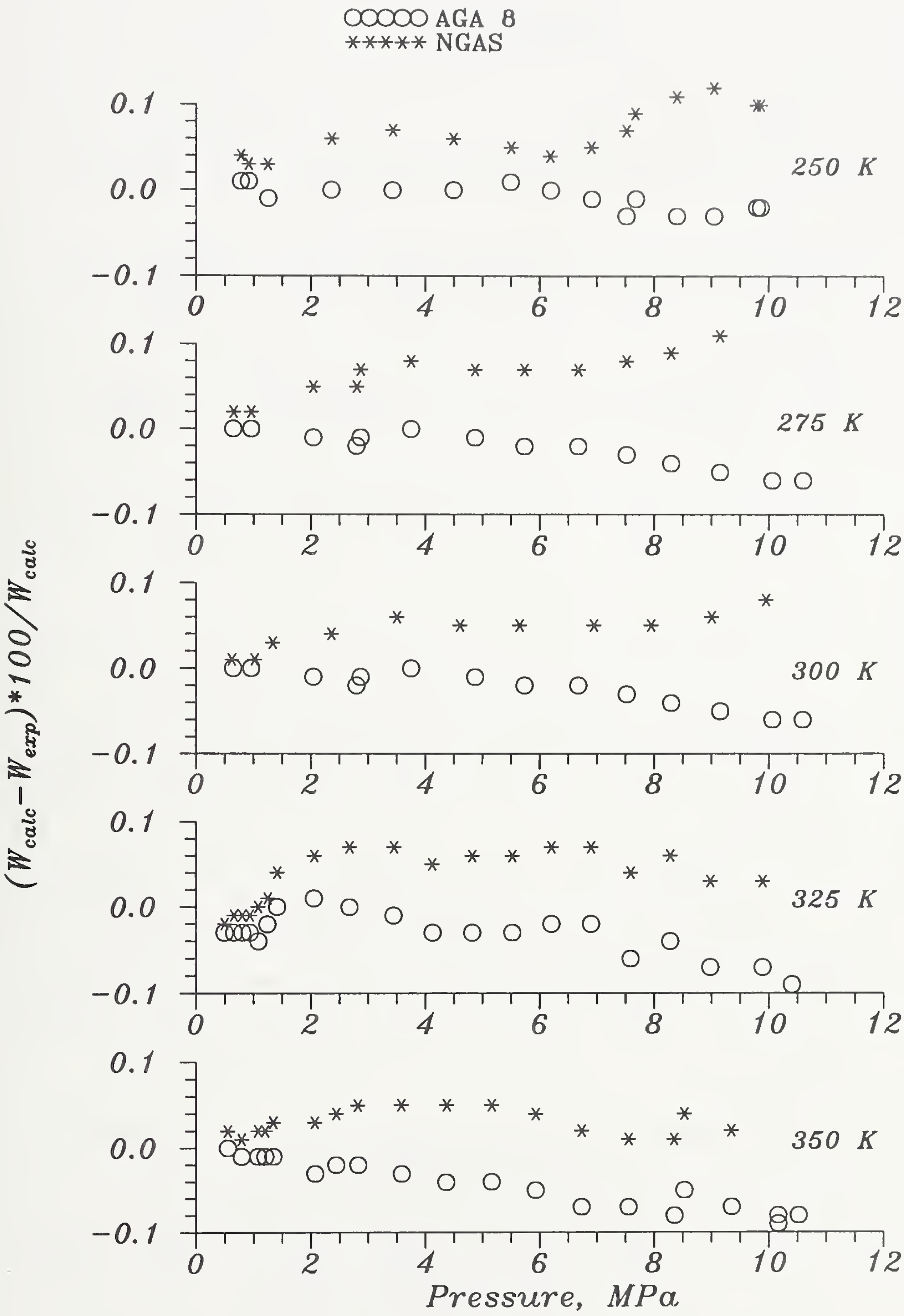


*Figure 21. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.95 − ethane 0.05.*

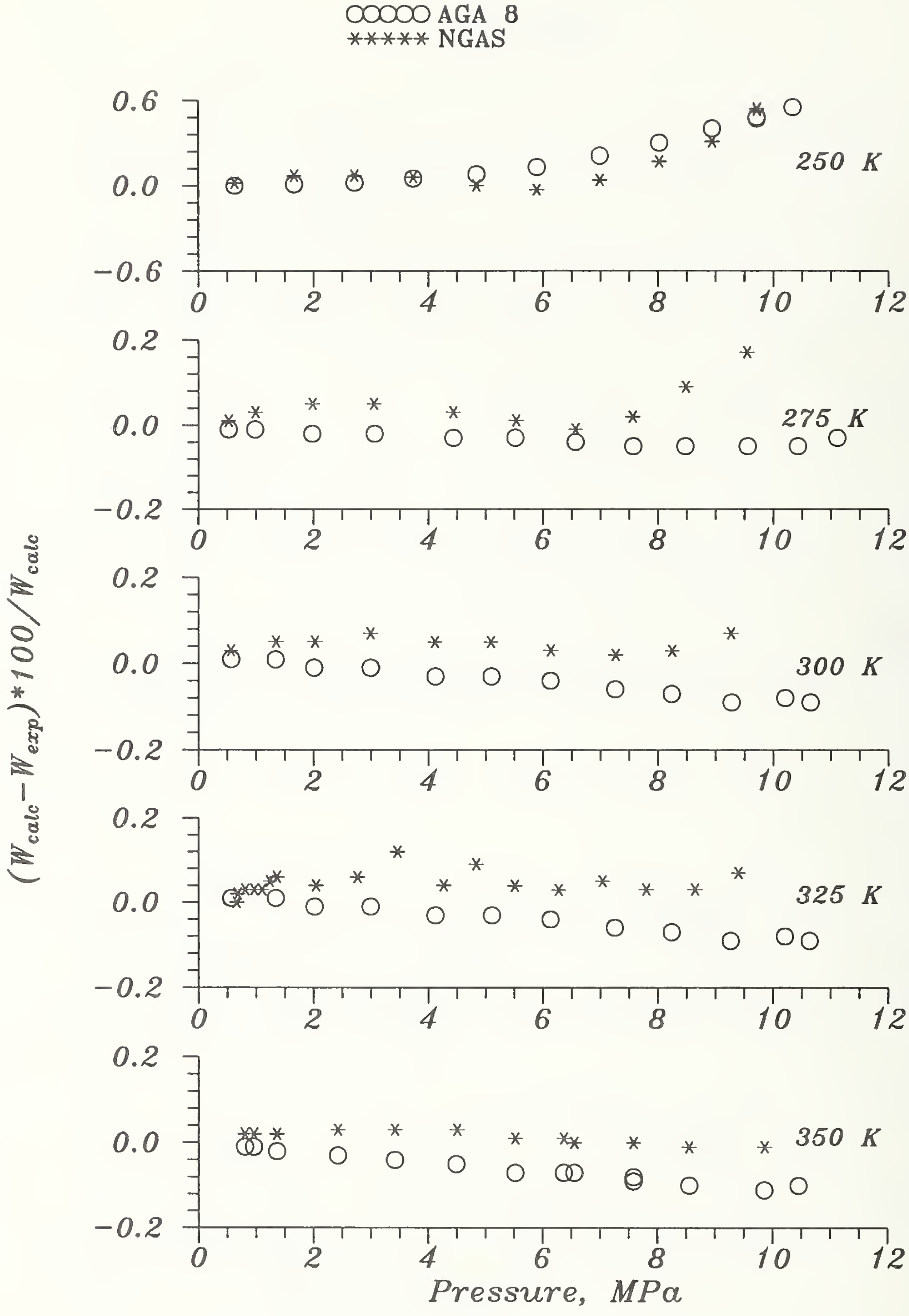


*Figure 22. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.85 – ethane 0.15.*

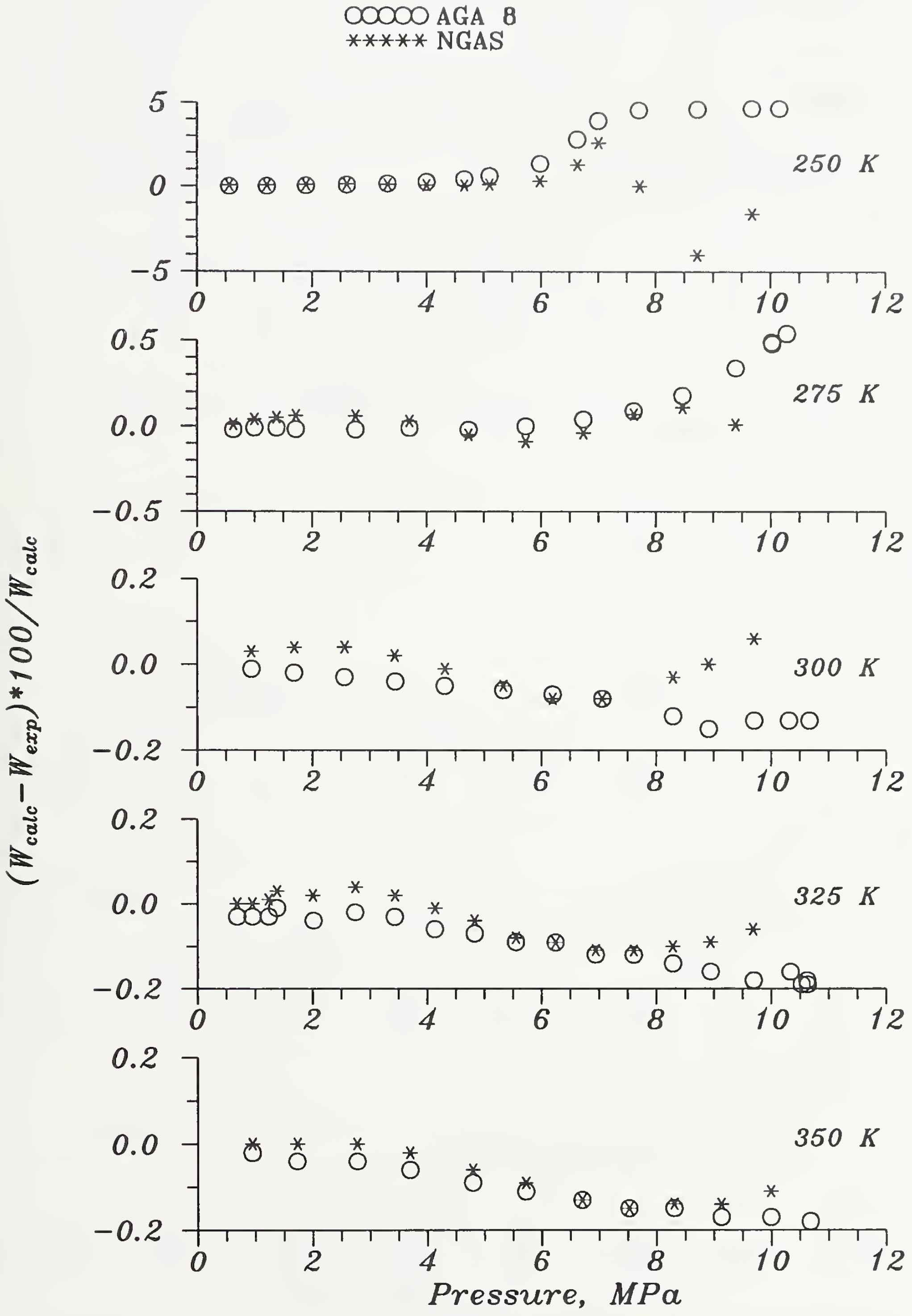


*Figure 23. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.69 – ethane 0.31.*

