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THERMOPHYSICAL PROPERTIES OF SODIUM

by W. H. Yunker

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FOR THE
PHYSICAL AND THERMOPHYSICAL PROPERTIES OF SODIUM

by W. H. Yunker

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STANDARD FFTF VALUES
FOR THE
PHYSICAL AND THERMOPHYSICAL PROPERTIES OF SODIUM

W. H. Yunker

The purpose of this document is to present a single set of values for the physical and thermophysical properties of sodium, for use on the FFTF Project. It is expected that all individuals and organizations contributing to or associated with the FFTF will use these values. Through a cooperative effort of this type, the discrepancies in calculated results of different groups (and the accompanying time and frustration of reconciling them) should be kept to a minimum.

It is recognized that many properties are not well known and that the selection of "best" values usually involves some risk. The expressions and data were selected from the best information presently available. They have not been checked for overall self-consistency. No credit is taken here for original work. The expressions given are based on and generally in agreement with the recommendations of the Liquid Metal Information Center¹ and supplemented by information from the detailed review by Golden and Tokar.²

In most cases an analytical expression and a graph of each property is given, in engineering units. In a few cases and for the thermodynamic data, the information is available only in tabular form and linear interpolation is recommended. The precision of each expression has been

purposely omitted. It is felt that this judgment must be made by each user as it applies to his specific problem. Where this evaluation is necessary, the user is referred to the review of Golden and Tokar², the cited reference for the specific property or the Liquid Metals Handbook, when it is published (late 1970). It should not be inferred that the number of significant figures given in the equations and tables is an indication of the accuracy of the value.

Should serious problems arise from the use of these values, or should errors be found, please notify the author so that a solution can be found and distributed. In this way, the objective of the document can continue to be met.

I wish to thank J. D. Christian, A. Padilla and R. D. Peak for their help and discussions during the preparation of this document.

MELTING POINT

208.1°F

Reference: Evans et al.⁽³⁾

HEAT OF FUSION

48.69 BTU/lb

Reference: Evans et al.⁽³⁾

NORMAL BOILING POINT

1618.5°F

Reference: Stone et al.⁽⁴⁾

HEAT OF VAPORIZATION AT NBP

1666 BTU/lb

Reference: Stull and Sinke.⁽⁵⁾

CRITICAL CONSTANTS

T_{cr} 4919 °R
 P_{cr} 408 atm
 V_{cr} 2.02 ft³/lb mole

Reference: Miller et al. (6)

VAPOR PRESSURE - LIQUID

For the range m.p. $\leq t \leq 1600$ °F use

$$\log P_{(atmos)} = 6.4818 - \frac{10020.6}{T(^{\circ}R)} - 0.5 \log T(^{\circ}R) \quad (1)$$

Reference: Ditchburn and Gilmour. (7)

For the range 1600 °F $< t \leq 2540$ °F use

$$\log P_{(atmos)} = 6.83770 - \frac{9980.94}{T(^{\circ}R)} - 0.61344 \log T(^{\circ}R) \quad (2)$$

Reference: Stone, et al. (4)

Graphed in Figure 1, page 15.

SPECIFIC HEAT C_p - SOLID

$$C_p \text{ (BTU/lb } ^\circ\text{F)} = 0.2845 + 3.647 \times 10^{-5} t(^{\circ}\text{F}) + 7.765 \times 10^{-7} t^2(^{\circ}\text{F}) \quad (3)$$

Range: $32 ^\circ\text{F} \leq t \leq 208.1 ^\circ\text{F}$

Reference: Ginnings et al.⁽⁸⁾

Graphed in Figure 2, page 16.

SPECIFIC HEAT C_p - LIQUID

$$C_p \text{ (BTU/lb } ^\circ\text{F)} = 0.34574 - 0.79226 \times 10^{-4} t(^{\circ}\text{F}) + 0.34086 \times 10^{-7} t^2(^{\circ}\text{F}) \quad (4)$$

Range: $208.1 ^\circ\text{F} \leq t \leq 1650 ^\circ\text{F}$

Reference: Ginnings et al.⁽⁸⁾

Graphed in Figure 2, page 16.

SPECIFIC HEAT C_p - SATURATED VAPOR

The vapor specific heat is taken from Golden and Tokar⁽²⁾ for consistency with their tabulated thermodynamic properties. A graph of this data, for the saturated vapor, is shown in Figure 3, page 17. It should be noted that they consider this tentative data, due to the lack of good experimental verification.

PVT AND THERMODYNAMIC PROPERTIES

PVT and thermodynamic properties of sodium have been calculated by Golden and Tokar⁽²⁾ by their FORTRAN computer routine NAPROP. It is given in Appendix A. Their results are reproduced in Appendix B. For a Mollier diagram of sodium and a full discussion of the calculations, the reader is referred to Golden and Tokar.⁽²⁾

DENSITY - SOLID

$$\rho_s (\text{lb/ft}^3) = 60.93 - 6.792 \times 10^{-3} t(^{\circ}\text{F}) - 2.9 \times 10^{-6} t^2(^{\circ}\text{F}) \quad (5)$$

Range: $32^{\circ}\text{F} \leq t \leq 208.1^{\circ}\text{F}$

Reference: Thomson and Garelis.⁽⁹⁾

Graphed in Figure 4, page 18.

DENSITY - LIQUID

$$\rho_l (\text{lb/ft}^3) = 59.566 - 7.9504 \times 10^{-3} t - 0.2872 \times 10^{-6} t^2 + 0.06035 \times 10^{-9} t^3 \quad (6)$$

Range: $208.1^{\circ}\text{F} \leq t \leq 2500^{\circ}\text{F}$

Reference: Stone et al.⁽⁴⁾

Graphed in Figure 4, page 18.

THERMAL COEFFICIENT OF EXPANSION

The linear coefficient of expansion, α , of solid sodium is

$$\alpha = \frac{1}{l} \frac{dl}{dt} \quad (7)$$

and can be obtained from the expression for the density of solid sodium given in equation (5).

The volume expansion coefficient, β_p , of liquid sodium is

$$\beta_p = \frac{1}{V} \left(\frac{\partial V}{\partial t} \right)_p \quad (8)$$

and is tabulated in Golden and Tokar⁽²⁾.

SURFACE TENSION - LIQUID

$$\sigma \text{ (lb/ft)} = 0.01429 - 3.81 \times 10^{-6} t(^{\circ}\text{F}) \quad (9)$$

Range: m.p. $\leq t \leq 2500^{\circ}\text{F}$

Reference: Golden and Tokar.⁽²⁾

Graphed in Figure 5, page 19.

SPEED OF SOUND - LIQUID AT SATURATION PRESSURE

$$C(\text{ft/sec}) = 8488 - 0.95 t \text{ (}^\circ\text{F)} \quad (10)$$

Range: m.p. $\leq t \leq 1470$ $^\circ\text{F}$

Reference: Liquid Metals Information Center.⁽¹⁾

Graphed in Figure 6, page 20.

ISOTHERMAL COMPRESSIBILITY - SOLID

$$K_T (\text{atm}^{-1}) = - 3.09 \times 10^{-5} (1 - 4.004 V) \quad (11)$$

V is the molar volume of sodium, in $\text{ft}^3/\text{lb-mole}$, at temperature t , as given by equation (5).

