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A Helmholtz Free Energy Formulation of the Thermodynamic Properties of the Mixture {Water + Ammonia}

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A thermodynamic model incorporating a fundamental equation of state for the Helmholtz free energy of the mixture {water+ammonia} is presented which covers the thermodynamic space between the solid–liquid–vapor boundary and the critical locus. It is also valid in the vapor and liquid phases for pressures up to 40 MPa. It represents vapor–liquid equilibrium properties with an uncertainty of ±0.01 in liquid and vapor mole fractions. Typical uncertainties in the single-phase regions are ±0.3% for the density and ±200 J mol^{-1} for enthalpies. Details of the data selection and the optimization process are given. The behavior of the fundamental equation of state is discussed in all parts of the thermodynamic space. © *1998 American Institute of Physics and American Chemical Society.* [S0047-2689(98)00401-2]

Key words: ammonia-water, equation of state, Helmholtz free energy, thermodynamic properties.

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Nomenclature

a, Θ	coefficient
$\overline{A}$	molar Helmholtz free energy
$\overline{C}_p$	molar isobaric heat capacity
$\overline{C}_v$	molar isochoric heat capacity
$\overline{G}$	molar Gibbs free energy
$\overline{H}$	molar enthalpy
K	distribution coefficient
k_T, k_V	factors
M	molar mass
p	pressure
R_m	universal gas constant
s	uncertainty
S	sum of squares
$\overline{S}$	molar entropy
T	temperature
$\overline{u}$	molar internal energy
$\overline{V}$	molar volume
w	speed of sound
x	liquid or overall mole fraction of ammonia
y	vapor mole fraction of ammonia
Y	thermodynamic property
Z	compressibility factor
α, β, γ, t_i, d_i, e_i	exponents
φ_i	fugacity coefficient of component i
Φ	reduced Helmholtz free energy
δ	inverse reduced volume or reduced density
ϑ	reduced temperature
ξ	mass fraction
ϱ	molar density
τ	inverse reduced temperature

Subscripts

c	critical point parameter
n	reducing quantity
01	pure component 1 (water)
02	pure component 2 (ammonia)
$0i$	pure component i
tr	triple point parameter

Superscripts

$\circ$	ideal gas
E	excess
r	residual
$'$	saturated liquid
$''$	saturated vapor

1. Introduction

The mixture {water+ammonia} is an important working fluid in absorption–refrigeration cycles. Recently, this mixture has also been considered as a working fluid in future power generation plants based on the Kalina cycle[1]. For design and simulation of such machinery, an accurate description of the thermodynamic properties of the mixture {water +ammonia} for a wide range of pressure, temperature, and composition is needed.

Several thermodynamic models have been published in the past. Old sources correlate experimental data by graphical methods (Kracek,[2] Scatchard *et al.*[3]) and report tables for saturation properties. A recent source of tables which is widely used today is the work of Macriss *et al.*[4] from the Institute of Gas Technology (IGT). These tables cover the range up to 5 MPa for vapor–liquid equilibrium (VLE) and single-phase properties.

An early wide-ranging equation of state was developed by Schulz[5] in 1971. His model consists of two separate equations for the Gibbs free energy $G=G(p,T,x)$ of the vapor and of the liquid phases for pressures up to 2.5 MPa. Ziegler and Trepp[6] extended this model to pressures up to 5 MPa. A very recent modification reported by Ibrahim and Klein[7] is valid for temperatures above 230 K and pressures up to 11 MPa.

In addition to the Gibbs free energy models, numerous other approaches are found in the literature. A Benedict–Webb–Rubin (BWR)-type equation of state similar to that used by Lee and Kesler[8] is presented by Park and Sonntag.[9] They chose this model because of its capability to predict properties of {water+ammonia} up to 20 MPa and 650 K, where experimental data are scarce for the VLE and virtually nonexistent for other properties. El-Sayed and Tribus,[10] for example, took the approach of establishing separate equations for different properties which were then combined in cycle calculations. Ammonia–water mixtures can also be treated as weak electrolyte solutions based on the work of Edwards *et al.*[11] Such an approach is given by Kurz[12] for example. It yields good results for the VLE at low and moderate temperatures and pressures.

There are several other models reported in the literature,[13–17] but most of them are applicable only in a restricted range or allow calculation of only a limited number of thermodynamic properties of {water+ammonia}. None of these models, however, has been fitted to new measurements in the single- and two-phase regions. Most of the models available so far are based on a limited set of experimental data, and it is sometimes unclear whether the selection of data resulted from a comprehensive analysis. Furthermore, correlations for {water+ammonia} often use tabulated values, such as those published by Macriss *et al.*[4] or by Scatchard *et al.*,[3] rather than original experimental data. No correlation based on the results of a thorough data analysis could be found.

In this work, a fundamental equation of state for the Helmholtz free energy of {water+ammonia} is developed according to the approach of Tillner-Roth.[18] The equation incorporates accurate wide-ranging equations of state for the pure components and describes the entire thermodynamic space of the mixture by a single mathematical expression. All thermodynamic properties can be calculated from this model and, therefore, all types of measurements of thermodynamic properties can be used as input data during the optimization process.

Prior to the development of this correlation, data available in the literature were compiled. Simultaneously with the development of the new equation of state, all experimental data were evaluated and the most consistent data were identified. The results of the data compilation and analysis are described separately by Tillner-Roth and Friend.[19]

2. The Fundamental Equation of State

A fundamental equation of state for the Helmholtz free energy $A=U-TS$ for a binary mixture has been developed by Tillner-Roth.[18] It is written in terms of the reduced Helmholtz free energy as

$$\frac{\overline{A}}{R_m T}=\Phi=\Phi^\circ(\tau^\circ,\delta^\circ,x)+\Phi^{\mathrm{r}}(\tau,\delta,x). \tag{1}$$

Φ is split into an ideal part Φ°, depending on the dimensionless variables $\tau^\circ=T_n^\circ/T$, $\delta^\circ=\overline{V_n^\circ}/\overline{V}$, and mole fraction x of ammonia, and a residual part Φ^{r}, depending on $\tau=T_n/T$, $\delta=\overline{V_n}/\overline{V}$, and x. In Eq. (1), $\overline{A}$ is the molar Helmholtz free energy and $R_m=8.314471\ \mathrm{J\ mol^{-1}\ K^{-1}}$ is the universal gas constant given by Moldover *et al.*[20]

Pure fluid equations of state in terms of the dimensionless Helmholtz free energy form the basis of this model. For water, the fundamental equation of state developed by Pruβ and Wagner[21] is used, which was adopted as the IAPWS Formulation in 1995 for the thermodynamic properties of ordinary water substance for general and scientific use by the International Association for the Properties of Water and Steam. For ammonia, the fundamental equation of state developed by Tillner-Roth *et al.*[22] is used. Both formulations are given in terms of $\Phi(\tau,\delta)$ and are based on the current temperature scale (ITS-90).

2.1. Ideal-Gas Properties

Ideal-gas properties of {water+ammonia} are represented by the ideal-gas part Φ° which is derived from the ideal-gas parts Φ_{01}° and Φ_{02}° of the water and ammonia equations of state. They are combined at constant T and constant $\overline{V}$ according to

$$\Phi^\circ(T,\overline{V},x)=(1-x)\Phi_{01}^\circ(T,\overline{V})+x\Phi_{02}^\circ(T,\overline{V})+(1-x)\ln(1-x)+x\ \ln x. \tag{2}$$

The last two terms result from the entropy of mixing of the ideal-gas mixture. Because Eq. (2) is evaluated at fixed T and $\overline{V}$, the dimensionless variables $\tau_{0i}=T_{n,0i}/T$ and $\delta_{0i}=\overline{V_{n,0i}}/\overline{V}$ used to evaluate the ideal-gas function for the pure components Φ_{0i}° are different due to different reducing parameters $T_{n,0i}$ and $\overline{V_{n,0i}}$ used in the pure fluid equations:

$$\Phi^\circ(T,\overline{V},x)=(1-x)\Phi_{01}^\circ(\tau_{01},\delta_{01})+x\Phi_{02}^\circ(\tau_{02},\delta_{02})+(1-x)\ln(1-x)+x\ \ln x. \tag{3}$$

For convenience, uniform variables,

$$\tau^\circ=T_n^\circ/T \quad \text{and} \quad \delta^\circ=\overline{V_n^\circ}/\overline{V}, \tag{4}$$

are introduced. Consequently, the coefficients of the pure fluid ideal-gas functions are transformed, and the ideal-gas function is written as

$$\Phi^\circ(\tau^\circ,\delta^\circ,x)=\ln\delta^\circ+(1-x)\left[a_1^\circ+a_2^\circ\,\tau^\circ+a_3^\circ\ln\tau^\circ+\ln(1-x)+\sum_{i=4}^{8}a_i^\circ\ln[1-\exp(-\theta_i\tau^\circ)]\right]+x\left[a_9^\circ+a_{10}^\circ\,\tau^\circ+a_{11}^\circ\ \ln\tau^\circ+\ln x+\sum_{i=12}^{14}a_i^\circ\,(\tau^\circ)^{t_i}\right]. \tag{5}$$

$T_n^\circ=500$ K and $1/\overline{V_n^\circ}=15\,000\ \mathrm{mol\ m^{-3}}$ were chosen arbitrarily. The coefficients for Eq. (5) are given in Table 1. They differ from the original coefficients[21,22] because of the variable transformation.

TABLE 1. Coefficients of the ideal-gas part of the Helmholtz free energy, Eq. (5)

i	a_i°	θ_i	i	a_i°	t_i
1	−7.720 435	–	9	−16.444 285	–
2	8.649 358	–	10	4.036 946	–
3	3.006 32	–	11	−1.0	–
4	0.012 436	1.666	12	10.699 55	1/3
5	0.973 15	4.578	13	−1.775 436	−3/2
6	1.279 50	10.018	14	0.823 740 34	−7/4
7	0.969 56	11.964			
8	0.248 73	35.600			

The reference values for enthalpy (or internal energy) and entropy of the mixture equation of state (EOS) are fixed because of preset reference values of the pure fluid equation of state. They can be changed by changing the coefficients a_1° and a_2°, which correspond to the water EOS, and a_9° and a_{10}° related to the ammonia equation of state. However, this would change the enthalpy and entropy values of the pure fluid equations of state as well. In the present work it has been chosen to set

$$u'=0 \quad \text{and} \quad s'=0$$

for saturated liquid at the triple-point temperatures of both pure components, 273.16 K for water and 195.495 K for ammonia.

TABLE 2. Coefficients of the reducing functions, Eqs. (9) and (10), and the departure function, Eq. (13)

Equation of state constants

water	ammonia
$T_{c,01}=647.096$ K	$T_{c,02}=405.40$ K
$\varrho_{c,01}=322$ kg m^{-3}	$\varrho_{c,02}=225$ kg m^{-3}
$p_{c,01}=22.064$ MPa	$p_{c,02}=11.36$ MPa
$M_1=0.018\,015\,268$ kg mol^{-1}	$M_2=0.017\,030\,26$ kg mol^{-1}

Reducing functions

$k_V=1.239\,5117$, $k_T=0.964\,8407$, $\alpha=1.125\,455$, $\beta=0.897\,8069$

Departure function

$\gamma=0.524\,8379$

i	a_i	t_i	d_i	e_i	i	a_i	t_i	d_i	e_i
1	−1.855 822E-02	3/2	4	–	8	−1.368 072E-08	4	15	1
2	5.258 010E-02	1/2	5	1	9	1.226 146E-02	7/2	4	1
3	3.552 874E-10	13/2	15	1	10	−7.181 443E-02	0	5	1
4	5.451 379E-06	7/4	12	1	11	9.970 849E-02	−1	6	2
5	−5.998 546E-13	15	12	1	12	1.058 4086E-03	8	10	2
6	−3.687 808E-06	6	15	2	13	−0.196 3687	15/2	6	2
7	0.258 6192	−1	4	1	14	−0.777 7897	4	2	2

2.2. The Residual Part of the Helmholtz Free Energy

The residual part Φ^{r} has the form

$$\Phi^{\mathrm{r}}(\tau,\delta,x)=(1-x)\Phi^{\mathrm{r}}_{01}(\tau,\delta)+x\Phi^{\mathrm{r}}_{02}(\tau,\delta)+\Delta\Phi^{\mathrm{r}}(\tau,\delta,x). \tag{6}$$

Φ^{r}_{01} and Φ^{r}_{02} are the residual contributions of the water and the ammonia equations of state given by Pruβ and Wagner[21] and Tillner-Roth *et al.*[22] They are combined at constant reduced variables τ and δ. An empirical departure function $\Delta\Phi^{\mathrm{r}}$ is needed to describe the thermodynamic properties of {water+ammonia} accurately. It is evaluated at the same reduced variables τ and δ as the residual parts of the pure fluids.

To ensure that the mixture model is valid also for the pure components, τ and δ are functions of composition,

$$\tau(x)=\frac{T_n(x)}{T}\quad\text{and}\quad\delta(x)=\frac{\overline{V_n}(x)}{\overline{V}}, \tag{7}$$

and they must fulfill the conditions

$$x\to0:\ T_n(x)\to T_{c,01}\quad\text{and}\quad\overline{V_n}(x)\to\overline{V}_{c,01},$$
$$x\to1:\ T_n(x)\to T_{c,02}\quad\text{and}\quad\overline{V_n}(x)\to\overline{V}_{c,02}. \tag{8}$$

For the functions $T_n(x)$ and $\overline{V_n}(x)$, the expressions

$$T_n(x)=(1-x)^2T_{c,01}+x^2T_{c,02}+2x(1-x^{\alpha})T_{c,12} \tag{9}$$

and

$$\overline{V_n}(x)=(1-x)^2\overline{V}_{c,01}+x^2\overline{V}_{c,02}+2x(1-x^{\beta})\overline{V}_{c,12} \tag{10}$$

are used where

$$T_{c,12}=k_T\,\tfrac{1}{2}(T_{c,01}+T_{c,02}) \tag{11}$$

and

$$\overline{V}_{c,12}=k_V\,\tfrac{1}{2}(\overline{V}_{c,01}+\overline{V}_{c,02}). \tag{12}$$

The reducing functions contain a total of four adjustable parameters α, β, k_T and k_V which have to be fitted to experimental data. The values are listed in Table 2. For the reducing constants of the pure fluids their critical parameters are used as listed also in Table 2.

For the departure function $\Delta\Phi^{\mathrm{r}}$, the following expression has been developed:

$$\frac{\Delta\Phi^{\mathrm{r}}(\tau,\delta,x)}{x(1-x^{\gamma})}=a_1\tau^{t_1}\delta^{d_1}+\sum_{i=2}^{6}a_i\exp(-\delta^{e_i})\tau^{t_i}\delta^{d_i}+x\sum_{i=7}^{13}a_i\exp(-\delta^{e_i})\tau^{t_i}\delta^{d_i}+a_{14}x^2\exp(-\delta^{e_{14}})\tau^{t_{14}}\delta^{d_{14}}. \tag{13}$$

The optimization process and the formulation of the equation of state are described in Section 4. Coefficients and exponents are listed in Table 2. Relations between thermodynamic properties and the fundamental equation of state are summarized in Table 3.

3. The Database

During the last 150 years, numerous experimental studies on the thermodynamic properties of {water+ammonia} were carried out. Available experimental data are summarized by Tillner-Roth and Friend.[19] The majority of measurements is concerned with VLE properties such as (p,T,x), (p,T,x,y), or (p,T,y) data. Few sources report single-phase measurements. Since the accuracy of VLE data varies strongly among different sources, an assessment of all these measurements is essential in order to determine the most reliable data. Furthermore, the selected VLE data have to be thermodynamically consistent with available single-phase data to allow the formulation of an accurate equation of state.

TABLE 3. Relations between the reduced Helmholtz free energy and thermodynamic properties

Compressibility factor Z	$\frac{p(\tau,\delta,x)\overline{V}}{R_m T}=1+\delta\Phi^{\mathrm{r}}_{\delta}$
Molar internal energy	$\frac{\overline{U}(\tau,\delta,\tau^\circ,\delta^\circ,x)}{R_m T}=\tau^\circ\Phi^\circ_{\tau^\circ}+\tau\Phi^{\mathrm{r}}_{\tau}$
Molar enthalpy	$\frac{\overline{H}(\tau,\delta,\tau^\circ,\delta^\circ,x)}{R_m T}=1+\delta\Phi^{\mathrm{r}}_{\delta}+\tau^\circ\Phi^\circ_{\tau^\circ}+\tau\Phi^{\mathrm{r}}_{\tau}$
Molar entropy	$\frac{\overline{S}(\tau,\delta,\tau^\circ,\delta^\circ,x)}{R_m}=\tau^\circ\Phi^\circ_{\tau^\circ}+\tau\Phi^{\mathrm{r}}_{\tau}-\Phi^\circ-\Phi^{\mathrm{r}}$
Molar isochoric heat capacity	$\frac{\overline{C_v}(\tau,\delta,\tau^\circ,\delta^\circ,x)}{R_m}=-\tau^{\circ 2}\Phi^\circ_{\tau^\circ\tau^\circ}-\tau^2\Phi^{\mathrm{r}}_{\tau\tau}$
Molar isobaric heat capacity	$\frac{\overline{C_p}(\tau,\delta,\tau^\circ,\delta^\circ,x)}{R_m}=\frac{\overline{C_v}}{R_m}+\frac{(1+\delta\Phi^{\mathrm{r}}_{\delta}-\delta\tau\Phi^{\mathrm{r}}_{\delta\tau})^2}{1+2\delta\Phi^{\mathrm{r}}_{\delta}+\delta^2\Phi^{\mathrm{r}}_{\delta\delta}}$
Speed of sound	$\frac{w^2(\tau,\delta,\tau^\circ,\delta^\circ,x)M}{R_m T}=1+2\delta\Phi^{\mathrm{r}}_{\delta}+\delta^2\Phi^{\mathrm{r}}_{\delta\delta}+\frac{(1+\delta\Phi^{\mathrm{r}}_{\delta}-\delta\tau\Phi^{\mathrm{r}}_{\delta\tau})^2}{(\overline{C_v}/R_m)}$
Fugacity coefficients	$\ln[Z\varphi_1(\tau,\delta,x)]=\Phi^{\mathrm{r}}+\delta\Phi^{\mathrm{r}}_{\delta}-xF_{\varphi}$
	$\ln[Z\varphi_2(\tau,\delta,x)]=\Phi^{\mathrm{r}}+\delta\Phi^{\mathrm{r}}_{\delta}+(1-x)F_{\varphi}$

Abbreviations:

$$\Phi^\circ_{\tau^\circ}=\left(\frac{\partial\Phi^\circ}{\partial\tau^\circ}\right)_{\delta^\circ,x},\Phi^\circ_{\tau^\circ\tau^\circ}=\left(\frac{\partial^2\Phi^\circ}{\partial\tau^{\circ 2}}\right)_{\delta^\circ,x},\Phi^{\mathrm{r}}_{\tau}=\left(\frac{\partial\Phi^{\mathrm{r}}}{\partial\tau}\right)_{\delta,x},\Phi^{\mathrm{r}}_{\delta}=\left(\frac{\partial\Phi^{\mathrm{r}}}{\partial\delta}\right)_{\tau,x}$$

$$\Phi^{\mathrm{r}}_{\tau\tau}=\left(\frac{\partial^2\Phi^{\mathrm{r}}}{\partial\tau^2}\right)_{\delta,x},\Phi^{\mathrm{r}}_{\delta\tau}=\left(\frac{\partial^2\Phi^{\mathrm{r}}}{\partial\tau\partial\delta}\right)_{x},\ \Phi^{\mathrm{r}}_{\delta\delta}=\left(\frac{\partial^2\Phi^{\mathrm{r}}}{\partial\delta^2}\right)_{\tau,x}\ \Phi^{\mathrm{r}}_{x}=\left(\frac{\partial\Phi^{\mathrm{r}}}{\partial x}\right)_{\delta,\tau},$$

$$\left[F_{\varphi}=\Phi^{\mathrm{r}}_{x}+\frac{\delta}{\overline{V}_n}\frac{d\overline{V}_n}{dx}\Phi^{\mathrm{r}}_{\delta}+\frac{\tau}{T_n}\frac{dT_n}{dx}\Phi^{\mathrm{r}}_{\tau}\right]$$

The data analysis was carried out simultaneously with the development of the equation of state presented here. Starting with the entire set of experimental data, interim results for the equation of state were used to compare measurements and to eliminate data which showed large scatter or significant systematic deviations. This process was repeated several times with more stringent criteria imposed at each step. Since the Helmholtz free energy model established here consists of a single expression describing the whole thermodynamic space, systematic deviations of data from the model are also an indicator for thermodynamic inconsistencies between measurements of different properties, especially between single-phase and two-phase properties.

The results of the data analysis are given by Tillner-Roth and Friend[19] for all available sets of measurements. From these results, the following experimental data were selected to establish the fundamental equation of state for {water +ammonia}:

(i) 402 (p,T,x) data of Sassen *et al.*,[23] Postma,[24] Mollier,[25] and Perman,[26]
(ii) 265 (p,T,x,y) data of Smolen *et al.*,[27] Polak and Lu,[28] and Iseli,[29]
(iii) 57 saturated liquid densities of Jennings,[30]
(iv) 1208 liquid $(p,\overline{V},T,x)$ data of Harms-Watzenberg,[31]
(v) 599 vapor $(p,\overline{V},T,x)$ data of Harms-Watzenberg[31] and of Ellerwald,[32]
(vi) 92 excess enthalpies in the liquid of Staudt,[33]
(vii) 146 enthalpies of the saturated liquid of Zinner,[34]
(viii) 98 isobaric heat capacities reported by Hildenbrand and Giauque,[35] Chan and Giauque,[36] and by Wrewsky and Kaigorodoff.[37]

The isobaric heat capacities from References 35 and 36 were found to be inconsistent with the enthalpies measured by Zinner,[34] as shown by Tillner-Roth and Friend.[19] Since these were the only caloric data at low temperatures, they were nevertheless included, although with a low weight, to give the equation of state at least some support in the low temperature liquid region. In addition to the selected data, the (p,T,x,y) data of Gillespie *et al.*[38] were generally included for comparisons during the optimization process. However, since they overlap the selected data, they were not used in fitting the coefficients.

In contrast to other correlations, no tabulated data like those of Macriss *et al.*[4] were used in this work, because the accuracy of tabulated values may be affected by the choice and weight of experimental input data used to generate the numbers.

At high temperatures and pressures, only experimental data for the (p,T,x) and (p,T,x,y) behavior are available. Coexisting densities in the critical region were obtained from a modified Leung–Griffiths model which was established simultaneously with the present equation of state. Details of the Leung–Griffiths formulation for {water+ammonia} will be published in a separate paper.[39] The Leung–Griffiths for-

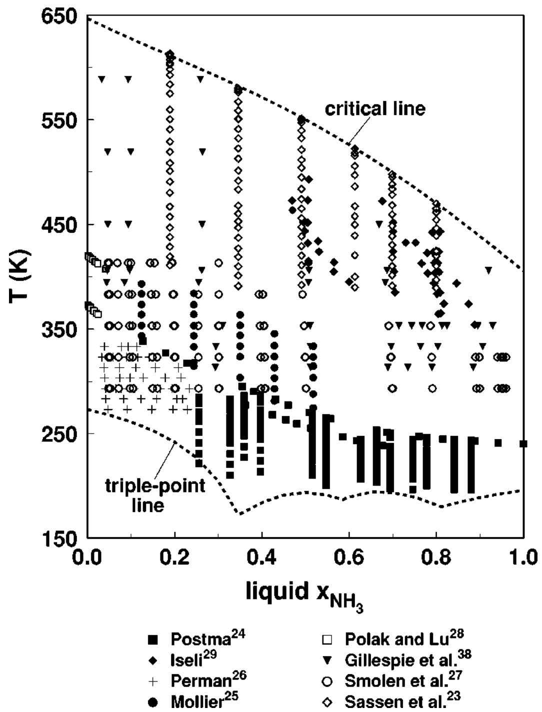

FIG. 1. Distribution of selected (p,T,x) and (p,T,x,y) data.

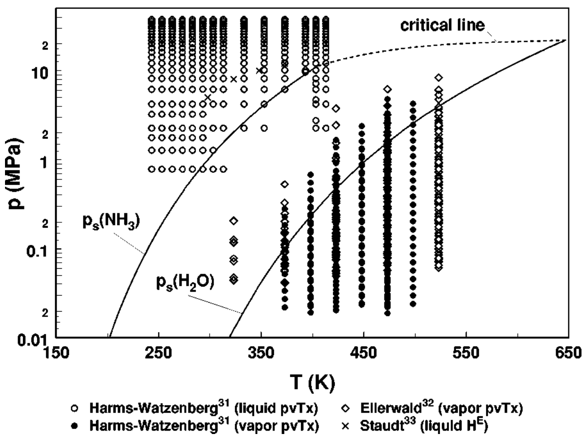

FIG. 2. Distribution of selected experimental data in the single-phase regions.

malism was chosen because it is based on scaling law theory and is able to accurately describe VLE behavior of mixtures in the critical region. Equilibrium data $(p,T,x,y,\varrho',\varrho'')$ were calculated from an interim Helmholtz free energy equation up to about three-fourths of the critical pressure. These data served as input during a subsequent optimization of the Leung–Griffiths model. Additionally, experimental (p,T,x) and (p,T,x,y) data were also considered in this stage. Densities from the improved Leung–Griffiths model in the critical region were included during a subsequent improvement of the Helmholtz free energy model.

VLE data (Fig. 1) cover the whole two-phase region between the solid–liquid–vapor boundary and the critical line. Single-phase properties (Fig. 2) are restricted to temperatures between 200 K and 413 K in the liquid reaching up to 40 MPa. In the vapor, available data cover temperatures between 323 K and 523 K at pressures up to 10 MPa and densities up to 1.5 $\mathrm{mol\,dm^{-3}}$. Leung–Griffiths data $(p,T,x,y,\varrho',\varrho'')$ were used for four temperatures between 450 K and 600 K. They are shown in Fig. 3 together with selected saturated liquid densities and enthalpies.

4. The Optimization Process

Several tasks had to be simultaneously accomplished during the optimization process:

(i) fitting all adjustable parameters to the selected experimental data,
(ii) finding a structure for the reducing functions $T_n(x)$ and $\overline{V_n}(x)$ and the departure function $\Delta\Phi^{\mathrm{r}}$,
(iii) assessing and modifying the database,
(iv) checking the behavior of the interim equation in the entire thermodynamic space.