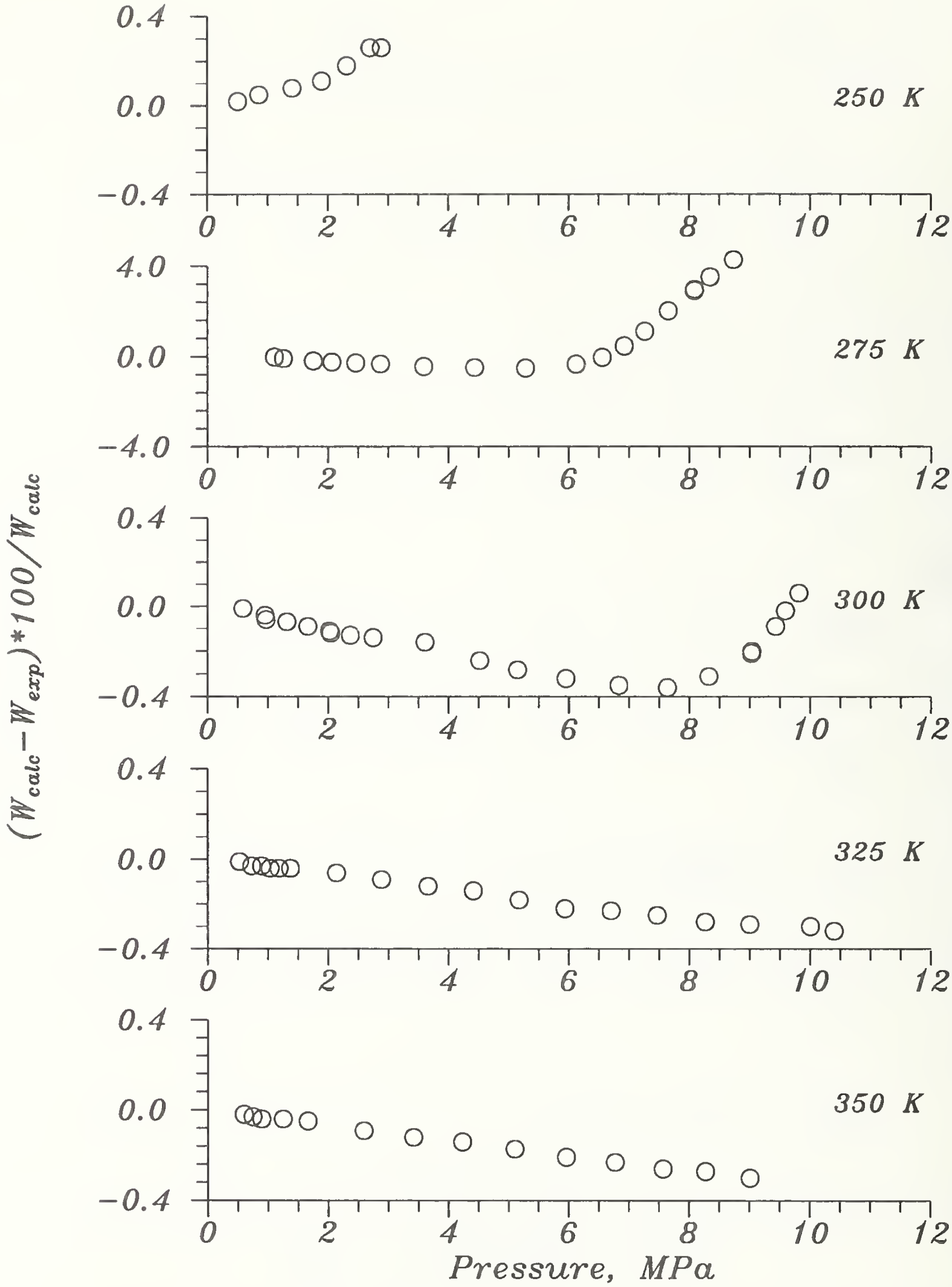


*Figure 24. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, methane 0.50 – ethane 0.50. Note: This composition is outside the range of AGA 8 and NGAS.*

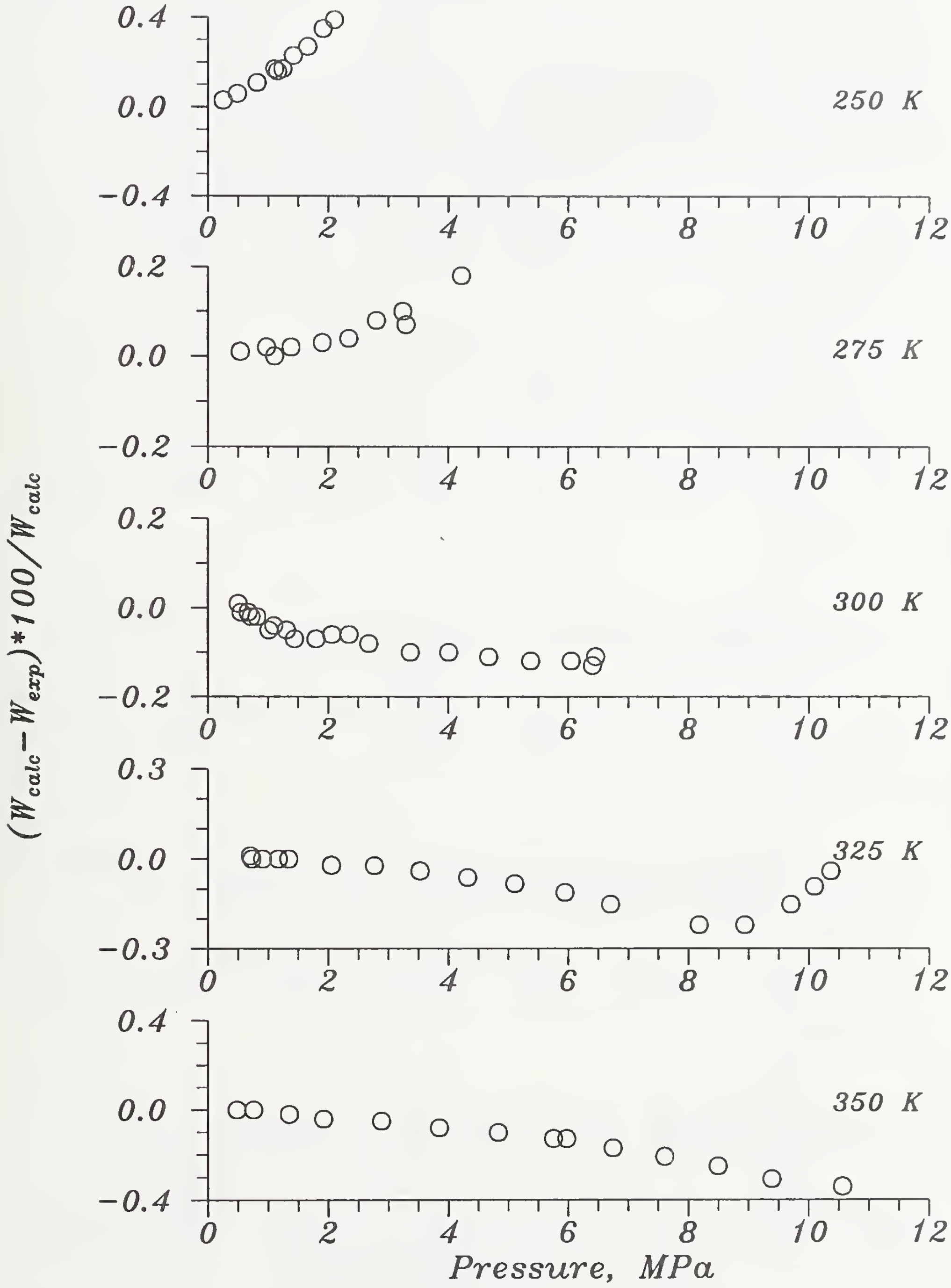


*Figure 25. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, methane 0.35 – ethane 0.65. NOTE: This composition is outside the range of AGA 8 and NGAS.*

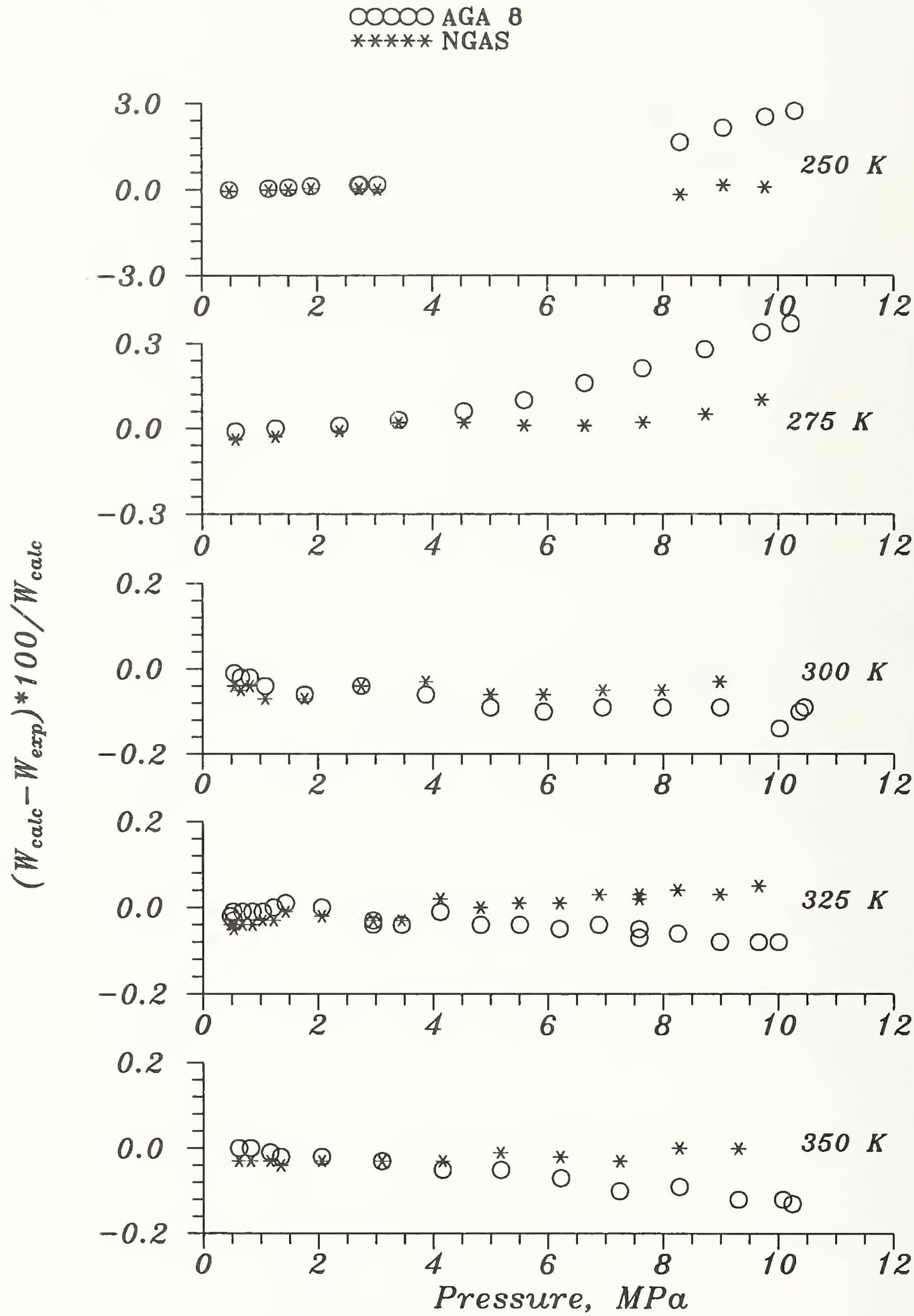


*Figure 26. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.90 – propane 0.10. NOTE: This composition is outside the range of AGA 8 and NGAS.*