Range: -424 $^\circ\text{F}$ to 186 $^\circ\text{F}$, valid up to 20,000 atmospheres.

Reference: Beecroft and Swenson.⁽¹⁰⁾

COMPRESSIBILITY - LIQUID

The adiabatic compressibility, K_S , is calculated from

$$K_S = 1 / \rho C^2. \quad (12)$$

C = speed of sound, equation (10).

ρ = density, equation (6).

The isothermal compressibility, K_T , is calculated from

$$K_T = K_S + \frac{T \beta^2}{\rho C_p}. \quad (13)$$

T = absolute temperature.

β = volume coefficient of expansion, equation (8).

C_p = specific heat at constant pressure, equation (4).

The values of K_T tabulated in Golden and Tokar⁽²⁾ are not consistent with the equations and input data which they recommend. A recalculation of K_T as a function of temperature is given in Figure 7, page 21 of this document.

ELECTRICAL RESISTIVITY - SOLID

$$r (\mu \text{ ohm} - \text{in}) = 1.551 + 4.283 \times 10^{-3} t (^\circ\text{F}) + 1.197 \times 10^{-6} t^2 (^\circ\text{F}) \quad (14)$$

Range: $-370^\circ\text{F} \leq t \leq 208.1^\circ\text{F}$

Reference: Dugdale and Guban.⁽¹¹⁾

Graphed in Figure 8, page 22.

ELECTRICAL RESISTIVITY - LIQUID

$$r (\mu \text{ ohm} - \text{in}) = 2.914 + 4.220 \times 10^{-3} t(^{\circ}\text{F}) + 4.228 \times 10^{-6} t^2(^{\circ}\text{F}) \quad (15)$$

Range: $208.1^{\circ}\text{F} \leq t \leq 2010^{\circ}\text{F}$

Reference: Liquid Metals Information Center. (1)

Graphed in Figure 8, page 22.

Note: This is not the expression tabulated in Golden and Tokar. (2)

THERMAL CONDUCTIVITY - SOLID

$$k(\text{BTU/ft-hr} - ^{\circ}\text{F}) = 80.07 - 0.0536 t (^{\circ}\text{F}) \quad (16)$$

Range: $32^{\circ}\text{F} \leq t \leq 208.1^{\circ}\text{F}$

Reference: Liquid Metals Information Center. (1)

Graphed in Figure 9, page 23.

THERMAL CONDUCTIVITY - LIQUID

$$k(\text{BTU/hr-ft} - ^{\circ}\text{F}) = 54.306 - 1.878 \times 10^{-2} t(^{\circ}\text{F}) + 2.0914 \times 10^{-6} t^2(^{\circ}\text{F}) \quad (17)$$

Range: $208.1^{\circ}\text{F} \leq t \leq 2500^{\circ}\text{F}$

Reference: Golden and Tokar. (2)

Graphed in Figure 9, page 23.

Note: This equation gives almost identical values as the two more complex equations suggested by LMIC. (1)

THERMAL CONDUCTIVITY - VAPOR

The latest tabulation of the thermal conductivity of saturated and unsaturated sodium is by Lee et al.⁽¹²⁾

Their graph of this data, in cgs units, is shown in Figure 10, page 24.

Note: These are not the values tabulated in Golden and Tokar.⁽²⁾

THERMAL DIFFUSIVITY

The thermal diffusivity, α , is determined by

$$\alpha = \frac{k}{C_p \rho} \quad (12)$$

k = thermal conductivity, equation (17) for liquid.

C_p = specific heat at constant pressure, equation (4) for liquid.

ρ = density, equation (6) for liquid.

The value of α for liquid sodium is calculated, as a function of temperature, by Golden and Tokar⁽²⁾ with the same values of k , ρ and C_p used in this document. The values are tabulated in their Appendix C and plotted in Figure 11, page 25 of this document.

Since the value of k for saturated vapor is chosen here from Lee et al.⁽¹²⁾, the values of α for vapor tabulated in Golden and Tokar are not applicable. It is plotted here, as a function of temperature, in Figure 12, page 26 as calculated from the values of k , C_p and ρ given herein.

PRANDTL NUMBER

The Prandtl number, Pr , is defined as

$$Pr = \frac{C_p \mu}{k} \quad (19)$$

μ = absolute viscosity, equation (21) for liquid.

C_p = specific heat at constant pressure, equation (4) for liquid.

k = thermal conductivity, equation (17) for liquid, and is dimensionless.

Since the values of μ , C_p and k used by Golden and Tokar⁽²⁾ for the liquid, are the ones given in this document, Golden and Tokar's tabulation of Pr for liquid sodium can be used. It is plotted in Figure 13, page 27 of this document.

For the vapor phase, the values of μ and k are chosen from Lee et al,⁽¹²⁾ hence the tabulation in Golden and Tokar of Pr for vapor is not applicable. The values of Pr have been calculated for saturated vapor using the values cited herein and are plotted in Figure 14, page 28. A least square fit of these data is adequately fit by the following cubic equation

$$Pr = 0.5572 + 1.020 \times 10^{-4} t(^{\circ}F) - 5.880 \times 10^{-8} t^2(^{\circ}F) + 2.258 \times 10^{-11} t^3(^{\circ}F) \quad (20)$$

with a standard deviation (σ) of 0.002.

VISCOSITY - LIQUID

$$\log \eta \text{ (lb}_m\text{/ft-hr)} = 1.0203 + \frac{397.17}{T(^{\circ}\text{R})} - 0.4925 \log T (^{\circ}\text{R}) \quad (21)$$

Range: $208.1^{\circ}\text{F} \leq t \leq 1500^{\circ}\text{F}$

Reference: Golden and Tokar.⁽²⁾

Graphed in Figure 15, page 29.

Note: This equation was chosen over the one recommended by LMIC.⁽¹⁾ It is felt the agreement between the two equations is satisfactory as compared to the experimental data. Hence, use of the analytically more complex equations (the Andrade equation with a cubic expression for density, over two temperature regions) is not justified for this project.

VISCOSITY - VAPOR

The latest tabulation by Lee et al⁽¹²⁾ is taken for the viscosity of both saturated and unsaturated sodium vapor. While these data may not, in truth, be more correct than those of Stefanov et al⁽¹³⁾, they are chosen because a more complete range of values is given. The saturated vapor curve is shown in Figure 16, page 30. An adequate least square fit of these data is given by

$$\eta \text{ (lb}_m\text{/ft-hr)} = 8.48 \times 10^{-3} + 1.66 \times 10^{-5} t (^{\circ}\text{F}). \quad (22)$$

which gives a standard deviation of 4.5×10^{-4} .

Range: $932^{\circ}\text{F} \leq t \leq 4532^{\circ}\text{F}$

Note: These are not the values tabulated in Golden and Tokar.⁽²⁾

SOLUBILITY OF OXYGEN IN LIQUID

$$\text{Log } S \text{ (wppm O)} - 6.239 - \frac{4405}{T(^{\circ}\text{R})} \quad (23)$$

Range: m.p. $\leq t \leq$ 1000 $^{\circ}\text{F}$

Reference: Eichelberger. (14)

Graphed in Figure 17, page 31.

