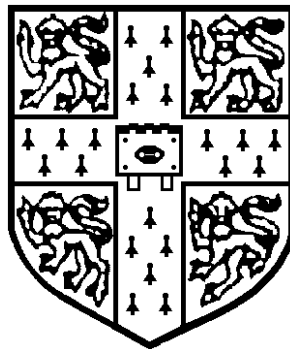


# Thermofluids Data Book

for Part I of the  
Engineering Tripos

**2017 Edition**



Cambridge University Engineering Department

## Latest revisions

Current release THERMOFLUIDS\_DATA\_v\_20 (12/01/21)

Previous release THERMOFLUIDS\_DATA\_v\_19 (19/7/19)

### Updates since previous release

Correction to the value of  $\bar{R}$  (page 13).

The pressure-enthalpy chart of R-134a has been replaced (page 39)

# CONTENTS

|  |    |
|--|----|
| Thermodynamic definitions & relationships .....  | 3  |
| Ideal gas relationships .....  | 4  |
| Perfect gas relationships .....  | 4  |
| Mixtures of perfect gases .....  | 4  |
| Non-dimensional groups .....   | 5  |
| Heat transfer .....  | 6  |
| Equations for systems .....  | 7  |
| Equations for control volumes .....  | 8  |
| Equations for streamlines .....  | 10 |
| Incompressible viscous pipe flow .....   | 10 |
| Equations of motion in differential form .....   | 10 |
| viscous steady flow of a fluid .....   | 10 |
| viscous unsteady flow of an incompressible fluid .....   | 10 |
| Thermodynamic efficiencies .....   | 11 |
| Combustion .....   | 12 |
| Properties of perfect gases .....  | 13 |
| Molar enthalpies of common gases at low pressures .....  | 14 |
| Thermochemical data for equilibrium reactions .....  | 15 |
| Data for steam .....   | 17 |
| Triple point data for steam .....  | 17 |
| Critical point data for steam .....  | 17 |
| Properties of saturated water & steam: Temperatures from the triple point to the critical point .  | 18 |
| Properties of saturated water & steam: Pressures from the triple point to the critical point ..... | 20 |
| Specific enthalpy of water and steam .....   | 24 |
| Specific Entropy of water and steam .....  | 25 |
| Density of water and steam .....   | 26 |
| Specific internal energy of water and steam .....  | 27 |
| Transport properties of saturated water & steam .....  | 28 |
| Transport properties of steam .....  | 29 |
| Transport properties of air .....  | 29 |
| Transport properties of carbon dioxide .....   | 30 |
| Transport properties of hydrogen .....   | 30 |
| Perfect gas relations for compressible flow for $\gamma=1.4$ .....                                 | 31 |
| Properties of gases at sea level conditions .....  | 32 |
| Properties of liquids at sea level conditions .....  | 32 |
| The International Standard Atmosphere .....  | 32 |
| Properties of the International Standard Atmosphere at altitude .....                              | 33 |
| Physical constants .....   | 34 |
| Conversion of Non-SI to SI Units .....   | 35 |
| Conversion of Non-SI to SI Units cont. ....  | 36 |
| Sources of Information .....   | 37 |
| Critical point data for Refrigerant R-134a ( $\text{CH}_2\text{FCF}_3$ ) .....                     | 37 |
| Properties Table for Refrigerant R-134a ( $\text{CH}_2\text{FCF}_3$ ) .....                        | 38 |
| Properties Chart for Refrigerant R-134a ( $\text{CH}_2\text{FCF}_3$ ) .....                        | 39 |
| Properties of steam .....  | 40 |

## THERMODYNAMIC DEFINITIONS & RELATIONSHIPS

Specific enthalpy

$$h \equiv u + pv$$

Specific heat capacity at constant volume

$$c_v \equiv \left( \frac{\partial u}{\partial T} \right)_v$$

Specific heat capacity at constant pressure

$$c_p \equiv \left( \frac{\partial h}{\partial T} \right)_p$$

Ratio of specific heat capacities

$$\gamma \equiv \frac{c_p}{c_v}$$

Coefficient of volume expansion

$$\beta \equiv \frac{1}{v} \left( \frac{\partial v}{\partial T} \right)_p$$

Coefficient of compressibility

$$\kappa \equiv -\frac{1}{v} \left( \frac{\partial v}{\partial p} \right)_T$$

For a simple compressible substance, in the absence of capillarity, electric and magnetic fields

$$Tds = du + pdv = dh - vdp$$

## IDEAL GAS RELATIONSHIPS

|  |  |
|--|--|
| Equation of state                          | $\begin{cases} pV = n\bar{R}T \\ pV = mRT \\ pv = RT \\ p = \rho RT \end{cases}$ |
| Relationship between $c_p$ , $c_v$ and $R$ | $c_p - c_v = R$  |
| Speed of sound                             | $a = \sqrt{\gamma RT}$   |

## PERFECT GAS RELATIONSHIPS

|                                    |   |
|------------------------------------|---|
| Change in specific internal energy | $u_2 - u_1 = c_v(T_2 - T_1)$  |
| Change in specific enthalpy        | $h_2 - h_1 = c_p(T_2 - T_1)$  |
| Change in specific entropy         | $s_2 - s_1 = \begin{cases} c_v \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{v_2}{v_1}\right) \\ c_p \ln\left(\frac{T_2}{T_1}\right) - R \ln\left(\frac{p_2}{p_1}\right) \\ c_v \ln\left(\frac{p_2}{p_1}\right) + c_p \ln\left(\frac{v_2}{v_1}\right) \end{cases}$ |
| For <i>Isentropic</i> changes      | $pv^\gamma = \text{const.}$ $Tv^{\gamma-1} = \text{const.}$ $T/p^{(\gamma-1)/\gamma} = \text{const.}$   |

## MIXTURES OF PERFECT GASES

For a mixture of  $N$  perfect gases where, for component  $-i$ ,  $m_i$  = mass,  $p_i$  = partial pressure,  $h_i = h_i(T)$  = partial specific enthalpy,  $s_i = s_i(T, p_i)$  = partial specific entropy,  $n_i$  = number of mols and the overbar signifies a partial molar quantity:

|                         |   |
|-------------------------|---|
| Pressure of the mixture | $P_{mixture} = \sum_{i=1}^{i=N} p_i$                                      |
| Enthalpy of the mixture | $H_{mixture} = \sum_{i=1}^{i=N} m_i h_i = \sum_{i=1}^{i=N} n_i \bar{h}_i$ |
| Entropy of the mixture  | $S_{mixture} = \sum_{i=1}^{i=N} m_i s_i = \sum_{i=1}^{i=N} n_i \bar{s}_i$ |

## NON-DIMENSIONAL GROUPS

Reynolds Number  $Re = \frac{\rho V d}{\mu} = \frac{V d}{\nu}$

Mach Number  $M = \frac{V}{a}$

Froude Number  $Fr = \frac{V}{\sqrt{gz}}$

Prandtl Number  $Pr = \frac{\mu c_p}{\lambda} = \frac{\nu}{\alpha}$

Biot Number  $Bi = \frac{hs}{\lambda}$

Fourier Number  $Fo = \frac{\alpha \tau}{s^2}$

Drag Coefficient  $C_D = \frac{D}{\frac{1}{2} \rho V^2 A}$

Lift Coefficient  $C_L = \frac{L}{\frac{1}{2} \rho V^2 A}$

Skin Friction Coefficient  $c_f = \frac{\tau_w}{\frac{1}{2} \rho V^2}$

Friction Factor  $f = 4c_f$

Discharge Coefficient  $C_d = \frac{\dot{m}_{actual}}{\dot{m}_{ideal}}$

Nusselt Number  $Nu = \frac{hd}{\lambda}$

Grashof Number  $Gr = \frac{gd^3 \beta \Delta T}{\nu^2}$

Stanton Number  $St = \frac{Nu}{Re Pr} = \frac{h}{\rho V c_p}$

# HEAT TRANSFER

## Conduction, Convection and Radiation

Rate of heat transfer  $\dot{Q}$  by *convection* from a body of surface area  $A$

$$\dot{Q} = hA(T_{body} - T_{surroundings})$$

Rate of heat transfer  $\dot{Q}$  by *conduction* along a straight bar of cross-sectional area  $A$

$$\dot{Q} = -\lambda A \frac{dT}{dx}$$

Rate of heat transfer  $\dot{Q}$  by *conduction* radially in a straight circular bar of length  $L$

$$\dot{Q} = -\lambda 2\pi r L \frac{dT}{dr}$$

Rate of heat transfer  $\dot{Q}$  by *radiation*<sup>1</sup> from a grey body of surface area  $A$  and emissivity  $\varepsilon$

$$\dot{Q} = \varepsilon \dot{Q}_{black} = \varepsilon \sigma A T^4$$

where  $\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$  is the Stefan-Boltzmann constant.

Logarithmic-Mean Temperature Difference (LMTD)

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$$

## Convective heat transfer for fully developed flow in circular pipes of diameter $d$

Overall heat transfer for laminar flow with constant wall temperature

$$Nu_d = 3.66 \qquad Re_d < 2300 \qquad 0.1 < Pr$$

Overall heat transfer for turbulent flow with constant wall temperature

$$Nu_d = 0.023 Re_d^{0.8} Pr^{0.4} \qquad 2300 < Re_d < 10^7 \qquad 0.5 < Pr < 120$$

## Heat transfer due to natural convection from a vertical isothermal plate of height $L$

Overall heat transfer

$$Nu_L = 0.52 (GrPr)^{0.25} \qquad Pr \approx 1$$

## Reynolds Analogy

$$St = \frac{c_f}{2}$$

<sup>1</sup> Note that the net rate of heat transfer will be less due to incident radiation

## EQUATIONS FOR SYSTEMS

### Definition of a system

A system is a fixed quantity of matter.

### Conservation of mass applied to a system

The mass of a system is constant, i.e.

$$m = \text{const.}$$

### 1<sup>st</sup> Law of Thermodynamics applied to a system

When heat transfer to, and work done by, a system are defined as positive and the system is undergoing a cyclic process

$$\oint dQ = \oint dW$$

When heat transfer to, and work done by, a system of mass  $m$  undergoing a process between state 1 and state 2 are defined as positive and in the absence of capillarity, electric and magnetic fields

$$Q - W = E_2 - E_1 = (U_2 + \frac{1}{2}mV_2^2 + mgz_2) - (U_1 + \frac{1}{2}mV_1^2 + mgz_1)$$

### 2<sup>nd</sup> Law of Thermodynamics applied to a system

When heat transfer to a system undergoing a cyclic process is defined as positive, the Clausius inequality is

$$\oint \frac{dQ}{T} \leq 0$$

When heat transfer to a system of mass  $m$  undergoing a process is defined as positive

$$m ds = \frac{dQ}{T} + m ds_{irrev} \quad \text{where} \quad ds_{irrev} \geq 0$$

where  $ds_{irrev}$  is the entropy created per unit mass by irreversibilities.

### *p*dv work for a system

When the surface of a system undergoes displacement between state 1 and state 2 and the pressure causing the displacement is known over the entire surface that is displaced, the displacement work done by the system during this process is

$$W = \int_1^2 p dV$$



## EQUATIONS FOR CONTROL VOLUMES

### Definition of a control volume

A control volume is that region of space that is enclosed by a rigid control surface.