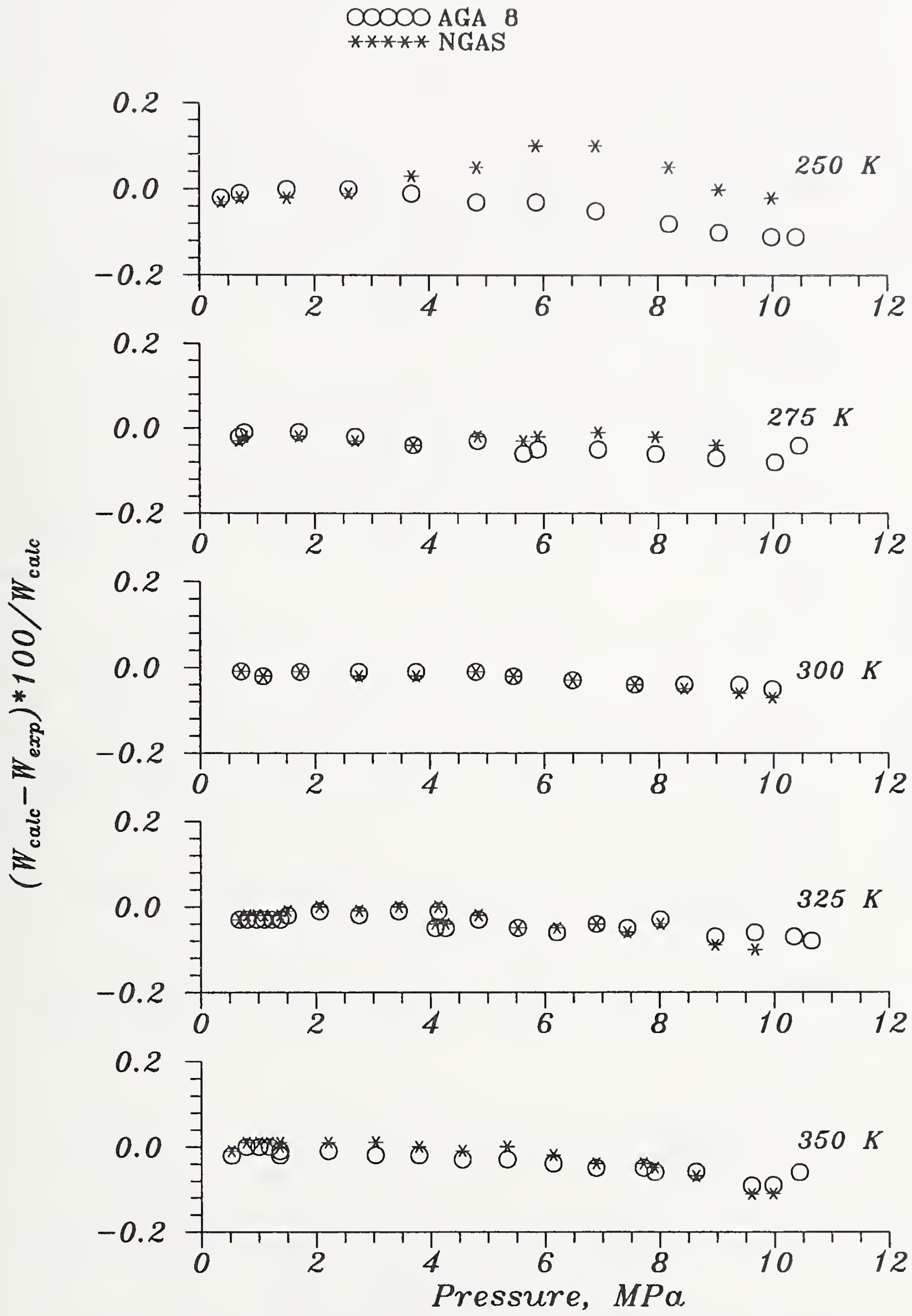


*Figure 27. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.95 − nitrogen 0.05.*

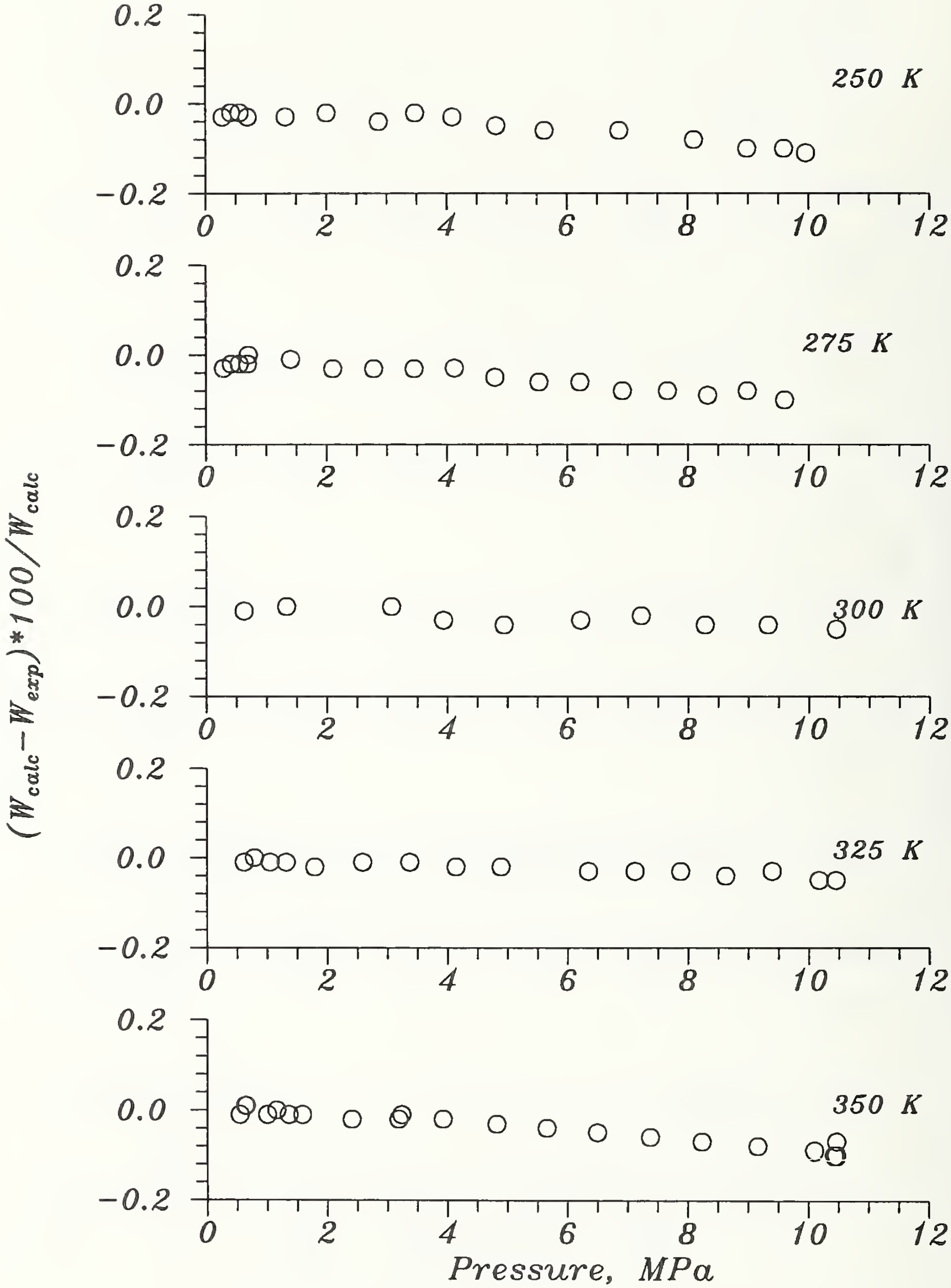


*Figure 28. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, methane 0.85 – nitrogen 0.15. NOTE: This composition is outside the range of NGAS.*

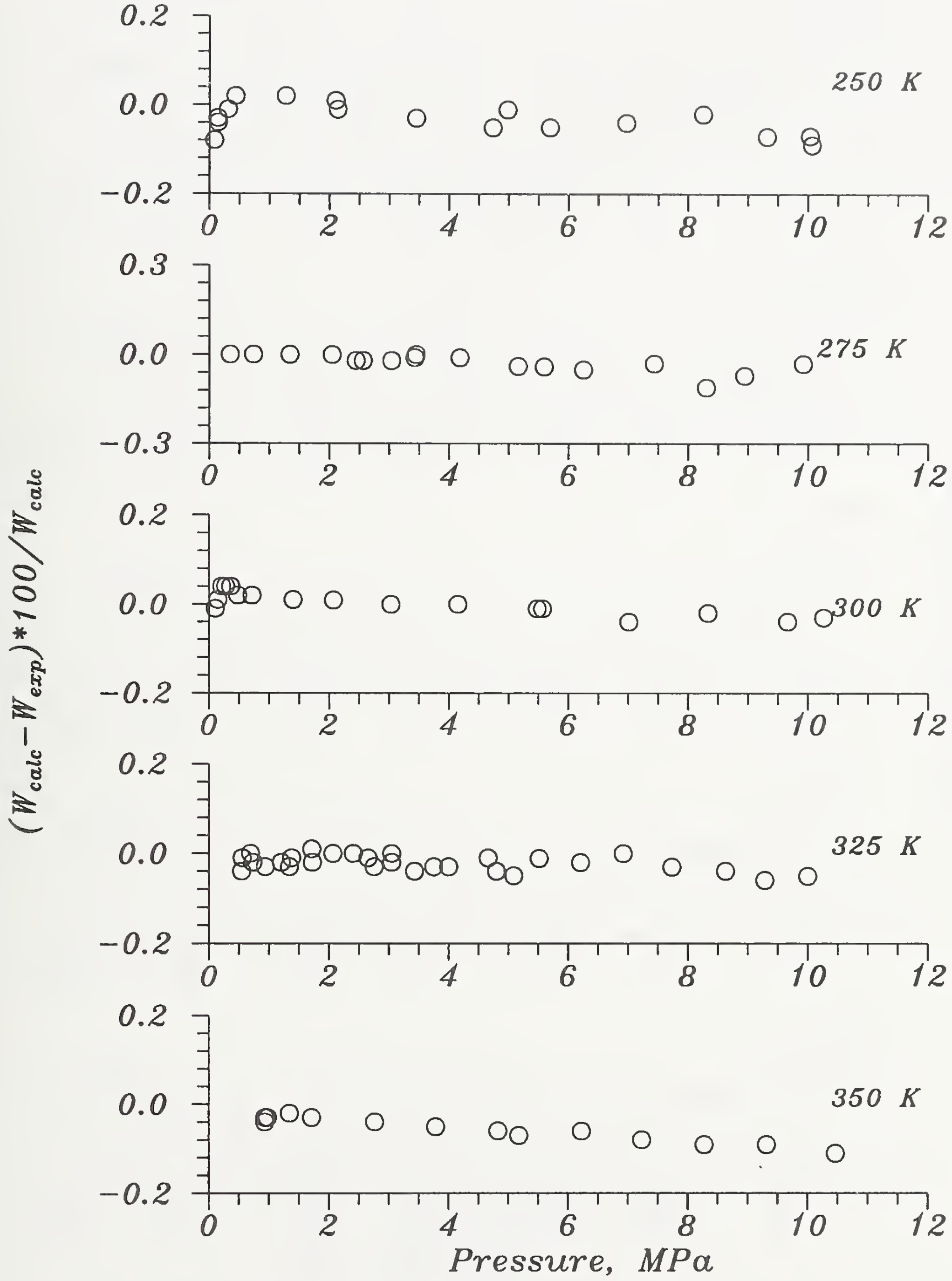


*Figure 29. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, methane 0.71 – nitrogen 0.29. NOTE: This composition is outside the range of NGAS.*