Vapor Pressure of Liquid Sodium

FIGURE 1

WHAN-D-3

Specific Heat of Solid and Liquid Sodium

FIGURE 2

FIGURE 3

Specific Heat of Saturated Sodium Vapor

FIGURE 4

Density Of Solid and Liquid Sodium

Surface Tension of Liquid Sodium

FIGURE 5

FIGURE 6
Speed of Sound in Liquid Sodium at Saturation Pressure

FIGURE 7

Isothermal Compressibility of Liquid Sodium

Electrical Resistivity of Solid and Liquid Sodium

FIGURE 8

FIGURE 9

Thermal Conductivity of Solid and Liquid Sodium

Figure 10

Thermal Conductivity of Sodium Vapor

FIGURE 11

Thermal Diffusivity of Liquid Sodium

FIGURE 12

Thermal Diffusivity of Saturated Sodium Vapor

FIGURE 13

Prandtl Number of Liquid Sodium

FIGURE 14

Prandtl Number for Saturated Sodium Vapor

(Revised
5/71)

FIGURE 14

Prandtl Number for Saturated Sodium Vapor

FIGURE 15
Viscosity of Liquid Sodium

FIGURE 16

Viscosity of Saturated Sodium Vapor

FIGURE 17

Solubility of Oxygen in Liquid Sodium

APPENDIX A. Sodium P-V-T and Thermodynamic Properties Subroutine

```

SUBROUTINE NAPROP(TEMPR,PATM)
  T=TEMPR
C  CALCULATION OF SATURATION PROPERTIES
100 IF(T-2059.7)110,110,112
110 PSAT=(3.03266E6/T**.5)*(EXP(-2.30733E4/T))
111 GO TO 120
112 PSAT=(6.8817602E6/(T**.61344))*EXP(-22981.96/T)
113 GO TO 120
120 HLS=.389352*T-.5529955E-4*(T)**2+.113726E-7*(T)**3-29.02
130 SLS=.389344*(LOGF(T))-1.10557E-4*T+.170408E-7*(T**2)-1.792026
140 DL=59.566-7.9504E-3*(T-459.7)-.2872E-6*((T-459.7)**2)+.06035E-9*
  1((T-459.7)**3)
150 TWO=EXP(-9.95845+(16588.3/T))
160 FOUR=EXP(-24.59115+(37589.7/T))
170 U=PSAT*TWO
180 W=((PSAT)**3)*FOUR
190 X1=0.8
200 X1P=X1
203 X1=X1-(W*(X1)**4+U*(X1)**2+X1-1.)/(4.*W*(X1)**3+2.*U*X1+1.)
205 IF(ABSF(X1-X1P)/X1-1.E-6)210,210,200
210 X2=U*(X1)**2
212 X4=1.-X1-X2
214 ABAR=22.991*(X1+2.*X2+4.*X4)
216 VSAT=(.730229*T)/(ABAR*PSAT)
217 Z=22.991/ABAR
218 DHF1=25980.7-2.21312*T+7.06278E-4*(T)**2-1.4526E-7*(T)**3
220 DHF2=2.*DHF1-18304.
222 DHF4=4.*DHF1-41478.
224 DHV=1.8*(X1*DHF1+X2*DHF2+X4*DHF4)/ABAR
226 HGS=HLS+DHV
228 SGS=SLS+(DHV/T)
C  TEST FOR STATE, I.E., SUBCOOLED, SATURATED, SUPERHEATED
250 IF(ABSF(PATM-PSAT)/PATM-1.E-4)463,463,260
260 IF(PATM-PSAT)270,463,410
C  CALCULATION OF SUPERHEATED VAPOR PROPERTIES
270 UH=PATM*TWO
272 WH=((PATM)**3)*FOUR
275 X1H=0.8
278 X1PH=X1H
280 X1H=X1H-(WH*(X1H)**4+UH*(X1H)**2+X1H-1.)/(4.*WH*(X1H)**3+2.*UH*
  1X1H+1.)
282 IF(ABSF(X1H-X1PH)/X1H-1.E-6)284,284,278
284 X2H=UH*(X1H)**2
286 X4H=1.-X1H-X2H
288 ABARH=22.991*(X1H+2.*X2H+4.*X4H)
290 VH=(.730229*T)/(ABARH*PATM)
292 ZH=22.991/ABARH
294 BD=X1+2.*X2+4.*X4
296 B2=2.*X2/BD
297 B4=4.*X4/BD
298 BDH=X1H+2.*X2H+4.*X4H
300 B2H=2.*X2H/BDH
301 B4H=4.*X4H/BDH
303 HGI=HGS+B2*716.54+B4*811.85

