

**Reference Correlation for the Thermal Conductivity  
of Ethane-1,2-diol (Ethylene Glycol)  
from the Triple Point to 475 K and Pressures up to 100 MPa**

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We present a new wide-ranging correlation for the thermal conductivity of ethane-1,2-diol (ethylene glycol) based on critically evaluated experimental data. The correlation is designed to be used with an existing equation of state, and it is valid from the triple point to 475 K, at pressures up to 100 MPa. The estimated uncertainty is 2.2 % (at the 95 % confidence level), except in the dilute-gas region which is estimated to be 20 %, as there are no measurements in this region for comparison.

Key words: Ethane-1,2-diol; Ethylene glycol; thermal conductivity; transport properties.

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## 1 Introduction

Ethane-1,2-diol (IUPAC name), also known as 1,2-ethanediol, ethylene glycol, monoethylene glycol, or 1,2-dihydroxyethane, is a very common heat-transfer fluid. Nevertheless, a reference correlation for its thermal conductivity does not exist, and the current formulation employed in REFPROP [1] is based on extended corresponding states [2]. Very recently, a reference correlation for the viscosity of ethane-1,2-diol was published [3] covering the range from the triple point to 465 K and 100 MPa. In this paper, we present a reference correlation for thermal conductivity. The methodology adopted is very similar to previously proposed reference correlations for some simple fluids [4-8], hydrocarbons [9-17], alcohols [18], and refrigerants [19-21].

The analysis that will be described here is based on the best available experimental data for thermal conductivity. Thus, a prerequisite to the analysis is a critical assessment of the experimental data. For this purpose, two categories of experimental data are defined: primary data, employed in the development of the correlation, and secondary data, used simply for comparison purposes. According to the recommendation adopted by the Subcommittee on Transport Properties (now known as The International Association for Transport Properties) of the International Union of Pure and Applied Chemistry, the primary data are identified by a well-established set of criteria [22]. These criteria have been successfully employed to establish standard reference values for the viscosity and thermal conductivity of fluids over wide ranges of conditions, with uncertainties in the range of 1 %. However, in many cases, such a narrow definition unacceptably limits the range of the data representation. Consequently, within the primary data set, it is also necessary to include results that extend over a wide range of conditions, albeit with a higher uncertainty, provided they are consistent with other lower uncertainty data or with theory. In all cases, the uncertainty claimed for the final recommended data must reflect the estimated uncertainty in the primary information.

## 2 The Correlation

The thermal conductivity  $\lambda$  can be expressed as the sum of three independent contributions, as

$$\lambda(\rho, T) = \lambda_0(T) + \Delta\lambda(\rho, T) + \Delta\lambda_c(\rho, T), \quad (1)$$

where  $\rho$  is the density,  $T$  is the temperature, and the first term,  $\lambda_0(T) = \lambda(0, T)$ , is the contribution to the thermal conductivity in the dilute-gas limit, where only two-body molecular interactions occur. The final term,  $\Delta\lambda_c(\rho, T)$ , the critical enhancement, arises from the long-range density fluctuations that occur in a fluid near its critical point, which contribute to the divergence of the thermal conductivity at the critical point. Finally, the term  $\Delta\lambda(\rho, T)$ , the residual property, represents the contribution of all other effects to the thermal conductivity of the fluid at elevated densities.

Table 1 summarizes, to the best of our knowledge, the experimental measurements of the thermal conductivity of ethane-1,2-diol reported in the literature. In the same table, the technique employed, the purity, the uncertainty (as given by the original authors), the number of measurements, as well as the range of temperatures and pressure investigated are also shown.

**Table 1** Thermal conductivity theoretical predictions and measurements of ethane-1,2-diol.

Authors	Year Publ.	Technique employed <sup>a</sup>	Purity <sup>b</sup> (%)	Uncertainty (%)	No. of data <sup>c</sup>	Temperature range (K)	Pressure range (MPa)
<b>Primary Data</b>							
Deng et al. [23]	2021	THW1 – 25 $\mu$ m Ta	99.00	2.0	9	263-372	0.1
Khayet et al. [24]	2005	THW1 – 25 $\mu$ m Pt	99.90	0.9	5	298-338	0.1
Cai et al. [25]	1993	THW1 – 25 $\mu$ m Pt	99.00	0.8	1	303	0.1
DiGuillo and Teja [26]	1990	THW1 – 25 $\mu$ m Pt	99.80	2.0	6	298-471	0.1
Assael et al. [27]	1989	THW2 – 25 $\mu$ m Ta	99.80	0.5	10	296-355	0.1
Bogacheva et al. [28]	1980	HF	-	1.5	7	312-363	0.1
Rastorguev et al. [29]	1978	CC	-	1.3	54	299-468	0.49-98.1
Ganiev [30]	1969	CC	-	1.0	9	293-453	0.1
Rastorguev and Gazduev [31]	1969	CC	-	1.5	7	313-433	0.1
Slawecki and Molstad [32]	1956	CC	PUR	0.8	9	313-363	0.1
<b>Secondary Data</b>							
Akilu et al. [33]	2019	THW	99	5.0	8	298-333	0.1
Bedoya et al. [34]	2018	THW1 – 76 $\mu$ m Pt	99.9	2.0	1	295	0.077
Guo et al.[35]	2018	THW1 – 50 $\mu$ m Pt	99	1.3	1	293	0.1
Sati et al.[36]	2018	HD	99	5	6	298-323	0.1
Zyla and Fal [37]	2017	THW	99	2	1	298	0.1
Selvam et al.[38]	2016	THW	99	5	3	303-323	0.1
Zyla and Fal[39]	2016	THW	99	2	1	298	0.1
Cabaleiro et al. [40]	2015	PP	99.5	6	4	239-343	0.1
Pastoriza-Gallego et al.[41]	2014	THW	99	3.0	4	283-343	0.1
Alvarado et al. [42]	2011	THW1 – 76 $\mu$ m Pt	99.90	3.5	1	293	0.1
Zhao et al. [43]	2007	THP	-	-	1	298	0.1
Fischer [44]	1986	HRot.Cyl.	-	2.0	7	264-452	0.1
Bohne [45]	1984	HRot.Cyl.	-	2.0	7	282-452	0.1
Wang et al. [46]	1984	THP	-	5.0	1	298	0.1
Grishchenko and Grishchenko[47]	1983	Unknown	-	-	1	298	0.1
Usmanov and Salikhov [48]	1975	CC	-	-	1	303	0.1
Sadykov et al. [49]	1973	S	-	-	20	293-463	0.1
Filippov [50]	1968	MCC	-	3.0	EQ	288-363	0.1
Venart and Krishnamurthy [51]	1968	THW1 – 62 $\mu$ m Pt	BPS	0.5	14	289-406	0.1
Vanderkooi et al. [52]	1967	CSph	98.00	1.0	4	273-406	0.1
Jamieson and Tudhope [53]	1964	THW1 – 75 $\mu$ m Pt	-	5.0	1	323	0.1
Sakiadis and Coates [54]	1955	CC	-	-	EQ	309-349	0.1
Woolf and Sibbitt [55]	1954	CC	-	4.0	2	299, 413	0.1
Van der Held et al. [56]	1953	THW	-	3.0	1	293	0.1
Riedel [57]	1951	S	-	-	6	273-373	0.1
Riedel [58]	1948	THW	-	-	1	293	0.1
Bates and Hazzard [59]	1945	PP	-	-	10	293-383	0.1
Goldschmidt [60]	1911	HW	-	-	1	273	0.1