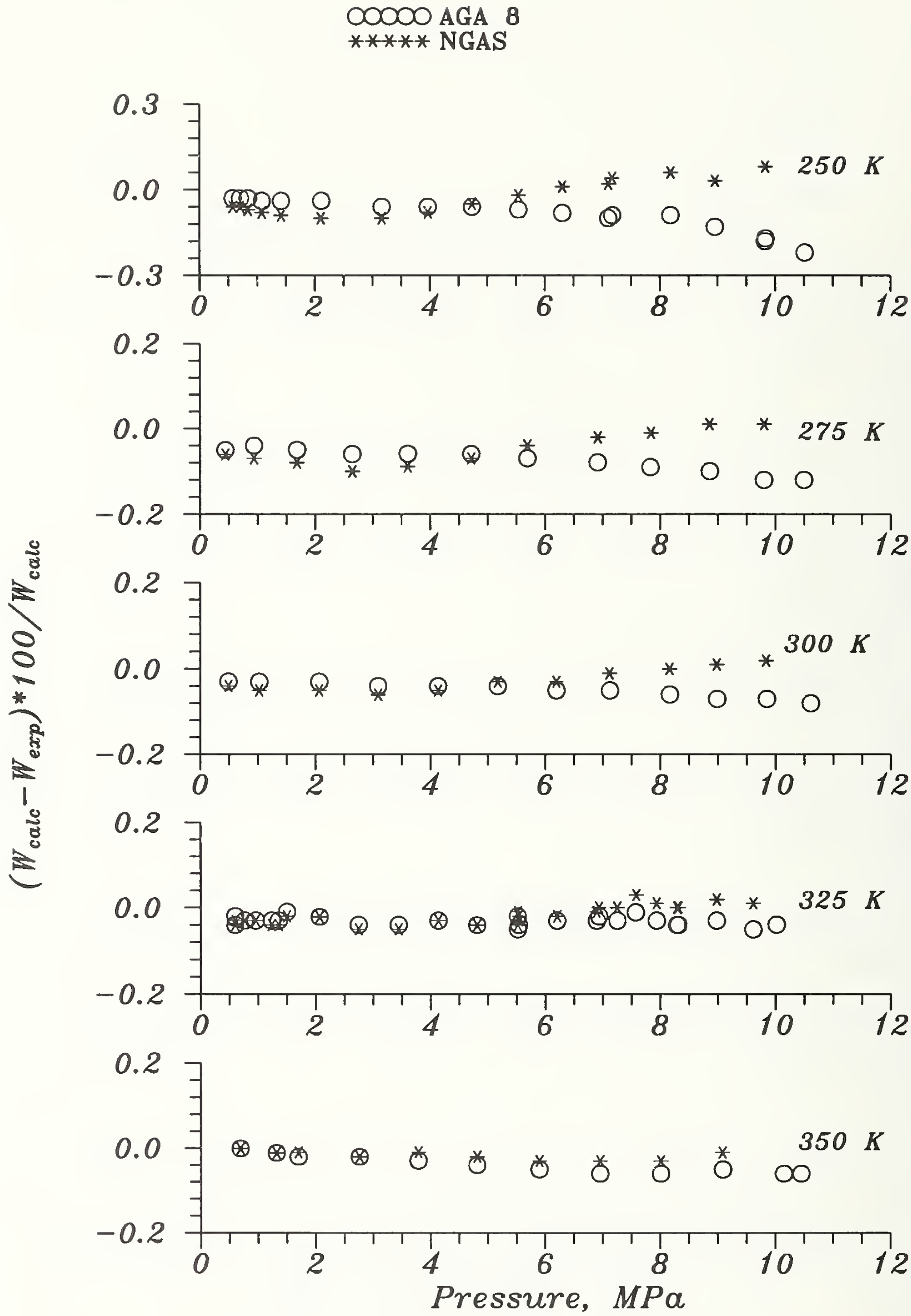


*Figure 30. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.95 – carbon dioxide 0.05.*

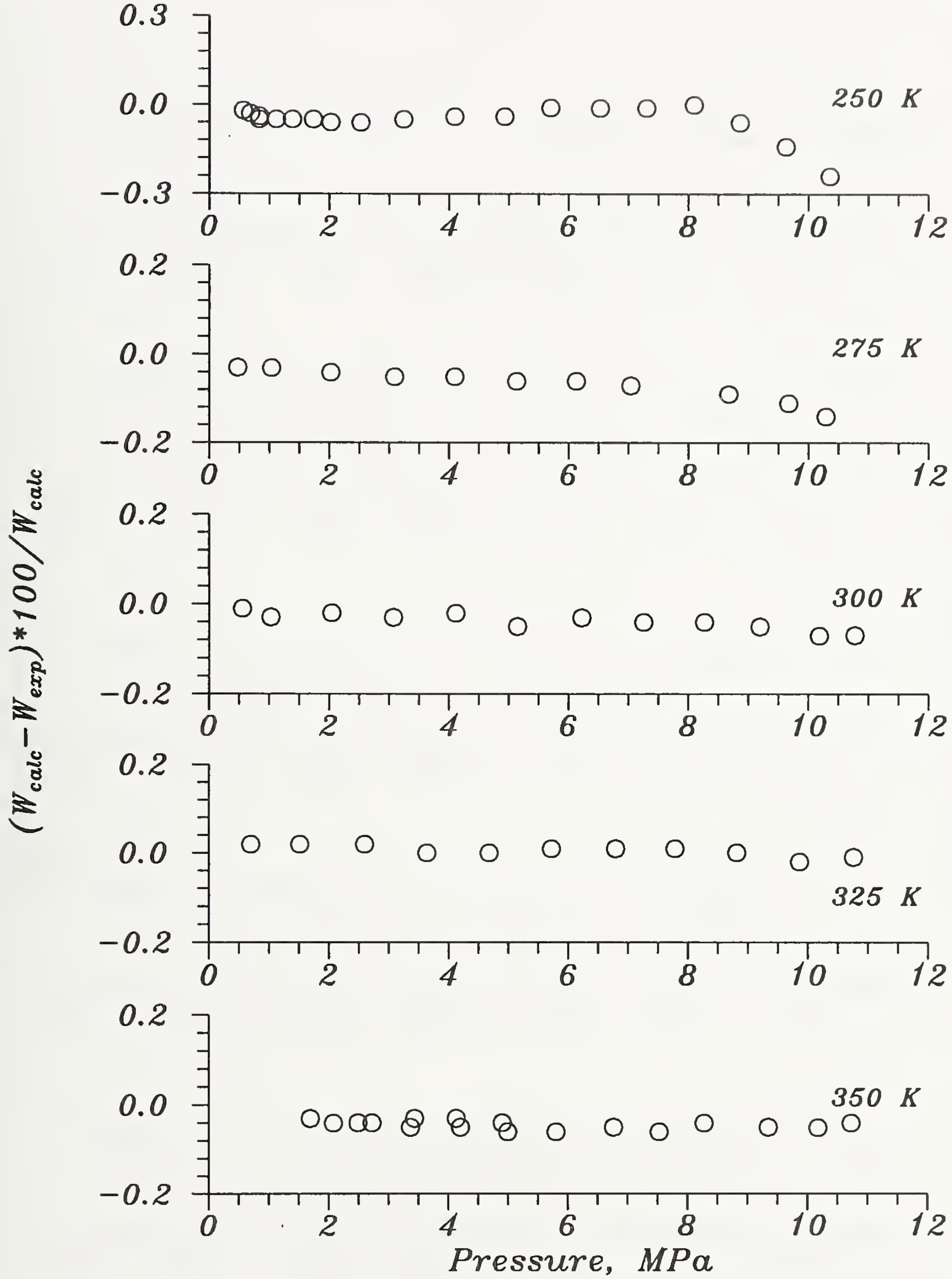


*Figure 31. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the binary mixture, methane 0.85 − carbon dioxide 0.15. NOTE: This composition is outside the range of NGAS.*