```

ATM

ATM

BTU/LB

BTU/LBR

LB/FT3

ATM-1

ATM-3

FT3/LB

CAL/MNA1

CAL/MNA2

CAL/MNA4

BTU/LB

MOLEFRX1

MOLEFRX2

MOLEFRX4

FT3/LB

WTFRX2S

WTFRX4S

WTFRX2H

WTFRX4H

APPENDIX A (Contd.)

```

305 HGH=HGI-B2H*716.54-B4H*811.85
308 SGI=SGS+82*716.54/T+B4*811.85/T+(1.987180/ABAR)*LOGF(PSAT)-(B2/
145.982)*(-19.78923+(32963.9/T))-(B4/91.964)*(-48.86704+(74697.5/
2T))+(1.987180/ABAR)*(X1*LOGF(X1)+X2*LOGF(X2)+X4*LOGF(X4))
310 SGH=SGI-B2H*716.54/T-B4H*811.85/T-(1.987180/ABARH)*LOGF(PATM)+(
182H/45.982)*(-19.78923+(32963.9/T))+(B4H/91.964)*(-48.86704+(746
297.5/T))-(1.987180/ABARH)*(X1H*LOGF(X1H)+X2H*LOGF(X2H)+X4H*LOGF(
3X4H))
PRINT 350
350 FORMAT(3X,4HTEMP,7X,4HPRES,10X,2HVV,9X,2HZH,7X,3HHGI,8X,3HHGH,7X,3
1HSGI,9X,3HSGH,5X,5HABARH,8X,3HX2H,9X,3HX4H)
PRINT 351
351 FORMAT(2X,5HDEG-F,7X,3HATM,8X,6HFT3/LB,16X,6HBTU/LB,4X,6HBTU/LB,4X
1,7HBTU/LBF,5X,7HBTU/LBF,15X,6HMOL FR,6X,6HMOL FR)
360 PRINT 370,T,PATM,VH,ZH,HGI,HGH,SGI,SGH,ABARH,X2H,X4H
370 FORMAT(/,1X,F7.1,2(2X,E11.4),2X,F8.5,2(2X,F8.2),2X,F8.5,4X,F8.5,2X
1,F7.3,2(4X,F8.6))
GO TO 80
C CALCULATION OF SUBCOOLED LIQUID PROPERTIES
410 DLP=-7.9504E-3-.5744E-6*(T-459.7)+.18105E-9*(T-459.7)**2
HLC=HLS+(1./DL)*(1.+(T/DL)*DLP)*(PATM-PSAT)*2.721308
SLC=SL5+2.721308*(1./(DL**2))*DLP*(PATM-PSAT)
PRINT 415
415 FORMAT(8X,4HTEMP,10X,4HPRES,11X,3HHLC,10X,3HSLC,/,8X,5HDEG-F,9X,3H
1ATM,10X,6HBTU/LB,7X,7HBTU/LBF)
420 PRINT 450,T,PATM,HLC,SLC
450 FORMAT(/,6X,F7.1,5X,E11.4,5X,F8.2,5X,F8.5)
GO TO 80
C OUTPUT SATURATION PROPERTIES
463 T=T-459.7
PRINT 10
10 FORMAT(1H1,2X,5HTEMPF,6X,4HPSAT,7X,4HVSAT,8X,1HZ,7X,2HDL,6X,3HHLS,
16X,3HDSV,6X,3HHGS,6X,3HSL5,6X,3HSGS,5X,4HABAR,5X,2HX2,7X,2HX4)
PRINT 11
11 FORMAT(2X,5HDEG-F,6X,3HATM,7X,6HFT3/LB,13X,6HLB/FT3,3X,6HBTU/LB,3X
1,6HBTU/LB,3X,6HBTU/LB,2X,7HBTU/LBF,2X,7HBTU/LBF,10X,6HMOL FR,3X,6H
2MOL FR)
PRINT 470,T,PSAT,VSAT,Z,DL,HLS,DHV,HGS,SLS,SGS,ABAR,X2,X4
470 FORMAT(/,F7.1,1X,E11.5,1X,E11.5,2X,F7.5,1X,F7.3,2X,F7.2,1X,F8.2,1X
1,F8.2,1X,F8.5,1X,F8.5,1X,F7.3,1X,F8.6,2X,F7.6)
80 RETURN
51 END

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APPENDIX B. Saturation P-V-T and Thermodynamic Properties of Sodium

Property: Temp (°F)	Vapor Pressure: PSAT (atmos)	Vapor Sp. Vol.: VSAT (ft ³ /lb)	Compr. Factor: Z	Liquid Density: DL (lb/ft ³)	Liquid Enthalpy: HLS (Btu/lb)	Heat of Vapn.: DHV (Btu/lb)	Vapor Enthalpy: HGS (Btu/lb)	Liquid Entropy: SLS (Btu/lb°F)	Vapor Entropy: SGS (Btu/lb°F)	Vapor Mol. Wt.: ABAR	Dimer Mole Fr.: X ₂ (mole fr.)	Tetramer Mole Fr.: X ₄ (mole fr.)
500.0	3.54292-6	8.55792+6	0.99470	55.527	303.76	1901.06	2204.83	0.79105	2.77194	23.113	0.005328	0.000000
510.0	4.51634-6	6.78099+6	0.99435	55.445	306.91	1899.58	2206.49	0.79430	2.75324	23.122	0.005679	0.000000
520.0	5.72845-6	5.39933+6	0.99399	55.363	310.04	1898.09	2208.13	0.79753	2.73494	23.130	0.006044	0.000000
530.0	7.23067-6	4.31961+6	0.99362	55.281	313.18	1896.57	2209.75	0.80071	2.71702	23.139	0.006425	0.000000
540.0	9.08395-6	3.47171+6	0.99323	55.199	316.31	1895.04	2211.36	0.80386	2.69947	23.148	0.006820	0.000000
550.0	1.13602-5	2.80271+6	0.99282	55.116	319.44	1893.50	2212.94	0.80697	2.68228	23.157	0.007231	0.000000
560.0	1.41440-5	2.27242+6	0.99240	55.034	322.56	1891.94	2214.50	0.81005	2.66543	23.167	0.007656	0.000000
570.0	1.75343-5	1.85021+6	0.99197	54.952	325.68	1890.36	2216.03	0.81309	2.64892	23.177	0.008097	0.000000
580.0	2.16466-5	1.51258+6	0.99152	54.870	328.79	1888.76	2217.55	0.81610	2.63274	23.188	0.008554	0.000000
590.0	2.66151-5	1.24147+6	0.99106	54.788	331.90	1887.14	2219.05	0.81908	2.61687	23.199	0.009025	0.000000
600.0	3.25952-5	1.02287+6	0.99058	54.705	335.01	1885.51	2220.52	0.82202	2.60131	23.210	0.009513	0.000000
610.0	3.97661-5	8.45906+5	0.99008	54.623	338.11	1883.86	2221.98	0.82494	2.58605	23.221	0.010015	0.000000
620.0	4.83342-5	7.02100+5	0.98958	54.541	341.21	1882.20	2223.41	0.82782	2.57108	23.233	0.010533	0.000000
630.0	5.85359-5	5.84798+5	0.98905	54.458	344.31	1880.52	2224.82	0.83067	2.55639	23.245	0.011067	0.000000
640.0	7.06413-5	4.88766+5	0.98852	54.376	347.40	1878.82	2226.21	0.83350	2.54198	23.258	0.011617	0.000000
650.0	8.49585-5	4.09866+5	0.98797	54.293	350.49	1877.10	2227.58	0.83629	2.52783	23.271	0.012181	0.000000
660.0	1.01837-4	3.44818+5	0.98740	54.211	353.57	1875.36	2228.93	0.83906	2.51394	23.284	0.012761	0.000000
670.0	1.21673-4	2.91010+5	0.98682	54.128	356.65	1873.61	2230.26	0.84180	2.50030	23.298	0.013357	0.000000
680.0	1.44913-4	2.46354+5	0.98622	54.046	359.73	1871.84	2231.57	0.84451	2.48691	23.312	0.013968	0.000000
690.0	1.72063-4	2.09174+5	0.98562	53.963	362.81	1870.06	2232.86	0.84720	2.47376	23.327	0.014594	0.000000
700.0	2.03686-4	1.78122+5	0.98499	53.881	365.88	1868.25	2234.13	0.84986	2.46084	23.341	0.015236	0.000000
710.0	2.40419-4	1.52111+5	0.98436	53.798	368.94	1866.43	2235.38	0.85249	2.44814	23.356	0.015892	0.000000
720.0	2.82969-4	1.30257+5	0.98371	53.715	372.01	1864.60	2236.61	0.85510	2.43567	23.372	0.016563	0.000000