Two optimization methods were employed. A modified Marquard–Fletcher algorithm developed by Dennis *et al.*[40] was used for all nonlinear optimizations. The structure of the departure function was determined using the implementation of Wagner's regression analysis,[41] which was developed at the Institute of Thermodynamics, University of Hannover, Germany.[42]

A weighted sum of squares

$$S=\sum_i \left(\frac{Y_i^{\mathrm{exp}}-Y_i^{\mathrm{calc}}}{s_i}\right)^2 \tag{14}$$

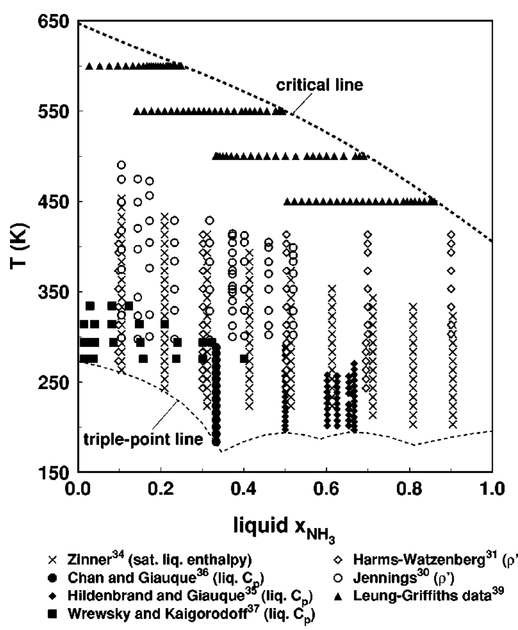

FIG. 3. Distribution of selected saturated liquid densities, enthalpies and isobaric heat capacities.

was used for the objective function. For the nonlinear optimization, it was formulated according to the direct method described by Ahrendts and Baehr.[43] In this case, Y_i can be any thermodynamic property and s_i is the corresponding total uncertainty estimated from experimental uncertainties according to the Gaussian error propagation law.

The sum of squares for the regression analysis is formulated differently. Since this optimization method is used to find the structure of the departure function, only the contribution of an experimental value to $\Delta\Phi^{\mathrm{r}}$ can be used for the quantity Y_i. For a given set of reducing functions, this contribution can be extracted from any experimental property which depends linearly on the coefficients of the departure function. The quantity Y for a $(p,\overline{V},T,x)$ value, for example, is calculated from

$$Y=\left(\frac{\partial\Delta\Phi^{\mathrm{r}}}{\partial\delta}\right)_{\tau}=\left[\frac{1}{\delta}\left(\frac{p\overline{V}}{R_mT}-1\right)-(1-x)\left(\frac{\partial\Phi^{\mathrm{r}}_{01}}{\partial\delta}\right)_{\tau}-x\left(\frac{\partial\Phi^{\mathrm{r}}_{02}}{\partial\delta}\right)_{\tau}\right]. \qquad (15)$$

In this case, Y is linearly related to the first derivative of $\Delta\Phi^{\mathrm{r}}$ with respect to δ. Similar linear relations can be derived for other properties.

Nonlinear properties have to be linearized before they can be considered during the regression analysis. Regarding the data situation for {water+ammonia}, this is important for VLE data which form the major part of the database. It is essential to use this experimental information during the linear regression analysis in order to formulate an accurate departure function. The linearization of VLE data is described in Appendix A.

In a first step, only the coefficients k_T and k_V of the reducing functions $T_n(x)$ and $\overline{V}_n(x)$ were optimized with the departure function $\Delta\Phi^{\mathrm{r}}$ in Eq. (6) set to zero. With this first equation, the available experimental data were assessed in order to identify unreliable measurements which were subsequently discarded from the database. It was also used for the linearization of VLE data to be included in the subsequent search for the departure function. The assessment of experimental data was repeated each time an improved equation of state was found.

The structure of the departure function was determined using Wagner's regression analysis.[41] Wagner's method allows the correlator to select from a bank of terms those terms which represent a given data set with the lowest possible value of the objective function.

The initial departure function was formulated from a bank of about 400 terms of the forms

$$x(1-x^{\gamma})\delta^m\tau^n \quad \text{and} \quad x(1-x^{\gamma})\delta^m\tau^n\exp(-\delta^e)$$

where $1<m<5$, $-0.5<n<20$, and $1<e<4$. The exponent γ remains constant during the regression analysis, and is optimized only in the nonlinear process.

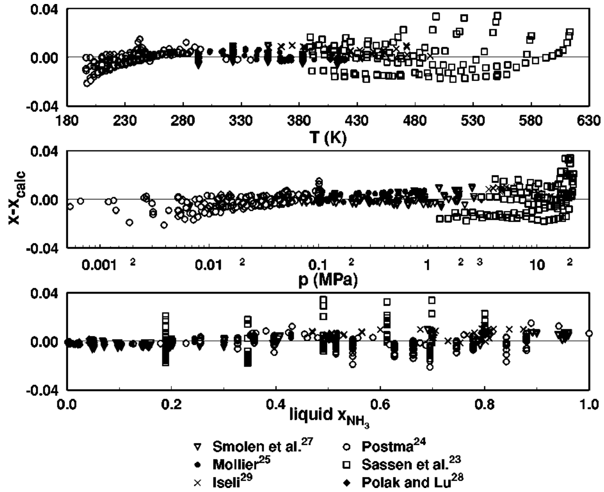

FIG. 4. Deviations between liquid mole fractions x and values from Eq. (1).

After a few steps of optimization, it became clear that these terms did not sufficiently describe the composition dependence of $\Delta\Phi^{\mathrm{r}}$. Therefore, terms of the form

$$x^2(1-x^{\gamma})\delta^m\tau^n\exp(-\delta^e) \quad \text{and} \quad x^3(1-x^{\gamma})\delta^m\tau^n\exp(-\delta^e)$$

were also included, bringing the total number of candidate terms to about 850. Subsequently, terms with $e>2$ were no longer selected. Therefore, the number of terms was restricted to about 650.

The search for the functional form of the departure function was initially based only on $(p,\overline{V},T,x)$ data and on linearized VLE properties which were obtained from the interim equation. As the equation became more accurate, linearized enthalpy and heat capacity data were also included.

5. Discussion

In the following sections, the behavior of the equation of state in the different regions of the thermodynamic space is examined. In addition to comparisons with selected experimental data, the general behavior of density, enthalpy, entropy, and heat capacity is discussed in regions where experimental data are scarce or unavailable. The equation of state is also extrapolated into the supercritical region. Comparisons for data which are not discussed here are given by Tillner-Roth and Friend[19] where the same equation of state has been used.

5.1. Vapor and Liquid Compositions

Experimental VLE data for the (p,T,x,y) behavior form the major part of available measurements. In Figs. 4 and 5, the liquid and vapor mole fractions x and y are compared with values which were obtained from flash calculations for given p and T. Absolute deviations of liquid mole fractions are plotted in Fig. 4 versus temperature, pressure and liquid composition for the data sets selected for the optimization.

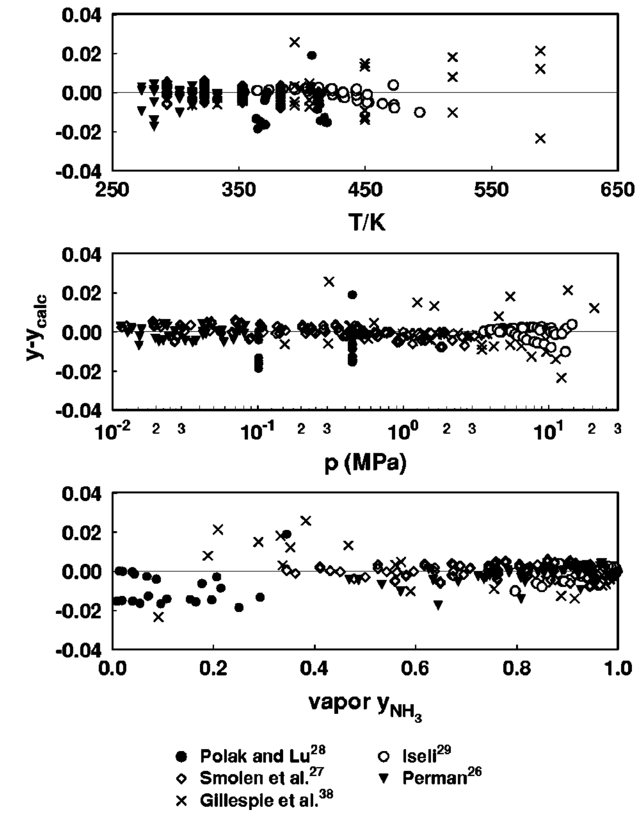

FIG. 5. Deviations between vapor mole fractions y and values from Eq. (1).

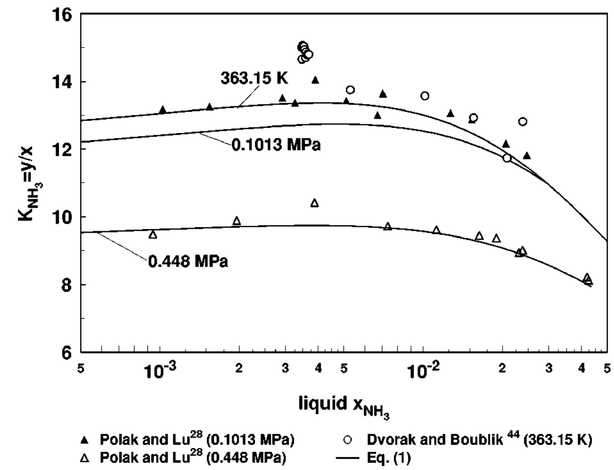

FIG. 6. Distribution coefficient K of ammonia in dilute solutions.

At temperatures below 250 K, a slight systematic deviation is observed reaching -0.02 in x for the lowest temperatures around 200 K. Above 250 K up to around 390 K liquid mole fractions are represented within ± 0.01, which is within the scatter of experimental data. Systematic deviations are observed for some of the data measured by Sassen *et al.*[23] Sassen's measurements at $x=0.189$ and $x=0.346$ show an offset of -0.01 in x compared to the data of Iseli[29] and Smolen *et al.*[27] in their overlapping temperature range. The mole fractions of these two series of Sassen *et al.*, therefore, were shifted to $x=0.199$ and $x=0.355$ during the optimization, so that they smoothly connect to the other selected data. However, the data shown in Fig. 4 are Sassen's original values. At high temperatures close to the critical temperature line, deviations in x increase up to 0.04 in mole fraction. For {water+ammonia} the dew-bubble curves are extremely flat in the vicinity of the critical line (see Fig. 11) and large deviations in x or y correspond to only small deviations of pressure. No other systematic pattern is observed for the deviations when they are plotted over pressure or liquid mole fraction x, except for the deviations at low and high temperatures discussed before. Representation of experimental data is mostly within ± 0.01.

Comparisons for vapor compositions y are given in Fig. 5 for selected data sets. The new EOS represents the vapor mole fractions generally within ± 0.01 or better, with the exception of data at high temperatures and pressures where deviations increase up to ± 0.03 when approaching the critical locus.

The good representation is partially due to the fact that the vapor mole fraction is close to 1 over a large range of temperature and pressure. In this region, the vapor phase behavior is dominated by the ammonia equation of state, which is very accurate in the gaseous phase. In the range of intermediate and low vapor mole fractions, the dew curve is very flat at low temperatures. Small uncertainties in pressure result in considerable deviations for the vapor composition. Accordingly, a scatter of ± 0.02 or less in y is a remarkable result.

In the range of very dilute ammonia solutions, only a few data are available. The distribution coefficient $K=y/x$ of ammonia is plotted over liquid mole fraction in Fig. 6 and is compared with experimental results at two different pressures and for one temperature. The K values obtained from (p,T,x,y) measurements of Polak and Lu[28] agree very well with the values obtained from Eq. (1), especially at 0.448 MPa where they are represented almost within the experimental scatter. At 0.1013 MPa they are slightly higher than K values from Eq. (1). Data of Dvorak and Boublik[44] are compared for $T=363.15$ K. At liquid mole fractions around 0.01 agreement is good, while at lower mole fractions the experimental distribution coefficients are higher than the calculated results. Furthermore, the uncertainty seems to increase for the more dilute systems.

5.2. Saturated Liquid Density

Measured saturated liquid densities cover temperatures between 243 K and 500 K. Densities at high temperatures are available only for water-rich mixtures and, thus, do not extend into the critical region. Measurements of King *et al.*,[45] Jennings,[30] and Harms-Watzenberg[31] are compared with results from the equation of state in Fig. 7. Densities are generally represented within $\pm 1\%$ over the entire range of temperature and composition. None of the three data sets shows a systematic pattern in the deviations, except the densities of Jennings[30] at $x=0.8$ which are probably too high.

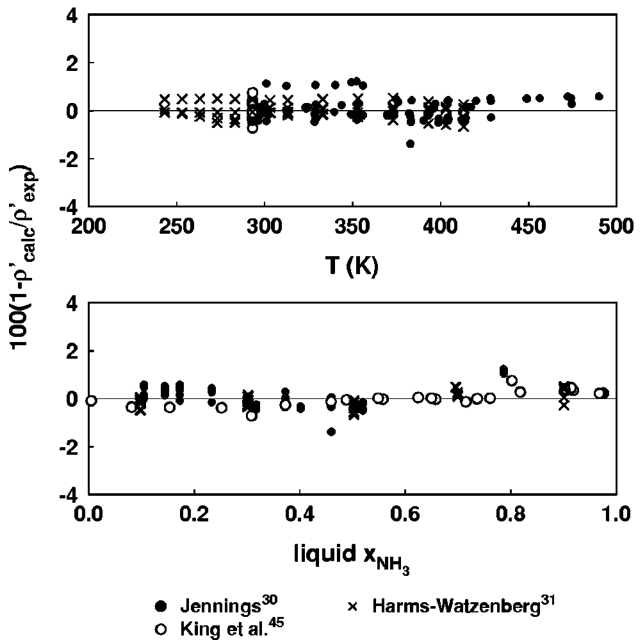

FIG. 7. Deviations between saturated liquid densities and values from Eq. (1).

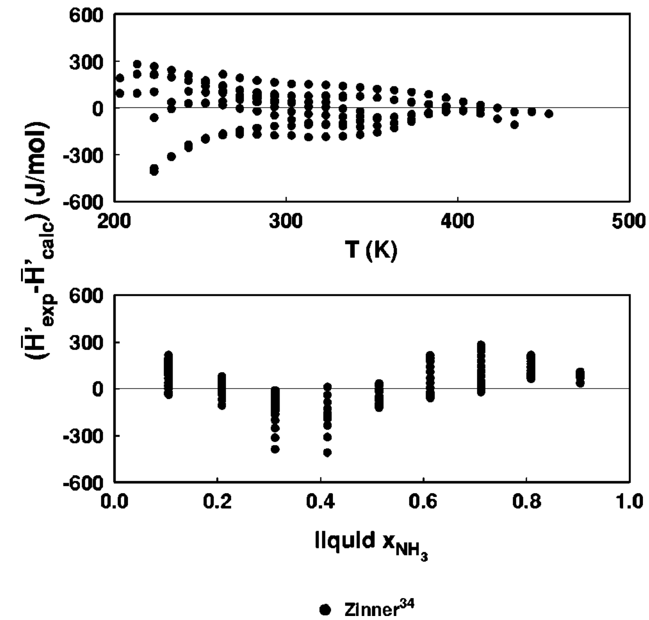

FIG. 8. Deviations between saturated liquid enthalpies and values from Eq. (1).

5.3. Caloric Properties of the Saturated Liquid

For the saturated liquid, Zinner[34] published a smoothed table of enthalpy data instead of the original measurements. These tabulated values were used during the correlation process to establish Eq. (1) because no other enthalpy data were available in this range. In addition to these enthalpies, liquid isobaric heat capacities were reported by two groups[35,36] at very low temperatures. These heat capacities were probably measured under atmospheric pressure and, therefore, do not exactly overlap the enthalpies. However, they are located very close to the saturation boundary and, therefore, significantly influence the representation of the caloric properties of the saturated liquid.

Unfortunately, the enthalpies and heat capacities are inconsistent, as described by Tillner-Roth and Friend.[19] Since no other enthalpy or heat capacity measurements are available in this range, it is not clear which data set is more reliable. This inconsistency can be resolved only by new reliable measurements of heat capacity or enthalpy. Since enthalpies and heat capacities were included during the optimization to prevent the development of nonphysical behavior at low temperatures, systematic deviations are observed for both properties where experimental data overlap.

In Fig. 8, Zinner's enthalpies are compared with results from Eq. (1). They are represented within ± 300 J/mol over the entire temperature range of his experiments; this is about twice our estimate of the experimental uncertainty. The largest deviations occur at low temperatures, where the tabulated data of Zinner may be an extrapolation of his underlying experimental results. At temperatures above 370 K, deviations are within ± 150 J mol^{-1} and thus correspond to the experimental uncertainty. Deviations are negative at liquid mole fractions between 0.3 and 0.4 and positive around $x=0.7$. This behavior is due to the inconsistency between enthalpies and heat capacities, which were measured between $x=0.333$ and $x=0.67$.

Heat capacities are discussed in Fig. 9. The negative deviations of up to 10% observed for the data of Giauque and his co-workers[35,36] reflect the inconsistency between these heat capacities and the saturated liquid enthalpies of Zinner. Deviations for the heat capacities of Wrewsky and

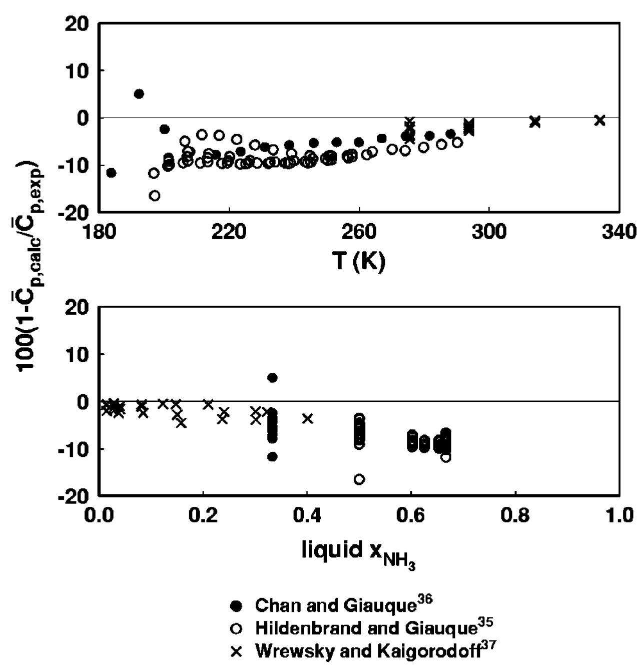

FIG. 9. Deviations between isobaric heat capacities and values from Eq. (1).

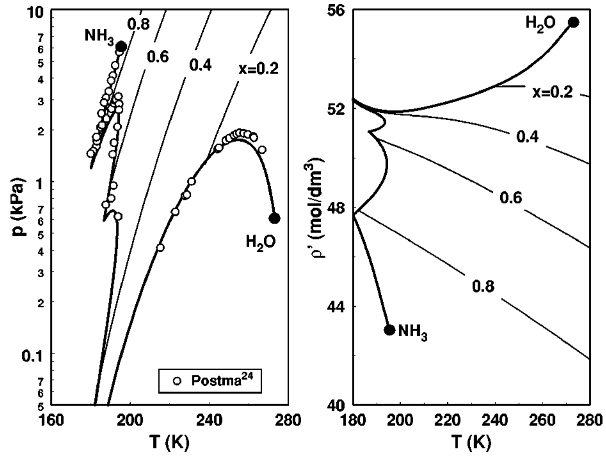

FIG. 10. Equilibrium pressures and saturated liquid densities at the solid–liquid–vapor boundary from Eq. (1).

Kaigorodoff,[37] measured at higher temperatures, are only within $\pm 4\%$. These data seem to be more consistent with Zinner's results than the heat capacities from Refs. 35 and 36.

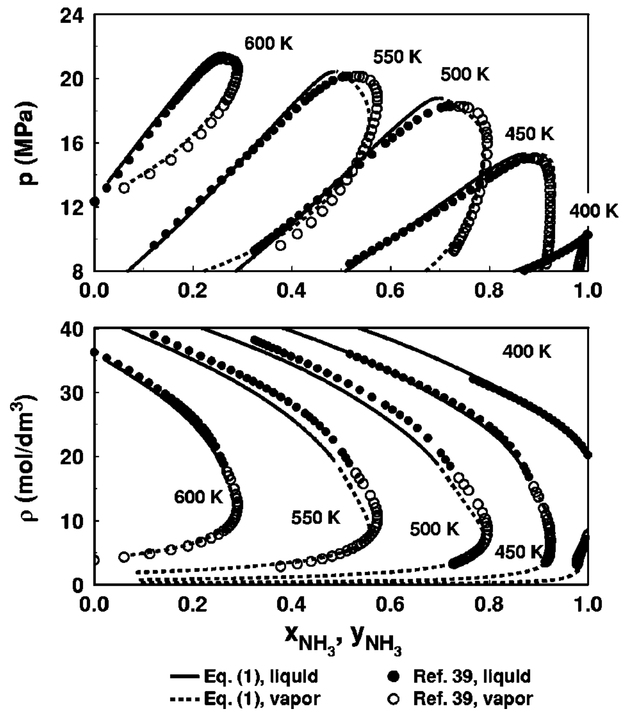

FIG. 11. Dew-bubble curves and coexisting densities at high temperatures.

5.4. Pressure and Density at the Solid–Liquid–Vapor Boundary

The solid–liquid–vapor temperature as a function of mixture composition is described by the correlation given by Tillner-Roth and Friend.[19] When the reduced temperature $T_{tr}(x)/T_n(x)$ is calculated at this boundary, values down to 0.28 are obtained. The lower temperature limits of the pure fluid equations of state are given by the respective triple point temperatures corresponding to $T_{tr,01}/T_{c,01}=0.43$ for water and $T_{tr,02}/T_{c,02}=0.48$ for ammonia. Since the mixture model uses pure fluid equations combined at constant reduced variables, the pure fluid equations must be extrapolated considerably beyond their lower temperature limits for calculation of properties close to the three-phase locus. Any spurious behavior due to extrapolation has to be compensated for by the departure function, in order to achieve an adequate representation of thermodynamic properties of the {water+ammonia} mixture close to its three-phase locus.

At low temperatures, Eq. (1) has been fitted to experimental (p,T,x) data of Postma[24] down to 200 K and to liquid densities from Harms-Watzenberg[31] reaching down to 243.15 K. The behavior at very low temperatures is illustrated by Fig. 10. Equilibrium pressures and liquid densities shown in this graph were obtained from VLE calculations for a given x and a temperature obtained from the triple-point temperature equation established by Tillner-Roth and Friend.[19] The results are shown in Fig. 10. For comparison, triple-point pressures measured by Postma[24] are also included. No density measurements are available below 243 K.

Postma's equilibrium pressures are represented fairly well over the full range of the solid–liquid–vapor boundary. Triple-point pressures are extremely low (<50 Pa) near the eutectic point at $x=0.33$. In addition to the pressures on the three-phase boundary, equilibrium pressures were calculated along lines of constant composition. These lines show a physically reasonable shape in the entire range of composition.

An interesting result is obtained for the saturated liquid density along the solid–liquid–vapor boundary. Starting from pure water, the density decreases for increasing ammonia content until a minimum is reached around 200 K and $x\approx 0.28$. Towards the eutectic point at $x=0.33$, Eq. (1) predicts an increasing density. Since no experimental data are available in this region, no conclusion can be drawn whether this prediction is correct or not. For liquid mole fractions increasing above $x=0.33$, liquid density decreases again towards the triple-point liquid density of ammonia at $x=1$.

5.5. The Two-Phase Envelope at High Temperatures

From the set of selected data, only the (p,T,x) data of Sassen *et al.*[23] and some (p,T,x,y) data of Iseli[29] at high ammonia concentrations extend to the critical locus. Deviations of vapor and liquid composition were already discussed in Figs. 4 and 5. In this section, the general form of the two-phase envelope is the topic of interest.

Properties on the two-phase boundary are shown in Figs. 11 and 12 in the near-critical range for five temperatures between 400 K and 600 K. Coexisting densities and (p,T,x,y) data from the modified Leung–Griffiths model established by Rainwater and Tillner-Roth[39] for the critical region of {water+ammonia} are included in Fig. 11.

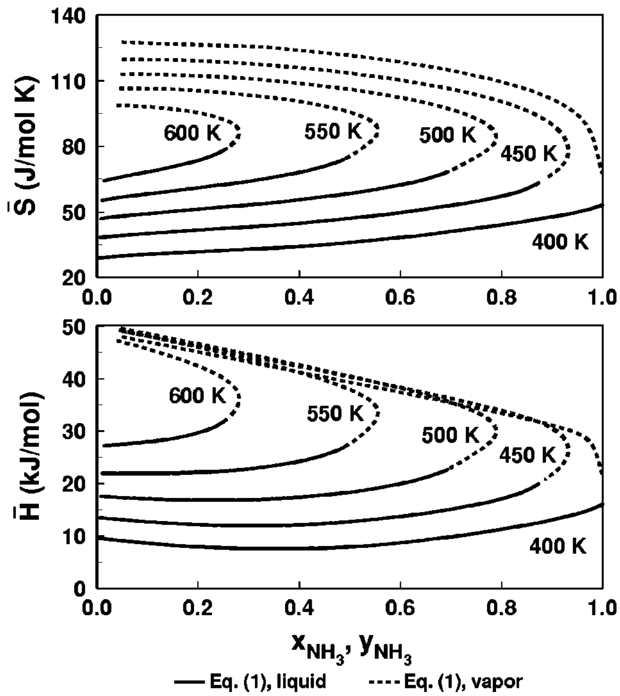

FIG. 12. Enthalpy and entropy on the two-phase boundary at high temperatures.