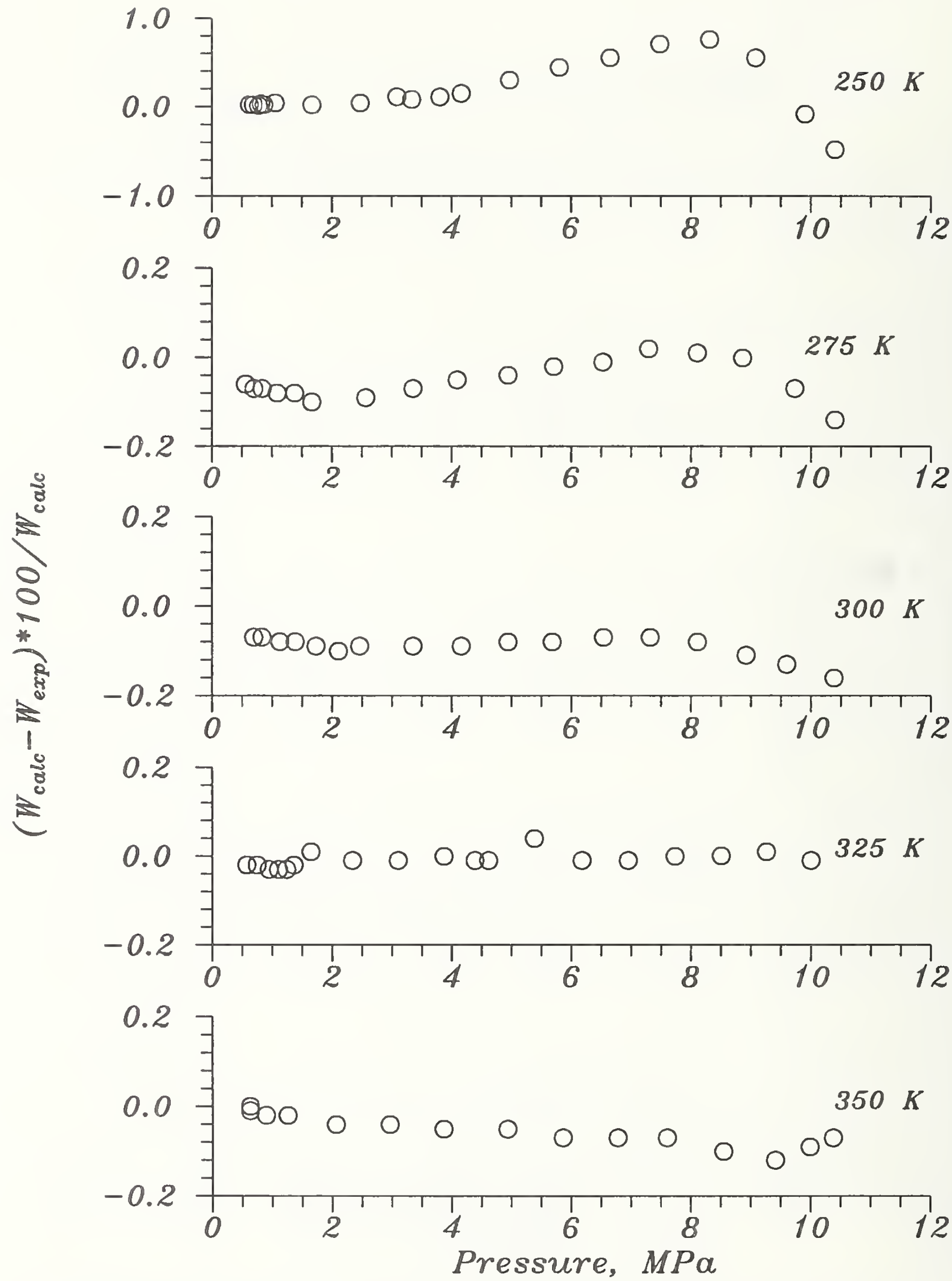


*Figure 32. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, methane 0.70 – carbon dioxide 0.30. NOTE: This composition is outside the range of NGAS.*

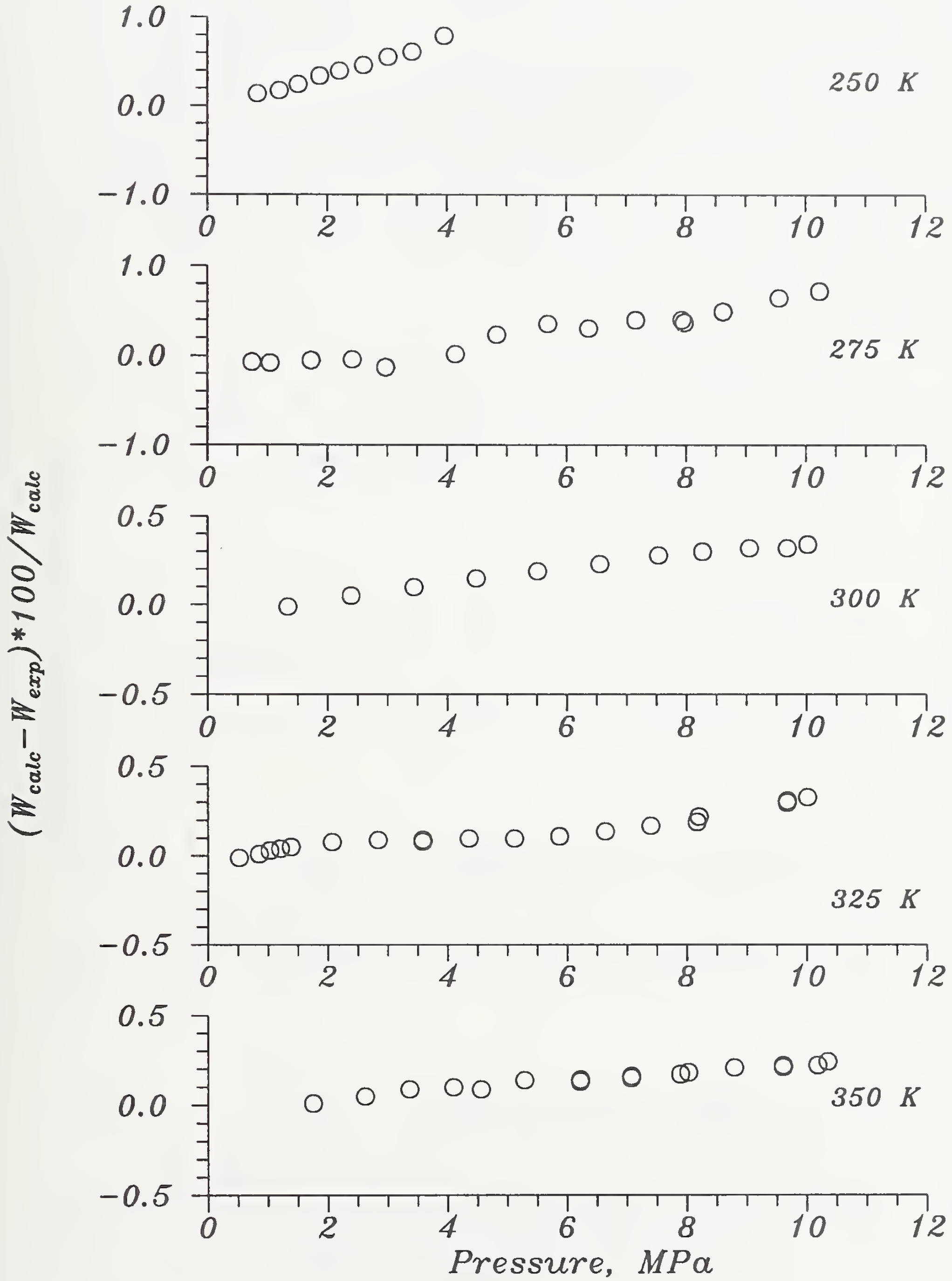


*Figure 33. Deviations of speed of sound computed by AGA 8 from the experimental values for the binary mixture, nitrogen 0.50 – carbon dioxide 0.50. NOTE: This composition is outside the range of AGA 8 and NGAS.*

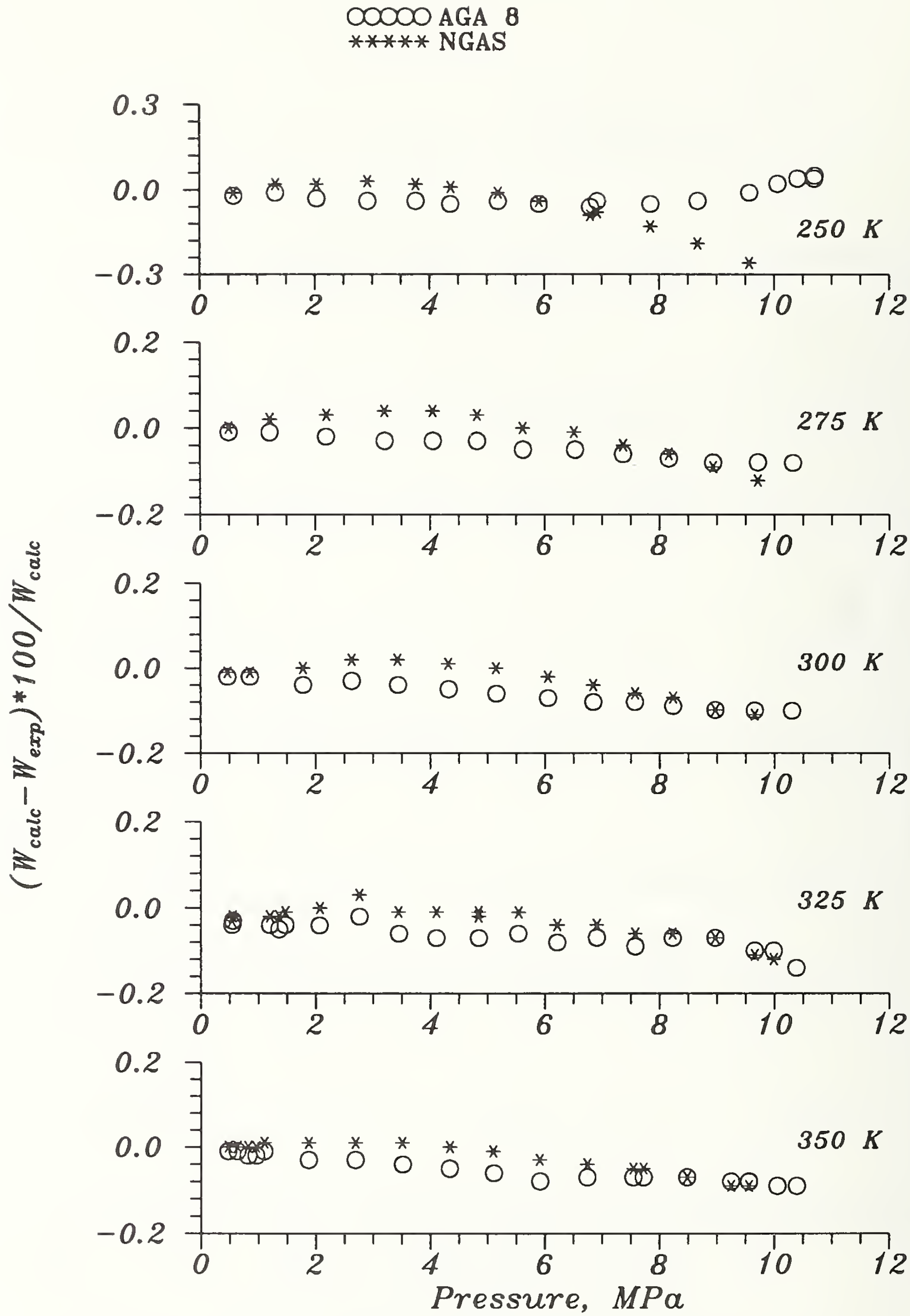


*Figure 34. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the Gulf Coast mixture.*