### The requirements for steady flow within a control volume

For steady-flow, conditions within the control volume are not, on average, changing so that the mass, momentum, energy and entropy within the control volume remain constant.

### Conservation of mass applied to a control volume - the *Continuity Equation*

In general, this may be written in vector form as

$$\frac{d}{dt} \iiint_{cv} \rho dV + \iint_{cs} \rho \underline{V} \cdot \underline{dA} = 0$$

where  $\underline{dA}$  is positive *out* of the control volume. It may also be written as

$$\frac{dm_{cv}}{dt} + \sum \dot{m}_{out} - \sum \dot{m}_{in} = 0$$

For *steady flow*, the above becomes

$$\sum \dot{m}_{out} = \sum \dot{m}_{in}$$

### Momentum equations applied to a control volume, including the *Steady Flow Momentum Equation (SFME)*

In general, this may be written in vector form as

$$\frac{d}{dt} \iiint_{cv} \rho \underline{V} dV + \iint_{cs} \rho \underline{V} \underline{V} \cdot \underline{dA} = \underline{F} - \iint_{cs} p \underline{dA}$$

where  $\underline{dA}$  is positive *out* of the control volume and  $\underline{F}$  is the sum of all the non-pressure forces on the flow.

For *steady flow*, the above becomes the *Steady Flow Momentum Equation (SFME)*

$$\iint_{cs} \rho \underline{V} \underline{V} \cdot \underline{dA} = \underline{F} - \iint_{cs} p \underline{dA}$$

and in  $x$  and  $y$  coordinates, the *SFME* is

$$\sum \dot{m}_{out} V_{x,out} - \sum \dot{m}_{in} V_{x,in} = \sum F_x + \left( \sum pA \right)_x$$

$$\sum \dot{m}_{out} V_{y,out} - \sum \dot{m}_{in} V_{y,in} = \sum F_y + \left( \sum pA \right)_y$$

where care is needed with respect to the sign of the  $V_x$ ,  $V_y$  and  $A$  terms.

### 1<sup>st</sup> Law of Thermodynamics applied to a control volume, including the *Steady Flow Energy Equation (SFEE)*

In the absence of capillarity, electric and magnetic fields, the 1<sup>st</sup> Law becomes

$$\frac{dE_{cv}}{dt} + \sum \dot{m}_{out} \left( h_{out} + \frac{1}{2} V_{out}^2 + gz_{out} \right) - \sum \dot{m}_{in} \left( h_{in} + \frac{1}{2} V_{in}^2 + gz_{in} \right) = \dot{Q} - \dot{W}_x$$

where  $E_{cv}$  is the total energy within the control volume,  $\dot{Q}$  is the rate of heat transfer to the control volume and  $\dot{W}_x$  is the rate of shaft work transferred from the control volume.

For *steady flow*, the above becomes the *Steady Flow Energy Equation (SFEE)*

$$\sum \dot{m}_{out} \left( h_{out} + \frac{1}{2} V_{out}^2 + gz_{out} \right) - \sum \dot{m}_{in} \left( h_{in} + \frac{1}{2} V_{in}^2 + gz_{in} \right) = \dot{Q} - \dot{W}_x$$

### 2<sup>nd</sup> Law of Thermodynamics applied to a control volume

When heat transfer to a control volume is defined as positive

$$\frac{dS_{cv}}{dt} + \sum \dot{m}_{out} s_{out} - \sum \dot{m}_{in} s_{in} = \int_A \frac{d\dot{Q}}{T} + \dot{S}_{irrev} \quad \text{where} \quad \dot{S}_{irrev} \geq 0$$

where  $d\dot{Q}$  is the rate of heat transfer to an area  $dA$  of the control surface at temperature  $T$  and the integration is over the whole area  $A$  of the control surface,  $S_{cv}$  is the total entropy within the control volume and  $\dot{S}_{irrev}$  is the rate of entropy creation within the control volume due to irreversibilities.

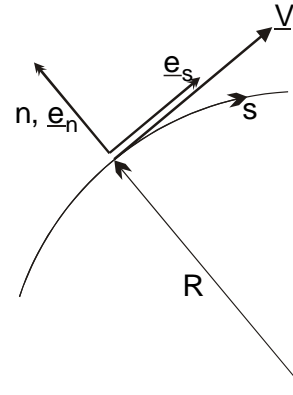
## EQUATIONS FOR STREAMLINES

**Bernoulli's Equation for incompressible inviscid steady flow along a streamline**

$$p + \frac{1}{2} \rho V^2 + \rho g z = \text{const.}$$

**The pressure gradient normal to a streamline with a radius of curvature  $R$**

$$\frac{dp}{dn} = \frac{\rho V^2}{R}$$



## INCOMPRESSIBLE VISCOUS PIPE FLOW

**The pressure drop along a pipe of constant diameter  $d$  and length  $L$ , with viscous flow**

$$\Delta p = 4c_f \frac{L}{d} \frac{1}{2} \rho V^2 = f \frac{L}{d} \frac{1}{2} \rho V^2$$

## EQUATIONS OF MOTION IN DIFFERENTIAL FORM

### VISCOUS STEADY FLOW OF A FLUID

**Mass conservation (continuity)**

Intrinsic coordinates  $\left( e_s \frac{\partial}{\partial s} + e_n \frac{\partial}{\partial n} \right) \cdot (\rho V e_s) = 0$

Vector Notation  $\nabla \cdot (\rho \underline{V}) = 0$

**Momentum**

Intrinsic coordinates  $\rho \left( V \frac{\partial V}{\partial s} e_s - \frac{V^2}{R} e_n \right) = -\frac{\partial p}{\partial s} e_s - \frac{\partial p}{\partial n} e_n + \rho \underline{g} + \underline{viscous}$

Vector Notation  $\rho \underline{V} \cdot \nabla \underline{V} = -\nabla p + \rho \underline{g} + \underline{viscous}$

### VISCOUS UNSTEADY FLOW OF AN INCOMPRESSIBLE FLUID

$\nabla \cdot \underline{V} = 0$   $\rho \left( \frac{\partial \underline{V}}{\partial t} + \underline{V} \cdot \nabla \underline{V} \right) = -\nabla p + \rho \underline{g} + \mu \nabla^2 \underline{V}$

# THERMODYNAMIC EFFICIENCIES

## Efficiency of a cycle

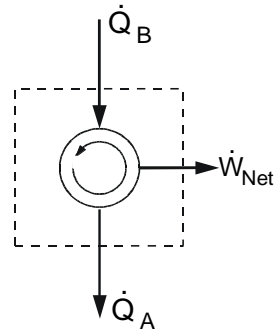
$$\eta_{cycle} \equiv \frac{\dot{W}_{net}}{\dot{Q}_B}$$

but

$$\dot{W}_{net} = \dot{Q}_B - \dot{Q}_A$$

so

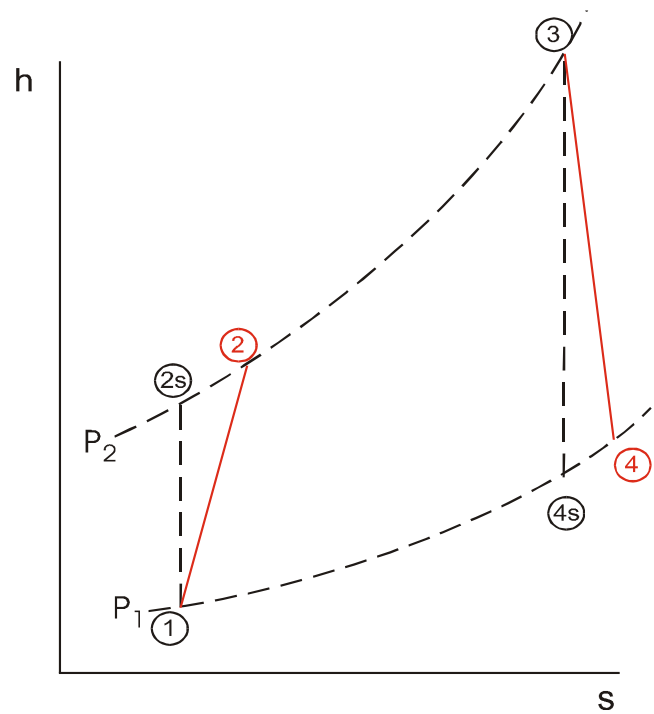
$$\eta_{cycle} = 1 - \frac{\dot{Q}_A}{\dot{Q}_B}$$



## Isentropic efficiencies of compressors and turbines

$$\eta_c \equiv \frac{\text{Ideal Work Input}}{\text{Actual Work Input}} = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$\eta_t \equiv \frac{\text{Actual Work Output}}{\text{Ideal Work Output}} = \frac{h_3 - h_4}{h_3 - h_{4s}}$$



## COMBUSTION

### The SFEE applied to stoichiometric combustion at constant $T$ and $p$

When heat transfer to a control volume is defined as positive and in the absence of shaft work, changes in KE and PE, capillarity, electric and magnetic fields, the rate of heat transfer and the calorific value ( $CV$ ) are related by

$$\dot{Q} = \dot{m}_{fuel}(-CV) = \dot{n}_{fuel}\Delta\bar{h}$$

where

$$\dot{m}_{fuel} = M\dot{n}_{fuel}$$

### Calorific values of common fuels (Enthalpies of Reaction)

In the following table, the calorific value is equal and opposite to the enthalpy of reaction when the reactants and products are at 25°C and 1.01324 bar. In the evaluation of the lower calorific value and lower enthalpy of reaction, the steam is assumed to be dry saturated.

| Stoichiometric Equation                         | Molar<br>Mass $M$ of<br>Fuel<br>$\frac{\text{kg}}{\text{kmol}}$ | Phase  | Calorific Value<br>MJ/kg   |                           |
|---|---|--------|----------------------------|---------------------------|
|   |   |        | Higher: $H_2O$<br>to water | Lower: $H_2O$<br>to steam |
| $C + \frac{1}{2}O_2 \rightarrow CO$             | 12  | solid  | 9.190                      |                           |
| $C + O_2 \rightarrow CO_2$                      | 12  | solid  | 32.760                     |                           |
| $CO + \frac{1}{2}O_2 \rightarrow CO_2$          | 28  | gas    | 10.100                     |                           |
| $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$         | 2 <sup>†</sup>  | gas    | 142.000                    | 120.000                   |
| $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$          | 16  | gas    | 55.500                     | 50.010                    |
| $C_2H_6 + 3.5O_2 \rightarrow 2CO_2 + 3H_2O$     | 30  | gas    | 51.870                     | 47.470                    |
| $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$       | 44  | gas    | 50.360                     | 46.360                    |
| $C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$  | 58  | gas    | 49.520                     | 45.730                    |
| $C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$ | 114   | gas    | 48.270                     | 44.800                    |
| $C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$ | 114   | liquid | 47.900                     | 44.430                    |

<sup>†</sup> A more exact value is 2.016

## PROPERTIES OF PERFECT GASES

### Values of $M$ , $R$ , $c_p$ , $c_v$ and $\gamma$

At normal atmospheric conditions, and over a limited range of temperature and pressure, the gases listed below may be assumed to behave as perfect gases. That is, they may be assumed to have the equation of state  $p\bar{v} = \bar{R}T$ , and to have constant specific heat capacities.