<sup>a</sup> CC, Concentric Cylinders; CSph, Concentric Spheres; HD, Hot Disc; HF, Hot Filament; HRot.Cyl., Horizontal Rotating Cylinder; HW, Hot Wire; MCC, Modified Concentric Cylinders; PP, Parallel Plates; S, Smoothed data; THP, transient hot probe; THW, Transient Hot Wire; THW1, Transient Hot Wire with 1 wire; THW2, Transient Hot Wire with 2 wires.

<sup>b</sup> BPS, British Pharmacopoeia Standards; PUR, Purified in the Laboratory.

<sup>c</sup> EQ, Equation.

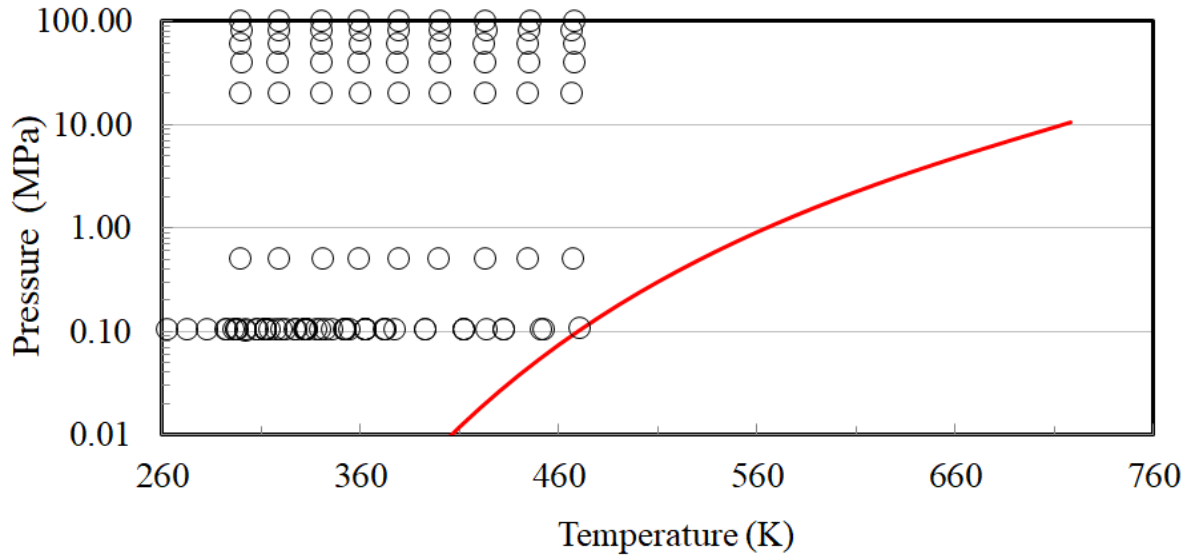
The measurements of Assael et al. [27] were obtained in an absolute transient hot-wire instrument employing two anodized, 25  $\mu\text{m}$ -diameter, Ta wires. The operation of this instrument is based on a full theoretical model and it is proven to operate with an uncertainty of less than 0.5%. Measurements performed by the group of Assael have already been successfully employed in many thermal-conductivity reference correlations (e.g., *n*-hexane [61], *n*-heptane [12], benzene [10], toluene [9], methanol [18], hydrogen [4], and water [6]). Hence, this set was considered as primary data. A very similar instrument, but with a single anodized, 25  $\mu\text{m}$ -diameter, Ta wire, and an uncertainty of 2 %, was employed by Deng et al. [23], while Khayet et al. [24], Cai et al. [25], and DiGuillo and Teja [26], employed a single 25  $\mu\text{m}$ -diameter Pt wire (instead of Ta wire), with corresponding uncertainties 0.9, 0.8 and 2 %. These four sets were also included in the primary data set. We further note that, according to the THW full theory, the wire employed should be a very thin wire, of diameter less than 30  $\mu\text{m}$ , so that the corrections to the line source model can be evaluated and applied without introducing a significant error [62]. Thus, investigators that employed larger diameter wires in their THW instruments were not included in the primary data set.

Rastorguev et al. [29] employed a concentric-cylinders instrument to measure the thermal conductivity of ethane-1,2-diol up to 98.1 MPa pressure with a 1.3 % uncertainty. This is the only set of measurements performed at high pressures. It should also be noted that measurements from this group have previously successfully been employed in the development of thermal-conductivity reference correlations of xylenes and ethylbenzene [16], benzene [10], and sulfur hexafluoride [5]. Hence this set of measurements was included in the primary data set. Concentric-cylinders instruments were also employed by Ganiev [30], Rastorguev and Gazduev [31], and Slawewski and Molsted [32], with corresponding uncertainties 1.0, 1.5, and 0.8 %. These were also included in the primary data set.

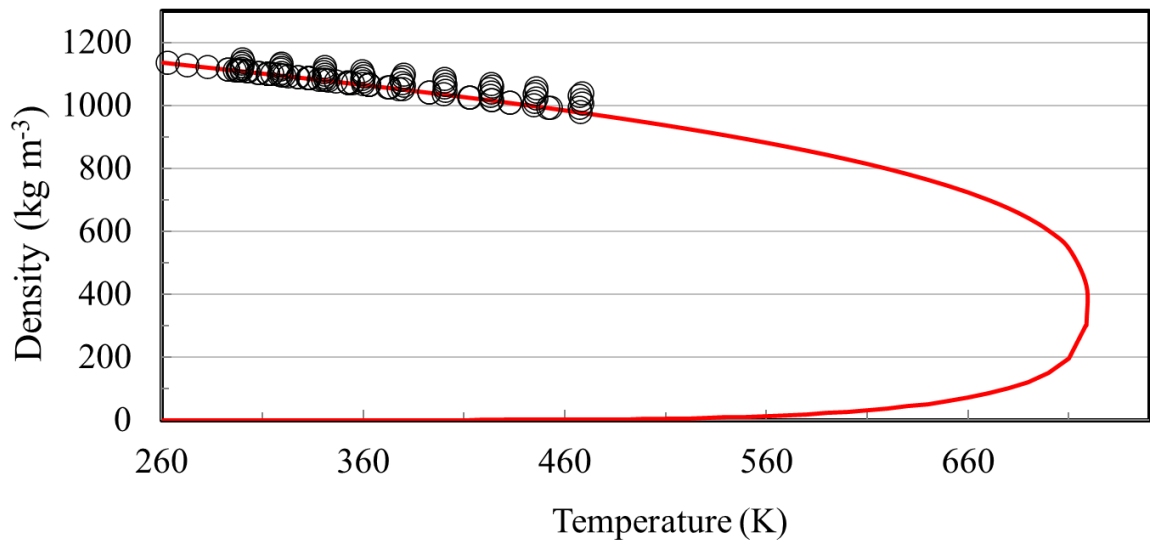
The secondary data set included the remaining measurements, performed a) in THW instruments with thicker wires, b) in instruments like concentric spheres or horizontal rotating cylinders that do not produce the most accurate measurements, c) in instruments that quote no uncertainty or higher than 2 % uncertainty.