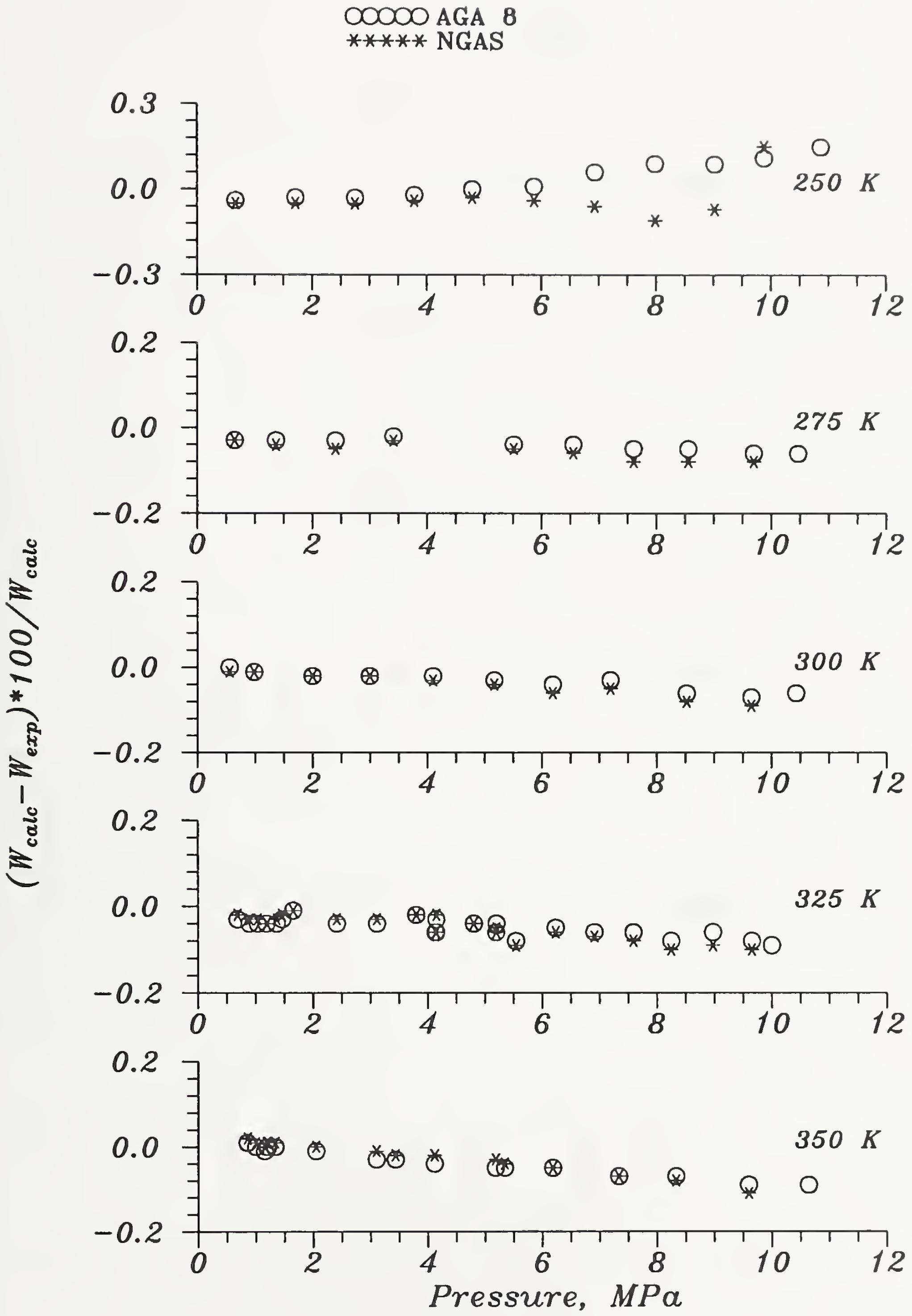


*Figure 35. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the Amarillo mixture.*

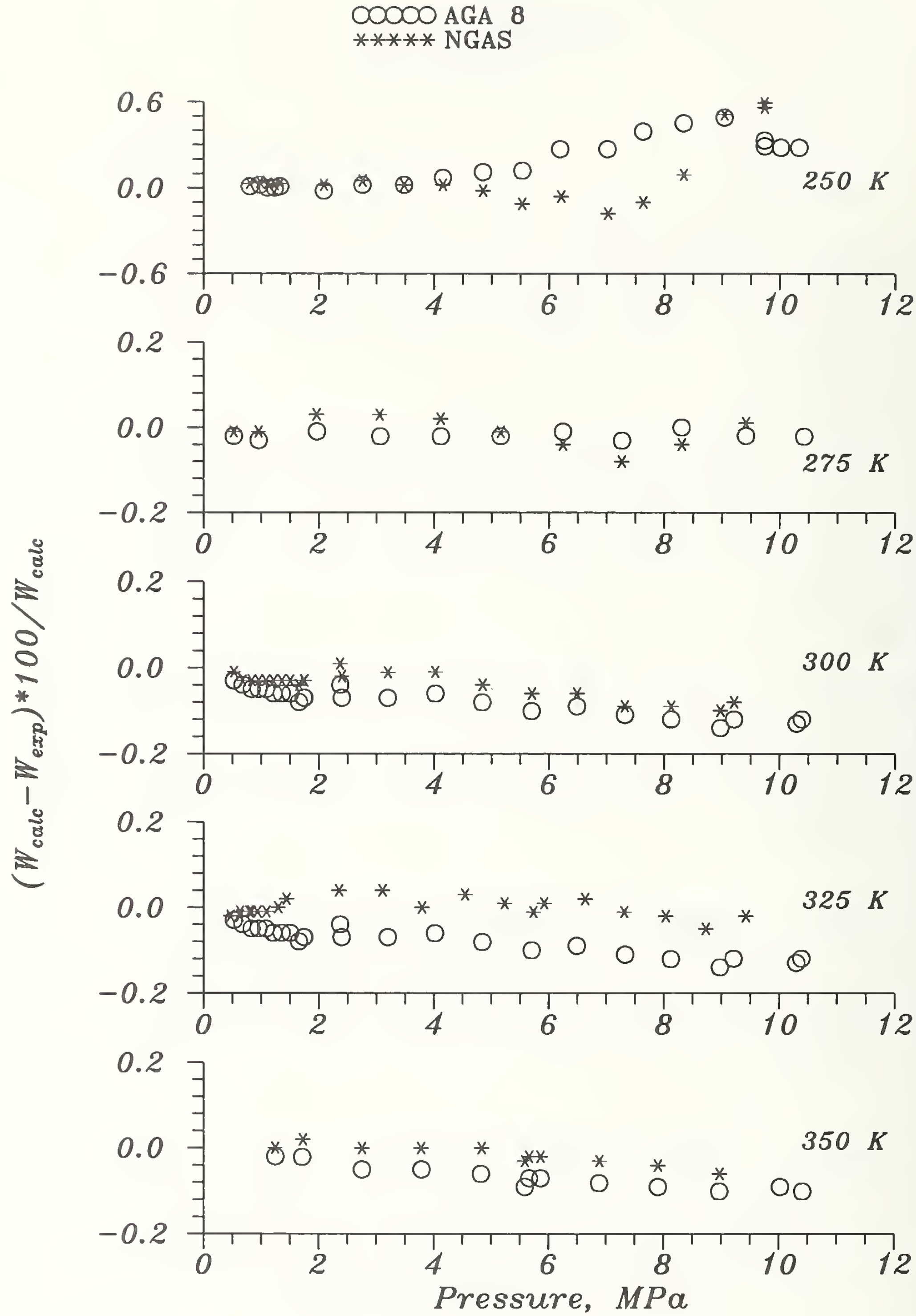


*Figure 36. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the Statoil dry gas mixture.*

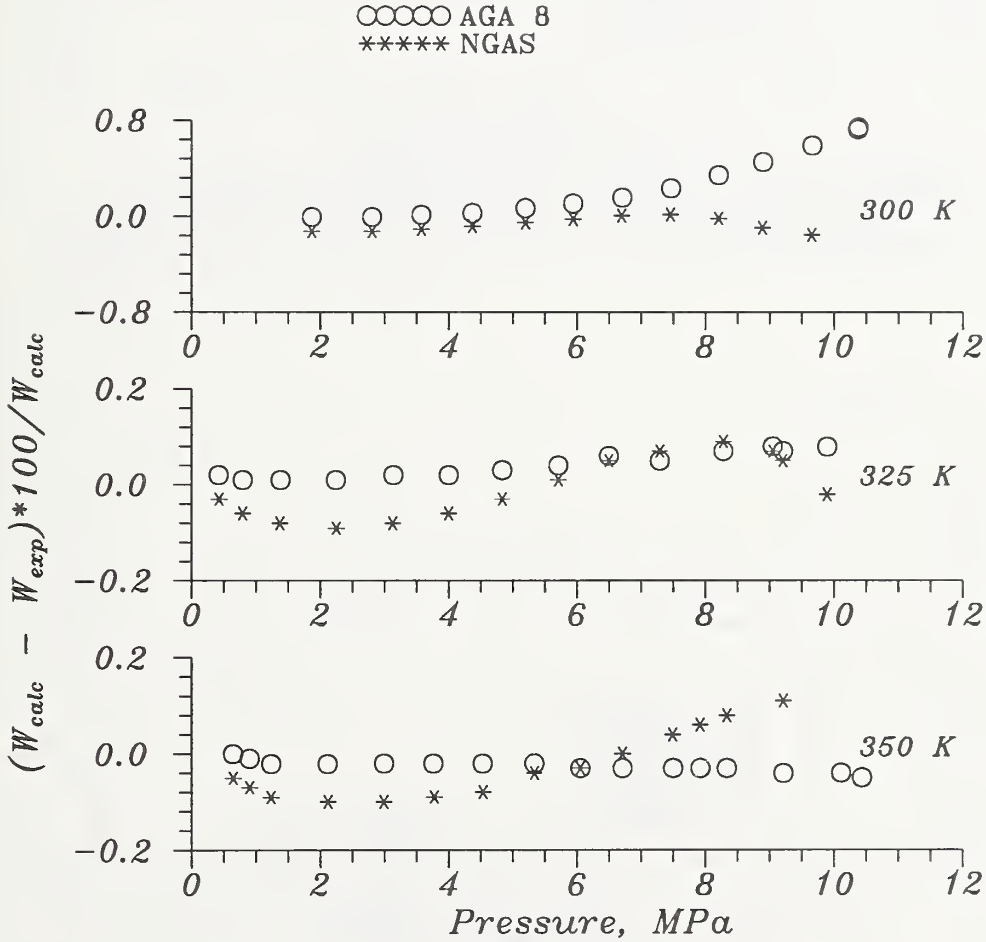


*Figure 37. Deviations of speed of sound computed by AGA 8 and NGAS from the experimental values for the Statoil Statvordgass mixture.*

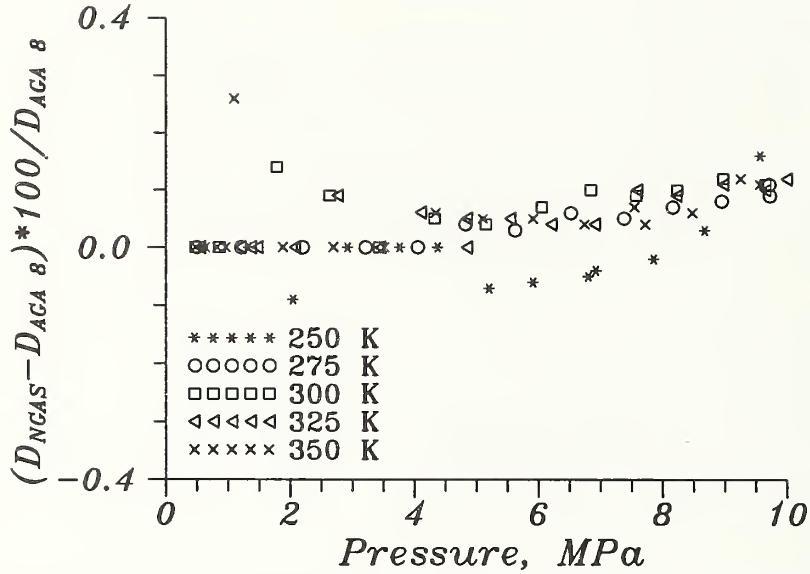


*Figure 38. Deviations of the densities computed by NGAS from those computed using AGA 8 for the Gulf Coast mixture.*