| Gas                               | Molar mass $M$<br>kg/kmol | Gas constant $R$<br>kJ/kg K | $c_p$<br>kJ/kg K | $c_v$<br>kJ/kg K | $\gamma \equiv \frac{c_p}{c_v}$ |
|-----------------------------------|---------------------------|-----------------------------|------------------|------------------|---------------------------------|
| Air <sup>#</sup>                  | 29.0                      | 0.287                       | 1.005            | 0.718            | 1.40                            |
| Atmospheric nitrogen <sup>†</sup> | 28.15                     | 0.295                       | 1.033            | 0.738            | 1.40                            |
| N <sub>2</sub>                    | 28                        | 0.297                       | 1.04             | 0.74             | 1.40                            |
| O <sub>2</sub>                    | 32                        | 0.260                       | 0.92             | 0.66             | 1.40                            |
| Ar                                | 40                        | 0.208                       | 0.52             | 0.31             | 1.67                            |
| H <sub>2</sub>                    | 2*                        | 4.120                       | 14.20            | 10.08            | 1.41                            |
| He                                | 4                         | 2.080                       | 5.19             | 3.11             | 1.67                            |
| CO                                | 28                        | 0.297                       | 1.04             | 0.74             | 1.40                            |
| CO <sub>2</sub>                   | 44                        | 0.189                       | 0.83             | 0.63             | 1.31                            |
| SO <sub>2</sub>                   | 64                        | 0.130                       | 0.61             | 0.48             | 1.26                            |
| CH <sub>4</sub>                   | 16                        | 0.520                       | 2.23             | 1.71             | 1.31                            |
| C <sub>2</sub> H <sub>6</sub>     | 30                        | 0.277                       | 1.75             | 1.47             | 1.19                            |
| C <sub>3</sub> H <sub>6</sub>     | 42                        | 0.198                       | 1.52             | 1.32             | 1.15                            |

Real gases are not perfect gases, and the rounded values for  $R$ ,  $c_p$ ,  $c_v$  and  $c_p/c_v$  listed above do not exactly satisfy the relationships between these quantities that would be obtained for perfect gases.

### Molar (universal) gas constant

$$\bar{R} = MR = 8.3145 \text{ kJ/kmol K}$$

### Molar volume of a perfect gas

1 kmol of any perfect gas occupies a volume of approximately 22.7 m<sup>3</sup> at s.t.p. (0 °C and 1 bar) and contains 6.022x10<sup>26</sup> particles.

<sup>#</sup> Air contains 21.0% O<sub>2</sub> and 79.0% atmospheric nitrogen by volume (*Volumetric and Molar Analyses*); 23.2% O<sub>2</sub> and 76.8% atmospheric nitrogen by weight (*Gravimetric Analysis*).

<sup>†</sup> Air contains 0.93 % of argon (Ar) and traces of other gases; these and the nitrogen together are called *atmospheric nitrogen*.

\* A more exact value is 2.016.

## MOLAR ENTHALPIES OF COMMON GASES AT LOW PRESSURES

At low pressures, and over the temperature range quoted, the gases listed in this Table behave as semi-perfect gases. That is, while having the molar equation of state  $p\bar{v} = \bar{R}T$ , their specific heat capacities  $c_p$  and  $c_v$  are not constant but are functions only of temperature.

| Gas                   | Air                       | N <sub>2</sub> | O <sub>2</sub> | H <sub>2</sub> | CO     | CO <sub>2</sub> | H <sub>2</sub> O | Gas                   |
|-----------------------|---------------------------|----------------|----------------|----------------|--------|-----------------|------------------|-----------------------|
| Molar Mass<br>kg/kmol | 29                        | 28             | 32             | 2 <sup>†</sup> | 28     | 44              | 18               | Molar Mass<br>kg/kmol |
| Temperature<br>K      | Molar enthalpy<br>MJ/kmol |                |                |                |        |                 |                  | Temperature<br>K      |
| 200                   | 5.79                      | 5.81           | 5.79           | 5.69           | 5.81   | 5.96            | 6.62             | 200                   |
| 298.15=25°C           | 8.64                      | 8.67           | 8.66           | 8.46           | 8.67   | 9.37            | 9.90             | 25°C=298.15           |
| 300                   | 8.70                      | 8.72           | 8.71           | 8.52           | 8.72   | 9.44            | 9.96             | 300                   |
| 400                   | 11.62                     | 11.64          | 11.68          | 11.42          | 11.64  | 13.37           | 13.35            | 400                   |
| 500                   | 14.57                     | 14.58          | 14.74          | 14.34          | 14.60  | 17.67           | 16.82            | 500                   |
| 600                   | 17.59                     | 17.56          | 17.90          | 17.27          | 17.61  | 22.27           | 20.39            | 600                   |
| 700                   | 20.66                     | 20.61          | 21.16          | 20.21          | 20.69  | 27.12           | 24.09            | 700                   |
| 800                   | 23.81                     | 23.72          | 24.50          | 23.16          | 23.85  | 32.18           | 27.90            | 800                   |
| 900                   | 27.03                     | 26.89          | 27.90          | 26.13          | 27.07  | 37.41           | 31.83            | 900                   |
| 1000                  | 30.30                     | 30.14          | 31.37          | 29.14          | 30.36  | 42.78           | 35.90            | 1000                  |
| 1100                  | 33.64                     | 33.44          | 34.88          | 32.18          | 33.71  | 48.27           | 40.09            | 1100                  |
| 1200                  | 37.02                     | 36.79          | 38.43          | 35.26          | 37.11  | 53.87           | 44.41            | 1200                  |
| 1300                  | 40.44                     | 40.19          | 42.01          | 38.38          | 40.54  | 59.55           | 48.84            | 1300                  |
| 1400                  | 43.90                     | 43.62          | 45.63          | 41.54          | 44.02  | 65.31           | 53.39            | 1400                  |
| 1500                  | 47.39                     | 47.09          | 49.27          | 44.75          | 47.53  | 71.13           | 58.05            | 1500                  |
| 1600                  | 50.92                     | 50.59          | 52.94          | 48.00          | 51.07  | 77.01           | 62.81            | 1600                  |
| 1700                  | 54.47                     | 54.12          | 56.63          | 51.29          | 54.63  | 82.94           | 67.65            | 1700                  |
| 1800                  | 58.04                     | 57.67          | 60.35          | 54.62          | 58.21  | 88.92           | 72.58            | 1800                  |
| 1900                  | 61.63                     | 61.25          | 64.09          | 58.00          | 61.81  | 94.93           | 77.59            | 1900                  |
| 2000                  | 65.24                     | 64.84          | 67.86          | 61.40          | 65.42  | 100.97          | 82.67            | 2000                  |
| 2100                  | 68.87                     | 68.44          | 71.65          | 64.84          | 69.06  | 107.05          | 87.81            | 2100                  |
| 2200                  | 72.52                     | 72.06          | 75.46          | 68.31          | 72.70  | 113.15          | 93.01            | 2200                  |
| 2300                  | 76.18                     | 75.70          | 79.29          | 71.82          | 76.36  | 119.28          | 98.27            | 2300                  |
| 2400                  | 79.86                     | 79.35          | 83.14          | 75.35          | 80.03  | 125.43          | 103.58           | 2400                  |
| 2500                  | 83.55                     | 83.01          | 87.02          | 78.90          | 83.71  | 131.61          | 108.94           | 2500                  |
| 2600                  | 87.25                     | 86.68          | 90.92          | 82.48          | 87.40  | 137.80          | 114.34           | 2600                  |
| 2700                  | 90.96                     | 90.36          | 94.83          | 86.09          | 91.10  | 144.02          | 119.78           | 2700                  |
| 2800                  | 94.69                     | 94.05          | 98.77          | 89.72          | 94.80  | 150.25          | 125.26           | 2800                  |
| 2900                  | 98.42                     | 97.74          | 102.72         | 93.37          | 98.51  | 156.50          | 130.77           | 2900                  |
| 3000                  | 102.16                    | 101.44         | 106.70         | 97.04          | 102.23 | 162.76          | 136.31           | 3000                  |

Notes:

- (1) The molar enthalpies listed are those in the ideal gas state at zero pressure, but the values given are also valid at and around atmospheric pressure.
- (2) In this table, the arbitrary datum state for zero enthalpy is that of the substance in the ideal gas state at zero pressure and zero absolute temperature.
- (3) The values for atmospheric nitrogen,  $N_2^*$ , may be taken to be the same as those for  $N_2$ .

<sup>†</sup> A more exact value is 2.016

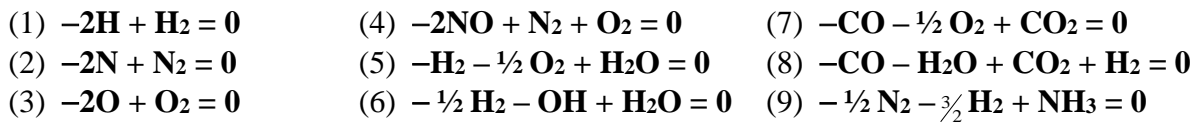
# THERMOCHEMICAL DATA FOR EQUILIBRIUM REACTIONS

The tables of equilibrium constants and standard enthalpy change on the next page relate to the reactions listed below

## Stoichiometric equations

$$\sum_i v_i A_i = 0$$

where  $v_i$  is the stoichiometric coefficient of the substance whose chemical symbol is  $A_i$ .



## Equilibrium constants

The equilibrium constant  $K_p$  is given by

$$\ln(K_p) = \sum_i v_i \ln p_i^*$$

where  $p_i^* \equiv p_i' / p_0$

$p_i'$   $\equiv$  partial pressure of species  $A_i$  in **bars**

$p_0 \equiv$  standard pressure  $\equiv$  **1 bar**

Thus  $p_i^*$  is numerically equal to  $p_i'$  but is dimensionless.

## Standard free enthalpy of reaction

At a given temperature, the standard free enthalpy of reaction (or the *standard Gibbs function change*)  $\Delta G_T^0$  may be calculated from the listed value of  $\ln(K_p)$  by the following equation:

$$\begin{aligned} \Delta G_T^0 &= -\bar{R}T \ln K_p \\ &= -8.3145 T \ln(K_p) \quad \text{kJ kmol}^{-1} \end{aligned}$$

## Standard enthalpy of reaction

The Standard enthalpy of reaction is given by

$$\Delta H_T^0 = \sum_i v_i [\tilde{h}_i]_T^0 = \sum_i v_i ([\Delta H_f]_T^0)_i$$

where

$$[\tilde{h}_i]_T^0 = ([\Delta H_f]_{298}^0)_i + ([\bar{h}]_T^0 - [\bar{h}]_{298}^0)_i$$

where  $([\Delta H_f]_T^0)_i$  is the *standard enthalpy of formation* of species  $i$  at temperature  $T$  and a pressure  $p_0 = 1$  bar.