730.0	3.32127-4	1.11843+5	0.98304	53.632	375.07	1862.74	2237.82	0.85769	2.42341	23.388	0.017249	0.000000
740.0	3.88771-4	9.62839+4	0.98237	53.550	378.13	1860.88	2239.01	0.86025	2.41137	23.404	0.017950	0.000000
750.0	4.53877-4	8.31016+4	0.98168	53.467	381.19	1858.99	2240.18	0.86278	2.39952	23.420	0.018665	0.000000
760.0	5.28524-4	7.19030+4	0.98097	53.384	384.24	1857.09	2241.33	0.86530	2.38788	23.437	0.019395	0.000000
770.0	6.13906-4	6.23647+4	0.98026	53.301	387.29	1855.18	2242.47	0.86779	2.37643	23.454	0.020139	0.000000

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
780.0	7.11337-4	5.42201+4	0.97953	53.219	390.34	1853.25	2243.59	0.87026	2.36517	23.471	0.020897	0.000000
790.0	8.22263-4	4.72483+4	0.97879	53.135	393.39	1851.30	2244.69	0.87270	2.35410	23.489	0.021669	0.000000
800.0	9.48273-4	4.12658+4	0.97804	53.053	396.43	1849.34	2245.77	0.87513	2.34321	23.507	0.022454	0.000000
810.0	1.09111-3	3.61203+4	0.97728	52.970	399.47	1847.37	2246.84	0.87753	2.33250	23.526	0.023253	0.000000
820.0	1.25267-3	3.16845+4	0.97650	52.887	402.51	1845.38	2247.89	0.87992	2.32196	23.544	0.024065	0.000000
830.0	1.43503-3	2.78517+4	0.97571	52.804	405.54	1843.38	2248.92	0.88228	2.31159	23.563	0.024890	0.000000
840.0	1.64045-3	2.45329+4	0.97492	52.721	408.58	1841.36	2249.94	0.88462	2.30138	23.583	0.025728	0.000000
850.0	1.87140-3	2.16528+4	0.97411	52.638	411.61	1839.34	2250.94	0.88695	2.29134	23.602	0.026578	0.000000
860.0	2.13055-3	1.91482+4	0.97329	52.555	414.64	1837.30	2251.93	0.88925	2.28146	23.622	0.027441	0.000000
870.0	2.42078-3	1.69657+4	0.97246	52.472	417.66	1835.24	2252.91	0.89153	2.27173	23.642	0.028316	0.000001
880.0	2.74524-3	1.50601+4	0.97162	52.388	420.69	1833.18	2253.87	0.89380	2.26215	23.662	0.029202	0.000001
890.0	3.10730-3	1.33929+4	0.97078	52.305	423.71	1831.10	2254.81	0.89605	2.25272	23.683	0.030100	0.000001
900.0	3.51062-3	1.19316+4	0.96992	52.222	426.73	1829.01	2255.74	0.89828	2.24344	23.704	0.031010	0.000001
910.0	3.95911-3	1.06482+4	0.96905	52.139	429.75	1826.91	2256.67	0.90049	2.23430	23.725	0.031931	0.000001
920.0	4.45701-3	9.51917+3	0.96818	52.056	432.77	1824.80	2257.57	0.90269	2.22529	23.747	0.032862	0.000001
930.0	5.00884-3	8.52403+3	0.96730	51.972	435.79	1822.68	2258.47	0.90486	2.21643	23.768	0.033804	0.000001
940.0	5.61948-3	7.64540+3	0.96641	51.889	438.80	1820.55	2259.35	0.90703	2.20770	23.790	0.034756	0.000001
950.0	6.29411-3	6.86830+3	0.96551	51.806	441.81	1818.41	2260.23	0.90917	2.19910	23.812	0.035719	0.000002
960.0	7.03832-3	6.17984+3	0.96460	51.722	444.83	1816.26	2261.09	0.91130	2.19063	23.835	0.036691	0.000002
970.0	7.85803-3	5.56890+3	0.96369	51.639	447.84	1814.10	2261.94	0.91341	2.18228	23.857	0.037672	0.000002
980.0	8.75957-3	5.02588+3	0.96277	51.556	450.85	1811.94	2262.78	0.91551	2.17406	23.880	0.038663	0.000003
990.0	9.74970-3	4.54247+3	0.96184	51.472	453.85	1809.76	2263.62	0.91759	2.16596	23.903	0.039663	0.000003
1000.0	1.08356-2	4.11145+3	0.96091	51.389	456.86	1807.58	2264.44	0.91966	2.15798	23.926	0.040671	0.000003
1010.0	1.20248-2	3.72657+3	0.95997	51.305	459.87	1805.39	2265.26	0.92171	2.15012	23.950	0.041688	0.000004
1020.0	1.33255-2	3.38237+3	0.95902	51.222	462.87	1803.19	2266.06	0.92375	2.14237	23.973	0.042713	0.000004
1030.0	1.47462-2	3.07410+3	0.95807	51.138	465.87	1800.99	2266.86	0.92577	2.13473	23.997	0.043746	0.000005
1040.0	1.62960-2	2.79763+3	0.95712	51.055	468.88	1798.78	2267.65	0.92778	2.12720	24.021	0.044786	0.000006
1050.0	1.79844-2	2.54932+3	0.95616	50.971	471.88	1796.56	2268.44	0.92977	2.11978	24.045	0.045834	0.000007
1060.0	1.98216-2	2.32600+3	0.95519	50.888	474.88	1794.34	2269.22	0.93175	2.11247	24.070	0.046888	0.000007

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
1070.0	2.18182-2	2.12489+3	0.95422	50.804	477.88	1792.11	2269.99	0.93372	2.10526	24.094	0.047950	0.000008
1080.0	2.39856-2	1.94354+3	0.95325	50.721	480.88	1789.87	2270.75	0.93568	2.09816	24.119	0.049018	0.000009
1090.0	2.63354-2	1.77978+3	0.95227	50.637	483.88	1787.63	2271.51	0.93762	2.09115	24.143	0.050092	0.000011
1100.0	2.88803-2	1.63174+3	0.95129	50.553	486.88	1785.39	2272.27	0.93955	2.08425	24.168	0.051172	0.000012
1110.0	3.16332-2	1.49774+3	0.95030	50.470	489.88	1783.14	2273.02	0.94146	2.07744	24.193	0.052258	0.000013
1120.0	3.46079-2	1.37629+3	0.94931	50.386	492.87	1780.89	2273.76	0.94337	2.07072	24.219	0.053350	0.000015
1130.0	3.78189-2	1.26608+3	0.94832	50.302	495.87	1778.63	2274.50	0.94526	2.06410	24.244	0.054446	0.000017
1140.0	4.12810-2	1.16597+3	0.94732	50.219	498.87	1776.37	2275.24	0.94714	2.05758	24.269	0.055548	0.000019
1150.0	4.50103-2	1.07492+3	0.94633	50.135	501.87	1774.11	2275.97	0.94900	2.05114	24.295	0.056654	0.000021
1160.0	4.90231-2	9.92012+2	0.94533	50.051	504.86	1771.84	2276.70	0.95086	2.04479	24.321	0.057765	0.000023
1170.0	5.33368-2	9.16439+2	0.94433	49.968	507.86	1769.57	2277.43	0.95271	2.03853	24.346	0.058880	0.000026