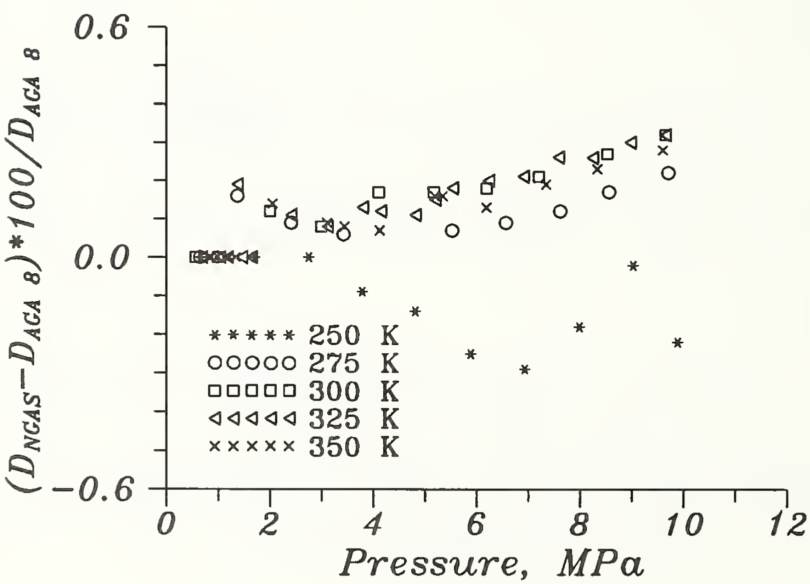


*Figure 39. Deviations of the densities computed by NGAS from those computed using AGA 8 for the Amarillo mixture.*

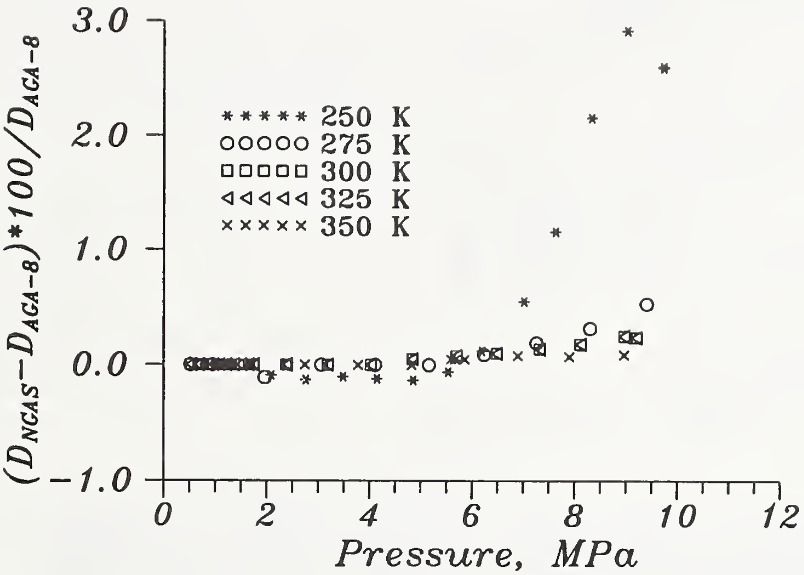


*Figure 40. Deviations of the densities computed by NGAS from those computed using AGA 8 for the Statoil dry gas mixture.*

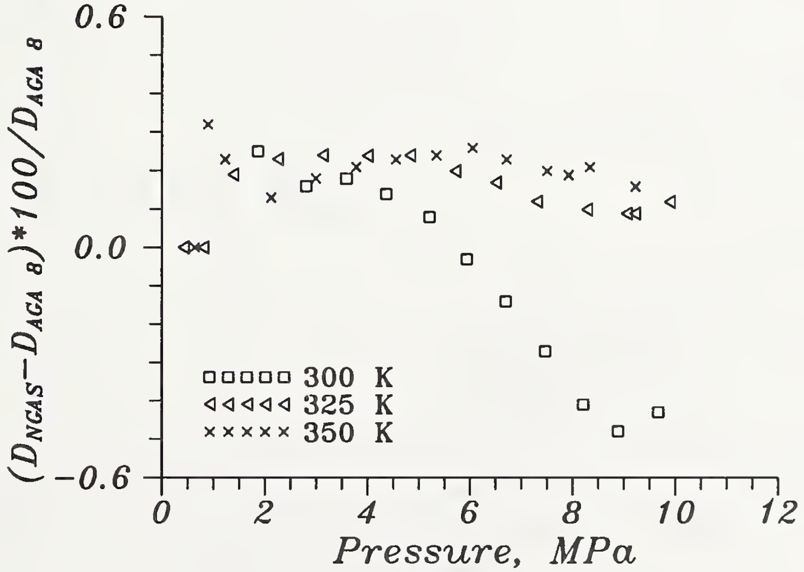


*Figure 41. Deviations of the densities computed by NGAS from those computed using AGA 8 for the Statoil Statvordgass mixture.*

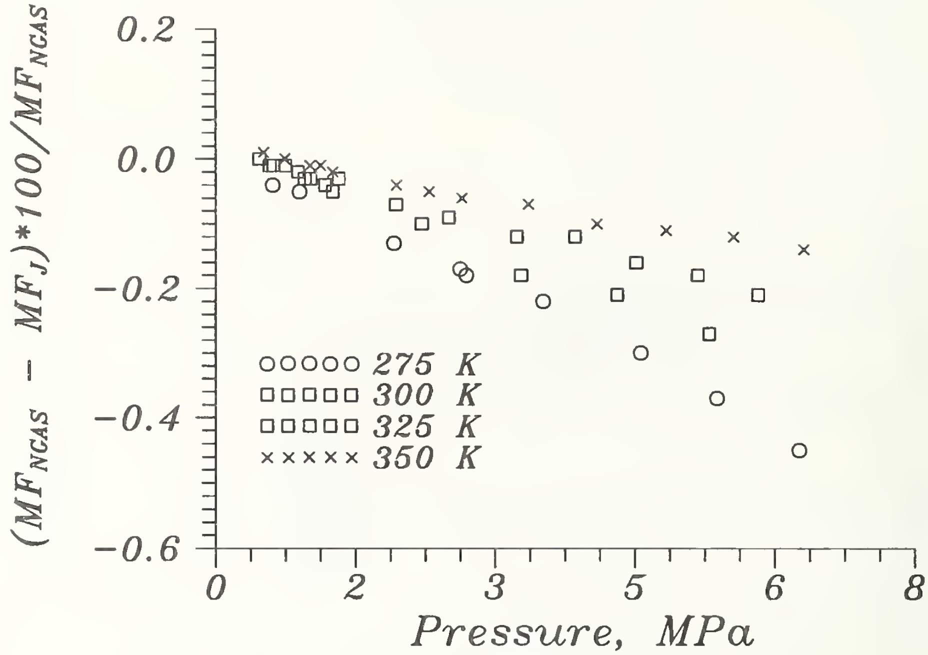


*Figure 42. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.95 − ethane 0.05.*

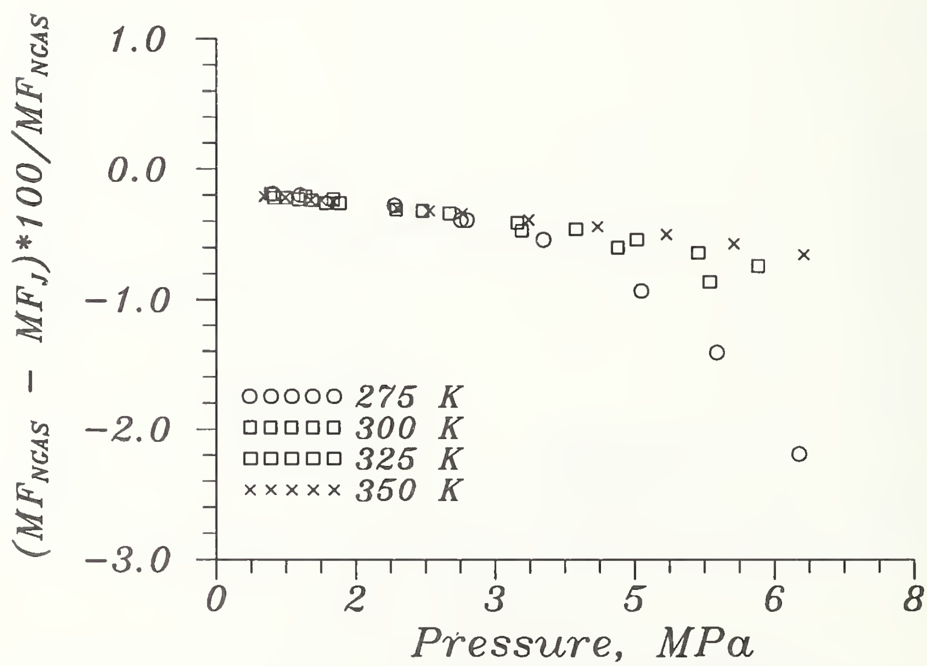


*Figure 43. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.70 − ethane 0.30.*

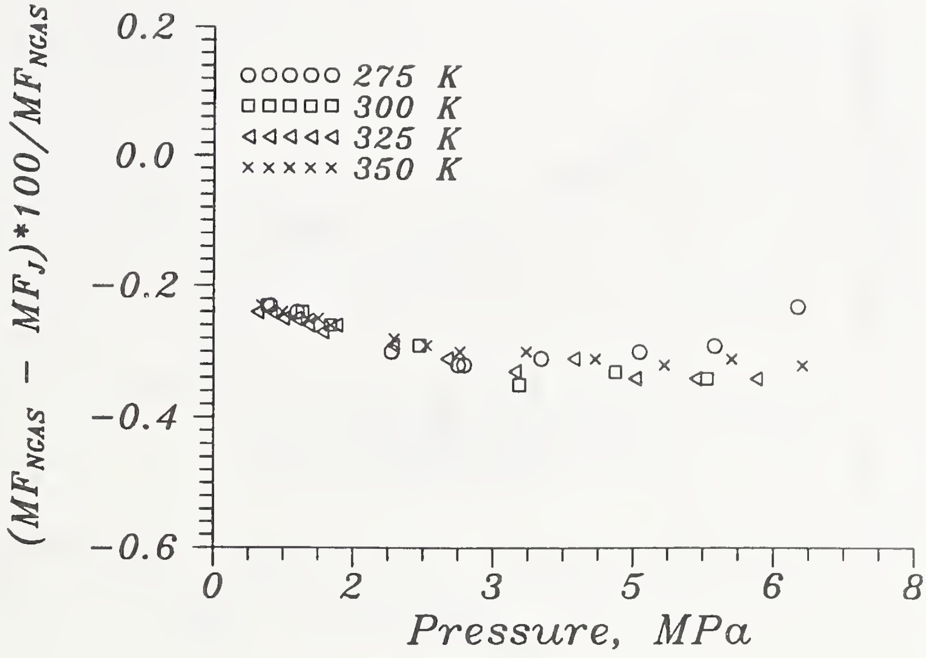


*Figure 44. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.95 – carbon dioxide 0.05.*