Figures 1 and 2 show the ranges of the primary measurements outlined in Table 1, and the phase boundary. The lack of data in the vapor phase, near the critical temperature, and in the supercritical region is apparent. The development of the correlation requires densities; Zhou and Lemmon [63] developed an accurate, wide-ranging equation of state that is valid from the triple point up to 750 K and 100 MPa. It is available in REFPROP [1] but is not yet published. The equation of state has an uncertainty in density [63] of 0.15% in the liquid phase from (260 to 360) K with pressures to 100 MPa, 0.3% in the liquid phase at pressures above 100 MPa and for all liquid states between (360 to 400) K, and increase to 1% at higher temperatures, although the values above 400 K are not fully known due to

a lack of high-temperature experimental data. Uncertainties in density in the vapor phase are also not known. We adopt the values for the critical point from their equation of state; the critical temperature,  $T_c$ , and the critical density,  $\rho_c$ , are 719.0 K and 364.959 kg m<sup>-3</sup>, respectively. We also adopt the value they used for the triple-point temperature, 260.6 K.



**FIG. 1** Temperature-pressure ranges of the primary experimental thermal conductivity data for ethane-1,2-diol. (—) saturation curve.



**FIG. 2** Temperature-density ranges of the primary experimental thermal conductivity data for ethane-1,2-diol. (—) saturation curve.

## 2.1 The dilute-gas limit

The dilute-gas-limit thermal conductivity,  $\lambda_0(T)$  in  $\text{mW m}^{-1} \text{K}^{-1}$ , can be analyzed independently of all other contributions in Eq. 1. As there are no measurements in the vapor phase, a theoretically based scheme was used to provide estimated data for the dilute-gas-limit thermal conductivity,  $\lambda_0(T)$ , over a wide temperature range. This same scheme was successfully adopted in the case of the dilute-gas-limit thermal conductivity correlation of normal and parahydrogen [4], sulfur hexafluoride [5], toluene [9], benzene [10], and *n*-hexane [61]. A reasonable estimate of the thermal conductivity,  $\lambda_0(T)$ , of a pure dilute gas may be obtained from the viscosity,  $\eta_0(T)$ , and the ideal-gas heat capacity at constant volume,  $C_{v0}$ , through the modified Eucken correlation [64],

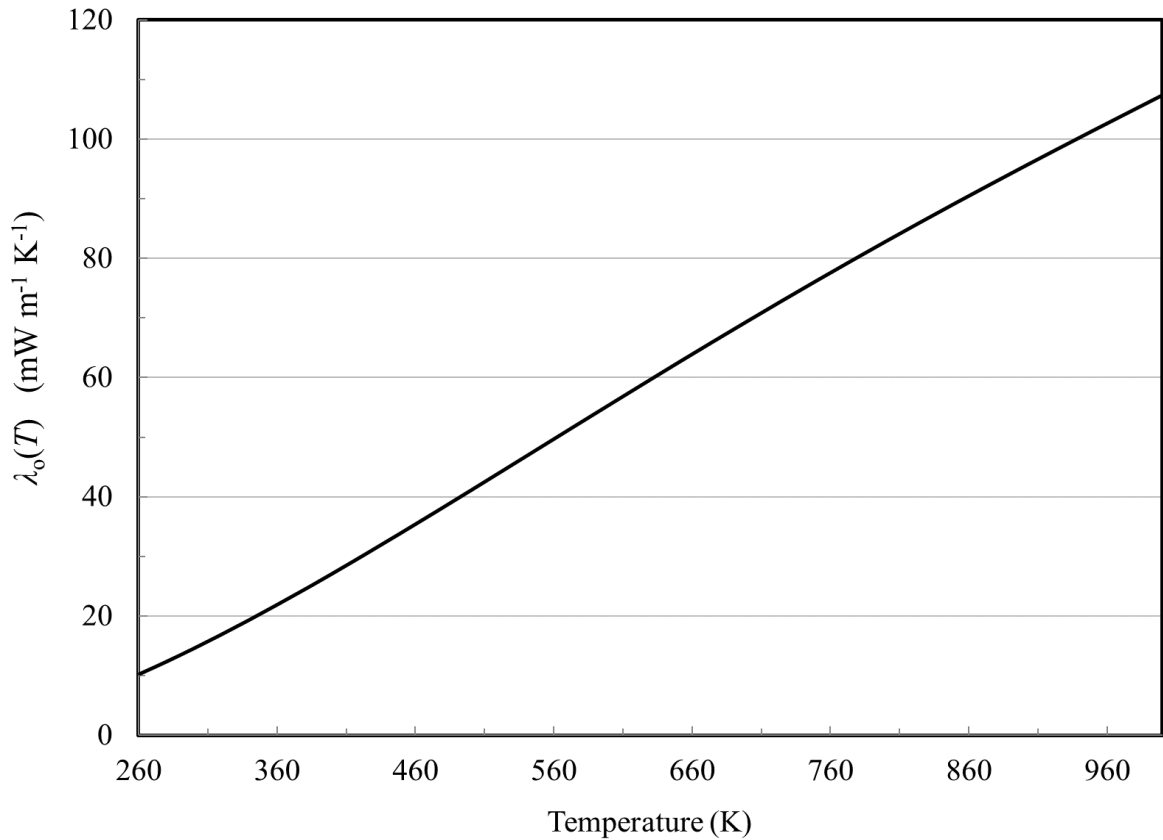
$$f_{\text{Eu}} = \frac{\lambda_0(T) M}{\eta_0(T) C_{v0}} = 1.32 + 1.77 \left( \frac{R}{C_{v0}} \right). \quad (2)$$

In the above equation,  $M$  represents the molar mass of ethane-1,2-diol ( $62.06784 \text{ g mol}^{-1}$ ) [63], and  $R$  the universal gas constant ( $8.314 462 618 \text{ J mol}^{-1} \text{K}^{-1}$ ) [65]

To calculate the dilute-gas thermal conductivity,  $\lambda_0(T)$ , from Eq. 2, we employed the values of the dilute-gas viscosity,  $\eta_0(T)$ , from a recently published correlation [3], and the  $C_{v0}$  values from the equation of state of Zhou and Lemmon [63]. The resulting values were fitted to a 4<sup>th</sup>-degree polynomial as a function of the reduced temperature,  $T_r = T/T_c$ , as

$$\lambda_0(T) (\text{mW m}^{-1} \text{K}^{-1}) = 32.40568T_r^4 - 142.01157T_r^3 + 212.14796T_r^2 - 29.94381T_r - 0.59047. \quad (3)$$

This equation represents the calculated values in the temperature range from the triple point to 1000 K to within 0.8 %. However, as the values of the dilute-gas viscosity are from estimation and have a 15 % uncertainty, the thermal conductivity values obtained from Eq. 3 have an estimated uncertainty of about 20 %. Figure 3 shows the dilute-gas thermal conductivity calculated from Eq. 3, as a function of the temperature.