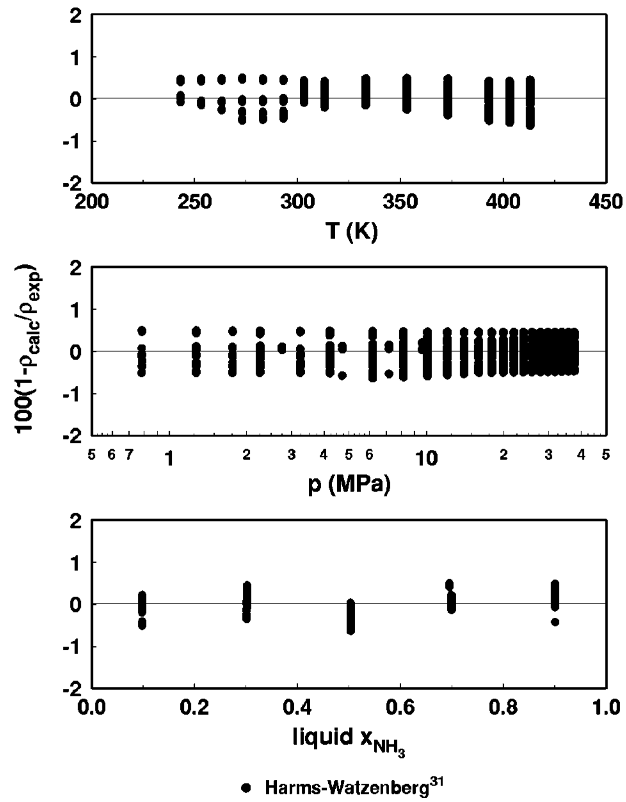

FIG. 13. Deviations between liquid densities and values from Eq. (6).

Slight differences between results from Eq. (1) and the Leung–Griffiths model are observed for 500 K and 550 K close to the critical locus. Vapor mole fractions from the Leung–Griffiths model are higher by about 0.03 to 0.05, liquid mole fractions are higher by up to 0.02 than values from Eq. (1) for these isotherms. Agreement between the two models for liquid and vapor compositions is good at 400 K, 450 K, and 600 K.

Differences between coexisting densities correspond to the deviations observed for the (p,T,x,y) behavior. Agreement is excellent for the isotherms at 400 K, 450 K, and 600 K, while the coexistence curves at 500 K and 550 K from Eq. (1) are shifted to slightly lower ammonia mole fractions compared to the Leung–Griffiths data. Reasonable behavior is also observed for entropy and enthalpy on the two-phase envelope, Fig. 12. The curves for all isotherms go smoothly from the saturated vapor to the saturated liquid. It has to be emphasized again that no experimental densities or caloric properties are available to verify the accuracy of these predictions.

5.6. Properties of the Compressed Liquid

Equation (1) has been fitted to the extensive set of liquid densities measured by Harms-Watzenberg.[31] His results are compared with Eq. (1) in Fig. 13. The data are represented within $\pm 0.8\%$ with a few exceptions where his results approach the critical region at high ammonia mole fractions. At temperatures below 300 K, the data show larger scatter, but on average they are represented well. Other data, which all overlap the results of Harms-Watzenberg, are discussed by Tillner-Roth and Friend.[19]

In addition to density, the enthalpy of mixing has also been measured in the liquid phase. Results of Staudt[33] are compared with results from Eq. (1) in Fig. 14. The enthalpy of mixing is almost independent of pressure and temperature in the range of available experimental data between 298 K and 373 K and at pressures between 2 MPa and 12 MPa. Higher deviations occur only at intermediate mole fractions around $x=0.5$, where differences of about $-250\ \mathrm{J\ mol^{-1}}$ are observed at high temperatures. The excess enthalpy is particularly well represented for $x>0.6$.

5.7. Properties of Superheated Vapor

Two sets of $(p,\overline{V},T,x)$ properties are available in the vapor phase.[31,32] In Fig. 15 density deviations are plotted for both sets over p, T, and x. Most data are represented within $\pm 0.5\%$ in the entire range of experiments. Deviations for the data of Harms-Watzenberg[31] generally increase with increasing pressure, reaching $+1.3\%$ at high temperatures. Ellerwald's data[32] do not show this behavior. Deviations for his densities remain within $\pm 0.5\%$ at pressures up to 10 MPa.

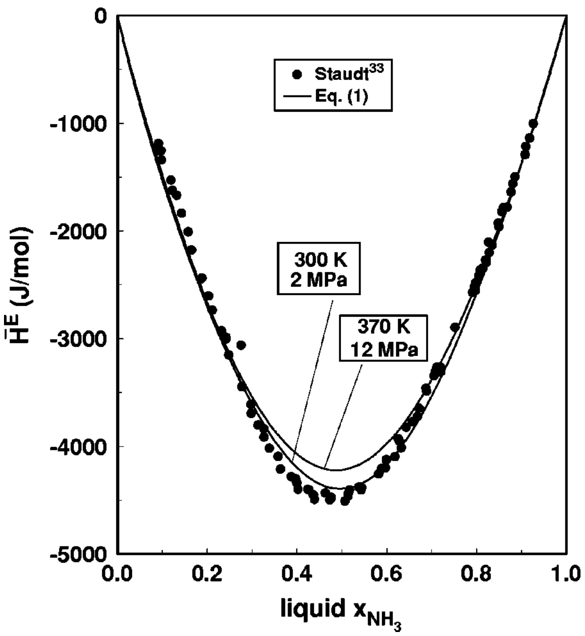

FIG. 14. Molar excess enthalpy $\overline{H^E}$ in the liquid.

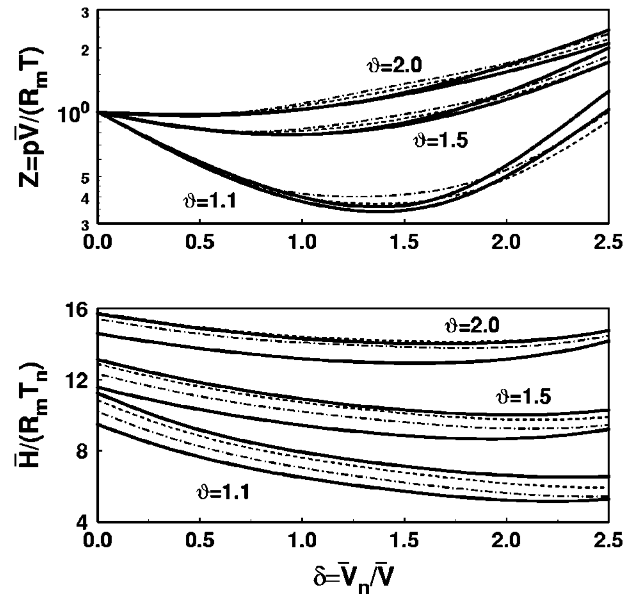

FIG. 16. Compressibility factor Z and reduced enthalpy $\overline{H}/(R_mT_n)$ in the supercritical region for three reduced temperatures. (——-) pure components; (– – – –) $x=1/3$; (-·-·) $x=2/3$.

5.8. The Supercritical Region

No experimental data are available in the supercritical region. Therefore, only the general behavior of the equation of state can be analyzed. For this purpose, the compressibility factor $Z=p\overline{V}/(R_mT)$ and the reduced enthalpy $\overline{H}/(R_mT_n)$ are plotted over the reduced density δ in Fig. 16. The reducing functions, Eqs. (9) and (10), were used to calculate $\delta(x)=\overline{V_n}(x)/\overline{V}$ and $\vartheta=1/\tau=T/T_n(x)$. Results are shown for the pure components and for the mixtures at $x=1/3$ and $x=2/3$ for three reduced temperatures $\vartheta=T/T_n=1/\tau$ at 1.1, 1.5, and 2.0.

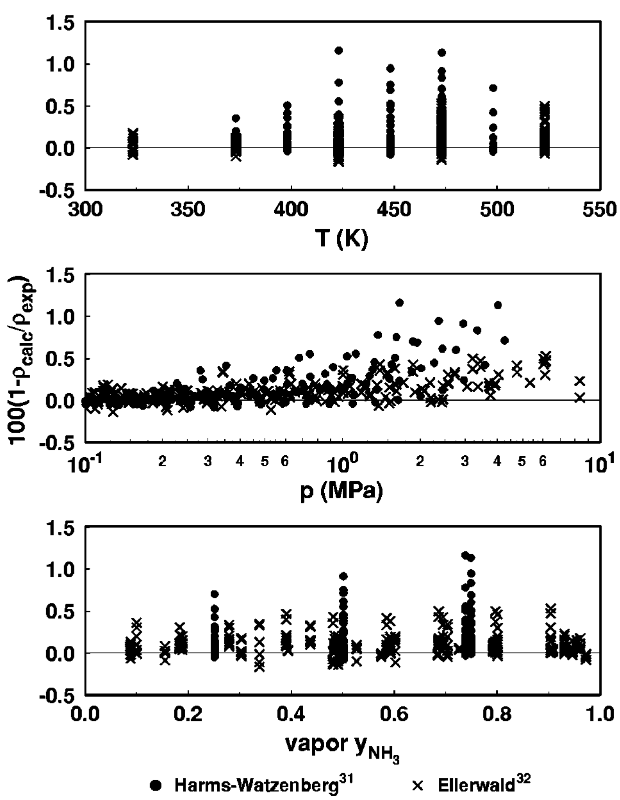

FIG. 15. Deviations between vapor densities and values from Eq. (1).

Reasonable behavior is obtained for all three temperatures. The compressibility factor of the mixtures shows about the same behavior as for the pure fluids, although it is slightly higher for the mixtures around $\delta=1.2$ than for the pure components. This might be a property of the mixture, but it is also possible that there is a small structural error in the equation of state, due to the lack of experimental data in this region.

Enthalpies for the mixtures are located between the enthalpies for the pure components for ϑ up to 1.5. At $\vartheta=2$, the enthalpy of the mixture is closer to the enthalpy of pure ammonia, especially around $\delta=1.5$. This behavior corresponds to the observations for the compressibility factor Z. Experimental data in the supercritical region are required to determine whether or not this result is correct.

Overall, the behavior of the equation of state is reasonable even when extrapolated to $2\times T_n$ which corresponds to 810 K for ammonia and to 1295 K for pure water. However, since no experimental data are available in this region, no estimates of accuracy can be given for supercritical states.

6. Conclusions

A fundamental equation of state for the Helmholtz free energy of {water+ammonia} has been established from which all thermodynamic properties can be derived by thermodynamic relations. The entire thermodynamic space from vapor to liquid, including VLE, is described by a single mathematical expression.

The Helmholtz free energy model covers the entire two-phase region between the solid–liquid–vapor boundary and the critical locus. The uncertainty of liquid and vapor mole fractions is about ± 0.01 except in the vicinity of the critical locus, where it can increase up to 0.04. Enthalpies and densities show a reasonable behavior on the whole two-phase envelope, although experimental data for these properties are available only in a limited range of temperature and composition.

Experimental data in the single-phase regions are restricted to subcritical temperatures, for the liquid below 420 K and 40 MPa and for the vapor for pressures below 10 MPa. Typical uncertainties are $\pm 0.3\%$ for the density and ± 200 J/mol for enthalpy in this range. No experimental data are available for supercritical temperatures. Extrapolation into the supercritical area gives reasonable results, but the accuracy in these regions is unknown.

In conclusion, the new equation of state represents the currently available measurements mostly within the limits of experimental error, but more experimental data are needed in order to verify the reliability of calculated thermodynamic properties especially in the single-phase regions.

7. Acknowledgments

This work has been carried out at NIST from April 1995 to March 1996. R. T.-R. thanks W. M. Haynes and M. O. McLinden for the opportunity to work at NIST as a guest researcher. Partial support from the U.S. Department of Energy, Geothermal Division, is gratefully acknowledged.

8. Appendices

8.1. Appendix A: Linearization of VLE Data

The vapor–liquid equilibrium of a binary mixture is calculated by solving simultaneously the four equations

$$p=p(\overline{V'},T,x), \tag{A1}$$

$$p=p(\overline{V''},T,y), \tag{A2}$$

$$(1-x)\ \varphi_1(\overline{V'},T,x)=(1-y)\ \varphi_1(\overline{V''},T,y), \tag{A3}$$

$$x\varphi_2(\overline{V'},T,x)=y\varphi_2(\overline{V''},T,y). \tag{A4}$$

φ_i is the fugacity coefficient of component i calculated as given in Table 3; x and y are the liquid and vapor mole fractions of component 2.

When an interim equation is known from which the VLE can be calculated, these four equations can be linearized and the information of a VLE measurement can be included in the linear regression analysis to determine the functional form of $\Delta\Phi^{\mathrm{r}}$. Regardless of the type of experimental VLE data, (p,T,x), (p,T,x,y), or (p,T,y) values, the interim equation of state is used to determine the properties remaining to complete the full information $(p,T,x,y,\overline{V'},\overline{V''})$ for a vapor–liquid equilibrium state. For a (p,T,x) value, for example, y, $\overline{V'}$, and $\overline{V''}$ have to be calculated.

From the first two equations two independent conditions can be determined for the saturated vapor and saturated liquid which are identical to those for single-phase $(p,\overline{V},T,x)$ data as described in Section 4. Using the formula from Table 3 for calculation of the fugacity coefficient, Eqs. (A3) and (A4) transform into

$$\begin{aligned}\ln\frac{1-x}{1-y}=&-\ln\frac{Z''}{Z'}+\Phi^{\mathrm{r}''}-\Phi^{\mathrm{r}'}+\delta''\Phi^{\mathrm{r}''}_{\delta}-\delta'\Phi^{\mathrm{r}'}_{\delta}\\&-y(\Phi^{\mathrm{r}''}_{x}+\tau'_x\Phi^{\mathrm{r}''}_{\tau}+\delta''_x\Phi^{\mathrm{r}''}_{\delta})\\&+x(\Phi^{\mathrm{r}'}_{x}+\tau_x{}'\Phi^{\mathrm{r}'}_{\tau}+\delta'_x\Phi^{\mathrm{r}'}_{\delta}),\end{aligned} \tag{A5}$$

$$\begin{aligned}\ln\frac{x}{y}=&-\ln\frac{Z''}{Z'}+\Phi^{\mathrm{r}''}-\Phi^{\mathrm{r}'}+\delta''\Phi^{\mathrm{r}''}_{\delta}-\delta'\Phi^{\mathrm{r}'}_{\delta}\\&+(1-y)(\Phi^{\mathrm{r}''}_{x}+\tau''_x\Phi^{\mathrm{r}''}_{\tau}+\delta''_x\Phi^{\mathrm{r}''}_{\delta})\\&-(1-x)(\Phi^{\mathrm{r}'}_{x}+\tau'_x\Phi^{\mathrm{r}'}_{\tau}+\delta'_x\Phi^{\mathrm{r}'}_{\delta}).\end{aligned} \tag{A6}$$

Partial differentials are abbreviated as in Table 3. Reduced variables for the saturated vapor are given by

$$\delta''=\frac{\overline{V_n}(y)}{\overline{V''}}\quad\text{and}\quad\tau''=\frac{T_n(y)}{T};$$

those of the saturated liquid are

$$\delta'=\frac{\overline{V_n}(x)}{\overline{V'}}\quad\text{and}\quad\tau'=\frac{T_n(x)}{T}.$$

The derivatives of the reduced variables with respect to x are abbreviated as

$$\tau_x=\left(\frac{\partial\tau}{\partial x}\right)_T\quad\text{and}\quad\delta_x=\left(\frac{\partial\delta}{\partial x}\right)_\varrho.$$

Upon introducing the general structure of the residual Helmholtz free energy of the binary mixture,

$$\Phi^{\mathrm{r}}=(1-x)\Phi^{\mathrm{r}}_{01}+x\Phi^{\mathrm{r}}_{02}+\Delta\Phi^{\mathrm{r}}, \tag{A7}$$

the contributions of the departure function can be separated from the contributions of the pure fluid equations in Eqs. (A5) and (A6):

$$\begin{aligned}Y_1=\ln\frac{1-x}{1-y}+\ln\frac{Z''}{Z'}-A=&\Delta\Phi^{\mathrm{r}''}-\Delta\Phi^{\mathrm{r}'}-y\Delta\Phi^{\mathrm{r}''}_{x}+x\Delta\Phi^{\mathrm{r}'}_{x}\\&+(\delta''-y\delta''_x)\Delta\Phi^{\mathrm{r}''}_{\delta}-(\delta'-x\delta'_x)\Delta\Phi^{\mathrm{r}'}_{\delta}-y\tau''_x\Delta\Phi^{\mathrm{r}''}_{\tau}\\&+x\tau'_x\Delta\Phi^{\mathrm{r}'}_{\tau},\end{aligned} \tag{A8}$$

$$Y_2=\ln\frac{x}{y}+\ln\frac{Z''}{Z'}-B=\Delta\Phi^{r''}-\Delta\Phi^{r'}+(1-y)\Delta\Phi_x^{r''}$$
$$-(1-x)\Delta\Phi_x^{r'}+[\delta''+(1-y)\delta_x'']\Delta\Phi_\delta^{r''}$$
$$-[\delta'+(1-x)\delta_x']\Delta\Phi_\delta^{r'}+(1-y)\tau_x''\Delta\Phi_\tau^{r''}$$
$$-(1-x)\tau_x'\Delta\Phi_\tau^{r'}. \quad \text{(A9)}$$

A and B are determined only from the pure fluid equations and are given by

$$A=\Phi_{01}^{r}{}''-\Phi_{01}^{r}{}'+(\delta''-y\delta_x'')[(1-y)\Phi_{01,\delta}^{r}{}''+y\Phi_{02,\delta}^{r}{}'']$$
$$-(\delta'-x\delta_x')[(1-x)\Phi_{01,\delta}^{r}{}'+x\Phi_{02,\delta}^{r}{}']$$
$$-y\tau_x{}'[(1-y)\Phi_{01,\tau}^{r}{}''+y\Phi_{02,\tau}^{r}{}'']$$
$$+x\tau_x'[(1-x)\Phi_{01,\tau}^{r}{}'+x\Phi_{02,\tau}^{r}{}'], \quad \text{(A10)}$$

and

$$B=\Phi_{02}^{r}{}''-\Phi_{02}^{r}{}'+[\delta''+(1-y)\delta_x''][(1-y)\Phi_{01,\delta}^{r}{}''+y\Phi_{02,\delta}^{r}{}'']$$
$$-(\delta'+(1-x)\delta_x')[(1-x)\Phi_{01,\delta}^{r}{}'+x\Phi_{02,\delta}^{r}{}']$$
$$+(1-y)\tau_x''[(1-y)\Phi_{01,\tau}^{r}{}''+y\Phi_{02,\tau}^{r}{}'']$$
$$-(1-x)\tau_x{}'[(1-x)\Phi_{01,\tau}^{r}{}'+x\Phi_{02,\tau}^{r}{}']. \quad \text{(A11)}$$

The two quantities Y_1 and Y_2 are linear with respect to the coefficients of the departure function as long as a linear combination of terms is used for $\Delta\Phi^r$ and as long as all variables τ, δ and the composition of the saturated liquid and saturated vapor are given.

For (p,T,x) properties it proved to be effective to calculate $\overline{V'}$ for the experimental values of p, T, and x from an interim Helmholtz equation of state. The vapor mole fraction y is obtained from a flash calculation for given p and T; $\overline{V''}$ is calculated with the same equation using the experimental p and T, and the calculated mole fraction y. For (p,T,x,y) properties, only $\overline{V'}$ and $\overline{V''}$ have to be calculated using the experimental (p,T,x) or (p,T,y). Although the calculated properties may not be very reliable during the first step, their accuracy increases with the accuracy of the interim equation of state. The quantities Y_1 and Y_2 have to be recalculated whenever an improved equation has been found, and a new search for the departure function is initiated. Recalculation of the quantities A and B is also necessary whenever the coefficients of the reducing functions $T_n(x)$ and $\overline{V_n}(x)$ have been readjusted.

8.2. Appendix B: Tables of Thermodynamic Properties

Tables of thermodynamic properties are provided for the two-phase envelope, Table 4, and for the single-phase region, Table 5. For the two-phase region, pressure, density, enthalpy, and entropy are given as functions of temperature and composition. Values are listed for the bubble-point curve and for the dew-point curve. Mass based units have been chosen. Compositions are given in terms of mass fractions ξ of ammonia. At temperatures below 0 °C, the solid region is encountered and no VLE exist for most tabulated vapor compositions. At high temperatures, the VLE region is restricted by the critical line. In the single-phase region, properties were calculated on isobars as functions of temperature and mass fraction of ammonia.

9. References

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TABLE 4. Saturation properties of {water+ammonia}

t	$\bar{\xi}$	Bubble point ($\xi' = \bar{\xi}$) p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	Dew point ($\xi'' = \bar{\xi}$) p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m^3		kJ/kg		kJ/(kg K)		kPa		kg/m^3		kJ/kg		kJ/(kg K)	
−70	0.3	0.23	0.99905	919.11	0.0023	−374.91	1502.6	−0.8478	9.2757								
	0.4	0.59	0.99978	910.06	0.0060	−376.36	1501.9	−0.7632	8.8158								
	0.5	1.52	0.99996	895.37	0.0153	−370.71	1501.5	−0.7205	8.3560								
	0.6	3.44	0.99999	872.62	0.0347	−342.55	1500.9	−0.6543	7.9543								
	0.7	6.05	1.00000	840.22	0.0612	−280.46	1500.1	−0.5056	7.6752								
	0.8	8.29	1.00000	800.84	0.0840	−189.52	1499.5	−0.2843	7.5188								
	0.9	9.82	1.00000	760.62	0.0996	−83.00	1499.0	−0.0425	7.4343								
	1.0	10.94	1.00000	724.72	0.1110	32.33	1498.7	0.1622	7.3803	10.94	1.00000	724.72	0.1110	32.33	1498.7	0.1622	7.3803
−60	0.3	0.57	0.99847	920.70	0.0054	−340.08	1523.2	−0.6806	8.9408								
	0.4	1.44	0.99965	908.28	0.0138	−341.11	1522.0	−0.5937	8.4806								
	0.5	3.54	0.99993	890.50	0.0340	−333.68	1521.2	−0.5426	8.0384								
	0.6	7.51	0.99999	864.95	0.0724	−301.75	1520.3	−0.4583	7.6668								
	0.7	12.52	1.00000	830.76	0.1210	−236.87	1519.1	−0.2962	7.4128								
	0.8	16.74	1.00000	790.70	0.1621	−145.75	1518.1	−0.0741	7.2673								
	0.9	19.69	1.00000	750.19	0.1909	−39.91	1517.4	0.1645	7.1856								
	1.0	21.89	1.00000	713.62	0.2125	75.08	1516.9	0.3675	7.1318	21.89	1.00000	713.62	0.2125	75.08	1516.9	0.3675	7.1318
−50	0.3	1.27	0.99764	921.65	0.0116	−302.95	1543.9	−0.5103	8.6414								
	0.4	3.19	0.99945	905.62	0.0293	−305.38	1542.0	−0.4300	8.1834								
	0.5	7.53	0.99989	884.69	0.0693	−295.67	1540.8	−0.3684	7.7600								
	0.6	15.07	0.99998	856.60	0.1391	−259.74	1539.3	−0.2657	7.4156								
	0.7	24.02	0.99999	820.96	0.2224	−192.58	1537.6	−0.0932	7.1819								
	0.8	31.47	1.00000	780.32	0.2923	−101.49	1536.2	0.1287	7.0449								
	0.9	36.77	1.00000	739.43	0.3421	3.76	1535.1	0.3646	6.9652								
	1.0	40.84	1.00000	702.09	0.3806	118.42	1534.3	0.5661	6.9112	40.84	1.00000	702.09	0.3806	118.42	1534.3	0.5661	6.9112
−40	0.3	2.65	0.99655	921.18	0.0233	−264.86	1564.9	−0.3434	8.3710								
	0.4	6.57	0.99917	901.79	0.0578	−268.24	1562.0	−0.2672	7.9194								
	0.5	14.81	0.99982	877.99	0.1307	−255.86	1560.2	−0.1939	7.5156								
	0.6	28.13	0.99996	847.74	0.2492	−216.42	1558.0	−0.0759	7.1949								
	0.7	43.19	0.99999	810.90	0.3844	−147.65	1555.6	0.1036	6.9774								
	0.8	55.63	1.00000	769.71	0.4971	−56.75	1553.5	0.3247	6.8469								
	0.9	64.62	1.00000	728.34	0.5790	48.00	1552.1	0.5583	6.7688								
	1.0	71.69	1.00000	690.15	0.6438	162.32	1550.9	0.7583	6.7141	71.69	1.00000	690.15	0.6438	162.32	1550.9	0.7583	6.7141
−30	0.2	1.97	0.98190	940.47	0.0167	−213.40	1597.9	−0.2834	8.6296								
	0.3	5.23	0.99516	919.22	0.0441	−225.96	1586.1	−0.1801	8.1269								
	0.4	12.61	0.99878	896.87	0.1066	−229.42	1582.0	−0.1042	7.6850								
	0.5	27.22	0.99970	870.57	0.2308	−214.33	1579.3	−0.0196	7.3005								
	0.6	49.34	0.99992	838.53	0.4207	−172.05	1576.2	0.1103	6.9999								
	0.7	73.41	0.99997	800.67	0.6299	−102.19	1572.9	0.2943	6.7951								
	0.8	93.22	0.99999	758.89	0.8041	−11.54	1570.2	0.5144	6.6696								
	0.9	107.73	1.00000	716.91	0.9328	92.78	1568.1	0.7461	6.5924								
	1.0	119.43	1.00000	677.83	1.0374	206.75	1566.5	0.9446	6.5367	119.43	1.00000	677.83	1.0374	206.75	1566.5	0.9446	6.5367
−20	0.2	3.77	0.97624	940.10	0.0306	−171.23	1623.0	−0.1134	8.4043								
	0.3	9.76	0.99343	915.98	0.0792	−186.20	1607.5	−0.0198	7.9073								
	0.4	22.81	0.99825	891.07	0.1854	−189.05	1601.9	0.0584	7.4771								
	0.5	47.13	0.99954	862.63	0.3851	−171.42	1598.1	0.1532	7.1104								