**Equilibrium constants & standard enthalpies of reaction**

| Reaction Number  | 1   | 2       | 3       | 4       | 5       | 6       | 7       | 8      | 9       |
|------------------|---|---------|---------|---------|---------|---------|---------|--------|---------|
| $\sum_i \nu_i =$ | -1  | -1      | -1      | 0       | -1/2    | -1/2    | -1/2    | 0      | -1      |
| Temperature<br>K | Equilibrium Constant $\ln(K_p)$                                       |         |         |         |         |         |         |        |         |
| 200              | 250.149   | 554.472 | 285.471 | 105.592 | 139.972 | 161.789 | 159.692 | 19.719 | 15.433  |
| 298.15           | 163.986   | 367.479 | 186.975 | 69.865  | 92.207  | 106.228 | 103.762 | 11.554 | 6.593   |
| 400              | 119.150   | 270.329 | 135.715 | 51.311  | 67.321  | 77.284  | 74.669  | 7.348  | 1.778   |
| 600              | 75.217  | 175.356 | 85.523  | 33.203  | 42.897  | 48.905  | 46.245  | 3.348  | -3.191  |
| 800              | 53.126  | 127.753 | 60.319  | 24.145  | 30.592  | 34.634  | 32.036  | 1.444  | -5.822  |
| 1000             | 39.803  | 99.127  | 45.150  | 18.706  | 23.162  | 26.033  | 23.528  | 0.366  | -7.457  |
| 1200             | 30.874  | 80.011  | 35.005  | 15.082  | 18.182  | 20.281  | 17.871  | -0.311 | -8.570  |
| 1400             | 24.463  | 66.329  | 27.742  | 12.489  | 14.608  | 16.160  | 13.841  | -0.767 | -9.371  |
| 1600             | 19.632  | 56.055  | 22.285  | 10.546  | 11.921  | 13.065  | 10.829  | -1.091 | -9.972  |
| 1800             | 15.865  | 48.051  | 18.030  | 9.035   | 9.825   | 10.657  | 8.497   | -1.329 | -10.439 |
| 2000             | 12.835  | 41.645  | 14.622  | 7.824   | 8.145   | 8.727   | 6.634   | -1.510 | -10.810 |
| 2200             | 10.353  | 36.391  | 11.827  | 6.834   | 6.768   | 7.148   | 5.119   | -1.649 | -11.109 |
| 2400             | 8.276   | 32.011  | 9.497   | 6.010   | 5.619   | 5.831   | 3.859   | -1.759 | -11.358 |
| 2600             | 6.512   | 28.304  | 7.521   | 5.314   | 4.647   | 4.718   | 2.800   | -1.847 | -11.563 |
| 2800             | 5.002   | 25.117  | 5.286   | 4.720   | 3.811   | 3.763   | 1.893   | -1.918 | -11.738 |
| 3000             | 3.685   | 22.359  | 4.357   | 4.205   | 3.086   | 2.936   | 1.110   | -1.976 | -11.885 |
| Temperature<br>K | Standard Enthalpy of Reaction $\Delta H_T^0$<br>MJ kmol <sup>-1</sup> |         |         |         |         |         |         |        |         |
| 200              | -434.7  | -944.1  | -496.9  | -180.4  | -240.9  | -280.2  | -282.1  | -41.21 | -43.71  |
| 298.15           | -436.0  | -945.3  | -498.4  | -180.6  | -241.8  | -281.3  | -283.0  | -41.17 | -45.90  |
| 400              | -437.3  | -946.6  | -499.8  | -180.7  | -242.8  | -282.4  | -283.5  | -40.63 | -48.04  |
| 600              | -439.7  | -948.9  | -502.1  | -180.7  | -244.8  | -284.1  | -283.6  | -38.88 | -51.39  |
| 800              | -442.1  | -951.1  | -503.9  | -180.8  | -246.5  | -285.5  | -283.3  | -36.82 | -53.66  |
| 1000             | -444.5  | -953.0  | -505.4  | -180.9  | -247.9  | -286.6  | -282.6  | -34.74 | -55.07  |
| 1200             | -446.7  | -954.7  | -506.7  | -180.9  | -249.0  | -287.4  | -281.8  | -32.79 | -55.83  |
| 1400             | -448.7  | -956.1  | -507.8  | -181.0  | -249.9  | -287.9  | -280.9  | -30.98 | -56.07  |
| 1600             | -450.6  | -957.5  | -508.9  | -181.0  | -250.6  | -288.4  | -279.9  | -29.29 | -55.99  |
| 1800             | -452.3  | -958.7  | -509.8  | -181.0  | -251.2  | -288.6  | -278.9  | -27.71 | -55.66  |
| 2000             | -453.8  | -959.9  | -510.6  | -181.0  | -251.7  | -288.8  | -277.9  | -26.22 | -55.19  |
| 2200             | -455.2  | -961.0  | -511.4  | -180.8  | -252.1  | -288.9  | -276.8  | -24.79 | -54.61  |
| 2400             | -456.4  | -962.1  | -512.0  | -180.7  | -252.4  | -289.0  | -275.8  | -23.41 | -53.92  |
| 2600             | -457.6  | -963.1  | -512.5  | -180.4  | -252.7  | -289.0  | -274.8  | -22.07 | -53.12  |
| 2800             | -458.6  | -964.1  | -513.0  | -180.1  | -253.0  | -288.9  | -273.7  | -20.77 | -52.22  |
| 3000             | -459.6  | -965.0  | -513.4  | -179.7  | -253.3  | -288.9  | -272.7  | -19.49 | -51.20  |

Warning: These tables list *absolute* temperatures

## DATA FOR STEAM

### Source of data

The following tables have been produced using equations from the *IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use* and the *Supplementary Release: Saturation Properties of Ordinary Water Substance*. These documents can be found on the International Association for the Properties of Water and Steam website <http://www.iapws.org>.

### TRIPLE POINT DATA FOR STEAM

Temperature = 273.16 K (0.01°C)  
Pressure = 0.00611 bar

---

| Phase | Specific volume<br>m <sup>3</sup> /kg | Specific enthalpy<br>kJ/kg | Specific entropy<br>kJ/kg K |
|-------|---------------------------------------|----------------------------|-----------------------------|
| Ice   | 0.0010905                             | -333.5                     | -1.221                      |
| Water | 0.0010002                             | 0.000612                   | 0.0                         |
| Steam | 206                                   | 2500.9                     | 9.156                       |

---

### CRITICAL POINT DATA FOR STEAM

Temperature = 647.096 K (373.946°C)  
Pressure = 220.64 bar  
Density = 322 kg/m<sup>3</sup>