**FIG. 3** Dilute-gas thermal conductivity calculated from Eq. 3, as a function of the temperature.

## 2.2 The residual term

The thermal conductivities of pure fluids exhibit an enhancement over a large range of densities and temperatures around the critical point and become infinite at the critical point. This behavior can be described by models that produce a smooth crossover from the singular behavior of the thermal conductivity asymptotically close to the critical point to the background values far away from the critical point [66, 67]. The density-dependent terms for thermal conductivity can be grouped according to Eq. 1 as  $[\Delta\lambda(\rho, T) + \Delta\lambda_c(\rho, T)]$ . To assess the critical enhancement theoretically, we need to evaluate, in addition to the dilute-gas thermal conductivity, the residual thermal-conductivity contribution. The procedure adopted during this analysis used ODRPACK [68] to fit all the primary data simultaneously to the residual thermal conductivity and the critical enhancement term as described in the next section, while maintaining the values of the dilute-gas thermal conductivity already obtained. As mentioned earlier, the density values employed were obtained from the equation of state of Zhou and Lemmon [63]. The primary data were weighted in inverse proportion to the square of their uncertainty.

The residual thermal conductivity,  $\Delta\lambda(\rho, T)$  was represented with a polynomial in temperature and density:

$$\Delta\lambda(\rho, T) \text{ (mW m}^{-1} \text{ K}^{-1}\text{)} = 1000 \sum_{i=1}^5 [(B_{1,i} + B_{2,i}(T/T_c))(\rho/\rho_c)^i]. \quad (4)$$

Coefficients  $B_{1,i}$  and  $B_{2,i}$  are shown in Table 2.

**Table 2** Coefficients of Eq. 4 for the residual thermal conductivity of ethane-1,2-diol.

$i$	$B_{1,i}$ (mW m <sup>-1</sup> K <sup>-1</sup> )	$B_{2,i}$ (mW m <sup>-1</sup> K <sup>-1</sup> )
1	$-7.569\ 160 \times 10^{-2}$	$1.013\ 690 \times 10^{-1}$
2	$5.117180 \times 10^{-1}$	$-4.435\ 490 \times 10^{-1}$
3	$-5.127\ 560 \times 10^{-1}$	$4.196\ 610 \times 10^{-1}$
4	$1.858\ 730 \times 10^{-1}$	$-1.358\ 010 \times 10^{-1}$
5	$-2.240\ 910 \times 10^{-2}$	$1.467\ 970 \times 10^{-2}$

### 2.3 The critical enhancement term

The theoretically based crossover model proposed by Sengers and coworkers [66, 67] is complex and requires solution of a quartic system of equations in terms of complex variables. A simplified crossover model has been proposed by Olchoway and Sengers [69]. The critical enhancement of the thermal conductivity from this simplified model is given by

$$\Delta\lambda_c = \frac{\rho C_p R_D k_B T}{6\pi\eta\xi} (\bar{\Omega} - \bar{\Omega}_0), \quad (5)$$

with

$$\bar{\Omega} = \frac{2}{\pi} \left[ \left( \frac{C_p - C_v}{C_p} \right) \arctan(\bar{q}_D \xi) + \frac{C_v}{C_p} \bar{q}_D \xi \right] \quad (6)$$

and

$$\bar{\Omega}_0 = \frac{2}{\pi} \left[ 1 - \exp\left( -\frac{1}{(\bar{q}_D \xi)^{-1} + (\bar{q}_D \xi \rho_c / \rho)^2 / 3} \right) \right]. \quad (7)$$

In Eqs. 5-7,  $\eta$  is the viscosity, and  $C_p$  and  $C_v$  are the isobaric and isochoric specific heat, respectively, obtained from the equation of state, and  $k_B$  is the Boltzmann constant, and  $p$  is the pressure. The correlation length,  $\xi$  (m), is given by:

$$\xi = \xi_0 \left( \frac{p_c \rho}{\Gamma \rho_c^2} \right)^{\nu/\gamma} \left[ \left. \frac{\partial \rho(T, \rho)}{\partial p} \right|_T - \left( \frac{T_{\text{ref}}}{T} \right) \left. \frac{\partial \rho(T_{\text{ref}}, \rho)}{\partial p} \right|_T \right]^{\nu/\gamma}. \quad (8)$$



As already mentioned, the coefficients  $B_{1,i}$  and  $B_{2,i}$  in Eq. 4 were fitted with ODRPACK [68] to the primary data for the thermal conductivity of ethane-1,2-diol. This crossover model requires the universal amplitude,  $R_D = 1.02$  (-), and the universal critical exponents,  $\nu = 0.63$  and  $\gamma = 1.239$ , as well as the system-dependent amplitudes  $\Gamma$  and  $\xi_0$ . For this work, we adopted the values  $\Gamma = 0.073$  (-) and  $\xi_0 = 0.166 \times 10^{-9}$  m, and cutoff wavelength  $q_D^{-1} = 0.542 \times 10^{-9}$  m found using the estimation method of Perkins et al. [70]. The viscosity required for Eq. 5 was obtained by the recent correlation of Mebelli et al. [3]. The reference temperature  $T_{\text{ref}}$ , far above the critical temperature where the critical enhancement is negligible, was calculated by  $T_{\text{ref}} = (3/2) T_c$  [71], which for ethane-1,2-diol is 1078.5 K. We note that since the critical temperature for ethylene glycol (719.0 K) is well above the upper limit of temperature for the present correlation (475 K), this term would only contribute when extrapolating the correlation outside of its range of validity.