TABLE 4. Saturation properties of {water+ammonia}—Continued

t	$\bar{\xi}$	Bubble point ($\xi' = \bar{\xi}$) p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	Dew point ($\xi'' = \bar{\xi}$) p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m³	kg/m³	kJ/kg	kJ/kg	kJ/(kg K)	kJ/(kg K)	kPa		kg/m³	kg/m³	kJ/kg	kJ/kg	kJ/(kg K)	kJ/(kg K)
	0.6	82.03	0.99986	829.06	0.6752	−126.89	1593.9	0.2921	6.8266								
	0.7	118.88	0.99995	790.27	0.9864	−56.30	1589.5	0.4791	6.6318								
	0.8	149.09	0.99998	747.84	1.2456	34.13	1585.9	0.6981	6.5100								
	0.9	171.52	0.99999	705.15	1.4404	138.07	1583.1	0.9283	6.4330								
	1.0	190.08	1.00000	665.14	1.6033	251.70	1580.8	1.1253	6.3757	190.08	1.00000	665.14	1.6033	251.70	1580.8	1.1253	6.3757
−10	0.1	2.18	0.88136	968.09	0.0171	−100.01	1725.1	−0.0543	8.8505								
	0.2	6.87	0.96977	938.21	0.0537	−129.22	1648.7	0.0494	8.1997								
	0.3	17.30	0.99131	911.69	0.1351	−145.53	1629.2	0.1377	7.7103								
	0.4	39.06	0.99755	884.57	0.3062	−147.37	1621.8	0.2198	7.2923								
	0.5	77.53	0.99930	854.30	0.6118	−127.45	1616.6	0.3234	6.9418								
	0.6	130.22	0.99977	819.41	1.0375	−81.15	1611.0	0.4691	6.6717								
	0.7	184.49	0.99991	779.71	1.4851	−10.02	1605.3	0.6580	6.4847								
	0.8	228.90	0.99996	736.54	1.8586	80.24	1600.6	0.8763	6.3654								
	0.9	262.33	0.99999	693.06	2.1446	183.87	1597.0	1.1053	6.2880	2.53	0.11116	964.44	0.0198	−104.19	1709.0	−0.0426	8.7624
	1.0	290.71	1.00000	652.06	2.3906	297.16	1593.9	1.3009	6.2285	290.71	1.00000	652.06	2.3906	297.16	1593.9	1.3009	6.2285
0.01	0.0	0.61	0.00000	999.79	0.0049	0.00	2500.9	0.0000	9.1556	0.61	0.00000	999.79	0.0049	0.00	2500.9	0.0000	9.1556
	0.1	4.02	0.86180	966.81	0.0304	−56.37	1762.0	0.1084	8.6434	0.68	0.00442	999.02	0.0054	−3.58	2415.3	0.0088	9.2873
	0.2	11.99	0.96248	935.11	0.0903	−87.10	1675.0	0.2064	8.0142	0.77	0.00892	998.01	0.0060	−6.98	2329.6	0.0153	9.3398
	0.3	29.25	0.98873	906.54	0.2205	−104.00	1651.2	0.2925	7.5337	0.87	0.01407	996.66	0.0068	−10.70	2243.9	0.0217	9.3533
	0.4	63.81	0.99663	877.52	0.4832	−104.58	1641.5	0.3793	7.1279	1.02	0.02025	994.85	0.0079	−14.97	2158.1	0.0287	9.3339
	0.5	122.00	0.99895	845.66	0.9319	−82.64	1634.7	0.4903	6.7914	1.22	0.02800	992.37	0.0094	−20.06	2072.4	0.0368	9.2813
	0.6	198.62	0.99964	809.56	1.5358	−34.90	1627.4	0.6413	6.5325	1.51	0.03826	988.86	0.0116	−26.37	1986.6	0.0471	9.1910
	0.7	275.94	0.99985	768.97	2.1613	36.68	1620.2	0.8318	6.3514	1.98	0.05284	983.66	0.0151	−34.59	1900.9	0.0614	9.0520
	0.8	339.15	0.99993	724.96	2.6856	126.84	1614.3	1.0496	6.2335	2.88	0.07608	975.25	0.0218	−46.14	1815.1	0.0844	8.8391
	0.9	387.45	0.99997	680.61	3.0949	230.23	1609.6	1.2774	6.1550	5.33	0.12290	959.06	0.0402	−64.90	1729.1	0.1315	8.4768
	1.0	429.55	1.00000	638.56	3.4579	343.19	1605.4	1.4718	6.0925	429.55	1.00000	638.56	3.4579	343.19	1605.4	1.4718	6.0925
10	0.0	1.23	0.00000	999.65	0.0094	42.02	2519.2	0.1511	8.8998	1.23	0.00000	999.65	0.0094	42.02	2519.2	0.1511	8.8998
	0.1	7.07	0.84164	964.35	0.0516	−13.22	1799.3	0.2635	8.4551	1.37	0.00467	998.54	0.0104	38.36	2433.8	0.1607	9.0306
	0.2	20.07	0.95438	931.06	0.1459	−44.88	1702.0	0.3582	7.8467	1.54	0.00950	997.19	0.0116	34.85	2348.4	0.1680	9.0822
	0.3	47.37	0.98565	900.72	0.3451	−61.80	1673.3	0.4442	7.3759	1.75	0.01507	995.46	0.0132	30.99	2262.8	0.1753	9.0949
	0.4	99.84	0.99544	870.04	0.7319	−61.03	1661.2	0.5357	6.9817	2.04	0.02181	993.22	0.0153	26.54	2177.3	0.1834	9.0746
	0.5	184.44	0.99848	836.77	1.3672	−37.30	1652.3	0.6531	6.6573	2.44	0.03032	990.21	0.0181	21.21	2091.8	0.1929	9.0213
	0.6	292.15	0.99943	799.57	2.1985	11.67	1643.1	0.8083	6.4072	3.02	0.04166	986.05	0.0223	14.58	2006.2	0.2048	8.9303
	0.7	399.03	0.99975	758.04	3.0505	83.67	1634.2	1.0001	6.2303	3.95	0.05785	979.96	0.0291	5.89	1920.7	0.2214	8.7910
	0.8	486.44	0.99988	713.11	3.7695	173.80	1626.8	1.2177	6.1128	5.73	0.08365	970.31	0.0420	−6.34	1835.0	0.2473	8.5785
	0.9	554.33	0.99995	667.81	4.3430	277.00	1620.8	1.4447	6.0324	10.54	0.13489	952.16	0.0768	−26.10	1749.2	0.2977	8.2184
	1.0	615.05	1.00000	624.64	4.8679	389.71	1615.3	1.6380	5.9662	615.05	1.00000	624.64	4.8679	389.71	1615.3	1.6380	5.9662
20	0.0	2.34	0.00000	998.16	0.0173	83.91	2537.5	0.2965	8.6661	2.34	0.00000	998.16	0.0173	83.91	2537.5	0.2965	8.6661
	0.1	11.95	0.82096	960.94	0.0845	29.74	1837.0	0.4126	8.2827	2.60	0.00495	996.75	0.0191	80.17	2452.3	0.3070	8.7961
	0.2	32.34	0.94541	926.22	0.2276	−2.35	1729.6	0.5057	7.6954	2.92	0.01014	995.08	0.0214	76.54	2367.1	0.3152	8.8469
	0.3	73.85	0.98199	894.32	0.5209	−18.92	1695.8	0.5929	7.2347	3.34	0.01617	993.01	0.0243	72.52	2281.8	0.3234	8.8589
	0.4	150.56	0.99393	862.17	1.0706	−16.75	1680.7	0.6892	6.8512	3.88	0.02352	990.34	0.0281	67.87	2196.5	0.3326	8.8379
	0.5	269.50	0.99783	827.63	1.9431	8.61	1669.5	0.8121	6.5369	4.63	0.03287	986.80	0.0333	62.28	2111.2	0.3435	8.7840
	0.6	416.63	0.99913	789.37	3.0592	58.67	1658.2	0.9709	6.2938	5.72	0.04537	981.96	0.0409	55.28	2025.8	0.3571	8.6926
	0.7	560.61	0.99960	746.86	4.1956	131.10	1647.3	1.1640	6.1196	7.49	0.06326	974.97	0.0533	46.10	1940.4	0.3758	8.5532

TABLE 4. Saturation properties of {water+ammonia}—Continued

t	$\bar{\xi}$	Bubble point ($\xi' = \bar{\xi}$) p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	Dew point ($\xi'' = \bar{\xi}$) p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m^3		kJ/kg		kJ/(kg K)		kPa		kg/m^3		kJ/kg		kJ/(kg K)	
	0.8	678.61	0.99980	700.92	5.1634	221.29	1638.0	1.3816	6.0016	10.83	0.09166	964.07	0.0766	33.19	1854.9	0.4044	8.3412
	0.9	771.87	0.99991	654.59	5.9543	324.36	1630.5	1.6080	5.9183	19.75	0.14716	943.99	0.1391	12.63	1769.1	0.4578	7.9832
	1.0	857.48	1.00000	610.20	6.7025	436.93	1623.3	1.8005	5.8475	857.48	1.00000	610.20	6.7025	436.93	1623.3	1.8005	5.8475
30	0.0	4.25	0.00000	995.61	0.0304	125.73	2555.6	0.4368	8.4520	4.25	0.00000	995.61	0.0304	125.73	2555.6	0.4368	8.4520
	0.1	19.48	0.79991	956.74	0.1334	72.61	1874.8	0.5564	8.1248	4.72	0.00525	993.92	0.0336	121.90	2470.7	0.4482	8.5815
	0.2	50.37	0.93556	920.72	0.3435	40.46	1757.8	0.6493	7.5587	5.30	0.01083	991.95	0.0376	118.13	2385.7	0.4573	8.6317
	0.3	111.23	0.97768	887.43	0.7611	24.53	1718.6	0.7385	7.1084	6.05	0.01737	989.52	0.0426	113.94	2300.6	0.4665	8.6430
	0.4	219.63	0.99204	853.96	1.5180	28.12	1700.2	0.8394	6.7346	7.03	0.02538	986.42	0.0492	109.07	2215.6	0.4768	8.6215
	0.5	381.97	0.99696	818.26	2.6848	54.98	1686.3	0.9671	6.4288	8.38	0.03563	982.34	0.0583	103.18	2130.5	0.4891	8.5671
	0.6	577.83	0.99870	778.95	4.1509	106.04	1672.5	1.1291	6.1908	10.35	0.04937	976.80	0.0717	95.80	2045.3	0.5044	8.4755
	0.7	767.35	0.99937	735.41	5.6387	178.95	1659.3	1.3236	6.0181	13.52	0.06901	968.89	0.0931	86.12	1960.1	0.5252	8.3360
	0.8	923.28	0.99967	688.36	6.9214	269.28	1648.0	1.5414	5.8985	19.48	0.10004	956.72	0.1335	72.60	1874.8	0.5565	8.1246
	0.9	1048.9	0.99985	640.93	7.9982	372.32	1638.6	1.7674	5.8115	35.29	0.15972	934.71	0.2407	51.49	1788.9	0.6130	7.7687
	1.0	1167.2	1.00000	595.17	9.0533	484.90	1629.3	1.9597	5.7347	1167.2	1.00000	595.17	9.0533	484.90	1629.3	1.9597	5.7347
40	0.0	7.38	0.00000	992.18	0.0512	167.53	2573.5	0.5724	8.2556	7.38	0.00000	992.18	0.0512	167.53	2573.5	0.5724	8.2556
	0.1	30.71	0.77857	951.85	0.2041	115.47	1912.7	0.6955	7.9798	8.20	0.00558	990.22	0.0566	163.59	2488.9	0.5848	8.3846
	0.2	76.01	0.92482	914.65	0.5031	83.57	1786.6	0.7891	7.4351	9.22	0.01158	987.96	0.0632	159.68	2404.2	0.5948	8.4343
	0.3	162.41	0.97267	880.11	1.0799	68.50	1741.7	0.8810	6.9954	10.51	0.01866	985.16	0.0717	155.31	2319.4	0.6051	8.4451
	0.4	311.06	0.98969	845.44	2.0939	73.50	1719.6	0.9864	6.6303	12.21	0.02739	981.61	0.0828	150.20	2234.5	0.6166	8.4232
	0.5	526.90	0.99581	808.64	3.6183	101.77	1702.7	1.1184	6.3314	14.54	0.03859	976.97	0.0981	144.00	2149.7	0.6302	8.3685
	0.6	781.75	0.99809	768.29	5.5077	153.82	1686.1	1.2833	6.0972	17.94	0.05364	970.71	0.1203	136.23	2064.7	0.6473	8.2766
	0.7	1026.1	0.99902	723.65	7.4251	227.25	1670.3	1.4792	5.9247	23.38	0.07511	961.85	0.1561	126.07	1979.7	0.6703	8.1372
	0.8	1228.4	0.99947	675.40	9.1037	317.83	1656.7	1.6975	5.8025	33.59	0.10878	948.39	0.2231	112.01	1894.4	0.7041	7.9264
	0.9	1394.6	0.99975	626.76	10.556	420.93	1645.0	1.9234	5.7107	60.41	0.17253	924.47	0.3999	90.72	1808.4	0.7641	7.5722
	1.0	1555.4	1.00000	579.44	12.034	533.78	1633.1	2.1161	5.6265	1555.4	1.00000	579.44	12.034	533.78	1633.1	2.1161	5.6265
50	0.0	12.35	0.00000	988.00	0.0831	209.34	2591.3	0.7038	8.0749	12.35	0.00000	988.00	0.0831	209.34	2591.3	0.7038	8.0749
	0.1	46.97	0.75702	946.36	0.3034	158.38	1950.6	0.8303	7.8461	13.72	0.00593	985.78	0.0918	205.28	2507.0	0.7172	8.2035
	0.2	111.48	0.91316	908.07	0.7172	126.99	1815.8	0.9255	7.3233	15.41	0.01238	983.21	0.1025	201.22	2422.5	0.7282	8.2528
	0.3	230.63	0.96688	872.39	1.4928	112.93	1765.1	1.0204	6.8941	17.56	0.02004	980.03	0.1162	196.65	2338.0	0.7395	8.2633
	0.4	429.13	0.98681	836.62	2.8187	119.36	1738.9	1.1301	6.5369	20.39	0.02954	976.02	0.1342	191.29	2253.4	0.7523	8.2410
	0.5	709.44	0.99432	798.76	4.7701	148.98	1718.6	1.2661	6.2436	24.26	0.04176	970.79	0.1588	184.79	2168.7	0.7674	8.1860
	0.6	1034.3	0.99727	757.35	7.1645	202.01	1699.0	1.4338	6.0118	29.90	0.05817	963.77	0.1946	176.63	2084.0	0.7863	8.0941
	0.7	1343.7	0.99853	711.52	9.6020	276.05	1680.3	1.6312	5.8385	38.90	0.08154	953.94	0.2520	166.02	1999.1	0.8114	7.9548
	0.8	1601.8	0.99917	661.97	11.776	366.99	1664.0	1.8502	5.7127	55.71	0.11788	939.19	0.3592	151.55	1913.9	0.8480	7.7444
	0.9	1818.5	0.99959	612.03	13.721	470.30	1649.6	2.0764	5.6148	99.56	0.18567	913.33	0.6404	130.47	1827.5	0.9122	7.3916
	1.0	2034.0	1.00000	562.86	15.785	583.77	1634.2	2.2706	5.5213	2034.0	1.00000	562.86	15.785	583.77	1634.2	2.2706	5.5213
60	0.0	19.95	0.00000	983.16	0.1304	251.18	2608.9	0.8313	7.9082	19.95	0.00000	983.16	0.1304	251.18	2608.9	0.8313	7.9082
	0.1	69.88	0.73531	940.33	0.4393	201.38	1988.2	0.9613	7.7226	22.15	0.00630	980.68	0.1440	247.00	2524.8	0.8458	8.0365
	0.2	159.30	0.90058	901.03	0.9979	170.72	1845.5	1.0586	7.2218	24.87	0.01323	977.78	0.1608	242.78	2440.6	0.8577	8.0855
	0.3	319.39	0.96025	864.30	2.0159	157.80	1788.7	1.1569	6.8033	28.33	0.02151	974.22	0.1821	238.02	2356.3	0.8702	8.0957
	0.4	578.22	0.98333	827.49	3.7130	165.67	1758.1	1.2706	6.4533	32.87	0.03182	969.71	0.2102	232.41	2272.0	0.8843	8.0732
	0.5	934.75	0.99242	788.59	6.1666	196.63	1734.2	1.4105	6.1644	39.09	0.04512	963.87	0.2486	225.59	2187.5	0.9009	8.0180
	0.6	1341.4	0.99616	746.09	9.1563	250.67	1711.2	1.5808	5.9339	48.12	0.06298	956.06	0.3044	217.07	2103.0	0.9217	7.9259
	0.7	1726.7	0.99784	698.99	12.219	325.41	1689.4	1.7800	5.7588	62.51	0.08830	945.23	0.3936	206.07	2018.2	0.9491	7.7867
	0.8	2051.3	0.99873	648.04	15.013	416.82	1670.0	2.0000	5.6282	89.24	0.12735	929.16	0.5597	191.34	1933.0	0.9888	7.5768

TABLE 4. Saturation properties of {water+ammonia}—Continued

		Bubble point ($\xi' = \bar{\xi}$)								Dew point ($\xi'' = \bar{\xi}$)							
t	$\bar{\xi}$	p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m^3		kJ/kg		kJ/(kg K)		kPa		kg/m^3		kJ/kg		kJ/(kg K)	
	0.9	2330.1	0.99935	596.65	17.607	520.53	1652.1	2.2269	5.5227	158.56	0.19935	901.28	0.9933	170.87	1846.0	1.0580	7.2246
	1.0	2615.6	1.00000	545.24	20.493	635.11	1632.4	2.4239	5.4174	2615.6	1.00000	545.24	20.493	635.11	1632.4	2.4239	5.4174
70	0.0	31.20	0.00000	977.73	0.1984	293.07	2626.1	0.9551	7.7541	31.20	0.00000	977.73	0.1984	293.07	2626.1	0.9551	7.7541
	0.1	101.38	0.71350	933.80	0.6211	244.52	2025.5	1.0888	7.6081	34.63	0.00669	974.98	0.2190	288.77	2542.4	0.9707	7.8821
	0.2	222.33	0.88706	893.56	1.3583	214.79	1875.6	1.1887	7.1295	38.89	0.01413	971.75	0.2445	284.39	2458.4	0.9837	7.9309
	0.3	432.45	0.95270	855.85	2.6662	203.12	1812.6	1.2905	6.7218	44.28	0.02308	967.78	0.2769	279.42	2374.4	0.9974	7.9408
	0.4	762.82	0.97915	818.04	4.7979	212.43	1777.4	1.4083	6.3783	51.35	0.03426	962.75	0.3194	273.57	2290.3	1.0129	7.9181
	0.5	1207.8	0.99002	778.12	7.8340	244.74	1749.5	1.5517	6.0929	61.02	0.04870	956.26	0.3775	266.45	2206.0	1.0312	7.8628
	0.6	1708.3	0.99468	734.47	11.518	299.84	1722.8	1.7248	5.8628	75.04	0.06807	947.63	0.4620	257.60	2121.6	1.0540	7.7707
	0.7	2181.1	0.99687	686.00	15.326	375.40	1697.4	1.9258	5.6850	97.32	0.09542	935.76	0.5965	246.29	2037.0	1.0839	7.6315
	0.8	2584.3	0.99809	633.52	18.894	467.42	1674.4	2.1472	5.5484	138.57	0.13725	918.33	0.8466	231.47	1951.6	1.1269	7.4217
	0.9	2939.1	0.99899	580.51	22.347	571.79	1652.5	2.3754	5.4336	244.96	0.21373	888.30	1.4975	212.05	1863.9	1.2022	7.0696
	1.0	3313.5	1.00000	526.31	26.407	688.19	1627.1	2.5770	5.3131	3313.5	1.00000	526.31	26.407	688.19	1627.1	2.5770	5.3131
80	0.0	47.41	0.00000	971.77	0.2937	335.02	2643.0	1.0756	7.6111	47.41	0.00000	971.77	0.2937	335.02	2643.0	1.0756	7.6111
	0.1	143.72	0.69163	926.82	0.8593	287.83	2062.4	1.2130	7.5014	52.62	0.00711	968.73	0.3240	330.59	2559.6	1.0923	7.7390
	0.2	303.73	0.87261	885.68	1.8126	259.18	1905.9	1.3160	7.0452	59.07	0.01509	965.15	0.3617	326.06	2475.9	1.1065	7.7876
	0.3	573.74	0.94419	847.03	3.4614	248.86	1836.8	1.4214	6.6484	67.24	0.02475	960.74	0.4096	320.90	2392.1	1.1215	7.7974
	0.4	987.39	0.97419	808.27	6.0943	259.66	1796.6	1.5432	6.3109	77.94	0.03685	955.17	0.4723	314.81	2308.2	1.1384	7.7745
	0.5	1533.4	0.98702	767.31	9.7981	293.34	1764.5	1.6901	6.0284	92.55	0.05250	947.99	0.5580	307.42	2224.2	1.1586	7.7190
	0.6	2140.0	0.99275	722.44	14.285	349.58	1733.8	1.8659	5.7979	113.72	0.07346	938.51	0.6825	298.28	2139.9	1.1835	7.6267
	0.7	2712.5	0.99555	672.48	18.978	426.07	1704.5	2.0692	5.6164	147.26	0.10292	925.55	0.8803	286.75	2055.3	1.2162	7.4875
	0.8	3207.8	0.99719	618.34	23.513	518.89	1677.4	2.2922	5.4726	209.20	0.14764	906.72	1.2474	272.05	1969.7	1.2629	7.2776
	0.9	3654.6	0.99846	563.49	28.111	624.26	1650.5	2.5226	5.3465	368.25	0.22883	874.41	2.2019	254.21	1880.8	1.3454	6.9246
	1.0	4142.0	1.00000	505.67	33.888	743.49	1617.5	2.7312	5.2060	4142.0	1.00000	505.67	33.888	743.49	1617.5	2.7312	5.2060
90	0.0	70.18	0.00000	965.30	0.4239	377.04	2659.6	1.1929	7.4782	70.18	0.00000	965.30	0.4239	377.04	2659.6	1.1929	7.4782
	0.1	199.49	0.66974	919.39	1.1659	331.33	2098.7	1.3343	7.4016	77.88	0.00755	961.96	0.4677	372.51	2576.4	1.2109	7.6060
	0.2	406.92	0.85723	877.39	2.3762	303.94	1936.4	1.4406	6.9679	87.40	0.01611	958.02	0.5221	367.83	2493.0	1.2263	7.6544
	0.3	747.33	0.93463	837.86	4.4196	295.06	1861.2	1.5498	6.5820	99.47	0.02652	953.14	0.5911	362.48	2409.5	1.2427	7.6640
	0.4	1256.3	0.96835	798.14	7.6235	307.38	1815.8	1.6755	6.2504	115.25	0.03960	946.99	0.6814	356.17	2325.8	1.2613	7.6410
	0.5	1915.9	0.98331	756.12	12.085	342.47	1779.2	1.8259	5.9701	136.78	0.05653	939.09	0.8049	348.54	2241.9	1.2833	7.5853
	0.6	2641.1	0.99025	709.95	17.491	399.95	1744.3	2.0046	5.7386	167.92	0.07917	928.70	0.9839	339.17	2157.7	1.3106	7.4929
	0.7	3325.7	0.99377	658.37	23.230	477.54	1710.8	2.2103	5.5527	217.19	0.11083	914.63	1.2682	327.54	2073.0	1.3463	7.3534
	0.8	3927.9	0.99592	602.43	28.974	571.35	1678.8	2.4354	5.4003	307.94	0.15859	894.32	1.7955	313.19	1987.1	1.3972	7.1430
	0.9	4485.4	0.99768	545.40	35.108	678.20	1645.9	2.6690	5.2603	540.27	0.24490	859.51	3.1679	297.49	1896.7	1.4883	6.7880
	1.0	5116.7	1.00000	482.75	43.484	801.75	1602.3	2.8884	5.0929	5116.7	1.00000	482.75	43.484	801.75	1602.3	2.8884	5.0929
100	0.0	101.42	0.00000	958.35	0.5982	419.17	2675.6	1.3072	7.3542	101.42	0.00000	958.35	0.5982	419.17	2675.6	1.3072	7.3542
	0.1	271.61	0.64787	911.53	1.5540	375.06	2134.4	1.4529	7.3078	112.53	0.00802	954.71	0.6600	414.53	2592.8	1.3266	7.4819
	0.2	535.61	0.84094	868.72	3.0654	349.07	1967.1	1.5628	6.8964	126.27	0.01719	950.37	0.7367	409.71	2509.6	1.3433	7.5302
	0.3	957.38	0.92399	828.31	5.5602	341.72	1885.7	1.6759	6.5219	143.67	0.02841	945.00	0.8340	404.20	2426.3	1.3612	7.5397
	0.4	1573.9	0.96152	787.65	9.4073	355.63	1835.0	1.8054	6.1958	166.42	0.04254	938.24	0.9615	397.69	2342.8	1.3816	7.5164
	0.5	2359.5	0.97878	744.52	14.719	392.20	1793.7	1.9594	5.9174	197.41	0.06083	929.56	1.1355	389.86	2259.0	1.4058	7.4606
	0.6	3215.2	0.98705	696.95	21.172	451.03	1754.3	2.1412	5.6845	242.20	0.08524	918.23	1.3878	380.33	2174.9	1.4357	7.3679
	0.7	4024.7	0.99140	643.58	28.140	529.89	1716.1	2.3496	5.4935	312.97	0.11922	902.98	1.7884	368.73	2090.1	1.4747	7.2280
	0.8	4750.2	0.99416	585.67	35.399	624.96	1678.7	2.5772	5.3309	443.07	0.17018	881.10	2.5314	354.99	2003.6	1.5305	7.0166
	0.9	5439.5	0.99653	526.03	43.614	733.94	1638.2	2.8156	5.1741	775.67	0.26209	843.53	4.4727	342.13	1911.1	1.6316	6.6582
	1.0	6255.3	1.00000	456.63	56.117	864.15	1579.8	3.0513	4.9691	6255.3	1.00000	456.63	56.117	864.15	1579.8	3.0513	4.9691