# PROPERTIES OF SATURATED WATER & STEAM:

Temperatures from the triple point to the critical point

| Temp.<br>°C | Pressure<br>bar | Specific volume<br>m <sup>3</sup> /kg |                      | Spec. int. energy<br>kJ/kg |                      | Specific enthalpy<br>kJ/kg |                       |                      | Specific entropy<br>kJ/kg K |                      | Temp.<br>°C |
|-------------|-----------------|---------------------------------------|----------------------|----------------------------|----------------------|----------------------------|-----------------------|----------------------|-----------------------------|----------------------|-------------|
| <i>T</i>    | <i>p</i>        | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>u<sub>f</sub></i>       | <i>u<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>fg</sub></i> | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>T</i>    |
| <b>0.01</b> | <b>0.00611</b>  | <b>0.001000</b>                       | <b>206.005</b>       | <b>0.0</b>                 | <b>2375.0</b>        | <b>0.0</b>                 | <b>2500.9</b>         | <b>2500.9</b>        | <b>0.000</b>                | <b>9.156</b>         | <b>0.01</b> |
| <b>2</b>    | 0.00706         | 0.001000                              | 179.776              | 8.4                        | 2377.6               | 8.4                        | 2496.2                | 2504.6               | 0.031                       | 9.103                | <b>2</b>    |
| <b>4</b>    | 0.00814         | 0.001000                              | 157.135              | 16.8                       | 2380.4               | 16.8                       | 2491.4                | 2508.2               | 0.061                       | 9.051                | <b>4</b>    |
| <b>6</b>    | 0.00935         | 0.001000                              | 137.652              | 25.2                       | 2383.1               | 25.2                       | 2486.7                | 2511.9               | 0.091                       | 8.999                | <b>6</b>    |
| <b>8</b>    | 0.01073         | 0.001000                              | 120.846              | 33.6                       | 2385.9               | 33.6                       | 2481.9                | 2515.6               | 0.121                       | 8.949                | <b>8</b>    |
| <b>10</b>   | 0.01228         | 0.001000                              | 106.319              | 42.0                       | 2388.6               | 42.0                       | 2477.2                | 2519.2               | 0.151                       | 8.900                | <b>10</b>   |
| <b>12</b>   | 0.01403         | 0.001001                              | 93.732               | 50.4                       | 2391.4               | 50.4                       | 2472.5                | 2522.9               | 0.181                       | 8.851                | <b>12</b>   |
| <b>14</b>   | 0.01599         | 0.001001                              | 82.804               | 58.8                       | 2394.1               | 58.8                       | 2467.7                | 2526.5               | 0.210                       | 8.804                | <b>14</b>   |
| <b>16</b>   | 0.01819         | 0.001001                              | 73.295               | 67.2                       | 2396.9               | 67.2                       | 2463.0                | 2530.2               | 0.239                       | 8.757                | <b>16</b>   |
| <b>18</b>   | 0.02065         | 0.001001                              | 65.005               | 75.5                       | 2399.6               | 75.5                       | 2458.3                | 2533.8               | 0.268                       | 8.711                | <b>18</b>   |
| <b>20</b>   | 0.02339         | 0.001002                              | 57.762               | 83.9                       | 2402.3               | 83.9                       | 2453.5                | 2537.4               | 0.296                       | 8.666                | <b>20</b>   |
| <b>22</b>   | 0.02645         | 0.001002                              | 51.422               | 92.3                       | 2405.0               | 92.3                       | 2448.8                | 2541.1               | 0.325                       | 8.622                | <b>22</b>   |
| <b>24</b>   | 0.02986         | 0.001003                              | 45.861               | 100.6                      | 2407.8               | 100.6                      | 2444.1                | 2544.7               | 0.353                       | 8.578                | <b>24</b>   |
| <b>25</b>   | <b>0.03170</b>  | <b>0.001003</b>                       | <b>43.340</b>        | <b>104.8</b>               | <b>2409.1</b>        | <b>104.8</b>               | <b>2441.7</b>         | <b>2546.5</b>        | <b>0.367</b>                | <b>8.557</b>         | <b>25</b>   |
| <b>26</b>   | 0.03364         | 0.001003                              | 40.975               | 109.0                      | 2410.5               | 109.0                      | 2439.3                | 2548.3               | 0.381                       | 8.535                | <b>26</b>   |
| <b>28</b>   | 0.03783         | 0.001004                              | 36.673               | 117.4                      | 2413.2               | 117.4                      | 2434.6                | 2551.9               | 0.409                       | 8.493                | <b>28</b>   |
| <b>30</b>   | 0.04247         | 0.001004                              | 32.879               | 125.7                      | 2415.9               | 125.7                      | 2429.8                | 2555.5               | 0.437                       | 8.452                | <b>30</b>   |
| <b>32</b>   | 0.04760         | 0.001005                              | 29.527               | 134.1                      | 2418.6               | 134.1                      | 2425.1                | 2559.2               | 0.464                       | 8.411                | <b>32</b>   |
| <b>34</b>   | 0.05325         | 0.001006                              | 26.560               | 142.4                      | 2421.3               | 142.4                      | 2420.3                | 2562.8               | 0.492                       | 8.371                | <b>34</b>   |
| <b>36</b>   | 0.05948         | 0.001006                              | 23.929               | 150.8                      | 2424.0               | 150.8                      | 2415.5                | 2566.3               | 0.519                       | 8.332                | <b>36</b>   |
| <b>38</b>   | 0.06633         | 0.001007                              | 21.593               | 159.2                      | 2426.7               | 159.2                      | 2410.8                | 2569.9               | 0.546                       | 8.294                | <b>38</b>   |
| <b>40</b>   | 0.07385         | 0.001008                              | 19.515               | 167.5                      | 2429.4               | 167.5                      | 2406.0                | 2573.5               | 0.572                       | 8.256                | <b>40</b>   |
| <b>42</b>   | 0.08210         | 0.001009                              | 17.663               | 175.9                      | 2432.1               | 175.9                      | 2401.2                | 2577.1               | 0.599                       | 8.218                | <b>42</b>   |
| <b>44</b>   | 0.09113         | 0.001010                              | 16.010               | 184.2                      | 2434.7               | 184.2                      | 2396.4                | 2580.6               | 0.625                       | 8.181                | <b>44</b>   |
| <b>46</b>   | 0.10100         | 0.001010                              | 14.534               | 192.6                      | 2437.4               | 192.6                      | 2391.6                | 2584.2               | 0.652                       | 8.145                | <b>46</b>   |
| <b>48</b>   | 0.11178         | 0.001011                              | 13.212               | 201.0                      | 2440.1               | 201.0                      | 2386.8                | 2587.8               | 0.678                       | 8.110                | <b>48</b>   |
| <b>50</b>   | 0.12352         | 0.001012                              | 12.026               | 209.3                      | 2442.7               | 209.3                      | 2382.0                | 2591.3               | 0.704                       | 8.075                | <b>50</b>   |
| <b>52</b>   | 0.13632         | 0.001013                              | 10.962               | 217.7                      | 2445.4               | 217.7                      | 2377.1                | 2594.8               | 0.730                       | 8.040                | <b>52</b>   |
| <b>54</b>   | 0.15023         | 0.001014                              | 10.006               | 226.0                      | 2448.0               | 226.1                      | 2372.3                | 2598.3               | 0.755                       | 8.007                | <b>54</b>   |
| <b>56</b>   | 0.16534         | 0.001015                              | 9.145                | 234.4                      | 2450.7               | 234.4                      | 2367.4                | 2601.8               | 0.781                       | 7.973                | <b>56</b>   |
| <b>58</b>   | 0.18172         | 0.001016                              | 8.368                | 242.8                      | 2453.3               | 242.8                      | 2362.5                | 2605.3               | 0.806                       | 7.940                | <b>58</b>   |
| <b>60</b>   | 0.19947         | 0.001017                              | 7.667                | 251.1                      | 2455.9               | 251.2                      | 2357.7                | 2608.8               | 0.831                       | 7.908                | <b>60</b>   |
| <b>62</b>   | 0.21868         | 0.001018                              | 7.033                | 259.5                      | 2458.5               | 259.5                      | 2352.8                | 2612.3               | 0.856                       | 7.876                | <b>62</b>   |
| <b>64</b>   | 0.23944         | 0.001019                              | 6.460                | 267.9                      | 2461.1               | 267.9                      | 2347.9                | 2615.8               | 0.881                       | 7.845                | <b>64</b>   |
| <b>66</b>   | 0.26184         | 0.001020                              | 5.940                | 276.3                      | 2463.7               | 276.3                      | 2342.9                | 2619.2               | 0.906                       | 7.814                | <b>66</b>   |
| <b>68</b>   | 0.28600         | 0.001022                              | 5.468                | 284.6                      | 2466.3               | 284.7                      | 2338.0                | 2622.7               | 0.931                       | 7.784                | <b>68</b>   |
| <b>70</b>   | 0.31202         | 0.001023                              | 5.040                | 293.0                      | 2468.8               | 293.1                      | 2333.0                | 2626.1               | 0.955                       | 7.754                | <b>70</b>   |
| <b>72</b>   | 0.34002         | 0.001024                              | 4.650                | 301.4                      | 2471.4               | 301.4                      | 2328.1                | 2629.5               | 0.979                       | 7.725                | <b>72</b>   |
| <b>74</b>   | 0.37010         | 0.001025                              | 4.295                | 309.8                      | 2474.0               | 309.8                      | 2323.1                | 2632.9               | 1.004                       | 7.696                | <b>74</b>   |
| <b>76</b>   | 0.40240         | 0.001026                              | 3.971                | 318.2                      | 2476.5               | 318.2                      | 2318.1                | 2636.3               | 1.028                       | 7.667                | <b>76</b>   |
| <b>78</b>   | 0.43704         | 0.001028                              | 3.675                | 326.6                      | 2479.0               | 326.6                      | 2313.1                | 2639.7               | 1.052                       | 7.639                | <b>78</b>   |
| <b>80</b>   | 0.47416         | 0.001029                              | 3.405                | 335.0                      | 2481.5               | 335.0                      | 2308.0                | 2643.0               | 1.076                       | 7.611                | <b>80</b>   |
| <b>82</b>   | 0.51388         | 0.001030                              | 3.158                | 343.3                      | 2484.1               | 343.4                      | 2303.0                | 2646.4               | 1.099                       | 7.584                | <b>82</b>   |
| <b>84</b>   | 0.55636         | 0.001032                              | 2.932                | 351.7                      | 2486.5               | 351.8                      | 2297.9                | 2649.7               | 1.123                       | 7.557                | <b>84</b>   |
| <b>86</b>   | 0.60174         | 0.001033                              | 2.725                | 360.1                      | 2489.0               | 360.2                      | 2292.8                | 2653.0               | 1.146                       | 7.530                | <b>86</b>   |
| <b>88</b>   | 0.65018         | 0.001035                              | 2.534                | 368.6                      | 2491.5               | 368.6                      | 2287.6                | 2656.3               | 1.170                       | 7.504                | <b>88</b>   |
| <b>90</b>   | 0.70183         | 0.001036                              | 2.359                | 377.0                      | 2494.0               | 377.0                      | 2282.5                | 2659.5               | 1.193                       | 7.478                | <b>90</b>   |
| <b>92</b>   | 0.75685         | 0.001037                              | 2.198                | 385.4                      | 2496.4               | 385.4                      | 2277.3                | 2662.8               | 1.216                       | 7.453                | <b>92</b>   |
| <b>94</b>   | 0.81542         | 0.001039                              | 2.050                | 393.8                      | 2498.8               | 393.9                      | 2272.1                | 2666.0               | 1.239                       | 7.428                | <b>94</b>   |
| <b>96</b>   | 0.87771         | 0.001040                              | 1.914                | 402.2                      | 2501.2               | 402.3                      | 2266.9                | 2669.2               | 1.262                       | 7.403                | <b>96</b>   |
| <b>98</b>   | 0.94390         | 0.001042                              | 1.788                | 410.6                      | 2503.6               | 410.7                      | 2261.7                | 2672.4               | 1.285                       | 7.378                | <b>98</b>   |
| <b>100</b>  | 1.01418         | 0.001043                              | 1.672                | 419.1                      | 2506.0               | 419.2                      | 2256.4                | 2675.6               | 1.307                       | 7.354                | <b>100</b>  |
| <i>T</i>    | <i>p</i>        | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>u<sub>f</sub></i>       | <i>u<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>fg</sub></i> | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>T</i>    |

Properties of Saturated Water & Steam continued:  
Temperatures from the triple point to the critical point