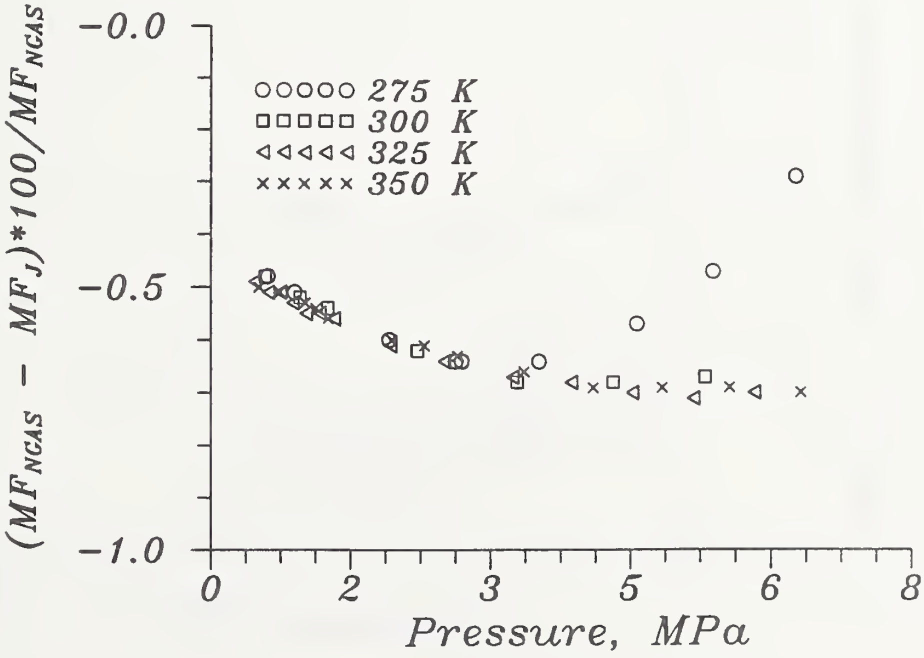


*Figure 45. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.90 – carbon dioxide 0.10.*

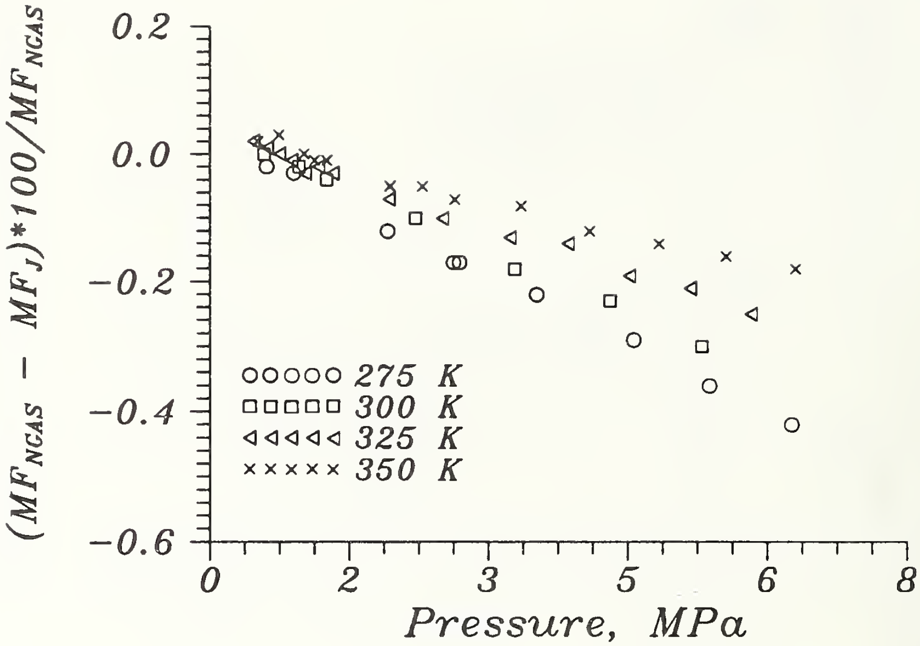


*Figure 46. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.95 – nitrogen 0.05.*

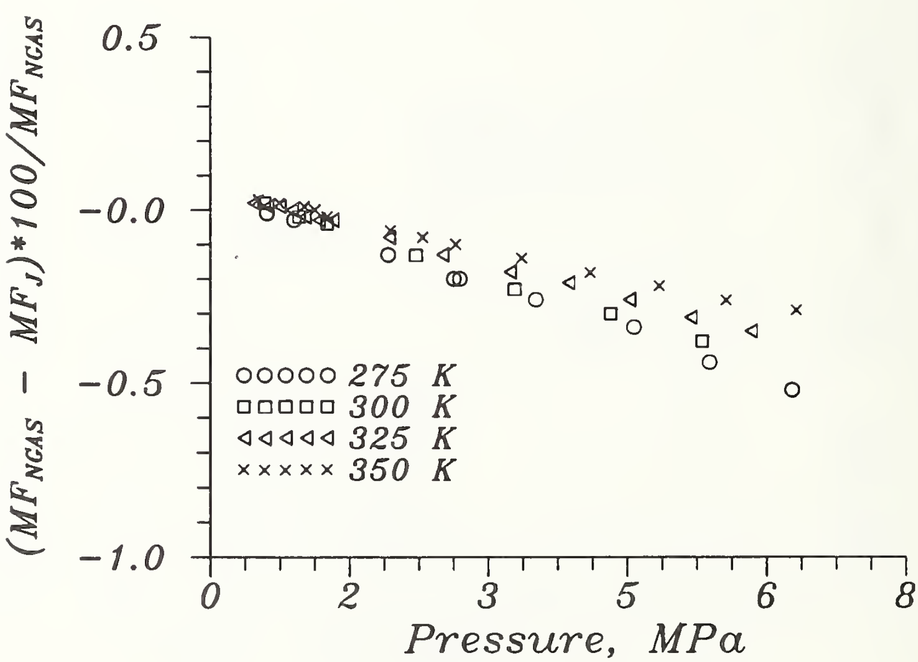


*Figure 47. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for methane 0.90 – nitrogen 0.10.*

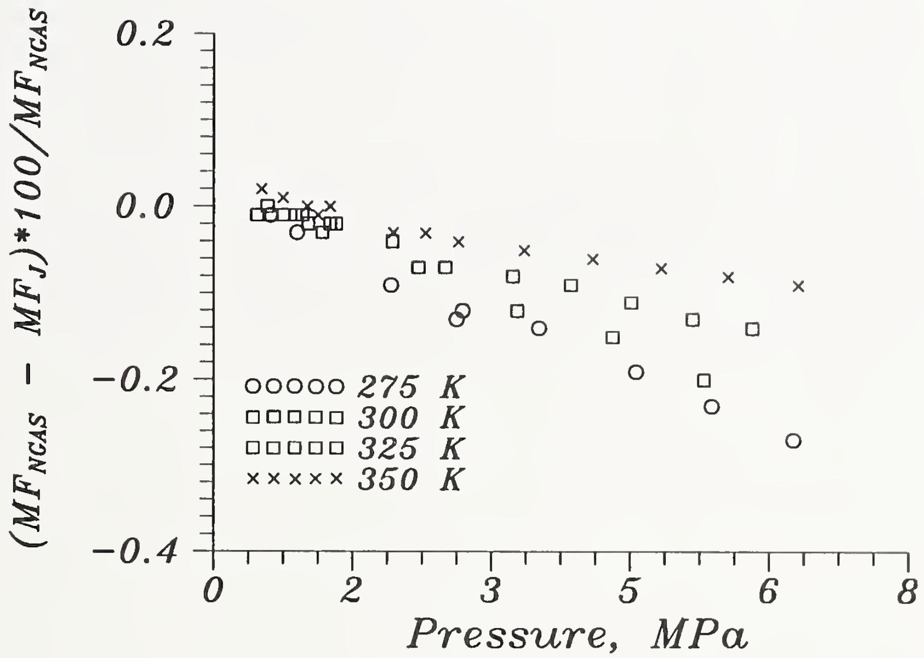


*Figure 48. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for the Gulf Coast mixture.*

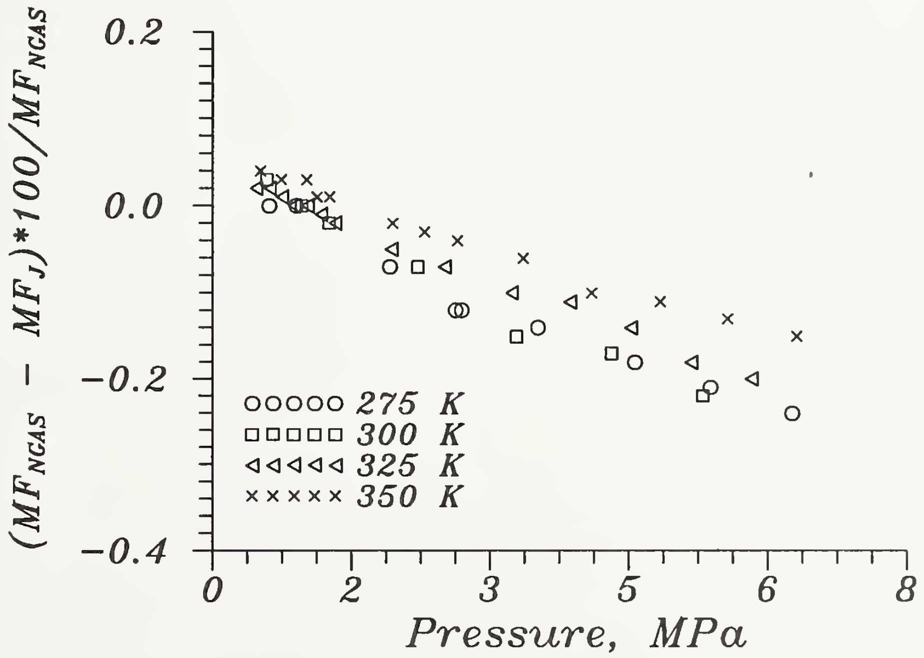


*Figure 49. Deviations of mass flow computed by the Johnson equation from that computed by NGAS for the Amarillo mixture.*

# NIST Technical Publications

## Periodical

**Journal of Research of the National Institute of Standards and Technology**—Reports NIST research and development in those disciplines of the physical and engineering sciences in which the Institute is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Institute's technical and scientific programs. Issued six times a year.

## Nonperiodicals

**Monographs**—Major contributions to the technical literature on various subjects related to the Institute's scientific and technical activities.

**Handbooks**—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

**Special Publications**—Include proceedings of conferences sponsored by NIST, NIST annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

**Applied Mathematics Series**—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

**National Standard Reference Data Series**—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NIST under the authority of the National Standard Data Act (Public Law 90-396). NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published bimonthly for NIST by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

**Building Science Series**—Disseminates technical information developed at the Institute on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

**Technical Notes**—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NIST under the sponsorship of other government agencies.

**Voluntary Product Standards**—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NIST administers this program in support of the efforts of private-sector standardizing organizations.

**Consumer Information Series**—Practical information, based on NIST research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

*Order the* **above** *NIST publications from: Superintendent of Documents, Government Printing Office, Washington, DC 20402.*

*Order the* **following** *NIST publications—FIPS and NISTIRs—from the National Technical Information Service, Springfield, VA 22161.*

**Federal Information Processing Standards Publications (FIPS PUB)**—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NIST pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

**NIST Interagency Reports (NISTIR)**—A special series of interim or final reports on work performed by NIST for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service, Springfield, VA 22161, in paper copy or microfiche form.

**U.S. Department of Commerce**
National Institute of Standards and Technology
Gaithersburg, MD 20899