TABLE 4. Saturation properties of {water+ammonia}—Continued

		Bubble point ($\xi' = \bar{\xi}$)								Dew point ($\xi'' = \bar{\xi}$)							
t	$\bar{\xi}$	p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m³		kJ/kg		kJ/(kg K)		kPa		kg/m³		kJ/kg		kJ/(kg K)	
110	0.0	143.38	0.00000	950.95	0.8269	461.42	2691.1	1.4188	7.2381	143.38	0.00000	950.95	0.8269	461.42	2691.1	1.4188	7.2381
	0.1	363.32	0.62604	903.27	2.0381	419.04	2169.4	1.5689	7.2192	159.07	0.00851	946.98	0.9125	456.69	2608.6	1.4396	7.3658
	0.2	693.71	0.82376	859.65	3.8980	394.59	1997.6	1.6827	6.8300	178.48	0.01835	942.23	1.0186	451.75	2525.7	1.4578	7.4141
	0.3	1208.1	0.91220	818.38	6.9032	388.87	1910.4	1.7998	6.4669	203.06	0.03042	936.33	1.1533	446.10	2442.6	1.4774	7.4233
	0.4	1944.3	0.95361	776.75	11.468	404.43	1854.3	1.9332	6.1465	235.15	0.04567	928.91	1.3296	439.42	2359.2	1.4997	7.3999
	0.5	2867.7	0.97330	732.45	17.729	442.59	1808.0	2.0908	5.8697	278.86	0.06541	919.42	1.5704	431.43	2275.5	1.5262	7.3437
	0.6	3865.2	0.98302	683.35	25.362	502.92	1763.8	2.2759	5.6351	341.97	0.09170	907.09	1.9196	421.84	2191.4	1.5590	7.2506
	0.7	4812.4	0.98827	628.02	33.772	583.26	1720.6	2.4874	5.4382	441.57	0.12812	890.59	2.4740	410.43	2106.4	1.6017	7.1100
	0.8	5678.9	0.99173	567.95	42.929	679.91	1676.9	2.7183	5.2639	624.54	0.18253	867.02	3.5044	397.59	2019.1	1.6631	6.8972
	0.9	6523.4	0.99483	505.07	53.993	791.96	1627.1	2.9634	5.0868	1092.5	0.28081	826.25	6.2152	388.39	1923.8	1.7764	6.5335
	1.0	7578.3	1.00000	425.61	73.550	932.83	1546.2	3.2249	4.8258	7578.3	1.00000	425.61	73.550	932.83	1546.2	3.2249	4.8258
120	0.0	198.68	0.00000	943.11	1.1221	503.82	2705.9	1.5279	7.1292	198.68	0.00000	943.11	1.1221	503.82	2705.9	1.5279	7.1292
	0.1	478.19	0.60430	894.59	2.6342	463.32	2203.4	1.6827	7.1350	220.42	0.00904	938.79	1.2384	499.01	2623.7	1.5503	7.2569
	0.2	885.35	0.80570	850.18	4.8933	440.55	2028.1	1.8005	6.7678	247.31	0.01958	933.59	1.3827	493.98	2541.1	1.5700	7.3050
	0.3	1503.9	0.89922	808.05	8.4705	436.56	1935.1	1.9217	6.4164	281.34	0.03257	927.14	1.5659	488.20	2458.1	1.5914	7.3140
	0.4	2371.3	0.94451	765.42	13.831	453.86	1873.5	2.0592	6.1017	325.77	0.04902	919.01	1.8058	481.40	2374.9	1.6159	7.2903
	0.5	3443.6	0.96672	719.85	21.142	493.71	1822.1	2.2205	5.8264	386.26	0.07030	908.65	2.1335	473.33	2291.3	1.6450	7.2337
	0.6	4593.4	0.97798	669.07	30.100	555.73	1773.0	2.4092	5.5898	473.56	0.09858	895.25	2.6089	463.76	2207.1	1.6809	7.1400
	0.7	5690.8	0.98421	611.59	40.195	637.79	1724.3	2.6243	5.3865	611.26	0.13762	877.42	3.3649	452.72	2121.6	1.7278	6.9984
	0.8	6716.8	0.98841	549.12	51.739	736.44	1673.2	2.8591	5.1987	864.23	0.19574	852.01	4.7743	441.16	2033.3	1.7956	6.7834
	0.9	7741.0	0.99230	482.07	66.746	852.94	1611.9	3.1141	4.9968	1513.1	0.30125	807.53	8.5250	436.64	1934.3	1.9233	6.4123
	1.0	9112.5	1.00000	385.49	100.07	1013.1	1493.4	3.4218	4.6435	9112.5	1.00000	385.49	100.07	1013.1	1493.4	3.4218	4.6435
130	0.0	270.28	0.00000	934.83	1.4970	546.39	2720.1	1.6347	7.0265	270.28	0.00000	934.83	1.4970	546.39	2720.1	1.6347	7.0265
	0.1	620.07	0.58266	885.50	3.3600	507.92	2236.4	1.7943	7.0547	299.88	0.00960	930.15	1.6526	541.53	2638.2	1.6587	7.1542
	0.2	1114.9	0.78681	840.31	6.0720	486.97	2058.2	1.9164	6.7090	336.48	0.02089	924.47	1.8459	536.42	2555.8	1.6802	7.2022
	0.3	1849.0	0.88502	797.29	10.286	484.82	1959.8	2.0418	6.3695	382.79	0.03487	917.41	2.0913	530.56	2473.0	1.7036	7.2110
	0.4	2858.8	0.93413	753.60	16.523	503.97	1892.7	2.1834	6.0606	443.26	0.05260	908.52	2.4128	523.69	2389.8	1.7304	7.1868
	0.5	4089.8	0.95889	706.66	24.990	545.66	1836.0	2.3487	5.7869	525.55	0.07554	897.23	2.8523	515.60	2306.1	1.7624	7.1298
	0.6	5401.0	0.97173	654.01	35.430	609.58	1781.7	2.5414	5.5481	644.32	0.10595	882.70	3.4907	506.20	2221.7	1.8019	7.0352
	0.7	6660.7	0.97897	594.15	47.496	693.66	1727.1	2.7606	5.3377	831.68	0.14779	863.43	4.5083	495.74	2135.7	1.8535	6.8922
	0.8	7864.6	0.98391	529.02	62.047	794.87	1667.6	3.0005	5.1346	1176.3	0.21000	835.96	6.4156	485.86	2045.9	1.9286	6.6741
	0.9	9091.3	0.98848	456.37	82.606	917.93	1591.8	3.2701	4.9024	2065.6	0.32391	787.01	11.578	487.39	1942.0	2.0739	6.2925
	1.0	10897.7	1.00000	312.29	156.77	1135.2	1382.5	3.7153	4.3287	10897.7	1.00000	312.29	156.77	1135.2	1382.5	3.7153	4.3287
140	0.0	361.54	0.00000	926.13	1.9667	589.17	2733.5	1.7392	6.9294	361.54	0.00000	926.13	1.9667	589.17	2733.5	1.7392	6.9294
	0.1	793.12	0.56116	876.00	4.2348	552.88	2268.3	1.9040	6.9775	401.19	0.01020	921.06	2.1721	584.28	2651.9	1.7651	7.0571
	0.2	1386.8	0.76713	830.00	7.4573	533.90	2087.8	2.0306	6.6528	450.21	0.02229	914.86	2.4273	579.13	2569.6	1.7885	7.1049
	0.3	2247.7	0.86956	786.08	12.376	533.72	1984.3	2.1604	6.3253	512.24	0.03733	907.15	2.7515	573.23	2486.9	1.8141	7.1133
	0.4	3410.3	0.92234	741.25	19.573	554.84	1911.7	2.3062	6.0224	593.24	0.05644	897.44	3.1768	566.34	2403.7	1.8436	7.0887
	0.5	4808.5	0.94965	692.80	29.310	598.56	1849.7	2.4758	5.7505	703.51	0.08116	885.15	3.7589	558.33	2320.0	1.8787	7.0309
	0.6	6288.5	0.96407	638.05	41.403	664.63	1790.0	2.6729	5.5095	862.70	0.11385	869.39	4.6061	549.24	2235.2	1.9221	6.9353
	0.7	7721.7	0.97228	575.57	55.782	751.08	1728.9	2.8968	5.2911	1114.1	0.15873	848.56	5.9613	539.62	2148.4	1.9790	6.7903
	0.8	9120.2	0.97779	507.40	74.154	855.66	1659.5	3.1435	5.0703	1577.8	0.22546	818.75	8.5218	531.95	2056.7	2.0627	6.5679
	0.9	10563.0	0.98253	426.74	102.77	988.84	1565.1	3.4357	4.8002	2786.5	0.34946	764.19	15.624	541.39	1946.2	2.2300	6.1718
150	0.0	476.17	0.00000	917.01	2.5481	632.18	2745.9	1.8418	6.8371	476.17	0.00000	917.01	2.5481	632.18	2745.9	1.8418	6.8371
	0.1	1001.8	0.53983	866.07	5.2799	598.24	2298.9	2.0119	6.9029	528.50	0.01084	911.50	2.8156	627.30	2664.6	1.8697	6.9649
	0.2	1705.8	0.74670	819.25	9.0746	581.38	2116.7	2.1432	6.5985	593.20	0.02380	904.75	3.1484	622.15	2582.5	1.8952	7.0124

TABLE 4. Saturation properties of {water+ammonia}—Continued

t	$\bar{\xi}$	Bubble point ($\xi' = \bar{\xi}$) p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	Dew point ($\xi'' = \bar{\xi}$) p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m^3		kJ/kg		kJ/(kg K)		kPa		kg/m^3		kJ/kg		kJ/(kg K)	
	0.3	2704.3	0.85284	774.36	14.770	583.30	2008.5	2.2776	6.2832	675.10	0.03998	896.33	3.5718	616.26	2499.8	1.9232	7.0204
	0.4	4029.0	0.90907	728.31	23.019	606.56	1930.4	2.4279	5.9865	782.09	0.06057	885.74	4.1279	609.43	2416.6	1.9556	6.9952
	0.5	5601.3	0.93883	678.18	34.148	652.52	1863.0	2.6020	5.7164	927.82	0.08720	872.37	4.8905	601.61	2332.6	1.9942	6.9365
	0.6	7255.7	0.95475	621.06	48.091	721.07	1797.7	2.8042	5.4730	1138.4	0.12236	855.27	6.0037	593.00	2247.4	2.0421	6.8394
	0.7	8872.3	0.96378	555.70	65.210	810.33	1729.5	3.0336	5.2457	1471.6	0.17054	832.70	7.7938	584.53	2159.5	2.1051	6.6918
	0.8	10477.1	0.96945	483.90	88.517	919.49	1648.4	3.2896	5.0042	2089.0	0.24238	800.18	11.214	579.73	2065.3	2.1989	6.4637
	0.9	12118.4	0.97272	390.56	129.56	1069.7	1528.1	3.6199	4.6827	3724.9	0.37893	738.26	21.046	599.80	1945.5	2.3945	6.0470
160	0.0	618.24	0.00000	907.45	3.2596	675.48	2757.5	1.9426	6.7492	618.24	0.00000	907.45	3.2596	675.48	2757.5	1.9426	6.7492
	0.1	1250.7	0.51870	855.71	6.5189	644.05	2328.0	2.1182	6.8303	686.38	0.01153	901.49	3.6043	670.64	2676.4	1.9727	6.8769
	0.2	2076.6	0.72557	808.03	10.953	629.47	2144.9	2.2545	6.5455	770.66	0.02542	894.13	4.0337	665.53	2594.3	2.0005	6.9241
	0.3	3223.3	0.83482	762.11	17.505	633.65	2032.2	2.3936	6.2424	877.39	0.04283	884.93	4.5808	659.70	2511.7	2.0312	6.9316
	0.4	4718.2	0.89420	714.70	26.905	659.24	1948.8	2.5487	5.9520	1016.9	0.06503	873.39	5.3008	653.02	2428.3	2.0667	6.9055
	0.5	6469.4	0.92623	662.66	39.564	707.71	1875.8	2.7279	5.6838	1207.1	0.09372	858.83	6.2908	645.52	2344.0	2.1093	6.8456
	0.6	8301.6	0.94348	602.86	55.590	779.11	1804.6	2.9357	5.4377	1482.5	0.13155	840.27	7.7420	637.62	2258.0	2.1621	6.7466
	0.7	10109.5	0.95304	534.36	76.021	871.76	1728.2	3.1718	5.1998	1919.5	0.18339	815.74	10.092	630.67	2168.7	2.2321	6.5956
	0.8	11921.6	0.95793	457.95	105.94	987.45	1632.5	3.4412	4.9324	2735.0	0.26111	779.97	14.653	629.60	2071.0	2.3382	6.3597
	0.9	13628.2	0.95669	340.98	168.64	1171.2	1472.4	3.8473	4.5311	4952.9	0.41409	707.73	28.487	664.66	1938.1	2.5724	5.9128
170	0.0	792.19	0.00000	897.45	4.1222	719.09	2767.9	2.0417	6.6650	792.19	0.00000	897.45	4.1222	719.09	2767.9	2.0417	6.6650
	0.1	1544.8	0.49779	844.88	7.9782	690.36	2355.6	2.2231	6.7593	879.84	0.01227	890.99	4.5619	714.33	2687.0	2.0742	6.7926
	0.2	2504.3	0.70380	796.30	13.125	678.22	2171.9	2.3646	6.4932	988.29	0.02717	882.97	5.1108	709.32	2605.0	2.1045	6.8394
	0.3	3809.1	0.81551	749.25	20.621	684.85	2055.1	2.5087	6.2020	1125.7	0.04591	872.93	5.8115	703.64	2522.3	2.1382	6.8461
	0.4	5480.8	0.87764	700.33	31.286	713.00	1966.5	2.6690	5.9181	1305.6	0.06984	860.33	6.7359	697.22	2438.6	2.1774	6.8191
	0.5	7413.6	0.91166	646.12	45.637	764.31	1887.9	2.8538	5.6516	1551.2	0.10078	844.49	8.0117	690.20	2353.7	2.2243	6.7576
	0.6	9424.5	0.92994	583.27	64.049	839.05	1810.3	3.0682	5.4023	1907.6	0.14153	824.29	9.8923	683.25	2266.8	2.2828	6.6561
	0.7	11428.3	0.93944	511.30	88.616	935.90	1724.2	3.3124	5.1509	2475.9	0.19745	797.51	12.968	678.31	2175.5	2.3610	6.5005
	0.8	13424.4	0.94143	428.42	128.16	1061.6	1608.4	3.6026	4.8472	3547.6	0.28211	757.71	19.068	682.15	2073.2	2.4820	6.2541
	0.9	14713.1	0.94024	269.07	210.16	1313.6	1427.3	4.1641	4.4089	6590.5	0.45846	669.51	39.209	740.13	1920.0	2.7736	5.7600
180	0.0	1002.8	0.00000	887.00	5.1588	763.06	2777.2	2.1393	6.5841	1002.8	0.00000	887.00	5.1588	763.06	2777.2	2.1393	6.5841
	0.1	1889.3	0.47711	833.57	9.6877	737.22	2381.5	2.3268	6.6895	1114.3	0.01306	879.99	5.7151	758.43	2696.5	2.1744	6.7115
	0.2	2994.0	0.68144	784.02	15.630	727.72	2197.7	2.4736	6.4408	1252.3	0.02905	871.25	6.4110	753.59	2614.5	2.2076	6.7576
	0.3	4465.9	0.79491	735.73	24.170	737.01	2077.1	2.6231	6.1613	1427.5	0.04924	860.28	7.3016	748.15	2531.4	2.2446	6.7635
	0.4	6319.7	0.85929	685.10	36.232	768.01	1983.3	2.7890	5.8837	1657.0	0.07506	846.53	8.4805	742.11	2447.4	2.2877	6.7351
	0.5	8434.1	0.89489	628.37	52.479	822.58	1899.0	2.9803	5.6187	1971.1	0.10844	829.25	10.115	735.77	2361.8	2.3396	6.6716
	0.6	10622.5	0.91373	562.07	73.703	901.24	1814.2	3.2023	5.3647	2428.4	0.15242	807.21	12.543	730.11	2273.4	2.4046	6.5669
	0.7	12819.7	0.92206	486.17	103.73	1003.6	1715.7	3.4572	5.0948	3162.5	0.21297	777.76	16.569	727.80	2179.6	2.4925	6.4052
	0.8	14918.5	0.91626	392.89	160.25	1146.0	1565.7	3.7829	4.7255	4568.9	0.30612	732.74	24.799	738.26	2070.8	2.6327	6.1441
190	0.0	1255.2	0.00000	876.08	6.3954	807.44	2785.3	2.2355	6.5060	1255.2	0.00000	876.08	6.3954	807.44	2785.3	2.2355	6.5060
	0.1	2289.6	0.45670	821.74	11.681	784.69	2405.6	2.4293	6.6203	1395.6	0.01392	868.47	7.0940	803.01	2704.6	2.2735	6.6330
	0.2	3550.8	0.65853	771.14	18.511	778.05	2221.9	2.5819	6.3879	1569.5	0.03109	858.93	7.9702	798.41	2622.4	2.3099	6.6784
	0.3	5198.2	0.77303	721.46	28.213	790.26	2097.8	2.7371	6.1195	1790.5	0.05286	846.94	9.0954	793.32	2539.1	2.3506	6.6831
	0.4	7237.4	0.83905	668.86	41.838	824.44	1998.8	2.9092	5.8478	2080.7	0.08073	831.91	10.591	787.82	2454.4	2.3982	6.6530
	0.5	9531.1	0.87568	609.21	60.253	882.79	1908.4	3.1078	5.5836	2479.0	0.11679	813.02	12.678	782.41	2367.7	2.4557	6.5870
	0.6	11892.9	0.89431	539.01	84.939	966.16	1815.2	3.3390	5.3223	3061.9	0.16437	788.86	15.809	778.44	2277.6	2.5283	6.4780
	0.7	14266.5	0.89922	458.29	122.90	1076.2	1699.2	3.6089	5.0234	4006.1	0.23031	756.16	21.096	779.60	2180.2	2.6279	6.3082
	0.8	16245.2	0.89783	346.59	231.56	1249.6	1461.0	4.0011	4.4587	5858.8	0.33436	703.92	32.405	799.39	2062.0	2.7938	6.0257

TABLE 4. Saturation properties of {water+ammonia}—Continued

		Bubble point ($\xi' = \bar{\xi}$)								Dew point ($\xi'' = \bar{\xi}$)							
t	$\bar{\xi}$	p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m³		kJ/kg		kJ/(kg K)		kPa		kg/m³		kJ/kg		kJ/(kg K)	
200	0.0	1554.9	0.00000	864.66	7.8610	852.28	2792.0	2.3306	6.4302	1554.9	0.00000	864.66	7.8610	852.28	2792.0	2.3306	6.4302
	0.1	2751.3	0.43655	809.36	13.997	832.84	2427.6	2.5310	6.5513	1730.0	0.01486	856.39	8.7330	848.12	2711.3	2.3718	6.5567
	0.2	4180.1	0.63514	757.59	21.824	829.31	2244.3	2.6897	6.3339	1947.2	0.03331	845.96	9.8302	843.86	2628.9	2.4116	6.6011
	0.3	6010.4	0.74986	706.35	32.830	844.73	2116.8	2.8511	6.0758	2223.7	0.05680	832.84	11.245	839.25	2545.0	2.4565	6.6044
	0.4	8236.6	0.81680	651.46	48.229	882.55	2012.7	3.0301	5.8092	2587.7	0.08692	816.38	13.136	834.50	2459.4	2.5092	6.5721
	0.5	10704.2	0.85370	588.39	69.201	945.34	1915.5	3.2372	5.5443	3089.2	0.12594	795.66	15.797	830.32	2371.3	2.5731	6.5027
	0.6	13231.8	0.87087	513.77	98.453	1034.5	1811.5	3.4796	5.2706	3828.2	0.17760	769.00	19.841	828.59	2278.7	2.6546	6.3881
	0.7	15732.3	0.86697	426.31	150.35	1156.3	1665.3	3.7731	4.9157	5041.4	0.24999	732.16	26.848	834.42	2176.3	2.7689	6.2072
210	0.0	1907.7	0.00000	852.72	9.5885	897.64	2797.3	2.4246	6.3564	1907.7	0.00000	852.72	9.5885	897.64	2797.3	2.4246	6.3564
	0.1	3280.1	0.41668	796.38	16.680	881.76	2447.4	2.6319	6.4822	2124.2	0.01587	843.71	10.672	893.84	2716.4	2.4693	6.4821
	0.2	4887.5	0.61131	743.31	25.632	881.61	2264.7	2.7971	6.2781	2393.3	0.03573	832.30	12.040	890.05	2633.5	2.5131	6.5252
	0.3	6906.9	0.72542	690.26	38.120	900.62	2133.8	2.9653	6.0291	2736.5	0.06109	817.91	13.813	886.08	2548.9	2.5626	6.5266
	0.4	9319.5	0.79242	632.69	55.581	942.61	2024.2	3.1522	5.7664	3189.9	0.09370	799.82	16.199	882.31	2462.1	2.6211	6.4916
	0.5	11952.8	0.82856	565.60	79.711	1010.7	1919.0	3.3694	5.4980	3818.0	0.13603	776.99	19.593	879.76	2372.2	2.6925	6.4179
	0.6	14631.5	0.84200	485.86	115.63	1107.4	1799.6	3.6262	5.2018	4751.9	0.19241	747.29	24.847	881.00	2276.2	2.7847	6.2959
	0.7	17145.4	0.83960	387.54	207.39	1249.4	1576.4	3.9604	4.6867	6315.6	0.27284	704.92	34.296	893.34	2166.4	2.9183	6.0988
220	0.0	2319.6	0.00000	840.22	11.615	943.59	2801.0	2.5177	6.2841	2319.6	0.00000	840.22	11.615	943.59	2801.0	2.5177	6.2841
	0.1	3882.1	0.39709	782.74	19.785	931.54	2464.9	2.7323	6.4124	2585.4	0.01697	830.39	12.956	940.25	2719.8	2.5664	6.4088
	0.2	5678.3	0.58706	728.21	30.016	935.10	2282.6	2.9044	6.2200	2916.3	0.03837	817.87	14.657	937.07	2636.2	2.6145	6.4503
	0.3	7892.2	0.69968	673.06	44.216	958.15	2148.3	3.0802	5.9785	3339.6	0.06580	802.04	16.875	933.96	2550.6	2.6694	6.4493
	0.4	10488.0	0.76573	612.30	64.145	1005.0	2032.5	3.2762	5.7176	3901.0	0.10117	782.10	19.888	931.48	2462.2	2.7344	6.4107
	0.5	13275.7	0.79965	540.47	92.440	1079.6	1917.3	3.5056	5.4405	4684.4	0.14726	756.76	24.235	931.08	2369.6	2.8146	6.3314
	0.6	16074.7	0.80452	454.39	139.92	1187.0	1771.4	3.7828	5.0978	5864.3	0.20923	723.21	31.134	936.34	2268.8	2.9202	6.1990
	0.7	18374.1	0.72567	339.41	296.49	1362.2	1435.4	4.1845	4.3467	7901.2	0.30037	672.85	44.279	958.28	2147.8	3.0808	5.9775
230	0.0	2797.1	0.00000	827.12	13.985	990.20	2802.9	2.6101	6.2129	2797.1	0.00000	827.12	13.985	990.20	2802.9	2.6101	6.2129
	0.1	4563.4	0.37777	768.38	23.374	982.29	2479.7	2.8324	6.3416	3121.1	0.01818	816.37	15.639	987.46	2721.3	2.6633	6.3362
	0.2	6558.4	0.56241	712.16	35.077	989.95	2297.7	3.0121	6.1587	3525.4	0.04126	802.59	17.751	985.07	2636.8	2.7163	6.3756
	0.3	8970.4	0.67261	654.55	51.296	1017.6	2159.6	3.1962	5.9227	4044.4	0.07099	785.11	20.526	983.07	2549.7	2.7772	6.3716
	0.4	11743.8	0.73649	589.97	74.305	1070.2	2036.5	3.4029	5.6601	4736.7	0.10944	763.00	24.342	982.30	2459.2	2.8499	6.3285
	0.5	14670.2	0.76588	512.50	108.64	1153.0	1907.0	3.6477	5.3647	5711.8	0.15987	734.60	29.952	984.76	2363.0	2.9407	6.2416
	0.6	17525.8	0.74761	417.50	184.87	1277.0	1697.9	3.9568	4.8943	7208.2	0.22877	695.96	39.190	995.63	2255.1	3.0637	6.0944
240	0.0	3347.0	0.00000	813.37	16.749	1037.6	2803.0	2.7020	6.1424	3347.0	0.00000	813.37	16.749	1037.6	2803.0	2.7020	6.1424
	0.1	5330.4	0.35871	753.21	27.526	1034.1	2491.7	2.9325	6.2692	3739.6	0.01950	801.56	18.788	1035.6	2720.6	2.7601	6.2639
	0.2	7533.4	0.53737	695.04	40.943	1046.4	2309.6	3.1204	6.0936	4230.7	0.04446	786.35	21.409	1034.2	2634.8	2.8188	6.3007
	0.3	10145.6	0.64415	634.50	59.607	1079.3	2166.9	3.3141	5.8602	4864.1	0.07673	766.96	24.890	1033.7	2545.9	2.8866	6.2928
	0.4	13087.9	0.70431	565.28	86.677	1139.0	2034.5	3.5336	5.5906	5715.2	0.11870	742.26	29.750	1035.1	2452.4	2.9684	6.2437
	0.5	16129.4	0.72497	480.93	131.14	1232.7	1881.4	3.7987	5.2558	6929.6	0.17428	710.00	37.092	1041.5	2351.0	3.0725	6.1462
	0.6	18933.7	0.66066	372.91	271.94	1383.4	1555.3	4.1592	4.5393	8848.0	0.25229	664.05	49.883	1060.6	2232.3	3.2196	5.9765
250	0.0	3976.2	0.00000	798.89	19.967	1085.8	2801.0	2.7935	6.0721	3976.2	0.00000	798.89	19.967	1085.8	2801.0	2.7935	6.0721
	0.1	6189.6	0.33989	737.12	32.336	1087.3	2500.6	3.0328	6.1947	4449.3	0.02096	785.89	22.480	1084.8	2717.5	2.8572	6.1914
	0.2	8608.9	0.51191	676.66	47.786	1104.6	2317.8	3.2298	6.0237	5043.3	0.04799	769.01	25.740	1084.7	2630.1	2.9223	6.2249
	0.3	11421.5	0.61415	612.58	69.512	1143.8	2169.2	3.4346	5.7890	5813.5	0.08314	747.37	30.126	1086.0	2538.6	2.9982	6.2119
	0.4	14519.8	0.66845	537.68	102.36	1212.2	2023.6	3.6700	5.5030	6858.6	0.12918	719.49	36.382	1090.5	2441.0	3.0911	6.1546
	0.5	17636.4	0.67033	444.35	168.81	1321.7	1821.0	3.9642	5.0716	8378.4	0.19112	682.08	46.209	1102.3	2332.0	3.2123	6.0421