| Temp.<br>°C   | Pressure<br>bar | Specific volume<br>m <sup>3</sup> /kg |                      | Spec. int. energy<br>kJ/kg |                      | Specific enthalpy<br>kJ/kg |                       |                      | Specific entropy<br>kJ/kg K |                      | Temp.<br>°C   |
|---------------|-----------------|---------------------------------------|----------------------|----------------------------|----------------------|----------------------------|-----------------------|----------------------|-----------------------------|----------------------|---------------|
| <i>T</i>      | <i>p</i>        | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>u<sub>f</sub></i>       | <i>u<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>fg</sub></i> | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>T</i>      |
| <b>100</b>    | 1.014           | 0.001043                              | 1.67196              | 419.1                      | 2506.0               | 419.2                      | 2256.4                | 2675.6               | 1.307                       | 7.354                | <b>100</b>    |
| <b>105</b>    | 1.209           | 0.001047                              | 1.41856              | 440.1                      | 2511.9               | 440.3                      | 2243.1                | 2683.4               | 1.363                       | 7.295                | <b>105</b>    |
| <b>110</b>    | 1.434           | 0.001052                              | 1.20945              | 461.3                      | 2517.7               | 461.4                      | 2229.6                | 2691.1               | 1.419                       | 7.238                | <b>110</b>    |
| <b>115</b>    | 1.692           | 0.001056                              | 1.03598              | 482.4                      | 2523.3               | 482.6                      | 2216.0                | 2698.6               | 1.474                       | 7.183                | <b>115</b>    |
| <b>120</b>    | 1.987           | 0.001060                              | 0.89133              | 503.6                      | 2528.8               | 503.8                      | 2202.1                | 2705.9               | 1.528                       | 7.129                | <b>120</b>    |
| <b>125</b>    | 2.322           | 0.001065                              | 0.77012              | 524.8                      | 2534.3               | 525.1                      | 2188.0                | 2713.1               | 1.582                       | 7.077                | <b>125</b>    |
| <b>130</b>    | 2.703           | 0.001070                              | 0.66808              | 546.1                      | 2539.5               | 546.4                      | 2173.7                | 2720.1               | 1.635                       | 7.026                | <b>130</b>    |
| <b>135</b>    | 3.132           | 0.001075                              | 0.58179              | 567.4                      | 2544.6               | 567.7                      | 2159.1                | 2726.9               | 1.687                       | 6.977                | <b>135</b>    |
| <b>140</b>    | 3.615           | 0.001080                              | 0.50850              | 588.8                      | 2549.6               | 589.2                      | 2144.3                | 2733.4               | 1.739                       | 6.929                | <b>140</b>    |
| <b>145</b>    | 4.157           | 0.001085                              | 0.44600              | 610.2                      | 2554.4               | 610.6                      | 2129.2                | 2739.8               | 1.791                       | 6.883                | <b>145</b>    |
| <b>150</b>    | 4.762           | 0.001091                              | 0.39248              | 631.7                      | 2559.0               | 632.2                      | 2113.7                | 2745.9               | 1.842                       | 6.837                | <b>150</b>    |
| <b>155</b>    | 5.435           | 0.001096                              | 0.34648              | 653.2                      | 2563.5               | 653.8                      | 2098.0                | 2751.8               | 1.892                       | 6.793                | <b>155</b>    |
| <b>160</b>    | 6.182           | 0.001102                              | 0.30680              | 674.8                      | 2567.8               | 675.5                      | 2082.0                | 2757.4               | 1.943                       | 6.749                | <b>160</b>    |
| <b>165</b>    | 7.009           | 0.001108                              | 0.27244              | 696.5                      | 2571.8               | 697.2                      | 2065.6                | 2762.8               | 1.992                       | 6.707                | <b>165</b>    |
| <b>170</b>    | 7.922           | 0.001114                              | 0.24260              | 718.2                      | 2575.7               | 719.1                      | 2048.8                | 2767.9               | 2.042                       | 6.665                | <b>170</b>    |
| <b>175</b>    | 8.926           | 0.001121                              | 0.21659              | 740.0                      | 2579.4               | 741.0                      | 2031.7                | 2772.7               | 2.091                       | 6.624                | <b>175</b>    |
| <b>180</b>    | 10.028          | 0.001127                              | 0.19384              | 761.9                      | 2582.8               | 763.1                      | 2014.2                | 2777.2               | 2.139                       | 6.584                | <b>180</b>    |
| <b>185</b>    | 11.235          | 0.001134                              | 0.17390              | 783.9                      | 2586.0               | 785.2                      | 1996.2                | 2781.4               | 2.188                       | 6.545                | <b>185</b>    |
| <b>190</b>    | 12.552          | 0.001141                              | 0.15636              | 806.0                      | 2589.0               | 807.4                      | 1977.8                | 2785.3               | 2.235                       | 6.506                | <b>190</b>    |
| <b>195</b>    | 13.988          | 0.001149                              | 0.14089              | 828.2                      | 2591.7               | 829.8                      | 1959.0                | 2788.8               | 2.283                       | 6.468                | <b>195</b>    |
| <b>200</b>    | 15.549          | 0.001157                              | 0.12721              | 850.5                      | 2594.2               | 852.3                      | 1939.7                | 2792.0               | 2.331                       | 6.430                | <b>200</b>    |
| <b>205</b>    | 17.243          | 0.001164                              | 0.11508              | 872.9                      | 2596.4               | 874.9                      | 1919.9                | 2794.8               | 2.378                       | 6.393                | <b>205</b>    |
| <b>210</b>    | 19.077          | 0.001173                              | 0.10429              | 895.4                      | 2598.3               | 897.6                      | 1899.6                | 2797.3               | 2.424                       | 6.356                | <b>210</b>    |
| <b>215</b>    | 21.059          | 0.001181                              | 0.09468              | 918.0                      | 2599.9               | 920.5                      | 1878.8                | 2799.3               | 2.471                       | 6.320                | <b>215</b>    |
| <b>220</b>    | 23.196          | 0.001190                              | 0.08609              | 940.8                      | 2601.2               | 943.6                      | 1857.4                | 2800.9               | 2.518                       | 6.284                | <b>220</b>    |
| <b>225</b>    | 25.497          | 0.001199                              | 0.07841              | 963.7                      | 2602.2               | 966.8                      | 1835.3                | 2802.2               | 2.564                       | 6.248                | <b>225</b>    |
| <b>230</b>    | 27.971          | 0.001209                              | 0.07151              | 986.8                      | 2602.9               | 990.2                      | 1812.7                | 2802.9               | 2.610                       | 6.213                | <b>230</b>    |
| <b>235</b>    | 30.626          | 0.001219                              | 0.06530              | 1010.0                     | 2603.2               | 1013.8                     | 1789.4                | 2803.2               | 2.656                       | 6.178                | <b>235</b>    |
| <b>240</b>    | 33.470          | 0.001229                              | 0.05971              | 1033.4                     | 2603.1               | 1037.6                     | 1765.4                | 2803.0               | 2.702                       | 6.142                | <b>240</b>    |
| <b>245</b>    | 36.512          | 0.001240                              | 0.05466              | 1057.0                     | 2602.7               | 1061.5                     | 1740.7                | 2802.2               | 2.748                       | 6.107                | <b>245</b>    |
| <b>250</b>    | 39.762          | 0.001252                              | 0.05009              | 1080.8                     | 2601.8               | 1085.8                     | 1715.2                | 2800.9               | 2.793                       | 6.072                | <b>250</b>    |
| <b>255</b>    | 43.229          | 0.001263                              | 0.04594              | 1104.8                     | 2600.5               | 1110.2                     | 1688.9                | 2799.1               | 2.839                       | 6.037                | <b>255</b>    |
| <b>260</b>    | 46.923          | 0.001276                              | 0.04218              | 1129.0                     | 2598.7               | 1134.9                     | 1661.7                | 2796.6               | 2.885                       | 6.002                | <b>260</b>    |
| <b>265</b>    | 50.853          | 0.001289                              | 0.03875              | 1153.4                     | 2596.5               | 1159.9                     | 1633.6                | 2793.5               | 2.930                       | 5.966                | <b>265</b>    |
| <b>270</b>    | 55.030          | 0.001303                              | 0.03562              | 1178.1                     | 2593.7               | 1185.2                     | 1604.5                | 2789.7               | 2.976                       | 5.930                | <b>270</b>    |
| <b>275</b>    | 59.464          | 0.001317                              | 0.03277              | 1203.0                     | 2590.3               | 1210.9                     | 1574.3                | 2785.2               | 3.022                       | 5.894                | <b>275</b>    |
| <b>280</b>    | 64.166          | 0.001333                              | 0.03015              | 1228.3                     | 2586.4               | 1236.8                     | 1543.0                | 2779.9               | 3.068                       | 5.858                | <b>280</b>    |
| <b>285</b>    | 69.146          | 0.001349                              | 0.02776              | 1253.9                     | 2581.8               | 1263.2                     | 1510.5                | 2773.7               | 3.114                       | 5.821                | <b>285</b>    |
| <b>290</b>    | 74.418          | 0.001366                              | 0.02555              | 1279.8                     | 2576.5               | 1290.0                     | 1476.7                | 2766.7               | 3.161                       | 5.783                | <b>290</b>    |
| <b>295</b>    | 79.991          | 0.001384                              | 0.02353              | 1306.1                     | 2570.5               | 1317.2                     | 1441.5                | 2758.7               | 3.208                       | 5.745                | <b>295</b>    |
| <b>300</b>    | 85.879          | 0.001404                              | 0.02166              | 1332.8                     | 2563.6               | 1344.9                     | 1404.7                | 2749.6               | 3.255                       | 5.706                | <b>300</b>    |
| <b>305</b>    | 92.094          | 0.001425                              | 0.01993              | 1360.1                     | 2555.8               | 1373.2                     | 1366.2                | 2739.4               | 3.302                       | 5.666                | <b>305</b>    |
| <b>310</b>    | 98.650          | 0.001447                              | 0.01833              | 1387.8                     | 2547.1               | 1402.1                     | 1325.8                | 2727.9               | 3.351                       | 5.624                | <b>310</b>    |
| <b>315</b>    | 105.561         | 0.001472                              | 0.01685              | 1416.2                     | 2537.2               | 1431.7                     | 1283.3                | 2715.0               | 3.399                       | 5.582                | <b>315</b>    |
| <b>320</b>    | 112.843         | 0.001499                              | 0.01547              | 1445.2                     | 2526.0               | 1462.1                     | 1238.5                | 2700.6               | 3.449                       | 5.537                | <b>320</b>    |
| <b>325</b>    | 120.510         | 0.001528                              | 0.01418              | 1475.0                     | 2513.4               | 1493.4                     | 1190.9                | 2684.3               | 3.500                       | 5.491                | <b>325</b>    |
| <b>330</b>    | 128.581         | 0.001560                              | 0.01298              | 1505.7                     | 2499.2               | 1525.8                     | 1140.2                | 2666.0               | 3.552                       | 5.442                | <b>330</b>    |
| <b>335</b>    | 137.073         | 0.001597                              | 0.01185              | 1537.5                     | 2483.0               | 1559.4                     | 1086.0                | 2645.4               | 3.605                       | 5.391                | <b>335</b>    |
| <b>340</b>    | 146.007         | 0.001638                              | 0.01078              | 1570.7                     | 2464.5               | 1594.6                     | 1027.4                | 2621.9               | 3.660                       | 5.336                | <b>340</b>    |
| <b>345</b>    | 155.406         | 0.001685                              | 0.00977              | 1605.4                     | 2443.2               | 1631.6                     | 963.4                 | 2595.1               | 3.718                       | 5.276                | <b>345</b>    |
| <b>350</b>    | 165.293         | 0.001741                              | 0.00881              | 1642.3                     | 2418.3               | 1671.1                     | 892.7                 | 2563.8               | 3.779                       | 5.211                | <b>350</b>    |
| <b>355</b>    | 175.700         | 0.001808                              | 0.00787              | 1682.1                     | 2388.6               | 1713.9                     | 812.9                 | 2526.9               | 3.844                       | 5.138                | <b>355</b>    |
| <b>360</b>    | 186.660         | 0.001895                              | 0.00695              | 1726.2                     | 2351.8               | 1761.5                     | 720.0                 | 2481.6               | 3.916                       | 5.054                | <b>360</b>    |
| <b>365</b>    | 198.218         | 0.002015                              | 0.00601              | 1777.2                     | 2303.6               | 1817.2                     | 605.5                 | 2422.7               | 4.000                       | 4.949                | <b>365</b>    |
| <b>370</b>    | 210.438         | 0.002217                              | 0.00495              | 1844.5                     | 2230.1               | 1891.2                     | 443.1                 | 2334.3               | 4.112                       | 4.801                | <b>370</b>    |
| <b>373.95</b> | <b>220.640</b>  | <b>0.003106</b>                       | <b>0.00311</b>       | <b>2018.1</b>              | <b>2018.1</b>        | <b>2086.6</b>              | <b>0.0</b>            | <b>2086.6</b>        | <b>4.410</b>                | <b>4.410</b>         | <b>373.95</b> |
| <i>T</i>      | <i>p</i>        | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>u<sub>f</sub></i>       | <i>u<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>fg</sub></i> | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>T</i>      |