1180.0	5.79692-2	8.47476+2	0.94332	49.884	510.86	1767.30	2278.15	0.95454	2.03236	24.372	0.059999	0.000029
1190.0	6.29393-2	7.84477+2	0.94231	49.800	513.85	1765.02	2278.88	0.95636	2.02627	24.398	0.061121	0.000032
1200.0	6.82665-2	7.26866+2	0.94131	49.716	516.85	1762.74	2279.60	0.95817	2.02026	24.425	0.062247	0.000035
1210.0	7.39713-2	6.74127+2	0.94030	49.632	519.85	1760.46	2280.31	0.95997	2.01433	24.451	0.063377	0.000039
1220.0	8.00748-2	6.25800+2	0.93929	49.549	522.85	1758.18	2281.03	0.96176	2.00849	24.477	0.064509	0.000043
1230.0	8.65990-2	5.81470+2	0.93827	49.465	525.85	1755.90	2281.74	0.96354	2.00272	24.503	0.065644	0.000047
1240.0	9.35670-2	5.40769+2	0.93726	49.381	528.85	1753.61	2282.46	0.96531	1.99703	24.530	0.066782	0.000052
1250.0	1.01002-1	5.03362+2	0.93625	49.297	531.85	1751.32	2283.17	0.96707	1.99142	24.557	0.067922	0.000057
1260.0	1.08930-1	4.68950+2	0.93523	49.213	534.85	1749.04	2283.88	0.96882	1.98588	24.583	0.069064	0.000063
1270.0	1.17375-1	4.37264+2	0.93422	49.129	537.85	1746.75	2284.59	0.97056	1.98042	24.610	0.070208	0.000069
1280.0	1.26364-1	4.08062+2	0.93320	49.046	540.85	1744.46	2285.30	0.97229	1.97502	24.637	0.071354	0.000076
1290.0	1.35925-1	3.81125+2	0.93218	48.962	543.85	1742.16	2286.01	0.97401	1.96970	24.664	0.072501	0.000083
1300.0	1.46086-1	3.56254+2	0.93117	48.878	546.85	1739.87	2286.72	0.97572	1.96445	24.691	0.073650	0.000091
1310.0	1.56875-1	3.33272+2	0.93015	48.794	549.86	1737.58	2287.44	0.97742	1.95927	24.718	0.074799	0.000099
1320.0	1.68324-1	3.12017+2	0.92913	48.710	552.86	1735.28	2288.15	0.97912	1.95416	24.745	0.075950	0.000108
1330.0	1.80464-1	2.92342+2	0.92811	48.626	555.87	1732.99	2288.86	0.98080	1.94911	24.772	0.077101	0.000118
1340.0	1.93327-1	2.74116+2	0.92710	48.542	558.88	1730.69	2289.57	0.98248	1.94413	24.799	0.078253	0.000128
1350.0	2.06945-1	2.57217+2	0.92608	48.458	561.89	1728.40	2290.28	0.98414	1.93922	24.826	0.079405	0.000140

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
1360.0	2.21354-1	2.41536+2	0.92506	48.374	564.90	1726.10	2291.00	0.98580	1.93437	24.854	0.080557	0.000152
1370.0	2.36589-1	2.26975+2	0.92404	48.290	567.91	1723.80	2291.71	0.98745	1.92958	24.881	0.081709	0.000164
1380.0	2.52685-1	2.13443+2	0.92302	48.206	570.92	1721.50	2292.43	0.98909	1.92485	24.908	0.082861	0.000178
1390.0	2.69681-1	2.00857+2	0.92201	48.122	573.94	1719.21	2293.14	0.99073	1.92018	24.936	0.084013	0.000193
1400.0	2.87614-1	1.89142+2	0.92099	48.038	576.95	1716.91	2293.86	0.99235	1.91557	24.963	0.085163	0.000209
1410.0	3.06524-1	1.78231+2	0.91997	47.954	579.97	1714.61	2294.58	0.99397	1.91102	24.991	0.086314	0.000226
1420.0	3.26452-1	1.68060+2	0.91895	47.870	582.99	1712.31	2295.30	0.99558	1.90653	25.019	0.087463	0.000244
1430.0	3.47438-1	1.58573+2	0.91794	47.786	586.01	1710.01	2296.02	0.99719	1.90210	25.046	0.088611	0.000263
1440.0	3.69526-1	1.49717+2	0.91692	47.702	589.03	1707.71	2296.74	0.99878	1.89772	25.074	0.089758	0.000284
1450.0	3.92759-1	1.41446+2	0.91590	47.618	592.06	1705.41	2297.47	1.00037	1.89339	25.102	0.090904	0.000305
1460.0	4.17182-1	1.33714+2	0.91488	47.534	595.08	1703.11	2298.19	1.00195	1.88912	25.130	0.092048	0.000329
1470.0	4.42841-1	1.26481+2	0.91387	47.450	598.11	1700.81	2298.92	1.00352	1.88491	25.158	0.093190	0.000353
1480.0	4.69782-1	1.19712+2	0.91285	47.366	601.14	1698.50	2299.65	1.00509	1.88074	25.186	0.094331	0.000380
1490.0	4.98054-1	1.13373+2	0.91183	47.282	604.18	1696.20	2300.37	1.00665	1.87663	25.214	0.095470	0.000407
1500.0	5.27706-1	1.07431+2	0.91082	47.198	607.21	1693.89	2301.10	1.00820	1.87256	25.242	0.096606	0.000437
1510.0	5.58787-1	1.01859+2	0.90980	47.114	610.25	1691.59	2301.84	1.00975	1.86855	25.270	0.097740	0.000468
1520.0	5.91350-1	9.66307+1	0.90878	47.030	613.29	1689.28	2302.57	1.01128	1.86459	25.299	0.098872	0.000501
1530.0	6.25446-1	9.17214+1	0.90776	46.946	616.33	1686.97	2303.30	1.01282	1.86067	25.327	0.100001	0.000536
1540.0	6.61129-1	8.71092+1	0.90674	46.862	619.38	1684.66	2304.04	1.01434	1.85680	25.356	0.101128	0.000573
1550.0	6.98453-1	8.27734+1	0.90572	46.778	622.42	1682.35	2304.78	1.01586	1.85298	25.384	0.102252	0.000613
1560.0	7.37474-1	7.86950+1	0.90470	46.694	625.47	1680.04	2305.51	1.01738	1.84920	25.413	0.103373	0.000654
1570.0	7.78249-1	7.48566+1	0.90368	46.610	628.53	1677.73	2306.25	1.01888	1.84547	25.441	0.104491	0.000697
1580.0	8.20835-1	7.12420+1	0.90266	46.525	631.58	1675.41	2306.99	1.02039	1.84179	25.470	0.105605	0.000743
1590.0	8.65291-1	6.78362+1	0.90164	46.441	634.64	1673.09	2307.73	1.02188	1.83814	25.499	0.106717	0.000792
1600.0	9.11677-1	6.46254+1	0.90061	46.357	637.70	1670.77	2308.47	1.02337	1.83454	25.528	0.107825	0.000843
1610.0	9.57593-1	6.17683+1	0.89978	46.273	640.77	1668.72	2309.49	1.02485	1.83112	25.552	0.108706	0.000891
1618.6	1.00000+0	5.93350+1	0.89895	46.200	643.40	1666.79	2310.19	1.02612	1.82812	25.575	0.109594	0.000937
1620.0	1.00713+0	5.89506+1	0.89882	46.189	643.83	1666.48	2310.31	1.02633	1.82764	25.579	0.109738	0.000945