### 3 Comparison with Data

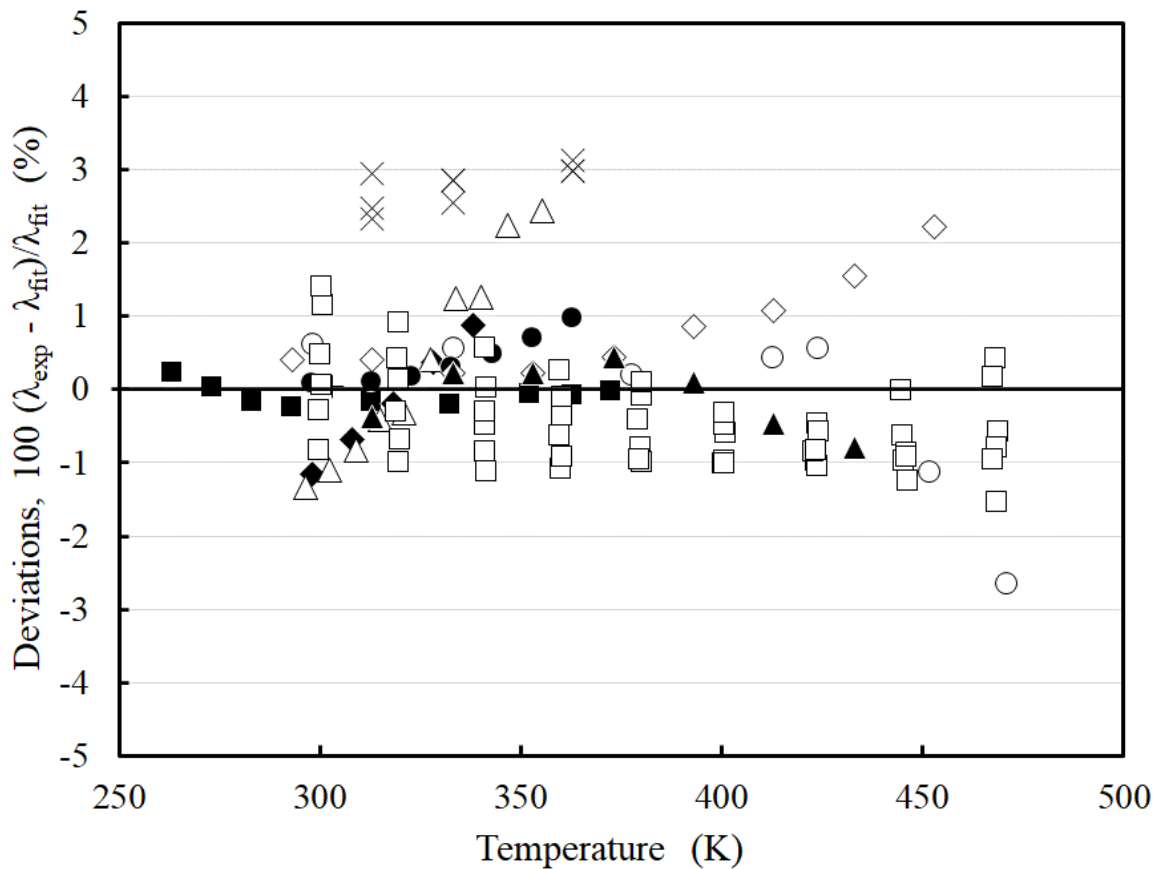
Table 3 summarizes comparisons of the primary data with the correlation. We have defined the percent deviation as  $\text{PCTDEV} = 100(\lambda_{\text{exp}} - \lambda_{\text{fit}})/\lambda_{\text{fit}}$ , where  $\lambda_{\text{exp}}$  is the experimental value of the thermal conductivity and  $\lambda_{\text{fit}}$  is the value calculated from the correlation. Thus, the average absolute percent deviation (AAD) is found with the expression  $\text{AAD} = (\sum |\text{PCTDEV}|)/n$ , where the summation is over all  $n$  points, the bias percent is found with the expression  $\text{BIAS} = (\sum \text{PCTDEV})/n$ . The average absolute percentage deviation of the fit for all primary data is 0.80 %, with a bias of 0.12 %. The uncertainty of the correlation from the triple point up to 475 K and 100 MPa is estimated at 2.2 % (at the 95% confidence level). Table 4 shows the average absolute percent deviation (AAD) and the bias for the secondary data.

**Table 3** Evaluation of ethane-1,2-diol's thermal-conductivity correlation for the primary data.

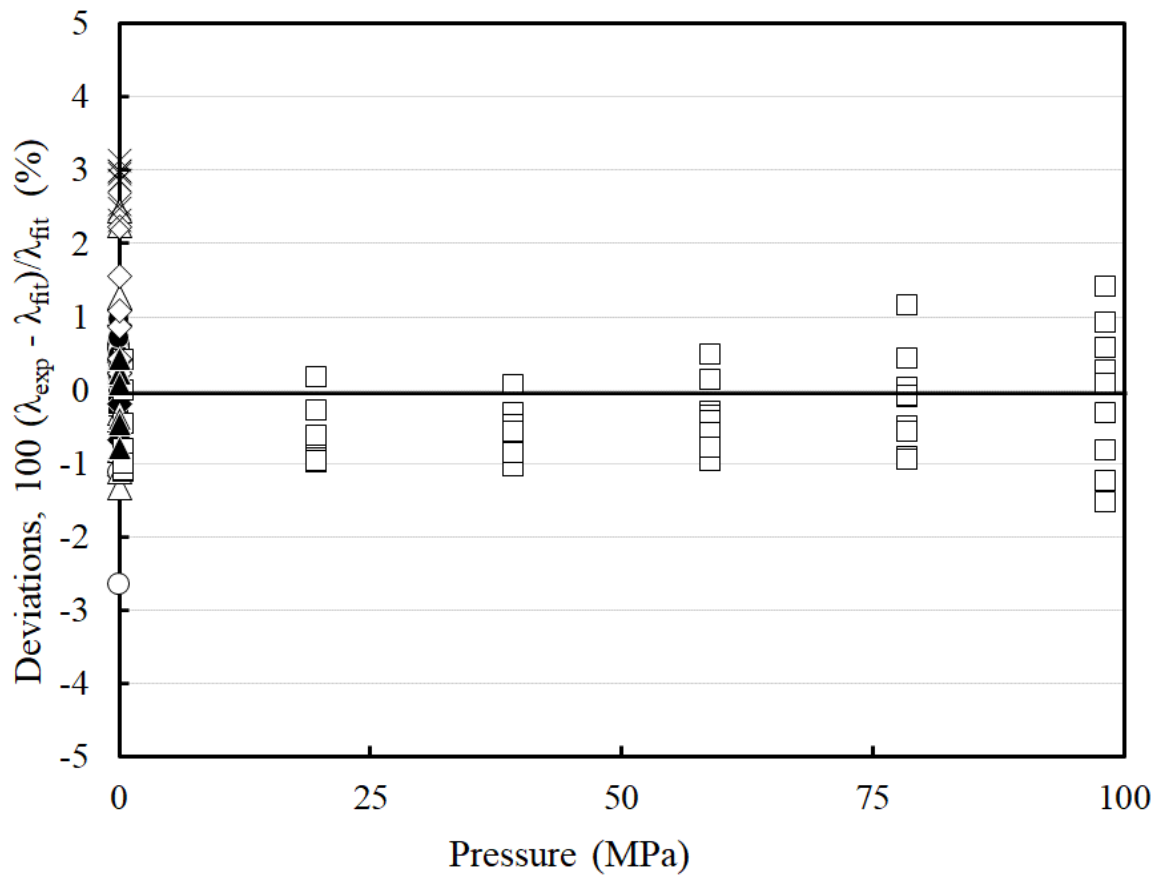
Authors	Year Publ.	AAD (%)	BIAS (%)
Deng et al. [23]	2021	0.14	-0.08
Khayet et al. [24]	2005	0.66	-0.16
Cai et al. [25]	1993	0.04	0.04
DiGuillo and Teja [26]	1990	0.88	0.20
Assael et al. [27]	1989	1.16	0.36
Bogacheva et al. [28]	1980	0.40	0.40
Rastorguev and Gazduev [31]	1978	0.67	-0.44
Rastorguev et al. [29]	1969	0.83	0.83
Ganiev [30]	1969	0.37	-0.09