# PROPERTIES OF SATURATED WATER & STEAM:

Pressures from the triple point to the critical point

| Pressure<br>bar<br>$p$ | Temp.<br>°C<br>$T$ | Specific volume<br>m <sup>3</sup> /kg |                 | Spec. int. energy<br>kJ/kg |               | Specific enthalpy<br>kJ/kg |               |               | Specific entropy<br>kJ/kg K |              | Pressure<br>bar<br>$p$ |
|------------------------|--------------------|---------------------------------------|-----------------|----------------------------|---------------|----------------------------|---------------|---------------|-----------------------------|--------------|------------------------|
|                        |                    | $v_f$                                 | $v_g$           | $u_f$                      | $u_g$         | $h_f$                      | $h_{fg}$      | $h_g$         | $s_f$                       | $s_g$        |                        |
| <b>0.00611</b>         | <b>0.01</b>        | <b>0.001000</b>                       | <b>206.0005</b> | <b>0.0</b>                 | <b>2375.0</b> | <b>0.0</b>                 | <b>2500.9</b> | <b>2500.9</b> | <b>0.000</b>                | <b>9.156</b> | <b>0.00611</b>         |
| <b>0.02</b>            | 17.50              | 0.001001                              | 66.990          | 73.4                       | 2398.9        | 73.4                       | 2459.5        | 2532.9        | 0.261                       | 8.723        | <b>0.02</b>            |
| <b>0.04</b>            | 28.96              | 0.001004                              | 34.791          | 121.4                      | 2414.5        | 121.4                      | 2432.3        | 2553.7        | 0.422                       | 8.473        | <b>0.04</b>            |
| <b>0.06</b>            | 36.16              | 0.001006                              | 23.733          | 151.5                      | 2424.2        | 151.5                      | 2415.2        | 2566.6        | 0.521                       | 8.329        | <b>0.06</b>            |
| <b>0.08</b>            | 41.51              | 0.001008                              | 18.099          | 173.8                      | 2431.4        | 173.8                      | 2402.4        | 2576.2        | 0.592                       | 8.227        | <b>0.08</b>            |
| <b>0.10</b>            | 45.81              | 0.001010                              | 14.670          | 191.8                      | 2437.2        | 191.8                      | 2392.1        | 2583.9        | 0.649                       | 8.149        | <b>0.10</b>            |
| <b>0.12</b>            | 49.42              | 0.001012                              | 12.358          | 206.9                      | 2442.0        | 206.9                      | 2383.4        | 2590.3        | 0.696                       | 8.085        | <b>0.12</b>            |
| <b>0.14</b>            | 52.55              | 0.001013                              | 10.691          | 220.0                      | 2446.1        | 220.0                      | 2375.8        | 2595.8        | 0.737                       | 8.031        | <b>0.14</b>            |
| <b>0.16</b>            | 55.31              | 0.001015                              | 9.431           | 231.5                      | 2449.8        | 231.6                      | 2369.1        | 2600.6        | 0.772                       | 7.985        | <b>0.16</b>            |
| <b>0.18</b>            | 57.80              | 0.001016                              | 8.443           | 241.9                      | 2453.0        | 241.9                      | 2363.0        | 2605.0        | 0.804                       | 7.944        | <b>0.18</b>            |
| <b>0.20</b>            | 60.06              | 0.001017                              | 7.648           | 251.4                      | 2456.0        | 251.4                      | 2357.5        | 2608.9        | 0.832                       | 7.907        | <b>0.20</b>            |
| <b>0.22</b>            | 62.13              | 0.001018                              | 6.994           | 260.1                      | 2458.7        | 260.1                      | 2352.4        | 2612.5        | 0.858                       | 7.874        | <b>0.22</b>            |
| <b>0.24</b>            | 64.05              | 0.001019                              | 6.446           | 268.1                      | 2461.2        | 268.1                      | 2347.7        | 2615.9        | 0.882                       | 7.844        | <b>0.24</b>            |
| <b>0.26</b>            | 65.84              | 0.001020                              | 5.979           | 275.6                      | 2463.5        | 275.6                      | 2343.3        | 2619.0        | 0.904                       | 7.817        | <b>0.26</b>            |
| <b>0.28</b>            | 67.52              | 0.001021                              | 5.578           | 282.6                      | 2465.7        | 282.6                      | 2339.2        | 2621.8        | 0.925                       | 7.791        | <b>0.28</b>            |
| <b>0.30</b>            | 69.09              | 0.001022                              | 5.229           | 289.2                      | 2467.7        | 289.3                      | 2335.3        | 2624.5        | 0.944                       | 7.767        | <b>0.30</b>            |
| <b>0.32</b>            | 70.58              | 0.001023                              | 4.922           | 295.5                      | 2469.6        | 295.5                      | 2331.6        | 2627.1        | 0.962                       | 7.745        | <b>0.32</b>            |
| <b>0.34</b>            | 72.00              | 0.001024                              | 4.650           | 301.4                      | 2471.4        | 301.4                      | 2328.1        | 2629.5        | 0.979                       | 7.725        | <b>0.34</b>            |
| <b>0.36</b>            | 73.34              | 0.001025                              | 4.407           | 307.0                      | 2473.1        | 307.1                      | 2324.7        | 2631.8        | 0.996                       | 7.705        | <b>0.36</b>            |
| <b>0.38</b>            | 74.63              | 0.001026                              | 4.190           | 312.4                      | 2474.8        | 312.5                      | 2321.5        | 2634.0        | 1.011                       | 7.687        | <b>0.38</b>            |
| <b>0.40</b>            | 75.86              | 0.001026                              | 3.993           | 317.6                      | 2476.3        | 317.6                      | 2318.4        | 2636.1        | 1.026                       | 7.669        | <b>0.40</b>            |
| <b>0.42</b>            | 77.03              | 0.001027                              | 3.815           | 322.5                      | 2477.8        | 322.6                      | 2315.5        | 2638.0        | 1.040                       | 7.652        | <b>0.42</b>            |
| <b>0.44</b>            | 78.16              | 0.001028                              | 3.652           | 327.3                      | 2479.2        | 327.3                      | 2312.6        | 2639.9        | 1.054                       | 7.637        | <b>0.44</b>            |
| <b>0.46</b>            | 79.25              | 0.001029                              | 3.503           | 331.8                      | 2480.6        | 331.9                      | 2309.9        | 2641.8        | 1.067                       | 7.621        | <b>0.46</b>            |
| <b>0.48</b>            | 80.30              | 0.001029                              | 3.367           | 336.2                      | 2481.9        | 336.3                      | 2307.2        | 2643.5        | 1.079                       | 7.607        | <b>0.48</b>            |
| <b>0.50</b>            | 81.32              | 0.001030                              | 3.240           | 340.5                      | 2483.2        | 340.5                      | 2304.7        | 2645.2        | 1.091                       | 7.593        | <b>0.50</b>            |
| <b>0.52</b>            | 82.30              | 0.001031                              | 3.123           | 344.6                      | 2484.4        | 344.6                      | 2302.2        | 2646.8        | 1.103                       | 7.580        | <b>0.52</b>            |
| <b>0.54</b>            | 83.25              | 0.001031                              | 3.015           | 348.6                      | 2485.6        | 348.6                      | 2299.8        | 2648.4        | 1.114                       | 7.567        | <b>0.54</b>            |
| <b>0.56</b>            | 84.17              | 0.001032                              | 2.914           | 352.4                      | 2486.8        | 352.5                      | 2297.4        | 2649.9        | 1.125                       | 7.555        | <b>0.56</b>            |
| <b>0.58</b>            | 85.06              | 0.001032                              | 2.820           | 356.2                      | 2487.9        | 356.3                      | 2295.2        | 2651.4        | 1.135                       | 7.543        | <b>0.58</b>            |
| <b>0.60</b>            | 85.93              | 0.001033                              | 2.732           | 359.8                      | 2488.9        | 359.9                      | 2293.0        | 2652.9        | 1.145                       | 7.531        | <b>0.60</b>            |
| <b>0.62</b>            | 86.77              | 0.001034                              | 2.649           | 363.4                      | 2490.0        | 363.4                      | 2290.8        | 2654.2        | 1.155                       | 7.520        | <b>0.62</b>            |
| <b>0.64</b>            | 87.59              | 0.001034                              | 2.572           | 366.8                      | 2491.0        | 366.9                      | 2288.7        | 2655.6        | 1.165                       | 7.509        | <b>0.64</b>            |
| <b>0.66</b>            | 88.39              | 0.001035                              | 2.499           | 370.2                      | 2492.0        | 370.3                      | 2286.6        | 2656.9        | 1.174                       | 7.499        | <b>0.66</b>            |
| <b>0.68</b>            | 89.17              | 0.001035                              | 2.430           | 373.5                      | 2492.9        | 373.5                      | 2284.6        | 2658.2        | 1.183                       | 7.489        | <b>0.68</b>            |
| <b>0.70</b>            | 89.93              | 0.001036                              | 2.365           | 376.7                      | 2493.9        | 376.7                      | 2282.7        | 2659.4        | 1.192                       | 7.479        | <b>0.70</b>            |
| <b>0.72</b>            | 90.67              | 0.001036                              | 2.304           | 379.8                      | 2494.8        | 379.9                      | 2280.8        | 2660.6        | 1.201                       | 7.470        | <b>0.72</b>            |
| <b>0.74</b>            | 91.40              | 0.001037                              | 2.245           | 382.9                      | 2495.7        | 382.9                      | 2278.9        | 2661.8        | 1.209                       | 7.460        | <b>0.74</b>            |
| <b>0.76</b>            | 92.11              | 0.001037                              | 2.190           | 385.8                      | 2496.5        | 385.9                      | 2277.0        | 2663.0        | 1.217                       | 7.451        | <b>0.76</b>            |
| <b>0.78</b>            | 92.81              | 0.001038                              | 2.137           | 388.8                      | 2497.4        | 388.8                      | 2275.2        | 2664.1        | 1.225                       | 7.443        | <b>0.78</b>            |
| <b>0.80</b>            | 93.49              | 0.001039                              | 2.087           | 391.6                      | 2498.2        | 391.7                      | 2273.5        | 2665.2        | 1.233                       | 7.434        | <b>0.80</b>            |
| <b>0.82</b>            | 94.15              | 0.001039                              | 2.040           | 394.4                      | 2499.0        | 394.5                      | 2271.7        | 2666.3        | 1.241                       | 7.426        | <b>0.82</b>            |
| <b>0.84</b>            | 94.80              | 0.001039                              | 1.994           | 397.2                      | 2499.8        | 397.3                      | 2270.0        | 2667.3        | 1.248                       | 7.418        | <b>0.84</b>            |
| <b>0.86</b>            | 95.44              | 0.001040                              | 1.951           | 399.9                      | 2500.6        | 400.0                      | 2268.4        | 2668.3        | 1.255                       | 7.410        | <b>0.86</b>            |
| <b>0.88</b>            | 96.07              | 0.001040                              | 1.909           | 402.5                      | 2501.3        | 402.6                      | 2266.7        | 2669.3        | 1.263                       | 7.402        | <b>0.88</b>            |
| <b>0.90</b>            | 96.69              | 0.001041                              | 1.870           | 405.1                      | 2502.1        | 405.2                      | 2265.1        | 2670.3        | 1.270                       | 7.394        | <b>0.90</b>            |
| <b>0.92</b>            | 97.29              | 0.001041                              | 1.832           | 407.6                      | 2502.8        | 407.7                      | 2263.5        | 2671.3        | 1.277                       | 7.387        | <b>0.92</b>            |
| <b>0.94</b>            | 97.89              | 0.001042                              | 1.795           | 410.1                      | 2503.5        | 410.2                      | 2262.0        | 2672.2        | 1.283                       | 7.380        | <b>0.94</b>            |
| <b>0.96</b>            | 98.47              | 0.001042                              | 1.760           | 412.6                      | 2504.2        | 412.7                      | 2260.4        | 2673.1        | 1.290                       | 7.373        | <b>0.96</b>            |
| <b>0.98</b>            | 99.04              | 0.001043                              | 1.726           | 415.0                      | 2504.9        | 415.1                      | 2258.9        | 2674.1        | 1.296                       | 7.366        | <b>0.98</b>            |
| <b>1.00</b>            | 99.61              | 0.001043                              | 1.694           | 417.4                      | 2505.5        | 417.5                      | 2257.4        | 2674.9        | 1.303                       | 7.359        | <b>1.00</b>            |
| $p$                    | $T$                | $v_f$                                 | $v_g$           | $u_f$                      | $u_g$         | $h_f$                      | $h_{fg}$      | $h_g$         | $s_f$                       | $s_g$        | $p$                    |