1630.0	1.05870+0	5.62880+1	0.89785	46.105	646.90	1664.24	2311.14	1.02781	1.82420	25.607	0.110767	0.001002

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
1640.0	1.11237+0	5.37706+1	0.89688	46.021	649.98	1661.99	2311.97	1.02927	1.82081	25.634	0.111791	0.001061
1650.0	1.16819+0	5.13893+1	0.89591	45.937	653.05	1659.74	2312.80	1.03073	1.81745	25.662	0.112810	0.001124
1660.0	1.22623+0	4.91356+1	0.89494	45.853	656.14	1657.49	2313.63	1.03219	1.81414	25.690	0.113825	0.001189
1670.0	1.28656+0	4.70016+1	0.89397	45.769	659.22	1655.24	2314.46	1.03364	1.81086	25.718	0.114835	0.001258
1680.0	1.34922+0	4.49799+1	0.89299	45.685	662.31	1652.98	2315.29	1.03509	1.80762	25.746	0.115841	0.001329
1690.0	1.41430+0	4.30638+1	0.89202	45.601	665.40	1650.72	2316.12	1.03653	1.80441	25.774	0.116842	0.001404
1700.0	1.48184+0	4.12467+1	0.89104	45.517	668.49	1648.46	2316.95	1.03796	1.80124	25.802	0.117838	0.001482
1710.0	1.55193+0	3.95229+1	0.89006	45.433	671.59	1646.19	2317.78	1.03939	1.79811	25.831	0.118828	0.001563
1720.0	1.62462+0	3.78867+1	0.88908	45.349	674.69	1643.92	2318.61	1.04082	1.79502	25.859	0.119814	0.001648
1730.0	1.69998+0	3.63330+1	0.88809	45.265	677.80	1641.65	2319.44	1.04224	1.79195	25.888	0.120795	0.001737
1740.0	1.77808+0	3.48570+1	0.88711	45.181	680.91	1639.37	2320.27	1.04366	1.78893	25.917	0.121771	0.001829
1750.0	1.85899+0	3.34541+1	0.88612	45.097	684.02	1637.08	2321.10	1.04507	1.78593	25.946	0.122741	0.001926
1760.0	1.94278+0	3.21201+1	0.88513	45.013	687.14	1634.80	2321.93	1.04648	1.78297	25.975	0.123706	0.002026
1770.0	2.02951+0	3.08512+1	0.88413	44.929	690.26	1632.50	2322.76	1.04788	1.78004	26.004	0.124665	0.002130
1780.0	2.11927+0	2.96435+1	0.88313	44.845	693.39	1630.20	2323.59	1.04928	1.77715	26.034	0.125619	0.002239
1790.0	2.21212+0	2.84937+1	0.88213	44.761	696.52	1627.90	2324.42	1.05067	1.77428	26.063	0.126567	0.002352
1800.0	2.30813+0	2.73986+1	0.88112	44.677	699.65	1625.59	2325.24	1.05206	1.77145	26.093	0.127510	0.002469
1810.0	2.40738+0	2.63550+1	0.88011	44.593	702.79	1623.28	2326.06	1.05345	1.76864	26.123	0.128447	0.002591
1820.0	2.50993+0	2.53603+1	0.87910	44.509	705.93	1620.96	2326.89	1.05483	1.76587	26.153	0.129378	0.002717
1830.0	2.61588+0	2.44116+1	0.87808	44.425	709.08	1618.63	2327.71	1.05621	1.76312	26.183	0.130304	0.002848
1840.0	2.72528+0	2.35066+1	0.87706	44.341	712.23	1616.29	2328.52	1.05758	1.76041	26.214	0.131223	0.002984
1850.0	2.83822+0	2.26428+1	0.87603	44.257	715.39	1613.95	2329.34	1.05895	1.75772	26.245	0.132137	0.003125
1860.0	2.95477+0	2.18181+1	0.87500	44.173	718.55	1611.60	2330.15	1.06031	1.75506	26.275	0.133045	0.003271
1870.0	3.07501+0	2.10304+1	0.87396	44.089	721.72	1609.25	2330.96	1.06168	1.75243	26.307	0.133946	0.003423
1880.0	3.19902+0	2.02777+1	0.87292	44.005	724.89	1606.89	2331.77	1.06303	1.74982	26.338	0.134841	0.003579
1890.0	3.32687+0	1.95583+1	0.87187	43.921	728.06	1604.51	2332.58	1.06439	1.74725	26.370	0.135730	0.003742
1900.0	3.45864+0	1.88704+1	0.87082	43.837	731.24	1602.14	2333.38	1.06574	1.74469	26.402	0.136613	0.003909
1910.0	3.59441+0	1.82124+1	0.86976	43.754	734.43	1599.75	2334.18	1.06708	1.74217	26.434	0.137490	0.004083
1920.0	3.73427+0	1.75828+1	0.86870	43.670	737.62	1597.35	2334.97	1.06843	1.73967	26.466	0.138360	0.004262

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
1930.0	3.87828+0	1.69801+1	0.86763	43.586	740.82	1594.95	2335.77	1.06977	1.73719	26.499	0.139223	0.004447
1940.0	4.02654+0	1.64030+1	0.86655	43.502	744.02	1592.54	2336.55	1.07110	1.73474	26.532	0.140081	0.004638
1950.0	4.17912+0	1.58501+1	0.86547	43.418	747.22	1590.11	2337.34	1.07244	1.73232	26.565	0.140931	0.004836
1960.0	4.33610+0	1.53204+1	0.86438	43.334	750.44	1587.68	2338.12	1.07377	1.72991	26.598	0.141775	0.005039
1970.0	4.49756+0	1.48127+1	0.86329	43.251	753.65	1585.24	2338.90	1.07509	1.72754	26.632	0.142612	0.005249
1980.0	4.66359+0	1.43258+1	0.86219	43.167	756.88	1582.79	2339.67	1.07642	1.72518	26.666	0.143443	0.005466
1990.0	4.83427+0	1.38588+1	0.86108	43.083	760.11	1580.33	2340.44	1.07774	1.72285	26.700	0.144267	0.005689
2000.0	5.00968+0	1.34108+1	0.85996	42.999	763.34	1577.86	2341.20	1.07905	1.72054	26.735	0.145084	0.005919
2010.0	5.18990+0	1.29807+1	0.85884	42.915	766.58	1575.38	2341.96	1.08037	1.71825	26.770	0.145894	0.006156
2020.0	5.37502+0	1.25678+1	0.85771	42.832	769.83	1572.88	2342.71	1.08168	1.71598	26.805	0.146697	0.006399
2030.0	5.56513+0	1.21713+1	0.85657	42.748	773.08	1570.38	2343.46	1.08299	1.71374	26.841	0.147494	0.006650
2040.0	5.76029+0	1.17904+1	0.85543	42.664	776.34	1567.87	2344.20	1.08429	1.71151	26.877	0.148283	0.006908
2050.0	5.96061+0	1.14243+1	0.85427	42.581	779.60	1565.34	2344.94	1.08560	1.70931	26.913	0.149065	0.007173
2060.0	6.16616+0	1.10724+1	0.85311	42.497	782.87	1562.80	2345.67	1.08690	1.70713	26.950	0.149840	0.007446
2070.0	6.37702+0	1.07340+1	0.85194	42.413	786.15	1560.25	2346.40	1.08819	1.70497	26.987	0.150608	0.007726