TABLE 4. Saturation properties of {water+ammonia}—Continued

		Bubble point ($\xi' = \bar{\xi}$)								Dew point ($\xi'' = \bar{\xi}$)							
t	$\bar{\xi}$	p_B	ξ''	ϱ'	ϱ''	h'	h''	s'	s''	p_D	ξ'	ϱ'	ϱ''	h'	h''	s'	s''
°C		kPa		kg/m³		kJ/kg		kJ/(kg K)		kPa		kg/m³		kJ/kg		kJ/(kg K)	
260	0.0	4692.3	0.00000	783.63	23.712	1135.0	2796.6	2.8850	6.0017	4692.3	0.00000	783.63	23.712	1135.0	2796.6	2.8850	6.0017
	0.1	7147.9	0.32129	719.98	37.926	1141.8	2506.0	3.1336	6.1175	5259.7	0.02258	769.22	26.814	1135.2	2711.7	2.9550	6.1180
	0.2	9790.5	0.48597	656.81	55.837	1165.0	2321.5	3.3408	5.9479	5975.2	0.05193	750.40	30.885	1136.7	2622.1	3.0275	6.1472
	0.3	12801.0	0.58236	588.39	81.562	1211.7	2165.1	3.5588	5.7063	6909.9	0.09036	726.04	36.458	1140.5	2527.2	3.1131	6.1277
	0.4	16036.0	0.62744	506.36	123.57	1291.6	1998.6	3.8147	5.3865	8195.3	0.14125	694.11	44.646	1149.1	2423.7	3.2196	6.0591
	0.5	19152.3	0.59035	400.26	243.48	1426.0	1693.6	4.1548	4.7424	10119.7	0.21154	649.32	58.317	1169.1	2302.7	3.3649	5.9232
270	0.0	5503.0	0.00000	767.46	28.073	1185.3	2789.7	2.9765	5.9305	5503.0	0.00000	767.46	28.073	1185.3	2789.7	2.9765	5.9305
	0.1	8212.0	0.30284	701.63	44.455	1198.1	2507.6	3.2354	6.0367	6180.9	0.02438	751.42	31.917	1187.0	2702.9	3.0539	6.0431
	0.2	11083.7	0.45943	635.17	65.421	1228.1	2320.0	3.4543	5.8646	7040.5	0.05637	730.26	37.034	1190.7	2610.3	3.1351	6.0667
	0.3	14285.5	0.54830	561.32	96.672	1284.0	2152.3	3.6883	5.6078	8174.4	0.09862	702.54	44.208	1197.8	2510.6	3.2323	6.0383
	0.4	17624.7	0.57769	469.96	155.98	1379.8	1947.6	3.9726	5.2158	9764.0	0.15549	665.17	55.215	1212.1	2398.4	3.3569	5.9534
	0.5	20238.1	0.51553	340.81	312.58	1561.5	1608.7	4.4010	4.5037	12268.6	0.23809	608.41	75.680	1245.7	2256.1	3.5399	5.7763
280	0.0	6416.6	0.00000	750.28	33.165	1236.9	2779.9	3.0685	5.8580	6416.6	0.00000	750.28	33.165	1236.9	2779.9	3.0685	5.8580
	0.1	9389.1	0.28449	681.85	52.133	1256.4	2504.7	3.3387	5.9515	7224.0	0.02641	732.29	37.954	1240.6	2690.4	3.1543	5.9658
	0.2	12493.1	0.43210	611.34	77.018	1294.4	2312.2	3.5711	5.7718	8255.0	0.06141	708.27	44.453	1247.1	2593.8	3.2459	5.9821
	0.3	15872.8	0.51108	530.51	116.52	1362.2	2127.3	3.8256	5.4863	9633.6	0.10822	676.21	53.871	1258.7	2487.3	3.3579	5.9413
	0.4	19241.8	0.51115	425.63	214.72	1482.7	1846.0	4.1537	4.9388	11625.2	0.17301	630.95	69.351	1281.8	2361.2	3.5078	5.8307
290	0.0	7441.8	0.00000	731.91	39.132	1290.0	2766.7	3.1612	5.7834	7441.8	0.00000	731.91	39.132	1290.0	2766.7	3.1612	5.7834
	0.1	10686.3	0.26614	660.34	61.255	1317.2	2496.7	3.4441	5.8606	8401.3	0.02871	711.55	45.149	1296.2	2673.8	3.2570	5.8851
	0.2	14022.3	0.40366	584.70	91.379	1364.9	2296.3	3.6928	5.6662	9638.3	0.06724	683.94	53.533	1306.5	2571.6	3.3614	5.8915
	0.3	17552.0	0.46874	494.45	144.66	1448.9	2082.8	3.9752	5.3272	11324.9	0.11972	645.98	66.289	1324.6	2454.9	3.4928	5.8325
	0.4	20625.0	0.43162	366.27	300.96	1614.7	1721.3	4.3839	4.6115	13897.0	0.19638	587.61	90.035	1362.7	2303.3	3.6835	5.6754
300	0.0	8588.0	0.00000	712.14	46.168	1345.0	2749.7	3.2552	5.7059	8588.0	0.00000	712.14	46.168	1345.0	2749.7	3.2552	5.7059
	0.1	12110.9	0.24768	636.67	72.241	1381.0	2482.5	3.5526	5.7621	9727.0	0.03136	688.83	53.823	1354.4	2652.1	3.3629	5.7995
	0.2	15671.8	0.37353	554.31	109.78	1441.1	2269.7	3.8218	5.5429	11215.0	0.07413	656.52	64.888	1370.0	2541.9	3.4835	5.7921
	0.3	19278.4	0.41678	449.87	189.97	1550.1	2004.3	4.1468	5.1000	13307.2	0.13418	609.81	83.096	1398.0	2408.7	3.6428	5.7042
310	0.0	9865.1	0.00000	690.67	54.541	1402.2	2728.0	3.3510	5.6244	9865.1	0.00000	690.67	54.541	1402.2	2728.0	3.3510	5.6244
	0.1	13669.7	0.22890	610.23	85.738	1448.8	2460.8	3.6655	5.6536	11218.0	0.03448	663.59	64.455	1416.0	2623.9	3.4734	5.7070
	0.2	17435.0	0.34060	518.53	134.67	1525.5	2227.8	3.9622	5.3928	13019.6	0.08254	624.73	79.590	1439.1	2501.7	3.6156	5.6793
	0.3	20854.0	0.34755	387.83	270.71	1682.1	1875.0	4.3684	4.7671	15702.7	0.15421	562.91	108.42	1485.0	2337.3	3.8216	5.5371
320	0.0	11284.4	0.00000	667.09	64.638	1462.2	2700.6	3.4495	5.5372	11284.4	0.00000	667.09	64.638	1462.2	2700.6	3.4495	5.5372
	0.1	15368.6	0.20950	580.03	102.81	1521.9	2429.3	3.7850	5.5311	12895.5	0.03822	634.93	77.816	1482.2	2587.3	3.5906	5.6045
	0.2	19279.0	0.30237	473.61	171.63	1624.3	2161.1	4.1237	5.1966	15107.7	0.09342	586.10	99.808	1517.1	2445.6	3.7645	5.5438
330	0.0	12858.2	0.00000	640.77	77.050	1525.9	2666.1	3.5518	5.4422	12858.2	0.00000	640.77	77.050	1525.9	2666.1	3.5518	5.4422
	0.1	17210.2	0.18892	544.27	125.43	1603.1	2384.1	3.9151	5.3874	14788.3	0.04292	601.35	95.290	1554.8	2538.8	3.7183	5.4867
	0.2	21060.9	0.25235	408.38	236.33	1755.6	2048.0	4.3364	4.9094	17600.5	0.10939	534.10	131.51	1612.6	2358.3	3.9482	5.3615
340	0.0	14600.8	0.00000	610.67	92.759	1594.5	2621.9	3.6601	5.3356	14600.8	0.00000	610.67	92.759	1594.5	2621.9	3.6601	5.3356
	0.1	19183.6	0.16586	498.63	158.04	1698.4	2316.6	4.0656	5.2071	16942.9	0.04924	559.59	119.84	1638.3	2471.3	3.8645	5.3425

TABLE 5. Properties of {water+ammonia} in the one-phase region

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 0.1$ MPa																	
−50							905.65	−305.29	−0.4300	856.63	−259.66	−0.2658	780.35	−101.43	0.1286	702.11	118.47	0.5659
−25				940.54	−192.18	−0.1974	894.10	−209.34	−0.0229	833.83	−149.52	0.2018				0.8447	1580.50	6.6782
0				935.14	−87.06	0.2062	877.54	−104.59	0.3791							0.7612	1635.65	6.8900
25	997.05	104.92	0.3672	923.57	19.07	0.5780										0.6942	1689.84	7.0799
50	988.03	209.42	0.7038													0.6387	1744.04	7.2544
75	974.84	314.08	1.0157										0.5998	1964.71	7.6155	0.5917	1798.74	7.4175
100	0.5897	2675.79	7.3611	0.5814	2512.40	7.6450	0.5736	2348.23	7.7682	0.5659	2183.79	7.8083	0.5585	2019.13	7.7665	0.5514	1854.24	7.5714
125	0.5503	2726.73	7.4933	0.5431	2563.94	7.7787	0.5362	2400.80	7.9046	0.5294	2237.54	7.9478	0.5227	2074.19	7.9093	0.5162	1910.71	7.7179
150	0.5164	2776.62	7.6148	0.5099	2615.13	7.9034	0.5036	2453.48	8.0329	0.4974	2291.79	8.0799	0.4913	2130.07	8.0454	0.4854	1968.27	7.8581
175	0.4866	2826.10	7.7284	0.4807	2666.34	8.0209	0.4749	2506.51	8.1547	0.4692	2346.70	8.2060	0.4636	2186.88	8.1758	0.4581	2027.02	7.9930
200	0.4603	2875.47	7.8356	0.4548	2717.77	8.1326	0.4494	2560.06	8.2709	0.4441	2402.38	8.3269	0.4388	2244.71	8.3014	0.4337	2087.02	8.1232
225	0.4368	2924.92	7.9375	0.4316	2769.55	8.2393	0.4265	2614.21	8.3824	0.4215	2458.90	8.4433	0.4166	2303.61	8.4227	0.4118	2148.32	8.2495
250	0.4156	2974.54	8.0346	0.4107	2821.76	8.3415	0.4059	2669.02	8.4898	0.4012	2516.31	8.5557	0.3966	2363.64	8.5402	0.3920	2210.96	8.3722
275	0.3964	3024.40	8.1278	0.3918	2874.45	8.4399	0.3872	2724.53	8.5934	0.3828	2574.66	8.6646	0.3784	2424.82	8.6544	0.3741	2274.98	8.4917
300	0.3790	3074.56	8.2172	0.3745	2927.65	8.5348	0.3702	2780.79	8.6938	0.3660	2633.97	8.7704	0.3618	2487.17	8.7657	0.3577	2340.39	8.6084
325	0.3630	3125.03	8.3034	0.3588	2981.40	8.6266	0.3546	2837.81	8.7912	0.3506	2694.25	8.8734	0.3466	2550.73	8.8742	0.3427	2407.22	8.7225
350	0.3483	3175.85	8.3867	0.3443	3035.71	8.7155	0.3403	2895.60	8.8858	0.3365	2755.54	8.9738	0.3326	2615.50	8.9803	0.3289	2475.48	8.8343
	$p = 0.2$ MPa																	
−50							905.67	−305.18	−0.4301	856.66	−259.57	−0.2659	780.39	−101.34	0.1284	702.15	118.56	0.5657
−25				940.58	−192.07	−0.1974	894.13	−209.25	−0.0230	833.87	−149.44	0.2016	753.43	11.31	0.6068	671.56	229.20	1.0355
0	999.89	0.16	−0.0001	935.18	−86.96	0.2062	877.57	−104.50	0.3790	809.58	−34.94	0.6412				1.5468	1626.97	6.5272
25	997.09	105.01	0.3672	923.60	19.16	0.5779	858.11	5.63	0.7647							1.4035	1683.67	6.7259
50	988.08	209.51	0.7037	908.11	127.06	0.9254										1.2873	1739.39	6.9054
75	974.89	314.16	1.0157													1.1903	1795.08	7.0714
100	958.40	419.24	1.3071							1.1417	2177.60	7.4647	1.1243	2014.70	7.4229	1.1076	1851.27	7.2272
125	1.1138	2716.61	7.1531	1.0971	2555.98	7.4395	1.0812	2394.47	7.5651	1.0657	2232.65	7.6075	1.0507	2070.59	7.5679	1.0361	1908.23	7.3750
150	1.0418	2769.12	7.2811	1.0275	2608.97	7.5686	1.0136	2448.44	7.6966	1.0000	2287.80	7.7419	0.9866	2127.08	7.7055	0.9735	1966.17	7.5161
175	0.9798	2820.25	7.3985	0.9671	2661.39	7.6890	0.9546	2502.39	7.8205	0.9423	2343.37	7.8695	0.9301	2184.34	7.8370	0.9183	2025.21	7.6516
200	0.9255	2870.75	7.5081	0.9139	2713.69	7.8026	0.9024	2556.60	7.9382	0.8911	2399.55	7.9915	0.8800	2242.52	7.9633	0.8690	2085.44	7.7824
225	0.8773	2921.01	7.6116	0.8665	2766.12	7.9105	0.8559	2611.26	8.0508	0.8454	2456.46	8.1087	0.8350	2301.71	8.0852	0.8249	2146.93	7.9090
250	0.8341	2971.24	7.7100	0.8240	2818.82	8.0137	0.8141	2666.46	8.1589	0.8042	2514.19	8.2217	0.7946	2361.96	8.2032	0.7851	2209.73	8.0320
275	0.7951	3021.57	7.8040	0.7856	2871.90	8.1129	0.7763	2722.30	8.2631	0.7670	2572.79	8.3311	0.7579	2423.33	8.3178	0.7489	2273.88	8.1518
300	0.7597	3072.09	7.8941	0.7507	2925.41	8.2083	0.7419	2778.82	8.3640	0.7331	2632.30	8.4373	0.7245	2485.84	8.4293	0.7160	2339.40	8.2687
325	0.7275	3122.87	7.9808	0.7189	2979.42	8.3005	0.7105	2836.05	8.4617	0.7021	2692.76	8.5405	0.6940	2549.53	8.5380	0.6859	2406.33	8.3829
350	0.6979	3173.93	8.0645	0.6897	3033.94	8.3898	0.6816	2894.03	8.5567	0.6737	2754.19	8.6412	0.6659	2614.42	8.6443	0.6582	2474.67	8.4949

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water ϱ	water h	water s	$\xi=0.2$ ϱ	$\xi=0.2$ h	$\xi=0.2$ s	$\xi=0.4$ ϱ	$\xi=0.4$ h	$\xi=0.4$ s	$\xi=0.6$ ϱ	$\xi=0.6$ h	$\xi=0.6$ s	$\xi=0.8$ ϱ	$\xi=0.8$ h	$\xi=0.8$ s	ammonia ϱ	ammonia h	ammonia s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$
	$p=0.3$ MPa																	
−50							905.70	−305.08	−0.4301	856.69	−259.48	−0.2661	780.42	−101.25	0.1283	702.20	118.65	0.5655
−25				940.62	−191.97	−0.1974	894.16	−209.15	−0.0230	833.90	−149.35	0.2015	753.48	11.39	0.6066	671.61	229.28	1.0352
0	999.94	0.26	−0.0001	935.22	−86.87	0.2062	877.61	−104.42	0.3789	809.62	−34.86	0.6410				2.3595	1617.88	6.3035
25	997.14	105.10	0.3671	923.64	19.24	0.5778	858.15	5.72	0.7646							2.1289	1677.34	6.5119
50	988.12	209.59	0.7037	908.15	127.14	0.9253										1.9464	1734.66	6.6965
75	974.93	314.24	1.0156	889.68	236.97	1.2526										1.7961	1791.38	6.8656
100	958.44	419.32	1.3071										1.6975	2010.19	7.2181	1.6690	1848.27	7.0234
125	939.06	525.12	1.5815				1.6358	2387.92	7.3611	1.6095	2227.65	7.4045	1.5840	2066.95	7.3654	1.5597	1905.74	7.1725
150	1.5772	2761.21	7.0792	1.5534	2602.59	7.3677	1.5304	2443.28	7.4959	1.5079	2283.76	7.5412	1.4858	2124.06	7.5045	1.4645	1964.06	7.3145
175	1.4800	2814.19	7.2009	1.4595	2656.33	7.4911	1.4393	2498.19	7.6220	1.4193	2340.01	7.6703	1.3997	2181.79	7.6370	1.3805	2023.40	7.4507
200	1.3958	2865.91	7.3132	1.3774	2709.55	7.6067	1.3592	2553.10	7.7412	1.3412	2396.71	7.7934	1.3234	2240.33	7.7641	1.3060	2083.86	7.5820
225	1.3217	2917.03	7.4185	1.3048	2762.64	7.7160	1.2881	2608.28	7.8549	1.2716	2454.01	7.9114	1.2553	2299.80	7.8866	1.2392	2145.54	7.7090
250	1.2556	2967.89	7.5181	1.2400	2815.85	7.8202	1.2245	2663.90	7.9638	1.2092	2512.05	8.0251	1.1940	2360.28	8.0050	1.1791	2208.50	7.8323
275	1.1962	3018.70	7.6130	1.1816	2869.33	7.9201	1.1671	2720.06	8.0687	1.1527	2570.90	8.1350	1.1386	2421.83	8.1200	1.1246	2272.78	7.9523
300	1.1424	3069.61	7.7038	1.1286	2923.16	8.0161	1.1150	2776.83	8.1700	1.1015	2630.63	8.2415	1.0881	2484.51	8.2318	1.0750	2338.42	8.0694
325	1.0934	3120.68	7.7910	1.0804	2977.42	8.1088	1.0674	2834.29	8.2681	1.0547	2691.27	8.3451	1.0421	2548.33	8.3408	1.0297	2405.44	8.1839
350	1.0486	3172.00	7.8750	1.0362	3032.16	8.1984	1.0239	2892.45	8.3633	1.0118	2752.85	8.4459	0.9998	2613.33	8.4472	0.9880	2473.86	8.2959
	$p=0.4$ MPa																	
−50							905.73	−304.98	−0.4301	856.72	−259.39	−0.2662	780.46	−101.16	0.1281	702.24	118.74	0.5652
−25				940.66	−191.86	−0.1974	894.19	−209.06	−0.0231	833.94	−149.27	0.2014	753.53	11.48	0.6064	671.66	229.36	1.0350
0	999.99	0.37	−0.0001	935.26	−86.77	0.2061	877.64	−104.33	0.3788	809.65	−34.78	0.6409	725.01	126.84	1.0493	3.2026	1608.30	6.1356
25	997.18	105.20	0.3671	923.68	19.33	0.5778	858.19	5.80	0.7645							2.8716	1670.81	6.3548
50	988.17	209.68	0.7036	908.18	127.23	0.9252										2.6164	1729.84	6.5449
75	974.98	314.32	1.0156	889.73	237.05	1.2525										2.4091	1787.64	6.7172
100	958.49	419.39	1.3070										2.2786	2005.61	7.0700	2.2355	1845.25	6.8770
125	939.11	525.19	1.5814							2.1609	2222.55	7.2574	2.1230	2063.27	7.2196	2.0871	1903.24	7.0274
150	2.1237	2752.81	6.9306	2.0881	2595.98	7.2213	2.0543	2438.00	7.3506	2.0213	2279.66	7.3965	1.9891	2121.01	7.3603	1.9582	1961.94	7.1704
175	1.9877	2807.91	7.0572	1.9580	2651.14	7.3480	1.9291	2493.92	7.4790	1.9005	2336.62	7.5273	1.8723	2179.22	7.4939	1.8450	2021.58	7.3073
200	1.8715	2860.95	7.1724	1.8455	2705.32	7.4656	1.8199	2549.56	7.5998	1.7944	2393.84	7.6516	1.7692	2238.12	7.6218	1.7446	2082.28	7.4391
225	1.7700	2912.98	7.2795	1.7466	2759.12	7.5764	1.7234	2605.28	7.7146	1.7003	2451.55	7.7704	1.6774	2297.88	7.7449	1.6549	2144.15	7.5665
250	1.6801	2964.50	7.3804	1.6586	2812.86	7.6817	1.6373	2661.31	7.8243	1.6160	2509.90	7.8847	1.5949	2358.59	7.8638	1.5742	2207.26	7.6901
275	1.5996	3015.81	7.4763	1.5796	2866.74	7.7823	1.5598	2717.80	7.9298	1.5400	2569.02	7.9951	1.5204	2420.34	7.9791	1.5011	2271.68	7.8104
300	1.5270	3067.10	7.5678	1.5082	2920.90	7.8789	1.4896	2774.85	8.0316	1.4711	2628.95	8.1020	1.4527	2483.17	8.0911	1.4347	2337.43	7.9277
325	1.4609	3118.49	7.6555	1.4432	2975.42	7.9720	1.4256	2832.52	8.1301	1.4082	2689.77	8.2059	1.3909	2547.13	8.2004	1.3739	2404.54	8.0423
350	1.4006	3170.06	7.7400	1.3838	3030.38	8.0620	1.3671	2890.86	8.2256	1.3506	2751.50	8.3070	1.3343	2612.25	8.3070	1.3182	2473.05	8.1545

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 0.5$ MPa																	
−50							905.76	−304.88	−0.4302	856.75	−259.30	−0.2663	780.50	−101.07	0.1279	702.28	118.83	0.5650
−25				940.70	−191.76	−0.1974	894.22	−208.96	−0.0232	833.97	−149.18	0.2012	753.58	11.56	0.6062	671.72	229.43	1.0347
0	1000.05	0.47	−0.0001	935.29	−86.68	0.2061	877.67	−104.24	0.3787	809.69	−34.70	0.6407	725.06	126.91	1.0491	638.62	343.19	1.4714
25	997.23	105.29	0.3671	923.72	19.42	0.5777	858.22	5.88	0.7644	784.19	82.31	1.0505				3.6329	1664.09	6.2286
50	988.21	209.76	0.7036	908.22	127.31	0.9251	836.65	119.41	1.1300							3.2979	1724.94	6.4246
75	975.02	314.40	1.0155	889.77	237.13	1.2524										3.0298	1783.85	6.6002
100	958.54	419.47	1.3069													2.8074	1842.20	6.7621
125	939.16	525.26	1.5813							2.7204	2217.34	7.1410	2.6677	2059.54	7.1049	2.6182	1900.72	6.9139
150	917.02	632.20	1.8418	2.6322	2589.13	7.1045	2.5856	2432.60	7.2355	2.5404	2275.49	7.2826	2.4967	2117.94	7.2472	2.4547	1959.82	7.0578
175	2.5032	2801.39	6.9428	2.4632	2645.82	7.2347	2.4242	2489.59	7.3664	2.3858	2333.19	7.4151	2.3481	2176.63	7.3819	2.3115	2019.75	7.1954
200	2.3528	2855.86	7.0611	2.3184	2701.03	7.3546	2.2845	2545.97	7.4888	2.2508	2390.94	7.5405	2.2174	2235.90	7.5106	2.1848	2080.69	7.3277
225	2.2225	2908.85	7.1702	2.1920	2755.55	7.4669	2.1616	2602.25	7.6047	2.1314	2449.07	7.6602	2.1013	2295.95	7.6343	2.0718	2142.76	7.4555
250	2.1078	2961.06	7.2725	2.0801	2809.83	7.5732	2.0524	2658.70	7.7153	2.0247	2507.75	7.7751	1.9973	2356.90	7.7536	1.9702	2206.03	7.5795
275	2.0055	3012.89	7.3693	1.9799	2864.13	7.6746	1.9543	2715.53	7.8214	1.9288	2567.12	7.8860	1.9034	2418.84	7.8693	1.8784	2270.57	7.7000
300	1.9135	3064.58	7.4615	1.8895	2918.62	7.7718	1.8657	2772.85	7.9236	1.8419	2627.27	7.9933	1.8182	2481.83	7.9817	1.7949	2336.44	7.8175
325	1.8300	3116.28	7.5498	1.8075	2973.41	7.8654	1.7851	2830.74	8.0225	1.7627	2688.26	8.0975	1.7406	2545.93	8.0911	1.7187	2403.65	7.9322
350	1.7539	3168.11	7.6347	1.7326	3028.59	7.9557	1.7114	2889.27	8.1184	1.6903	2750.14	8.1988	1.6694	2611.16	8.1979	1.6488	2472.24	8.0446
	$p = 0.6$ MPa																	
−50							905.79	−304.78	−0.4302	856.78	−259.21	−0.2664	780.54	−100.98	0.1278	702.32	118.92	0.5648
−25				940.73	−191.65	−0.1974	894.25	−208.87	−0.0232	834.01	−149.09	0.2011	753.62	11.65	0.6060	671.77	229.51	1.0344
0	1000.10	0.57	−0.0001	935.33	−86.58	0.2060	877.71	−104.15	0.3786	809.73	−34.61	0.6405	725.12	126.99	1.0488	638.69	343.26	1.4710
25	997.27	105.38	0.3671	923.75	19.51	0.5776	858.26	5.97	0.7643	784.24	82.39	1.0504				4.4142	1657.16	6.1216
50	988.25	209.85	0.7035	908.26	127.39	0.9251	836.69	119.49	1.1298							3.9913	1719.95	6.3240
75	975.06	314.49	1.0154	889.81	237.21	1.2523										3.6584	1780.01	6.5030
100	958.58	419.54	1.3068	868.75	349.11	1.5627										3.3846	1839.13	6.6670
125	939.21	525.33	1.5812										3.2183	2055.77	7.0098	3.1533	1898.19	6.8202
150	917.08	632.26	1.8417				3.1247	2427.06	7.1394	3.0655	2271.27	7.1881	3.0085	2114.84	7.1537	2.9542	1957.68	6.9651
175	3.0274	2794.60	6.8467	2.9752	2640.36	7.1402	2.9249	2485.18	7.2728	2.8755	2329.72	7.3223	2.8271	2174.03	7.2896	2.7803	2017.92	7.1034
200	2.8399	2850.64	6.9684	2.7963	2696.66	7.2624	2.7532	2542.34	7.3970	2.7104	2388.03	7.4489	2.6681	2233.68	7.4191	2.6268	2079.10	7.2363
225	2.6793	2904.64	7.0796	2.6411	2751.94	7.3763	2.6030	2599.19	7.5140	2.5649	2446.57	7.5695	2.5271	2294.02	7.5434	2.4900	2141.36	7.3645
250	2.5387	2957.57	7.1833	2.5043	2806.78	7.4837	2.4699	2656.08	7.6255	2.4354	2505.58	7.6850	2.4011	2355.20	7.6632	2.3673	2204.79	7.4887
275	2.4139	3009.94	7.2811	2.3823	2861.50	7.5859	2.3507	2713.25	7.7322	2.3191	2565.22	7.7964	2.2876	2417.33	7.7792	2.2565	2269.47	7.6095
300	2.3019	3062.03	7.3740	2.2726	2916.33	7.6837	2.2432	2770.84	7.8350	2.2139	2625.58	7.9041	2.1847	2480.49	7.8919	2.1559	2335.44	7.7272
325	2.2007	3114.06	7.4629	2.1732	2971.40	7.7777	2.1457	2828.96	7.9342	2.1182	2686.76	8.0085	2.0910	2544.72	8.0016	2.0640	2402.76	7.8421
350	2.1085	3166.15	7.5482	2.0825	3026.80	7.8685	2.0566	2887.68	8.0304	2.0308	2748.79	8.1101	2.0051	2610.07	8.1086	1.9798	2471.43	7.9546