Slawecki and Molstad [32]	1956	2.79	2.79
<b>Entire data set</b>		<b>0.80</b>	<b>0.12</b>

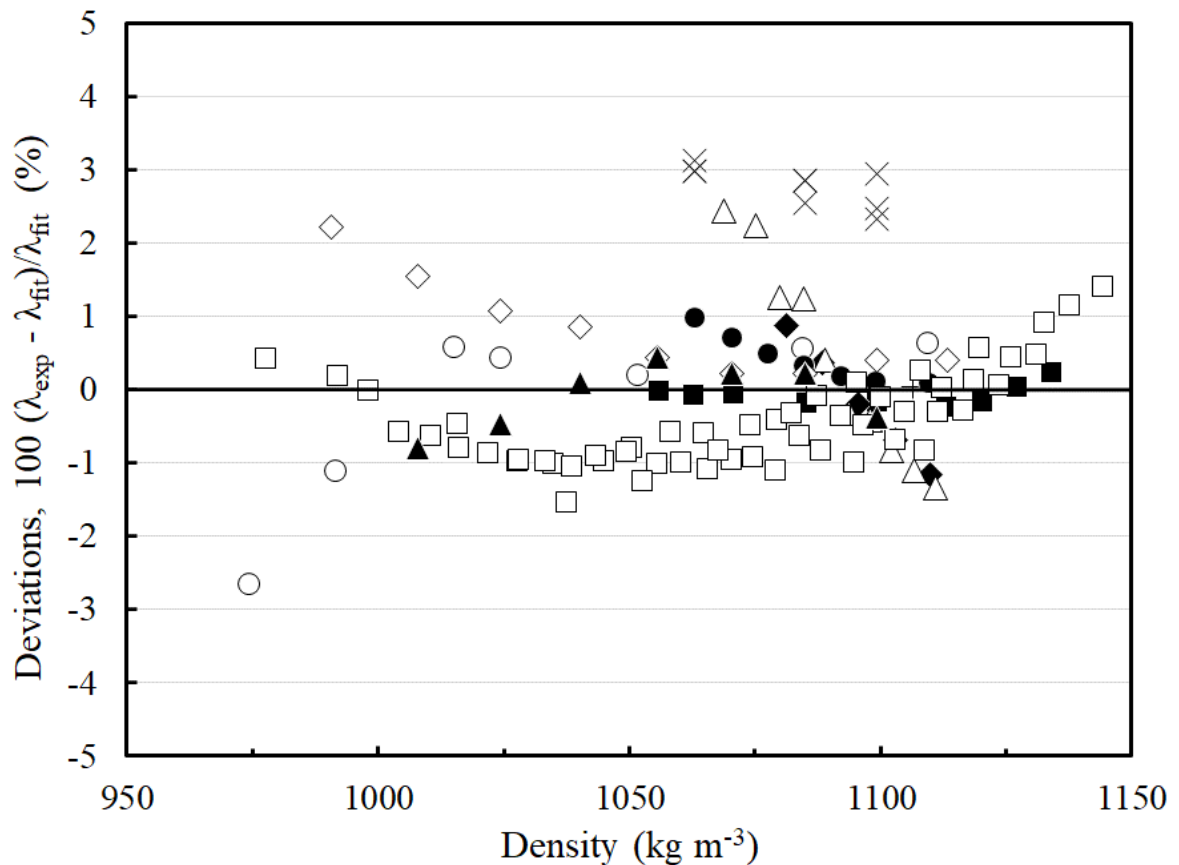
Figure 4 shows the percentage deviations of all primary thermal-conductivity data of ethane-1,2-diol from the developed correlation, as a function of temperature, while Figs. 5 and 6 present the same deviations, but as a function of pressure and density, respectively. Ethane-1,2-diol would benefit from additional high-pressure measurements, as currently the whole correlation is based on only one high-pressure set. Furthermore, there are no vapor-phase measurements at all. The availability of vapor-phase measurements would assist in better understanding of the gas-phase behavior of glycols.



**FIG. 4** Percentage deviations of primary experimental data of the thermal conductivity of ethane-1,2-diol from the values calculated by the present model, as a function of temperature. Deng et al. [23] (■), Khayet et al. [24] (◆), Cai et al. [25] (+), DiGuillo and Teja [26] (○), Assael et al. [27] (△), Bogacheva et al. [28] (●), Rastorguev et al. [29] (□), Ganiev [30] (◇), Rastorguev and Gazduev [31] (▲), Slawecki and Molstad [32] (×).



**FIG. 5** Percentage deviations of primary experimental data of the thermal conductivity of ethane-1,2-diol from the values calculated by the present model, as a function of pressure. Deng et al. [23] (■), Khayet et al. [24] (◆), Cai et al. [25] (+), DiGuillo and Teja [26] (○), Assael et al. [27] (Δ), Bogacheva et al. [28] (●), Rastorguev et al. [29] (□), Ganiev [30] (◇), Rastorguev and Gazduev [31] (▲), Slawewski and Molstad [32] (×).