2080.0	6.59329+0	1.04086+1	0.85077	42.330	789.43	1557.69	2347.12	1.08949	1.70282	27.024	0.151369	0.008014
2090.0	6.81505+0	1.00955+1	0.84958	42.246	792.72	1555.12	2347.84	1.09078	1.70070	27.062	0.152122	0.008309
2100.0	7.04237+0	9.79414+0	0.84839	42.163	796.01	1552.54	2348.55	1.09207	1.69860	27.100	0.152869	0.008612
2110.0	7.27536+0	9.50405+0	0.84719	42.079	799.31	1549.94	2349.25	1.09335	1.69651	27.138	0.153608	0.008923
2120.0	7.51408+0	9.22471+0	0.84598	41.995	802.62	1547.33	2349.95	1.09464	1.69445	27.177	0.154339	0.009242
2130.0	7.75863+0	8.95566+0	0.84476	41.912	805.93	1544.71	2350.64	1.09592	1.69240	27.216	0.155063	0.009569
2140.0	8.00910+0	8.69644+0	0.84353	41.828	809.26	1542.08	2351.33	1.09720	1.69037	27.256	0.155780	0.009905
2150.0	8.26556+0	8.44662+0	0.84229	41.745	812.58	1539.43	2352.01	1.09848	1.68836	27.296	0.156490	0.010248
2160.0	8.52811+0	8.20581+0	0.84105	41.661	815.92	1536.77	2352.69	1.09975	1.68637	27.336	0.157191	0.010600
2170.0	8.79682+0	7.97360+0	0.83979	41.578	819.26	1534.10	2353.35	1.10102	1.68440	27.377	0.157886	0.010961
2180.0	9.07179+0	7.74965+0	0.83853	41.494	822.61	1531.41	2354.02	1.10229	1.68244	27.418	0.158573	0.011329
2190.0	9.35310+0	7.53360+0	0.83726	41.411	825.96	1528.71	2354.67	1.10356	1.68050	27.460	0.159252	0.011707
2200.0	9.64083+0	7.32512+0	0.83598	41.328	829.32	1526.00	2355.32	1.10483	1.67857	27.502	0.159923	0.012092
2210.0	9.93508+0	7.12389+0	0.83469	41.244	832.69	1523.27	2355.96	1.10609	1.67667	27.544	0.160587	0.012488

APPENDIX B (Contd.)

Temp (°F)	PSAT (atmos)	VSAT (ft ³ /lb)	Z	DL (lb/ft ³)	HLS (Btu/lb)	DHV (Btu/lb)	HGS (Btu/lb)	SLS (Btu/lb°F)	SGS (Btu/lb°F)	ABAR	X ₂ (mole fr.)	X ₄ (mole fr.)
2220.0	1.02359+1	6.92961+0	0.83339	41.161	836.07	1520.53	2356.60	1.10735	1.67478	27.587	0.161244	0.012892
2230.0	1.05434+1	6.74200+0	0.83208	41.078	839.45	1517.78	2357.23	1.10861	1.67290	27.631	0.161892	0.013304
2240.0	1.08577+1	6.56078+0	0.83076	40.994	842.84	1515.01	2357.85	1.10987	1.67105	27.675	0.162533	0.013726
2250.0	1.11789+1	6.38570+0	0.82944	40.911	846.24	1512.23	2358.47	1.11113	1.66920	27.719	0.163166	0.014157
2260.0	1.15069+1	6.21651+0	0.82810	40.828	849.65	1509.43	2359.08	1.11238	1.66738	27.763	0.163791	0.014596
2270.0	1.18420+1	6.05297+0	0.82676	40.745	853.06	1506.62	2359.68	1.11363	1.66557	27.809	0.164409	0.015045
2280.0	1.21842+1	5.89485+0	0.82540	40.661	856.48	1503.80	2360.28	1.11488	1.66377	27.854	0.165019	0.015503
2290.0	1.25336+1	5.74194+0	0.82404	40.578	859.91	1500.96	2360.87	1.11613	1.66199	27.900	0.165621	0.015971
2300.0	1.28903+1	5.59405+0	0.82267	40.495	863.34	1498.11	2361.45	1.11738	1.66023	27.947	0.166215	0.016447
2310.0	1.32543+1	5.45096+0	0.82129	40.412	866.79	1495.24	2362.03	1.11862	1.65848	27.994	0.166801	0.016933
2320.0	1.36257+1	5.31249+0	0.81990	40.329	870.24	1492.36	2362.60	1.11986	1.65674	28.041	0.167379	0.017428
2330.0	1.40047+1	5.17848+0	0.81850	40.246	873.70	1489.47	2363.16	1.12111	1.65502	28.089	0.167950	0.017933
2340.0	1.43913+1	5.04873+0	0.81709	40.163	877.16	1486.56	2363.72	1.12235	1.65332	28.138	0.168512	0.018447
2350.0	1.47856+1	4.92310+0	0.81567	40.080	880.64	1483.63	2364.27	1.12358	1.65162	28.186	0.169067	0.018971
2360.0	1.51877+1	4.80143+0	0.81425	39.997	884.12	1480.70	2364.82	1.12482	1.64995	28.236	0.169614	0.019504
2370.0	1.55976+1	4.68356+0	0.81281	39.914	887.61	1477.74	2365.36	1.12606	1.64828	28.286	0.170153	0.020047
2380.0	1.60154+1	4.56936+0	0.81137	39.831	891.11	1474.78	2365.89	1.12729	1.64663	28.336	0.170684	0.020599
2390.0	1.64413+1	4.45869+0	0.80992	39.748	894.62	1471.80	2366.42	1.12852	1.64500	28.387	0.171207	0.021161
2400.0	1.68752+1	4.35142+0	0.80846	39.665	898.14	1468.80	2366.94	1.12976	1.64338	28.438	0.171722	0.021732
2410.0	1.73174+1	4.24742+0	0.80699	39.582	901.66	1465.79	2367.46	1.13099	1.64177	28.490	0.172229	0.022313
2420.0	1.77678+1	4.14658+0	0.80552	39.499	905.20	1462.77	2367.97	1.13221	1.64017	28.542	0.172728	0.022904
2430.0	1.82265+1	4.04877+0	0.80403	39.417	908.74	1459.73	2368.48	1.13344	1.63859	28.595	0.173220	0.023504
2440.0	1.86937+1	3.95390+0	0.80254	39.334	912.29	1456.68	2368.97	1.13467	1.63702	28.648	0.173703	0.024114
2450.0	1.91693+1	3.86185+0	0.80104	39.251	915.85	1453.62	2369.47	1.13589	1.63547	28.701	0.174179	0.024733
2460.0	1.96536+1	3.77253+0	0.79953	39.168	919.42	1450.54	2369.96	1.13712	1.63393	28.756	0.174646	0.025363
2470.0	2.01465+1	3.68584+0	0.79801	39.086	923.00	1447.45	2370.44	1.13834	1.63240	28.810	0.175106	0.026001
2480.0	2.06481+1	3.60168+0	0.79649	39.003	926.58	1444.34	2370.92	1.13956	1.63088	28.865	0.175558	0.026649
2490.0	2.11586+1	3.51997+0	0.79496	38.921	930.18	1441.22	2371.40	1.14078	1.62938	28.921	0.176002	0.027307
2500.0	2.16779+1	3.44062+0	0.79342	38.838	933.78	1438.08	2371.86	1.14200	1.62789	28.977	0.176438	0.027975
2510.0	2.22062+1	3.36355+0	0.79188	38.755	937.40	1434.93	2372.33	1.14322	1.62641	29.034	0.176867	0.028651

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