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water ϱ	water h	water s	$\xi = 0.2$ ϱ	$\xi = 0.2$ h	$\xi = 0.2$ s	$\xi = 0.4$ ϱ	$\xi = 0.4$ h	$\xi = 0.4$ s	$\xi = 0.6$ ϱ	$\xi = 0.6$ h	$\xi = 0.6$ s	$\xi = 0.8$ ϱ	$\xi = 0.8$ h	$\xi = 0.8$ s	ammonia ϱ	ammonia h	ammonia s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 0.8$ MPa																	
−50							905.85	−304.57	−0.4303	856.84	−259.03	−0.2667	780.62	−100.80	0.1274	702.41	119.10	0.5643
−25				940.81	−191.44	−0.1974	894.31	−208.68	−0.0234	834.08	−148.92	0.2008	753.72	11.81	0.6057	671.88	229.67	1.0338
0	1000.20	0.77	−0.0001	935.40	−86.39	0.2060	877.77	−103.98	0.3784	809.81	−34.45	0.6402	725.24	127.15	1.0484	638.83	343.38	1.4703
25	997.36	105.57	0.3670	923.83	19.69	0.5775	858.33	6.13	0.7640	784.33	82.54	1.0500	694.69	245.22	1.4619	6.0440	1642.56	5.9432
50	988.34	210.02	0.7035	908.34	127.56	0.9249	836.77	119.65	1.1296							5.4167	1709.67	6.1595
75	975.15	314.65	1.0153	889.89	237.36	1.2521										4.9401	1772.21	6.3459
100	958.68	419.69	1.3067	868.84	349.25	1.5625										4.5560	1832.91	6.5143
125	939.31	525.47	1.5810										4.3380	2048.09	6.8565	4.2355	1893.08	6.6704
150	917.19	632.38	1.8415							4.1342	2262.62	7.0353	4.0453	2108.57	7.0039	3.9619	1953.38	6.8173
175	4.1041	2780.06	6.6880	4.0213	2629.02	6.9863	3.9438	2476.13	7.1217	3.8683	2322.67	7.1732	3.7949	2168.77	7.1421	3.7244	2014.24	6.9570
200	3.8331	2839.77	6.8177	3.7675	2687.67	7.1136	3.7033	2534.95	7.2494	3.6396	2382.13	7.3023	3.5768	2229.19	7.2733	3.5157	2075.91	7.0909
225	3.6063	2896.00	6.9335	3.5507	2744.57	7.2308	3.4952	2592.99	7.3689	3.4397	2441.54	7.4246	3.3846	2290.13	7.3988	3.3305	2138.56	7.2199
250	3.4106	2950.46	7.0402	3.3615	2800.58	7.3405	3.3122	2650.79	7.4821	3.2627	2501.22	7.5415	3.2133	2351.79	7.5195	3.1647	2202.31	7.3448
275	3.2384	3003.94	7.1401	3.1940	2856.19	7.4444	3.1493	2708.65	7.5902	3.1044	2561.39	7.6539	3.0595	2414.32	7.6363	3.0152	2267.26	7.4660
300	3.0849	3056.89	7.2345	3.0441	2911.71	7.5434	3.0030	2766.81	7.6939	2.9618	2622.20	7.7623	2.9205	2477.80	7.7495	2.8797	2333.46	7.5841
325	2.9467	3109.58	7.3245	2.9088	2967.33	7.6384	2.8706	2825.38	7.7940	2.8323	2683.73	7.8674	2.7941	2542.30	7.8597	2.7562	2400.96	7.6994
350	2.8215	3162.20	7.4107	2.7858	3023.19	7.7299	2.7501	2884.48	7.8907	2.7143	2746.07	7.9695	2.6785	2607.88	7.9671	2.6431	2469.81	7.8121
	$p = 1.0$ MPa																	
−50							905.90	−304.37	−0.4304	856.90	−258.85	−0.2669	780.70	−100.62	0.1271	702.49	119.28	0.5638
−25				940.89	−191.23	−0.1974	894.38	−208.50	−0.0235	834.15	−148.75	0.2006	753.81	11.98	0.6053	671.99	229.83	1.0333
0	1000.30	0.98	−0.0001	935.48	−86.20	0.2059	877.84	−103.80	0.3782	809.89	−34.29	0.6399	725.35	127.30	1.0479	638.97	343.51	1.4697
25	997.45	105.75	0.3670	923.90	19.87	0.5774	858.41	6.30	0.7638	784.42	82.70	1.0497	694.84	245.36	1.4614	7.7778	1626.84	5.7927
50	988.43	210.20	0.7034	908.42	127.73	0.9247	836.85	119.80	1.1293							6.8984	1698.96	6.0252
75	975.24	314.81	1.0152	889.98	237.52	1.2519	813.26	236.08	1.4759							6.2568	1764.20	6.2198
100	958.77	419.84	1.3065	868.93	349.39	1.5622										5.7509	1826.59	6.3929
125	939.42	525.61	1.5809	845.30	463.70	1.8587							5.4838	2040.22	6.7340	5.3342	1887.91	6.5519
150	917.31	632.51	1.8412							5.2293	2253.70	6.9127	5.1006	2102.19	6.8849	4.9817	1949.05	6.7008
175	892.35	741.08	2.0905	5.0997	2617.06	6.8612	4.9874	2466.76	7.0003	4.8797	2315.47	7.0546	4.7761	2163.45	7.0256	4.6776	2010.53	6.8420
200	4.8538	2828.29	6.6956	4.7609	2678.35	6.9943	4.6712	2527.38	7.1319	4.5827	2376.14	7.1863	4.4957	2224.66	7.1585	4.4115	2072.69	6.9770
225	4.5526	2887.02	6.8166	4.4763	2737.00	7.1151	4.4007	2586.68	7.2541	4.3250	2436.44	7.3105	4.2498	2286.21	7.2853	4.1762	2135.74	7.1068
250	4.2965	2943.15	6.9265	4.2307	2794.26	7.2273	4.1647	2645.42	7.3691	4.0981	2496.82	7.4288	4.0316	2348.36	7.4070	3.9661	2199.82	7.2323
275	4.0735	2997.82	7.0286	4.0150	2850.80	7.3328	3.9558	2704.01	7.4785	3.8961	2557.54	7.5421	3.8363	2411.29	7.5245	3.7772	2265.04	7.3541
300	3.8761	3051.66	7.1247	3.8229	2907.04	7.4332	3.7691	2762.74	7.5833	3.7147	2618.79	7.6514	3.6602	2475.10	7.6383	3.6062	2331.47	7.4726
325	3.6994	3105.04	7.2159	3.6503	2963.23	7.5291	3.6006	2821.78	7.6841	3.5506	2680.69	7.7571	3.5004	2539.88	7.7489	3.4505	2399.17	7.5882
350	3.5398	3158.21	7.3029	3.4939	3019.55	7.6214	3.4477	2881.27	7.7816	3.4011	2743.34	7.8597	3.3545	2605.70	7.8567	3.3082	2468.18	7.7012

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg\cdot K}$
	$p = 1.2$ MPa																	
−50							905.96	−304.17	−0.4305	856.96	−258.67	−0.2671	780.78	−100.44	0.1267	702.58	119.45	0.5633
−25				940.97	−191.02	−0.1974	894.44	−208.31	−0.0237	834.21	−148.58	0.2003	753.91	12.15	0.6049	672.10	229.99	1.0327
0	1000.40	1.18	−0.0001	935.55	−86.01	0.2058	877.91	−103.62	0.3781	809.97	−34.12	0.6396	725.47	127.45	1.0475	639.11	343.64	1.4690
25	997.54	105.94	0.3669	923.98	20.05	0.5772	858.48	6.47	0.7636	784.51	82.85	1.0493	694.98	245.49	1.4609	602.95	460.89	1.8796
50	988.51	210.37	0.7033	908.49	127.89	0.9246	836.93	119.96	1.1291	757.44	202.13	1.4334				8.4429	1687.77	5.9096
75	975.33	314.97	1.0150	890.06	237.67	1.2517	813.35	236.22	1.4756							7.6111	1755.98	6.1130
100	958.86	419.99	1.3064	869.02	349.54	1.5620										6.9704	1820.16	6.2911
125	939.52	525.75	1.5807	845.40	463.83	1.8584										6.4501	1882.67	6.4532
150	917.42	632.63	1.8410										6.1752	2095.69	6.7855	6.0138	1944.67	6.6043
175	892.48	741.19	2.0902				6.0579	2457.05	6.8975	5.9110	2308.10	6.9551	5.7713	2158.06	6.9287	5.6399	2006.80	6.7469
200	5.9053	2816.08	6.5909	5.7783	2668.68	6.8934	5.6579	2519.61	7.0334	5.5401	2370.05	7.0897	5.4250	2220.08	7.0633	5.3144	2069.47	6.8830
225	5.5195	2877.68	6.7179	5.4190	2729.23	7.0181	5.3199	2580.26	7.1583	5.2210	2431.29	7.2158	5.1230	2282.27	7.1914	5.0273	2132.92	7.0136
250	5.1973	2935.63	6.8314	5.1126	2787.81	7.1328	5.0276	2639.97	7.2753	4.9418	2492.38	7.3354	4.8561	2344.92	7.3141	4.7718	2197.32	7.1398
275	4.9197	2991.57	6.9358	4.8456	2845.33	7.2402	4.7704	2699.31	7.3861	4.6944	2553.66	7.4499	4.6180	2408.24	7.4323	4.5425	2262.81	7.2621
300	4.6760	3046.34	7.0336	4.6092	2902.31	7.3419	4.5415	2758.63	7.4919	4.4728	2615.36	7.5599	4.4038	2472.38	7.5468	4.3353	2329.48	7.3810
325	4.4588	3100.45	7.1260	4.3978	2959.09	7.4389	4.3357	2818.16	7.5936	4.2729	2677.64	7.6663	4.2098	2537.45	7.6579	4.1470	2397.37	7.4969
350	4.2634	3154.18	7.2140	4.2068	3015.89	7.5319	4.1494	2878.03	7.6916	4.0913	2740.60	7.7694	4.0330	2603.50	7.7661	3.9750	2466.56	7.6102
	$p = 1.5$ MPa																	
−50							906.04	−303.86	−0.4306	857.04	−258.40	−0.2675	780.90	−100.17	0.1262	702.70	119.72	0.5626
−25				941.09	−190.71	−0.1974	894.53	−208.03	−0.0239	834.32	−148.32	0.1999	754.05	12.41	0.6043	672.26	230.23	1.0319
0	1000.55	1.48	−0.0001	935.66	−85.72	0.2057	878.01	−103.36	0.3778	810.09	−33.88	0.6392	725.64	127.68	1.0468	639.32	343.84	1.4680
25	997.68	106.22	0.3668	924.09	20.31	0.5770	858.59	6.72	0.7633	784.65	83.08	1.0488	695.20	245.68	1.4601	603.24	461.01	1.8784
50	988.64	210.63	0.7031	908.61	128.14	0.9243	837.06	120.19	1.1287	757.60	202.33	1.4329				10.90	1669.95	5.7577
75	975.46	315.21	1.0149	890.18	237.90	1.2514	813.49	236.44	1.4751							9.7198	1743.21	5.9763
100	959.00	420.22	1.3061	869.16	349.75	1.5616										8.8489	1810.30	6.1624
125	939.67	525.95	1.5804	845.56	464.02	1.8580										8.1576	1874.70	6.3295
150	917.59	632.82	1.8407										7.8255	2085.71	6.6601	7.5861	1938.03	6.4838
175	892.68	741.35	2.0898							7.4976	2296.73	6.8294	7.2916	2149.83	6.8073	7.1012	2001.16	6.6288
200	7.5498	2796.01	6.4537	7.3539	2653.44	6.7640	7.1759	2507.57	6.9086	7.0046	2360.72	6.9683	6.8393	2213.14	6.9448	6.6820	2064.60	6.7665
225	7.0125	2862.96	6.5917	6.8673	2717.16	6.8953	6.7262	2570.38	7.0380	6.5862	2423.43	7.0975	6.4482	2276.29	7.0748	6.3143	2128.66	6.8984
250	6.5784	2923.93	6.7111	6.4604	2777.89	7.0143	6.3424	2631.66	7.1580	6.2235	2485.63	7.2193	6.1048	2339.70	7.1990	5.9884	2193.56	7.0255
275	6.2112	2981.94	6.8194	6.1103	2836.96	7.1246	6.0080	2692.18	7.2710	5.9042	2547.78	7.3354	5.7999	2403.64	7.3184	5.6968	2259.47	7.1486
300	5.8925	3038.21	6.9198	5.8034	2895.11	7.2283	5.7124	2752.41	7.3785	5.6199	2610.18	7.4467	5.5266	2468.30	7.4337	5.4340	2326.48	7.2681
325	5.6111	3093.45	7.0142	5.5305	2952.81	7.3269	5.4482	2812.67	7.4814	5.3644	2673.04	7.5540	5.2799	2533.78	7.5456	5.1957	2394.67	7.3846
350	5.3594	3148.07	7.1036	5.2854	3010.35	7.4211	5.2099	2873.15	7.5805	5.1331	2736.47	7.6579	5.0556	2600.20	7.6544	4.9784	2464.11	7.4983

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 2.0$ MPa																	
−50							906.19	−303.35	−0.4308	857.19	−257.94	−0.2681	781.09	−99.73	0.1254	702.91	120.17	0.5614
−25				941.28	−190.18	−0.1975	894.68	−207.56	−0.0243	834.49	−147.89	0.1992	754.29	12.83	0.6033	672.53	230.62	1.0305
0	1000.81	1.99	0.0000	935.85	−85.24	0.2055	878.17	−102.92	0.3773	810.29	−33.46	0.6384	725.93	128.07	1.0457	639.67	344.16	1.4663
25	997.90	106.68	0.3667	924.27	20.76	0.5767	858.77	7.13	0.7627	784.88	83.46	1.0480	695.56	246.01	1.4588	603.71	461.22	1.8763
50	988.86	211.06	0.7029	908.80	128.56	0.9239	837.26	120.58	1.1280	757.87	202.68	1.4319	662.35	367.18	1.8490	15.45	1636.69	5.5357
75	975.69	315.62	1.0145	890.39	238.29	1.2509	813.72	236.79	1.4744	728.56	324.68	1.7955				13.47	1720.58	5.7861
100	959.24	420.60	1.3057	869.39	350.10	1.5611	787.88	355.89	1.8047							12.12	1793.22	5.9876
125	939.92	526.30	1.5799	845.82	464.33	1.8573										11.10	1861.07	6.1637
150	917.87	633.13	1.8401	819.43	581.53	2.1428							10.69	2068.43	6.4904	10.27	1926.77	6.3237
175	893.00	741.61	2.0892							10.26	2276.82	6.6581	9.9036	2135.74	6.6450	9.5858	1991.63	6.4727
200	865.00	852.46	2.3298				9.8185	2486.38	6.7383	9.5272	2344.62	6.8053	9.2533	2201.32	6.7874	8.9980	2056.39	6.6133
225	9.6328	2836.15	6.4160	9.3829	2695.87	6.7279	9.1488	2553.28	6.8761	8.9211	2410.00	6.9400	8.6995	2266.17	6.9209	8.4873	2121.50	6.7474
250	8.9688	2903.26	6.5475	8.7788	2760.66	6.8548	8.5917	2617.40	7.0017	8.4045	2474.17	7.0657	8.2187	2330.91	7.0477	8.0377	2187.26	6.8762
275	8.4272	2965.18	6.6632	8.2717	2822.58	6.9704	8.1147	2680.01	7.1186	7.9554	2537.84	7.1846	7.7953	2395.91	7.1691	7.6377	2253.86	7.0005
300	7.9676	3024.21	6.7685	7.8344	2882.84	7.0779	7.6982	2741.86	7.2290	7.5590	2601.45	7.2980	7.4183	2461.43	7.2860	7.2787	2321.46	7.1211
325	7.5681	3081.48	6.8663	7.4504	2942.15	7.1792	7.3293	2803.40	7.3340	7.2053	2665.28	7.4071	7.0796	2527.64	7.3990	6.9543	2390.16	7.2384
350	7.2149	3137.68	6.9583	7.1085	3000.97	7.2756	6.9990	2864.92	7.4348	6.8869	2729.54	7.5123	6.7730	2594.67	7.5088	6.6593	2460.03	7.3529
	$p = 3.0$ MPa																	
−50							906.47	−302.34	−0.4312	857.49	−257.04	−0.2692	781.48	−98.83	0.1236	703.33	121.07	0.5591
−25				941.67	−189.13	−0.1975	894.99	−206.62	−0.0250	834.83	−147.02	0.1978	754.76	13.67	0.6014	673.06	231.42	1.0277
0	1001.31	3.01	0.0000	936.22	−84.29	0.2050	878.51	−102.04	0.3764	810.68	−32.64	0.6369	726.50	128.84	1.0435	640.36	344.81	1.4630
25	998.35	107.60	0.3665	924.64	21.65	0.5761	859.13	7.97	0.7616	785.34	84.23	1.0463	696.27	246.67	1.4562	604.64	461.64	1.8721
50	989.30	211.92	0.7024	909.19	129.40	0.9231	837.66	121.36	1.1268	758.42	203.37	1.4299	663.28	367.66	1.8458	564.19	583.74	2.2652
75	976.13	316.42	1.0139	890.80	239.07	1.2499	814.18	237.50	1.4729	729.24	325.25	1.7932	626.17	493.06	2.2195	22.18	1668.54	5.4706
100	959.71	421.35	1.3050	869.85	350.82	1.5599	788.43	356.51	1.8029							19.33	1756.19	5.7140
125	940.43	526.99	1.5790	846.34	464.96	1.8559	759.83	479.02	2.1207							17.39	1832.34	5.9117
150	918.44	633.75	1.8390	820.04	582.05	2.1411										15.93	1903.40	6.0848
175	893.65	742.14	2.0879	790.42	702.97	2.4187							15.46	2105.97	6.3991	14.75	1972.06	6.2424
200	865.76	852.86	2.3283							14.93	2310.12	6.5560	14.32	2176.71	6.5527	13.78	2039.65	6.3892
225	834.16	966.91	2.5631	14.89	2647.95	6.4625	14.34	2516.29	6.6274	13.84	2381.75	6.7036	13.38	2245.32	6.6940	12.94	2106.97	6.5279
250	14.16	2856.56	6.2893	13.73	2723.25	6.6100	13.34	2587.21	6.7664	12.95	2450.36	6.8380	12.58	2312.91	6.8264	12.22	2174.49	6.6601
275	13.14	2928.68	6.4241	12.82	2792.02	6.7385	12.51	2654.63	6.8923	12.20	2517.36	6.9631	11.89	2380.16	6.9520	11.59	2242.55	6.7872
300	12.32	2994.36	6.5413	12.06	2857.12	6.8546	11.81	2720.06	7.0090	11.54	2583.57	7.0812	11.28	2447.49	7.0721	11.02	2311.36	6.9099
325	11.63	3056.36	6.6472	11.42	2920.06	6.9621	11.20	2784.38	7.1188	10.97	2649.49	7.1938	10.74	2515.20	7.1878	10.51	2381.08	7.0290
350	11.04	3116.09	6.7450	10.86	2981.68	7.0631	10.66	2848.12	7.2232	10.46	2715.46	7.3019	10.26	2583.49	7.2996	10.05	2451.83	7.1449

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 4.0$ MPa																	
−50							906.75	−301.32	−0.4316	857.78	−256.13	−0.2704	781.87	−97.93	0.1219	703.75	121.97	0.5567
−25				942.06	−188.08	−0.1976	895.30	−205.68	−0.0257	835.17	−146.16	0.1965	755.23	14.52	0.5995	673.59	232.21	1.0249
0	1001.82	4.02	0.0001	936.58	−83.33	0.2046	878.84	−101.16	0.3754	811.07	−31.82	0.6354	727.07	129.61	1.0413	641.05	345.47	1.4597
25	998.80	108.53	0.3662	925.01	22.54	0.5754	859.49	8.80	0.7605	785.79	85.00	1.0446	696.97	247.34	1.4536	605.57	462.07	1.8680
50	989.73	212.78	0.7020	909.57	130.23	0.9223	838.06	122.14	1.1255	758.96	204.06	1.4280	664.19	368.15	1.8427	565.54	583.75	2.2598
75	976.57	317.23	1.0133	891.22	239.85	1.2490	814.64	238.22	1.4714	729.90	325.82	1.7909	627.43	493.25	2.2154	516.90	715.23	2.6514
100	960.17	422.10	1.3042	870.30	351.53	1.5587	788.97	357.13	1.8012	697.63	451.33	2.1389				27.71	1714.09	5.4855
125	940.93	527.68	1.5780	846.86	465.59	1.8545	760.49	479.50	2.1186							24.35	1801.30	5.7119
150	919.00	634.37	1.8379	820.65	582.57	2.1395										22.01	1878.80	5.9007
175	894.29	742.67	2.0866	791.16	703.33	2.4167							21.55	2073.67	6.2050	20.21	1951.75	6.0682
200	866.51	853.27	2.3267										19.74	2150.67	6.3723	18.76	2022.45	6.2218
225	835.08	967.14	2.5612				20.12	2474.78	6.4261	19.15	2351.38	6.5196	18.30	2223.57	6.5224	17.55	2092.13	6.3653
250	798.92	1085.78	2.7935	19.22	2681.04	6.4119	18.47	2554.48	6.5822	17.77	2425.26	6.6643	17.12	2294.32	6.6610	16.52	2161.53	6.5012
275	18.31	2887.33	6.2312	17.73	2758.72	6.5570	17.18	2627.68	6.7190	16.64	2496.05	6.7965	16.12	2364.00	6.7911	15.62	2231.10	6.6311
300	16.99	2961.72	6.3640	16.55	2829.71	6.6837	16.12	2697.24	6.8431	15.69	2565.12	6.9198	15.25	2433.28	6.9147	14.83	2301.16	6.7561
325	15.93	3029.49	6.4797	15.58	2896.85	6.7983	15.22	2764.66	6.9582	14.86	2633.30	7.0362	14.49	2502.57	7.0331	14.13	2371.94	6.8770
350	15.04	3093.35	6.5843	14.75	2961.64	6.9045	14.45	2830.84	7.0666	14.13	2701.09	7.1472	13.81	2572.18	7.1471	13.49	2443.59	6.9943
	$p = 5.0$ MPa																	
−50							907.03	−300.31	−0.4319	858.08	−255.23	−0.2716	782.26	−97.03	0.1203	704.16	122.86	0.5544
−25				942.45	−187.03	−0.1976	895.60	−204.74	−0.0264	835.51	−145.30	0.1951	755.69	15.37	0.5976	674.12	233.02	1.0222
0	1002.32	5.03	0.0001	936.95	−82.38	0.2042	879.17	−100.27	0.3745	811.46	−31.00	0.6339	727.63	130.39	1.0391	641.73	346.13	1.4564
25	999.25	109.45	0.3659	925.38	23.43	0.5748	859.85	9.63	0.7594	786.24	85.78	1.0429	697.67	248.01	1.4510	606.48	462.51	1.8640
50	990.16	213.64	0.7015	909.95	131.06	0.9214	838.46	122.92	1.1242	759.49	204.75	1.4261	665.09	368.65	1.8395	566.86	583.78	2.2544
75	977.01	318.04	1.0127	891.63	240.62	1.2480	815.10	238.93	1.4699	730.56	326.40	1.7886	628.66	493.46	2.2115	519.13	714.31	2.6432
100	960.63	422.85	1.3034	870.76	352.24	1.5575	789.50	357.75	1.7995	698.48	451.71	2.1361	586.13	624.88	2.5759	37.93	1664.24	5.2690
125	941.44	528.37	1.5771	847.37	466.22	1.8532	761.15	479.99	2.1165	661.66	582.52	2.4753				32.17	1767.32	5.5368
150	919.56	634.99	1.8368	821.25	583.09	2.1378	729.13	606.83	2.4254							28.59	1852.76	5.7451
175	894.93	743.20	2.0852	791.88	703.70	2.4147										26.00	1930.64	5.9239
200	867.26	853.69	2.3251	758.35	829.41	2.6876							25.59	2122.94	6.2197	23.98	2004.76	6.0849
225	835.99	967.38	2.5593							24.95	2318.49	6.3618	23.53	2200.82	6.3802	22.33	2076.99	6.2337
250	800.08	1085.75	2.7910	25.45	2632.40	6.2325	24.09	2518.66	6.4232	22.92	2398.69	6.5190	21.88	2275.10	6.5257	20.94	2148.36	6.3735
275	24.13	2839.49	6.0572	23.09	2722.12	6.4001	22.17	2598.95	6.5732	21.32	2473.81	6.6593	20.51	2347.43	6.6608	19.75	2219.51	6.5063
300	22.05	2925.73	6.2111	21.34	2800.37	6.5398	20.67	2673.30	6.7058	20.00	2546.07	6.7882	19.34	2418.78	6.7880	18.71	2290.88	6.6336
325	20.49	3000.63	6.3391	19.96	2872.43	6.6628	19.42	2744.21	6.8270	18.88	2616.69	6.9088	18.33	2489.74	6.9092	17.80	2362.74	6.7564
350	19.24	3069.34	6.4516	18.81	2940.79	6.7748	18.37	2813.04	6.9397	17.91	2686.43	7.0230	17.44	2560.72	7.0255	16.98	2435.31	6.8752