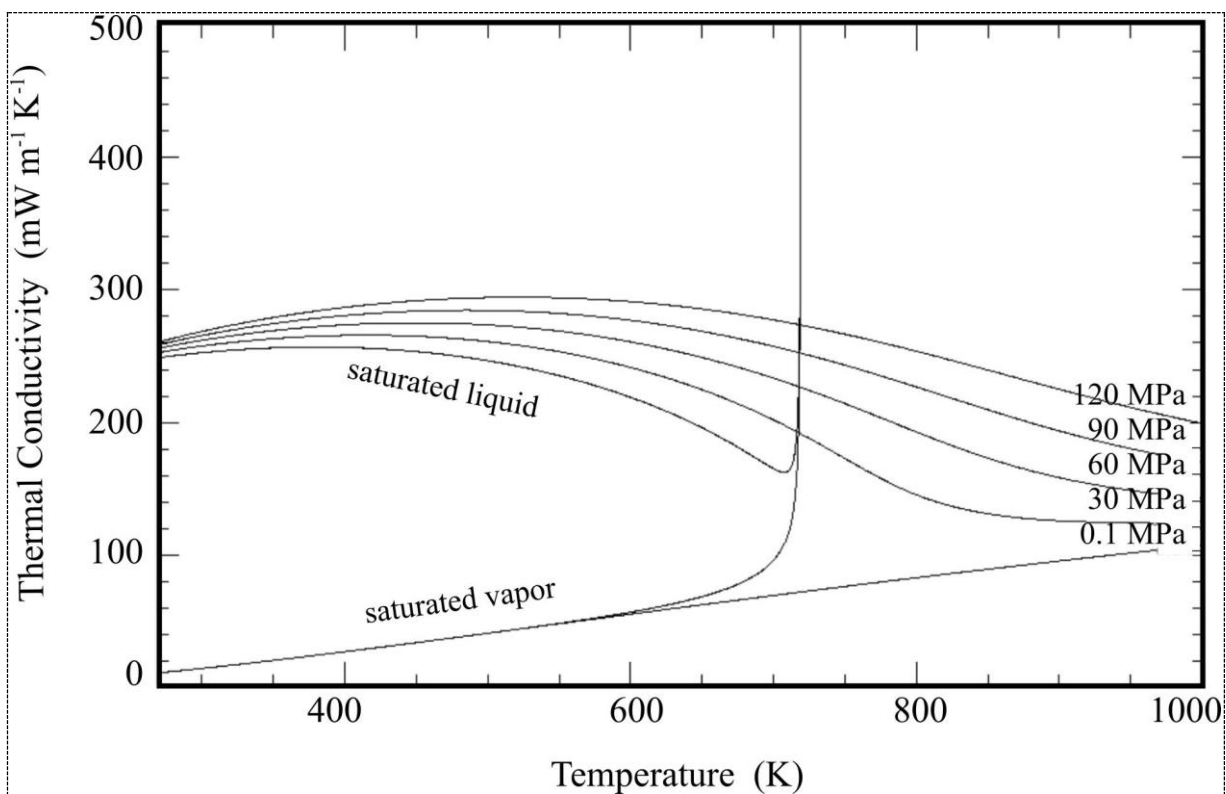


**FIG.6** Percentage deviations of primary experimental data of the thermal conductivity of ethane-1,2-diol from the values calculated by the present model, as a function of density. Deng et al. [23] (■), Khayet et al. [24] (◆), Cai et al. [25] (+), DiGuillo and Teja [26] (○), Assael et al. [27] (△), Bogacheva et al. [28] (●), Rastorguev et al. [29] (□), Ganiev [30] (◇), Rastorguev and Gazduev [31] (▲), Slawecki and Molstad [32] (×).

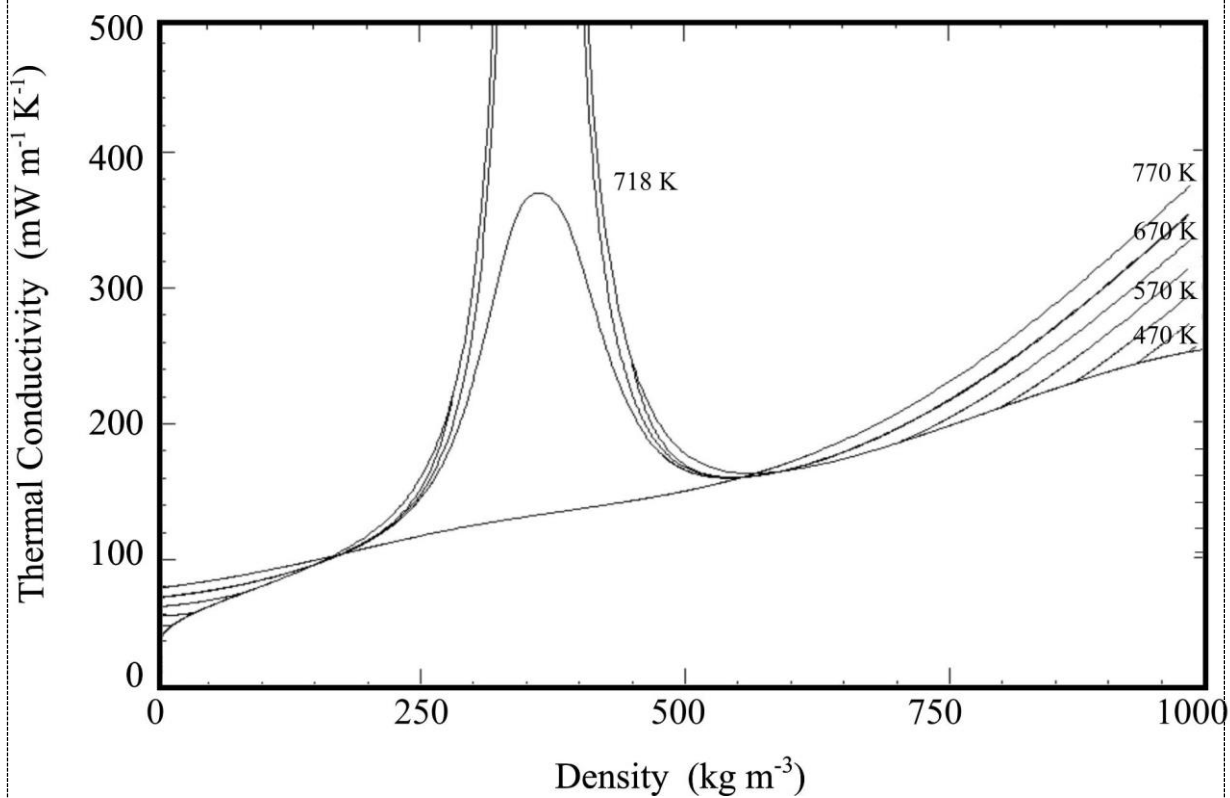
Figure 7 shows the plot of the thermal conductivity of ethane-1,2-diol as a function of temperature for different pressures as well as the saturated liquid and vapor values. The liquid isobars show the unusual behavior of passing through a maximum. This was noted by DiGuillo and Teja [26] and thought to be a characteristic of glycols, and not due to the onset of decomposition. We have seen this behavior in water [6] and heavy water as well. This plot also demonstrates the extrapolation behavior of the thermal conductivity correlation at temperatures that extend above the 750 K limit of the equation of state, and also to pressures higher than 100 MPa. Finally, the plot of Fig. 8 shows the thermal conductivity of ethane-1,2-diol as a function of density for different temperatures, including the critical enhancement.