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	$p = 6.0$ MPa																	
−50							907.31	−299.29	−0.4323	858.37	−254.32	−0.2727	782.64	−96.13	0.1186	704.58	123.77	0.5521
−25				942.83	−185.98	−0.1977	895.91	−203.81	−0.0271	835.85	−144.44	0.1938	756.15	16.22	0.5957	674.64	233.82	1.0194
0	1002.82	6.04	0.0002	937.31	−81.42	0.2038	879.49	−99.39	0.3735	811.84	−30.17	0.6324	728.18	131.17	1.0369	642.40	346.80	1.4531
25	999.69	110.37	0.3657	925.74	24.32	0.5742	860.21	10.47	0.7583	786.68	86.55	1.0413	698.36	248.68	1.4485	607.38	462.96	1.8600
50	990.59	214.50	0.7010	910.33	131.90	0.9206	838.86	123.71	1.1229	760.02	205.45	1.4242	665.97	369.16	1.8365	568.15	583.84	2.2491
75	977.45	318.84	1.0120	892.03	241.40	1.2470	815.55	239.65	1.4685	731.21	326.98	1.7863	629.87	493.69	2.2076	521.28	713.47	2.6353
100	961.10	423.61	1.3026	871.21	352.95	1.5564	790.04	358.37	1.7978	699.32	452.10	2.1334	587.93	624.57	2.5705	51.59	1600.27	5.0367
125	941.94	529.07	1.5762	847.88	466.85	1.8518	761.80	480.48	2.1144	662.83	582.58	2.4717				41.17	1729.47	5.3727
150	920.11	635.61	1.8357	821.85	583.62	2.1362	729.96	607.11	2.4228							35.79	1825.03	5.6057
175	895.56	743.74	2.0839	792.61	704.07	2.4127	692.96	740.33	2.7286							32.16	1908.64	5.7977
200	868.00	854.10	2.3236	759.27	829.55	2.6851							31.97	2093.22	6.0831	29.45	1986.56	5.9670
225	836.90	967.63	2.5574							31.37	2282.49	6.2178	29.09	2176.97	6.2556	27.28	2061.53	6.1214
250	801.23	1085.74	2.7886				30.34	2479.01	6.2767	28.45	2370.43	6.3901	26.87	2255.21	6.4089	25.50	2134.99	6.2653
275	759.09	1210.89	3.0223	29.03	2681.41	6.2554	27.56	2568.14	6.4432	26.26	2450.56	6.5398	25.07	2330.43	6.5493	23.98	2207.79	6.4012
300	27.63	2885.57	6.0704	26.50	2768.79	6.4113	25.48	2648.12	6.5859	24.50	2526.36	6.6750	23.56	2403.99	6.6806	22.67	2280.50	6.5309
325	25.39	2969.48	6.2137	24.59	2846.65	6.5443	23.81	2722.96	6.7138	23.04	2599.64	6.8002	22.27	2476.71	6.8048	21.52	2353.48	6.6556
350	23.67	3043.93	6.3357	23.05	2919.06	6.6630	22.43	2794.71	6.8313	21.79	2671.46	6.9179	21.14	2549.13	6.9234	20.50	2426.99	6.7760
	$p = 8.0$ MPa																	
−50							907.86	−297.26	−0.4331	858.95	−252.51	−0.2750	783.40	−94.32	0.1152	705.40	125.57	0.5475
−25				943.59	−183.89	−0.1978	896.51	−201.93	−0.0286	836.52	−142.71	0.1911	757.06	17.92	0.5919	675.68	235.43	1.0140
0	1003.82	8.06	0.0003	938.03	−79.51	0.2030	880.15	−97.63	0.3717	812.61	−28.52	0.6295	729.28	132.73	1.0326	643.73	348.15	1.4467
25	1000.58	112.21	0.3651	926.47	26.09	0.5729	860.92	12.14	0.7561	787.57	88.10	1.0379	699.71	250.04	1.4434	609.14	463.90	1.8521
50	991.45	216.22	0.7001	911.09	133.57	0.9190	839.65	125.27	1.1204	761.07	206.85	1.4204	667.70	370.19	1.8304	570.66	584.03	2.2388
75	978.32	320.46	1.0108	892.85	242.96	1.2450	816.45	241.08	1.4655	732.50	328.15	1.7818	632.21	494.19	2.1999	525.34	712.02	2.6202
100	962.02	425.11	1.3011	872.10	354.38	1.5541	791.09	359.63	1.7943	700.98	452.91	2.1279	591.37	624.08	2.5601	464.68	858.04	3.0247
125	942.94	530.46	1.5744	848.90	468.12	1.8491	763.08	481.47	2.1103	665.10	582.77	2.4646	541.29	764.45	2.9240	65.33	1634.43	5.0363
150	921.22	636.86	1.8335	823.03	584.68	2.1329	731.59	607.70	2.4178	622.33	720.70	2.8005				52.67	1763.07	5.3503
175	896.82	744.81	2.0814	794.04	704.83	2.4088	695.18	740.23	2.7220							45.86	1861.59	5.5767
200	869.48	854.95	2.3205	761.08	829.85	2.6802										41.24	1948.50	5.7654
225	838.68	968.15	2.5536	722.62	961.89	2.9520							41.45	2125.33	6.0364	37.77	2029.62	5.9326
250	803.49	1085.75	2.7839							41.03	2307.64	6.1582	37.65	2213.16	6.2085	35.02	2107.63	6.0854
275	762.16	1210.03	3.0159				39.91	2498.70	6.2065	37.09	2400.55	6.3318	34.74	2295.01	6.3614	32.74	2183.97	6.2279
300	41.19	2786.51	5.7938	38.29	2697.13	6.1767	36.09	2593.41	6.3755	34.16	2484.79	6.4821	32.40	2373.49	6.5014	30.82	2259.50	6.3627
325	36.49	2898.44	5.9851	34.79	2790.34	6.3360	33.27	2677.80	6.5197	31.83	2564.15	6.6177	30.45	2450.03	6.6321	29.16	2334.80	6.4913
350	33.36	2988.16	6.1321	32.18	2872.68	6.4709	31.04	2756.32	6.6483	29.90	2640.58	6.7429	28.78	2525.51	6.7557	27.70	2410.25	6.6148

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi=0.2$			$\xi=0.4$			$\xi=0.6$			$\xi=0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$	$\frac{\mathrm{kg}}{\mathrm{m^3}}$	$\frac{\mathrm{kJ}}{\mathrm{kg}}$	$\frac{\mathrm{kJ}}{\mathrm{kg\cdot K}}$
	p =10.0 MPa																	
−50							908.40	−295.22	−0.4339	859.52	−250.68	−0.2773	784.15	−92.51	0.1119	706.21	127.38	0.5429
−25				944.33	−181.80	−0.1979	897.10	−200.05	−0.0300	837.18	−140.97	0.1885	757.95	19.63	0.5881	676.70	237.05	1.0086
0	1004.82	10.06	0.0003	938.74	−77.60	0.2021	880.79	−95.86	0.3698	813.36	−26.86	0.6265	730.35	134.30	1.0283	645.03	349.51	1.4403
25	1001.46	114.05	0.3646	927.18	27.87	0.5716	861.62	13.80	0.7539	788.44	89.65	1.0346	701.03	251.40	1.4385	610.86	464.87	1.8443
50	992.30	217.94	0.6992	911.84	135.23	0.9173	840.43	126.84	1.1179	762.09	208.25	1.4166	669.38	371.25	1.8244	573.07	584.30	2.2289
75	979.19	322.06	1.0096	893.65	244.51	1.2430	817.34	242.52	1.4627	733.75	329.33	1.7774	634.45	494.75	2.1924	529.13	710.85	2.6059
100	962.93	426.61	1.2996	872.99	355.81	1.5517	792.13	360.89	1.7910	702.58	453.75	2.1225	594.61	623.72	2.5501	472.45	852.53	2.9985
125	943.92	531.84	1.5725	849.90	469.40	1.8463	764.34	482.48	2.1063	667.29	583.01	2.4577	546.58	762.13	2.9089	358.77	1061.77	3.5389
150	922.32	638.11	1.8314	824.20	585.74	2.1297	733.19	608.32	2.4128	625.62	719.83	2.7908				74.732	1688.47	5.0983
175	898.06	745.89	2.0788	795.44	705.60	2.4049	697.33	740.20	2.7155							61.911	1809.63	5.3769
200	870.93	855.80	2.3174	762.84	830.17	2.6753	654.28	881.43	3.0221							54.388	1907.99	5.5906
225	840.43	968.68	2.5499	724.98	961.48	2.9457							56.033	2067.10	5.8361	49.132	1996.35	5.7727
250	805.70	1085.80	2.7793	679.09	1103.36	3.2235				56.570	2233.28	5.9366	49.743	2167.65	6.0332	45.134	2079.47	5.9355
275	765.12	1209.27	3.0097				55.494	2414.16	5.9745	49.557	2344.84	6.1451	45.280	2257.56	6.2012	41.932	2159.64	6.0852
300	715.28	1343.34	3.2488	53.162	2608.94	5.9453	48.442	2531.46	6.1839	44.854	2439.97	6.3148	41.844	2341.71	6.3513	39.278	2238.19	6.2254
325	50.307	2810.35	5.7596	46.655	2726.04	6.1455	43.826	2628.53	6.3498	41.336	2526.62	6.4629	39.067	2422.51	6.4893	37.023	2315.93	6.3581
350	44.563	2924.04	5.9460	42.373	2821.72	6.3023	40.408	2715.38	6.4921	38.538	2608.37	6.5968	36.746	2501.32	6.6184	35.072	2393.41	6.4850
	p =12.0 MPa																	
−50							908.95	−293.19	−0.4346	860.10	−248.87	−0.2796	784.90	−90.70	0.1086	707.02	129.20	0.5384
−25				945.08	−179.71	−0.1980	897.70	−198.18	−0.0314	837.84	−139.25	0.1858	758.85	21.34	0.5844	677.72	238.69	1.0033
0	1005.81	12.07	0.0004	939.46	−75.70	0.2013	881.43	−94.10	0.3680	814.11	−25.21	0.6236	731.42	135.88	1.0241	646.33	350.90	1.4341
25	1002.35	115.89	0.3641	927.90	29.65	0.5703	862.32	15.48	0.7517	789.30	91.21	1.0314	702.33	252.79	1.4336	612.56	465.88	1.8368
50	993.16	219.66	0.6983	912.59	136.90	0.9157	841.21	128.41	1.1154	763.12	209.67	1.4129	671.02	372.35	1.8186	575.41	584.66	2.2192
75	980.06	323.68	1.0083	894.46	246.08	1.2411	818.23	243.97	1.4598	735.00	330.54	1.7731	636.63	495.37	2.1852	532.70	709.91	2.5924
100	963.84	428.13	1.2981	873.88	357.25	1.5495	793.17	362.17	1.7876	704.16	454.62	2.1172	597.68	623.51	2.5405	479.19	848.13	2.9755
125	944.91	533.24	1.5707	850.90	470.68	1.8437	765.59	483.51	2.1023	669.42	583.33	2.4510	551.41	760.20	2.8949	393.58	1025.54	3.4346
150	923.41	639.37	1.8292	825.36	586.82	2.1265	734.76	608.97	2.4079	628.74	719.12	2.7816	491.00	914.40	3.2702	107.34	1590.89	4.8145
175	899.31	746.99	2.0763	796.84	706.40	2.4010	699.43	740.24	2.7092	578.13	866.88	3.1207				81.27	1751.42	5.1840
200	872.37	856.67	2.3144	764.59	830.55	2.6706	657.35	880.32	3.0132							69.20	1864.78	5.4304
225	842.16	969.25	2.5463	727.30	961.16	2.9395	603.71	1035.60	3.3329				73.92	1999.84	5.6386	61.49	1961.70	5.6301
250	807.86	1085.91	2.7747	682.46	1101.72	3.2147							63.52	2118.06	5.8704	55.90	2050.53	5.8042
275	768.00	1208.61	3.0038	624.21	1260.26	3.5106				64.34	2281.70	5.9652	56.84	2217.90	6.0569	51.57	2134.87	5.9617
300	719.55	1341.18	3.2402				63.41	2459.57	5.9954	56.87	2391.33	6.1609	51.97	2308.62	6.2188	48.07	2216.63	6.1075
325	69.86	2688.32	5.4988	61.06	2650.58	5.9565	55.83	2574.28	6.1915	51.70	2486.88	6.3241	48.17	2394.17	6.3649	45.13	2296.93	6.2447
350	58.07	2848.12	5.7609	53.98	2765.16	6.1444	50.70	2671.55	6.3509	47.77	2574.77	6.4681	45.07	2476.61	6.5000	42.63	2376.50	6.3750

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
°C	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))	ϱ (kg/m³)	h (kJ/kg)	s (kJ/(kg·K))
	p = 15.0 MPa																	
−50							909.76	−290.14	−0.4357	860.95	−246.14	−0.2830	786.00	−87.98	0.1036	708.22	131.94	0.5316
−25				946.18	−176.59	−0.1982	898.58	−195.36	−0.0335	838.81	−136.65	0.1819	760.15	23.92	0.5788	679.22	241.16	0.9954
0	1007.29	15.07	0.0005	940.52	−72.85	0.2001	882.39	−91.45	0.3652	815.22	−22.72	0.6192	732.98	138.27	1.0178	648.23	353.02	1.4248
25	1003.66	118.64	0.3633	928.97	32.31	0.5684	863.36	17.99	0.7485	790.58	93.56	1.0265	704.23	254.90	1.4263	615.02	467.46	1.8256
50	994.43	222.23	0.6969	913.70	139.41	0.9133	842.37	130.77	1.1117	764.62	211.81	1.4073	673.40	374.04	1.8100	578.77	585.34	2.2052
75	981.35	326.10	1.0065	895.65	248.42	1.2382	819.54	246.14	1.4555	736.82	332.37	1.7666	639.74	496.39	2.1746	537.69	708.86	2.5733
100	965.20	430.39	1.2958	875.19	359.41	1.5461	794.69	364.09	1.7826	706.45	455.97	2.1094	602.00	623.39	2.5268	487.92	842.95	2.9450
125	946.38	535.34	1.5680	852.38	472.62	1.8397	767.42	485.08	2.0964	672.46	583.89	2.4412	557.97	757.86	2.8755	418.30	1001.96	3.3569
150	925.03	641.27	1.8260	827.07	588.46	2.1218	737.05	610.00	2.4007	633.12	718.29	2.7684	502.81	906.44	3.2371	231.55	1329.49	4.1492
175	901.14	748.64	2.0725	798.88	707.62	2.3954	702.46	740.39	2.7000	585.25	863.16	3.1009	419.76	1093.73	3.6664	120.08	1648.20	4.8855
200	874.50	858.00	2.3100	767.13	831.16	2.6636	661.71	878.89	3.0006	521.76	1028.04	3.4586				95.35	1794.39	5.2035
225	844.71	970.13	2.5409	730.64	960.78	2.9305	610.90	1030.78	3.3133				111.66	1873.25	5.3176	82.16	1907.15	5.4359
250	811.02	1086.13	2.7681	687.25	1099.54	3.2022	539.98	1210.00	3.6640				88.50	2034.40	5.6338	73.39	2005.80	5.6292
275	772.16	1207.76	2.9951	632.25	1253.97	3.4904				93.63	2166.73	5.6845	76.51	2153.91	5.8572	66.92	2097.00	5.7995
300	725.55	1338.31	3.2279				94.93	2320.98	5.6855	78.24	2309.68	5.9398	68.61	2256.49	6.0402	61.87	2183.90	5.9546
325	664.87	1485.60	3.4793	92.04	2500.62	5.6382	77.72	2480.77	5.9588	69.19	2422.64	6.1329	62.80	2350.17	6.2002	57.75	2268.23	6.0986
350	87.10	2693.14	5.4438	75.32	2666.14	5.9097	68.35	2599.50	6.1534	62.89	2521.61	6.2950	58.25	2438.62	6.3452	54.30	2351.07	6.2343
	p = 20.0 MPa																	
−50							911.09	−285.06	−0.4376	862.34	−241.59	−0.2886	787.79	−83.43	0.0956	710.19	136.54	0.5206
−25				947.98	−171.40	−0.1986	900.03	−190.67	−0.0370	840.41	−132.31	0.1754	762.28	28.23	0.5698	681.68	245.32	0.9826
0	1009.74	20.03	0.0005	942.25	−68.10	0.1980	883.95	−87.04	0.3607	817.03	−18.56	0.6120	735.50	142.27	1.0075	651.30	356.61	1.4098
25	1005.84	123.20	0.3619	930.72	36.75	0.5653	865.06	22.18	0.7431	792.66	97.49	1.0185	707.27	258.47	1.4145	618.96	470.23	1.8078
50	996.53	226.51	0.6946	915.52	143.58	0.9093	844.25	134.72	1.1055	767.05	215.41	1.3983	677.18	376.96	1.7961	584.04	586.79	2.1831
75	983.48	330.13	1.0035	897.60	252.33	1.2334	821.67	249.79	1.4485	739.74	335.48	1.7561	644.60	498.31	2.1577	545.23	707.91	2.5440
100	967.44	434.17	1.2921	877.34	363.03	1.5405	797.17	367.34	1.7745	710.11	458.34	2.0968	608.58	623.65	2.5054	500.05	836.89	2.9016
125	948.79	538.84	1.5635	854.80	475.87	1.8331	770.38	487.76	2.0868	677.25	585.09	2.4255	567.52	755.11	2.8462	443.22	980.98	3.2751
150	927.69	644.45	1.8208	829.87	591.24	2.1141	740.73	611.84	2.3890	639.81	717.45	2.7479	518.43	897.05	3.1918	359.41	1162.46	3.7164
175	904.14	751.42	2.0664	802.20	709.74	2.3862	707.26	740.89	2.6853	595.51	858.45	3.0715	453.71	1061.35	3.5687	225.39	1438.54	4.3494
200	877.97	860.27	2.3027	771.23	832.32	2.6523	668.42	877.09	2.9809	540.03	1014.19	3.4095	345.60	1297.39	4.0800	152.83	1662.85	4.8376
225	848.82	971.70	2.5322	735.95	960.43	2.9161	621.37	1024.38	3.2842	462.37	1202.55	3.7970	214.13	1620.01	4.7446	123.20	1810.47	5.1420
250	816.09	1086.68	2.7574	694.65	1096.56	3.1827	560.05	1191.48	3.6112	319.34	1512.01	4.4014	146.31	1870.31	5.2357	106.31	1928.64	5.3736
275	778.71	1206.71	2.9814	643.94	1245.52	3.4607	465.27	1408.74	4.0163	180.76	1900.27	5.1270	117.02	2035.93	5.5454	94.93	2032.71	5.5680
300	734.71	1334.38	3.2091	575.31	1419.49	3.7708				127.41	2145.63	5.5656	100.79	2163.74	5.7735	86.52	2128.90	5.7397
325	679.84	1475.19	3.4495				133.80	2275.56	5.5325	105.15	2302.39	5.8336	90.04	2273.56	5.9612	79.94	2220.34	5.8958
350	600.64	1646.01	3.7290	134.03	2432.35	5.4529	106.36	2458.74	5.8330	92.16	2425.81	6.0359	82.17	2373.41	6.1248	74.59	2308.84	6.0408

TABLE 5. Properties of {water+ammonia} in the one-phase region—Continued

t	water			$\xi = 0.2$			$\xi = 0.4$			$\xi = 0.6$			$\xi = 0.8$			ammonia		
	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s	ϱ	h	s
°C	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$	$\frac{kg}{m^3}$	$\frac{kJ}{kg}$	$\frac{kJ}{kg \cdot K}$
	p =30.0 MPa																	
−50							913.68	−274.89	−0.4411	865.06	−232.47	−0.2996	791.26	−74.28	0.0798	714.02	145.81	0.4993
−25				951.45	−161.05	−0.1993	902.85	−181.28	−0.0439	843.51	−123.60	0.1626	766.34	36.93	0.5521	686.40	253.80	0.9578
0	1014.54	29.86	0.0003	945.62	−58.63	0.1939	886.99	−78.20	0.3517	820.53	−10.20	0.5979	740.28	150.40	0.9877	657.14	364.08	1.3812
25	1010.12	132.28	0.3591	934.13	45.62	0.5591	868.37	30.58	0.7326	796.65	105.42	1.0029	712.98	265.80	1.3919	626.32	476.28	1.7742
50	1000.67	235.05	0.6901	919.09	151.94	0.9015	847.91	142.66	1.0935	771.69	222.74	1.3807	684.16	383.16	1.7698	593.59	590.66	2.1425
75	987.67	338.19	0.9975	901.42	260.19	1.2241	825.80	257.16	1.4348	745.27	341.92	1.7359	653.37	502.81	2.1264	558.22	708.15	2.4927
100	971.82	441.75	1.2847	881.52	370.31	1.5295	801.93	373.96	1.7587	716.89	463.48	2.0730	620.01	625.51	2.4667	519.02	830.47	2.8319
125	953.50	545.89	1.5548	859.49	482.46	1.8204	776.02	493.34	2.0684	685.91	588.21	2.3966	583.18	752.54	2.7962	474.12	960.48	3.1690
150	932.86	650.89	1.8106	835.24	596.94	2.0992	747.61	615.93	2.3669	651.41	717.35	2.7111	541.46	886.19	3.1216	420.74	1102.88	3.5157
175	909.94	757.12	2.0545	808.54	714.25	2.3685	716.03	742.70	2.6579	612.12	852.73	3.0218	492.20	1031.03	3.4540	355.49	1265.18	3.8880
200	884.62	865.02	2.2888	778.93	835.12	2.6309	680.23	875.17	2.9455	566.01	997.45	3.3359	429.71	1197.93	3.8161	282.43	1448.66	4.2863
225	856.64	975.18	2.5156	745.72	960.65	2.8894	638.55	1015.77	3.2350	509.45	1157.86	3.6661	346.59	1406.66	4.2456	222.63	1626.47	4.6527
250	825.56	1088.36	2.7373	707.74	1092.55	3.1477	588.20	1168.76	3.5345	434.22	1351.01	4.0441	267.80	1627.91	4.6791	183.63	1778.08	4.9499
275	790.64	1205.69	2.9563	663.09	1233.69	3.4112	523.69	1343.33	3.8603	333.71	1603.94	4.5160	213.80	1819.24	5.0366	158.35	1907.25	5.1912
300	750.66	1328.90	3.1761	608.12	1389.57	3.6891	431.91	1565.67	4.2565	252.14	1850.77	4.9566	177.63	1982.09	5.3273	140.78	2021.99	5.3960
325	703.37	1461.09	3.4018	534.39	1573.48	4.0030	310.83	1862.98	4.7640	199.53	2055.83	5.3070	153.24	2121.39	5.5653	127.75	2127.62	5.5764
350	643.95	1608.84	3.6436	416.21	1830.95	4.4240	225.09	2132.93	5.2064	165.67	2225.34	5.5848	136.10	2243.89	5.7660	117.60	2227.36	5.7398
	p =40.0 MPa																	
−50							916.17	−264.73	−0.4445	867.69	−223.31	−0.3103	794.56	−65.08	0.0645	717.72	155.20	0.4787
−25				954.77	−150.77	−0.2001	905.57	−171.89	−0.0506	846.49	−114.86	0.1501	770.19	45.71	0.5350	690.90	262.45	0.9342
0	1019.23	39.55	−0.0002	948.87	−49.19	0.1898	889.92	−69.34	0.3429	823.89	−1.80	0.5841	744.76	158.66	0.9686	662.64	371.84	1.3542
25	1014.32	141.30	0.3562	937.44	54.47	0.5529	871.56	39.00	0.7223	800.45	113.43	0.9877	718.27	273.36	1.3704	633.10	482.86	1.7430
50	1004.72	243.56	0.6855	922.54	160.31	0.8937	851.42	150.65	1.0819	776.07	230.20	1.3638	690.51	389.75	1.7452	602.12	595.52	2.1058
75	991.76	346.24	0.9916	905.11	268.07	1.2149	829.74	264.63	1.4215	750.42	348.61	1.7167	661.16	508.01	2.0976	569.29	710.37	2.4481
100	976.10	449.34	1.2775	885.55	377.66	1.5189	806.44	380.74	1.7436	723.11	469.04	2.0507	629.83	628.65	2.4322	533.95	828.41	2.7755
125	958.07	552.98	1.5464	863.98	489.17	1.8081	781.31	499.20	2.0508	693.63	592.13	2.3700	595.94	752.51	2.7535	495.25	951.11	3.0937
150	937.86	657.42	1.8008	840.36	602.84	2.0849	753.98	620.48	2.3462	661.36	718.75	2.6784	558.71	880.96	3.0663	452.28	1080.33	3.4084
175	915.51	762.96	2.0431	814.51	719.07	2.3518	723.95	745.34	2.6329	625.49	850.16	2.9800	516.94	1016.31	3.3770	404.43	1218.12	3.7246
200	890.94	870.01	2.2755	786.08	838.45	2.6110	690.48	874.90	2.9141	584.91	988.16	3.2796	468.54	1162.92	3.6952	352.51	1365.39	4.0443
225	863.97	979.04	2.5000	754.56	961.83	2.8650	652.52	1010.76	3.1939	538.01	1135.83	3.5836	410.49	1328.35	4.0357	301.04	1518.05	4.3587
250	834.29	1090.69	2.7187	719.16	1090.44	3.1169	608.56	1155.35	3.4770	481.92	1299.46	3.9040	345.18	1514.25	4.3997	256.74	1666.46	4.6495
275	801.35	1205.81	2.9336	678.67	1226.14	3.3702	556.24	1312.87	3.7710	412.42	1491.16	4.2617	288.52	1695.79	4.7388	222.35	1803.90	4.9062
300	764.36	1325.65	3.1474	631.20	1371.94	3.6302	491.60	1491.71	4.0899	337.27	1706.74	4.6462	246.29	1857.99	5.0283	196.53	1929.54	5.1304
325	721.98	1452.16	3.3634	573.50	1533.28	3.9057	410.27	1705.87	4.4553	278.85	1904.57	4.9842	214.69	2003.56	5.2770	176.95	2045.46	5.3284
350	671.86	1588.82	3.5871	499.82	1721.09	4.2131	327.69	1939.22	4.8376	237.03	2076.42	5.2658	190.62	2135.90	5.4938	161.69	2154.17	5.5065