**Table 4** Evaluation of the ethane-1,2-diol thermal-conductivity correlation for the secondary data.

Authors	Year Publ.	AAD (%)	BIAS (%)
Aklu et al. [33]	2019	0.50	-0.25
Bedoya et al. [34]	2018	0.70	0.70
Guo et al.[35]	2018	0.78	0.78
Sati et al.[36]	2018	0.70	-0.55
Zyla and Fal [37]	2017	3.27	3.27
Selvam et al.[38]	2016	1.07	-1.07
Zyla and Fal [39]	2016	3.57	3.57
Cabaleiro et al. [40]	2015	2.89	0.58
Pastoriza-Gallego et al. [41]	2014	2.38	1.80
Alvarado et al. [42]	2011	0.01	0.01
Zhao et al. [43]	2007	1.96	1.96
Fischer [44]	1986	0.68	-0.38
Bohne [45]	1984	1.50	-1.50
Wang et al. [46]	1984	1.62	1.62
Grishchenko and Grishchenko [47]	1983	1.00	1.00
Usmanov and Salikhov [48]	1975	0.80	-0.80
Sadykov et al. [49]	1973	1.95	0.99
Filippov [50]	1968	4.78	4.64
Venart and Krishnamurthy [51]	1968	1.69	1.51
Vanderkooi et al. [52]	1967	2.87	2.87
Jamieson and Tudhope [53]	1964	2.80	2.80
Sakiadis and Coates [54]	1955	3.15	3.15
Woolf and Sibbitt [55]	1954	3.26	-3.26
Van der Held et al. [56]	1953	8.81	8.81
Riedel [57]	1951	1.75	1.75
Riedel [58]	1948	0.80	-0.80
Bates and Hazzard [59]	1945	8.04	-1.05
Goldschmidt [60]	1911	6.22	6.22



**FIG. 7** Thermal conductivity of ethane-1,2-diol as a function of temperature for selected pressures.



**FIG. 8** Thermal conductivity of ethane-1,2-diol as a function of density for selected temperatures.

#### 4. Recommended Values

In Table 5, thermal conductivity values are given along the saturation curve, calculated from the present correlation between (265 to 470) K, while in Table 6 thermal conductivity values are calculated from the present correlation for temperatures between 265 K and 450 K at selected pressures. Saturation pressure and saturation density values for selected temperatures, as well as the density values for the selected temperature and pressure, are obtained from the equation of state of Zhou and Lemmon [63]. For computer verification of values, the following points may be used for the given  $T$ ,  $\rho$  conditions:  $T = 350$  K,  $\rho = 0.0$  kg m<sup>-3</sup>,  $\lambda = 20.543$  mW m<sup>-1</sup> K<sup>-1</sup>;  $T = 350$  K,  $\rho = 1100.0$  kg m<sup>-3</sup>,  $\lambda = 269.60$  mW m<sup>-1</sup> K<sup>-1</sup>.

**Table 5** Thermal conductivity values of ethane-1,2-diol along the saturation line, calculated by the present correlation.

$T$ (K)	$p$ (MPa)	$\rho_{\text{liq}}$ (kg m <sup>-3</sup> )	$\rho_{\text{vap}}$ (kg m <sup>-3</sup> )	$\lambda_{\text{liq}}$ (mW m <sup>-1</sup> K <sup>-1</sup> )	$\lambda_{\text{vap}}$ (mW m <sup>-1</sup> K <sup>-1</sup> )
265	$4.0017 \times 10^{-7}$	1133.07	$1.1273 \times 10^{-5}$	248.22	10.68
290	$5.6273 \times 10^{-6}$	1115.54	$1.4486 \times 10^{-4}$	251.58	13.38
310	$3.2874 \times 10^{-5}$	1101.47	$7.9164 \times 10^{-4}$	253.66	15.67
330	$1.5010 \times 10^{-4}$	1087.23	$3.3956 \times 10^{-3}$	255.22	18.06
350	$5.6009 \times 10^{-4}$	1072.73	$1.1948 \times 10^{-2}$	256.27	20.54
370	$1.7685 \times 10^{-3}$	1057.89	$3.5694 \times 10^{-2}$	256.80	23.10
390	$4.8564 \times 10^{-3}$	1042.62	$9.3043 \times 10^{-2}$	256.81	25.72
410	$1.1857 \times 10^{-2}$	1026.84	$2.1631 \times 10^{-1}$	256.28	28.40
430	$2.6202 \times 10^{-2}$	1010.47	$4.5663 \times 10^{-1}$	255.19	31.13
450	$5.3184 \times 10^{-2}$	993.42	$8.8837 \times 10^{-1}$	253.52	33.90
470	$1.0037 \times 10^{-1}$	975.59	1.6128	251.24	36.70

**Table 6** Thermal conductivity values of ethane-1,2-diol at selected temperatures and pressures, calculated by the present correlation.

$p$ (MPa)	$T$ (K)	$\rho$ (kg m <sup>-3</sup> )	$\lambda$ (mW m <sup>-1</sup> K <sup>-1</sup> )	$p$ (MPa)	$T$ (K)	$\rho$ (kg m <sup>-3</sup> )	$\lambda$ (mW m <sup>-1</sup> K <sup>-1</sup> )
0.1	265	1133.10	248.24	75	265	1158.89	256.28
	300	1108.56	252.70		300	1136.87	263.90
	330	1087.28	255.24		330	1118.05	269.16
	360	1065.41	256.63		360	1098.99	273.34
	390	1042.67	256.84		390	1079.51	276.48
	420	1018.78	255.83		420	1059.46	278.60
	450	993.45	253.54		450	1038.71	279.70
25	265	1142.19	251.35	100	265	1166.59	258.15
	300	1118.59	256.93		300	1145.23	266.72
	330	1098.24	260.44		330	1127.04	272.78
	360	1077.45	262.83		360	1108.69	277.77
	390	1055.98	264.11		390	1090.02	281.74
	420	1033.62	264.25		420	1070.87	284.71
	450	1010.15	263.24		450	1051.16	286.72
50	265	1150.77	254.02				
	300	1128.01	260.65				
	330	1108.48	265.06				
	360	1088.61	268.38				
	390	1068.22	270.63				
	420	1047.11	271.81				
	450	1025.13	271.91				

## 5. Conclusions

A new wide-ranging correlation for the thermal conductivity of ethane-1,2-diol was developed based on critically evaluated experimental data and theoretical results. The dilute-gas limit thermal conductivity was developed by employing a modified Eucken relation [64], as there are no measurements in the vapor phase. However, as this expression is based on the dilute-gas viscosity that is estimated with a 15 % uncertainty [3], the thermal conductivity values obtained have an estimated uncertainty of about 20 %. The expanded uncertainty (at a 95 % confidence level) in thermal conductivity of the liquid phase from the triple point up to 475 K and pressures up to 100 MPa, is 2.2 %. The correlation extrapolates in a physically realistic manner at temperatures up to the 750 K limit of the equation of state. However, one should note that thermal decomposition has been noted at temperatures ~ 530 K [72]. Experimental measurements in the vapor phase, and at pressures above atmospheric are recommended to enable improved correlations in the future.



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