Properties of Saturated Water & Steam continued:  
Pressures from the triple point to the critical point

| Pressure<br>bar | Temp.<br>°C | Specific volume<br>m <sup>3</sup> /kg |        | Spec. int. energy<br>kJ/kg |        | Specific enthalpy<br>kJ/kg |          |        | Specific entropy<br>kJ/kg K |       | Pressure<br>bar |
|-----------------|-------------|---------------------------------------|--------|----------------------------|--------|----------------------------|----------|--------|-----------------------------|-------|-----------------|
| $p$             | $T$         | $v_f$                                 | $v_g$  | $u_f$                      | $u_g$  | $h_f$                      | $h_{fg}$ | $h_g$  | $s_f$                       | $s_g$ | $p$             |
| <b>1.0</b>      | 99.61       | 0.001043                              | 1.6941 | 417.4                      | 2505.5 | 417.5                      | 2257.4   | 2674.9 | 1.303                       | 7.359 | <b>1.0</b>      |
| <b>1.5</b>      | 111.35      | 0.001053                              | 1.1594 | 467.0                      | 2519.2 | 467.1                      | 2226.0   | 2693.1 | 1.434                       | 7.223 | <b>1.5</b>      |
| <b>2.0</b>      | 120.21      | 0.001061                              | 0.8858 | 504.5                      | 2529.1 | 504.7                      | 2201.5   | 2706.2 | 1.530                       | 7.127 | <b>2.0</b>      |
| <b>2.5</b>      | 127.41      | 0.001067                              | 0.7187 | 535.1                      | 2536.8 | 535.3                      | 2181.1   | 2716.5 | 1.607                       | 7.053 | <b>2.5</b>      |
| <b>3.0</b>      | 133.52      | 0.001073                              | 0.6058 | 561.1                      | 2543.1 | 561.4                      | 2163.5   | 2724.9 | 1.672                       | 6.992 | <b>3.0</b>      |
| <b>3.5</b>      | 138.86      | 0.001079                              | 0.5242 | 583.9                      | 2548.5 | 584.3                      | 2147.7   | 2732.0 | 1.727                       | 6.940 | <b>3.5</b>      |
| <b>4.0</b>      | 143.61      | 0.001084                              | 0.4624 | 604.2                      | 2553.1 | 604.7                      | 2133.4   | 2738.1 | 1.776                       | 6.896 | <b>4.0</b>      |
| <b>4.5</b>      | 147.90      | 0.001088                              | 0.4139 | 622.7                      | 2557.1 | 623.1                      | 2120.2   | 2743.4 | 1.820                       | 6.856 | <b>4.5</b>      |
| <b>5.0</b>      | 151.83      | 0.001093                              | 0.3748 | 639.5                      | 2560.7 | 640.1                      | 2108.0   | 2748.1 | 1.860                       | 6.821 | <b>5.0</b>      |
| <b>5.5</b>      | 155.46      | 0.001097                              | 0.3426 | 655.2                      | 2563.9 | 655.8                      | 2096.6   | 2752.3 | 1.897                       | 6.789 | <b>5.5</b>      |
| <b>6.0</b>      | 158.83      | 0.001101                              | 0.3156 | 669.7                      | 2566.8 | 670.4                      | 2085.8   | 2756.1 | 1.931                       | 6.759 | <b>6.0</b>      |
| <b>6.5</b>      | 161.98      | 0.001104                              | 0.2926 | 683.4                      | 2569.4 | 684.1                      | 2075.5   | 2759.6 | 1.962                       | 6.732 | <b>6.5</b>      |
| <b>7.0</b>      | 164.95      | 0.001108                              | 0.2728 | 696.2                      | 2571.8 | 697.0                      | 2065.8   | 2762.8 | 1.992                       | 6.707 | <b>7.0</b>      |
| <b>7.5</b>      | 167.75      | 0.001111                              | 0.2555 | 708.4                      | 2574.0 | 709.2                      | 2056.4   | 2765.6 | 2.019                       | 6.684 | <b>7.5</b>      |
| <b>8.0</b>      | 170.41      | 0.001115                              | 0.2403 | 720.0                      | 2576.0 | 720.9                      | 2047.4   | 2768.3 | 2.046                       | 6.662 | <b>8.0</b>      |
| <b>8.5</b>      | 172.94      | 0.001118                              | 0.2269 | 731.0                      | 2577.9 | 732.0                      | 2038.8   | 2770.8 | 2.070                       | 6.641 | <b>8.5</b>      |
| <b>9.0</b>      | 175.35      | 0.001121                              | 0.2149 | 741.6                      | 2579.6 | 742.6                      | 2030.5   | 2773.0 | 2.094                       | 6.621 | <b>9.0</b>      |
| <b>9.5</b>      | 177.66      | 0.001124                              | 0.2041 | 751.7                      | 2581.2 | 752.7                      | 2022.4   | 2775.1 | 2.117                       | 6.603 | <b>9.5</b>      |
| <b>10.0</b>     | 179.88      | 0.001127                              | 0.1944 | 761.4                      | 2582.7 | 762.5                      | 2014.6   | 2777.1 | 2.138                       | 6.585 | <b>10.0</b>     |
| <b>10.5</b>     | 182.01      | 0.001130                              | 0.1855 | 770.8                      | 2584.1 | 771.9                      | 2007.0   | 2778.9 | 2.159                       | 6.568 | <b>10.5</b>     |
| <b>11.0</b>     | 184.06      | 0.001133                              | 0.1775 | 779.8                      | 2585.5 | 781.0                      | 1999.6   | 2780.6 | 2.178                       | 6.552 | <b>11.0</b>     |
| <b>11.5</b>     | 186.04      | 0.001136                              | 0.1701 | 788.5                      | 2586.7 | 789.8                      | 1992.4   | 2782.2 | 2.198                       | 6.537 | <b>11.5</b>     |
| <b>12.0</b>     | 187.96      | 0.001138                              | 0.1633 | 797.0                      | 2587.8 | 798.3                      | 1985.4   | 2783.7 | 2.216                       | 6.522 | <b>12.0</b>     |
| <b>12.5</b>     | 189.81      | 0.001141                              | 0.1570 | 805.2                      | 2588.9 | 806.6                      | 1978.6   | 2785.1 | 2.234                       | 6.507 | <b>12.5</b>     |
| <b>13.0</b>     | 191.60      | 0.001144                              | 0.1512 | 813.1                      | 2589.9 | 814.6                      | 1971.9   | 2786.5 | 2.251                       | 6.494 | <b>13.0</b>     |
| <b>13.5</b>     | 193.35      | 0.001146                              | 0.1458 | 820.8                      | 2590.9 | 822.4                      | 1965.3   | 2787.7 | 2.267                       | 6.480 | <b>13.5</b>     |
| <b>14.0</b>     | 195.04      | 0.001149                              | 0.1408 | 828.4                      | 2591.8 | 830.0                      | 1958.9   | 2788.8 | 2.284                       | 6.467 | <b>14.0</b>     |
| <b>14.5</b>     | 196.68      | 0.001151                              | 0.1361 | 835.7                      | 2592.6 | 837.4                      | 1952.6   | 2789.9 | 2.299                       | 6.455 | <b>14.5</b>     |
| <b>15.0</b>     | 198.29      | 0.001154                              | 0.1317 | 842.8                      | 2593.4 | 844.6                      | 1946.4   | 2791.0 | 2.314                       | 6.443 | <b>15.0</b>     |
| <b>15.5</b>     | 199.85      | 0.001156                              | 0.1276 | 849.8                      | 2594.1 | 851.6                      | 1940.3   | 2791.9 | 2.329                       | 6.431 | <b>15.5</b>     |
| <b>16.0</b>     | 201.37      | 0.001159                              | 0.1237 | 856.6                      | 2594.8 | 858.5                      | 1934.4   | 2792.8 | 2.343                       | 6.420 | <b>16.0</b>     |
| <b>16.5</b>     | 202.86      | 0.001161                              | 0.1201 | 863.3                      | 2595.5 | 865.2                      | 1928.5   | 2793.7 | 2.357                       | 6.409 | <b>16.5</b>     |
| <b>17.0</b>     | 204.31      | 0.001163                              | 0.1167 | 869.8                      | 2596.1 | 871.7                      | 1922.7   | 2794.5 | 2.371                       | 6.398 | <b>17.0</b>     |
| <b>17.5</b>     | 205.72      | 0.001166                              | 0.1134 | 876.1                      | 2596.7 | 878.2                      | 1917.0   | 2795.2 | 2.384                       | 6.388 | <b>17.5</b>     |
| <b>18.0</b>     | 207.11      | 0.001168                              | 0.1104 | 882.4                      | 2597.2 | 884.5                      | 1911.4   | 2795.9 | 2.397                       | 6.377 | <b>18.0</b>     |
| <b>18.5</b>     | 208.47      | 0.001170                              | 0.1075 | 888.5                      | 2597.8 | 890.7                      | 1905.9   | 2796.6 | 2.410                       | 6.368 | <b>18.5</b>     |
| <b>19.0</b>     | 209.80      | 0.001172                              | 0.1047 | 894.5                      | 2598.2 | 896.7                      | 1900.5   | 2797.2 | 2.423                       | 6.358 | <b>19.0</b>     |
| <b>19.5</b>     | 211.10      | 0.001175                              | 0.1021 | 900.4                      | 2598.7 | 902.7                      | 1895.1   | 2797.8 | 2.435                       | 6.348 | <b>19.5</b>     |
| <b>20.0</b>     | 212.38      | 0.001177                              | 0.0996 | 906.2                      | 2599.1 | 908.5                      | 1889.8   | 2798.3 | 2.447                       | 6.339 | <b>20.0</b>     |
| <b>20.5</b>     | 213.63      | 0.001179                              | 0.0972 | 911.8                      | 2599.5 | 914.2                      | 1884.6   | 2798.8 | 2.458                       | 6.330 | <b>20.5</b>     |
| <b>21.0</b>     | 214.86      | 0.001181                              | 0.0949 | 917.4                      | 2599.9 | 919.9                      | 1879.4   | 2799.3 | 2.470                       | 6.321 | <b>21.0</b>     |
| <b>21.5</b>     | 216.06      | 0.001183                              | 0.0928 | 922.9                      | 2600.2 | 925.4                      | 1874.3   | 2799.7 | 2.481                       | 6.312 | <b>21.5</b>     |
| <b>22.0</b>     | 217.25      | 0.001185                              | 0.0907 | 928.3                      | 2600.6 | 930.9                      | 1869.2   | 2800.1 | 2.492                       | 6.304 | <b>22.0</b>     |
| <b>22.5</b>     | 218.41      | 0.001187                              | 0.0887 | 933.6                      | 2600.9 | 936.3                      | 1864.2   | 2800.5 | 2.503                       | 6.295 | <b>22.5</b>     |
| <b>23.0</b>     | 219.56      | 0.001189                              | 0.0868 | 938.8                      | 2601.1 | 941.5                      | 1859.3   | 2800.8 | 2.513                       | 6.287 | <b>23.0</b>     |
| <b>23.5</b>     | 220.68      | 0.001191                              | 0.0850 | 943.9                      | 2601.4 | 946.7                      | 1854.4   | 2801.1 | 2.524                       | 6.279 | <b>23.5</b>     |
| <b>24.0</b>     | 221.79      | 0.001193                              | 0.0832 | 949.0                      | 2601.6 | 951.9                      | 1849.6   | 2801.4 | 2.534                       | 6.271 | <b>24.0</b>     |
| <b>24.5</b>     | 222.88      | 0.001195                              | 0.0816 | 954.0                      | 2601.9 | 956.9                      | 1844.8   | 2801.7 | 2.544                       | 6.263 | <b>24.5</b>     |
| <b>25.0</b>     | 223.95      | 0.001197                              | 0.0800 | 958.9                      | 2602.1 | 961.9                      | 1840.0   | 2801.9 | 2.554                       | 6.256 | <b>25.0</b>     |
| <b>25.5</b>     | 225.01      | 0.001199                              | 0.0784 | 963.8                      | 2602.2 | 966.8                      | 1835.3   | 2802.2 | 2.564                       | 6.248 | <b>25.5</b>     |
| $p$             | $T$         | $v_f$                                 | $v_g$  | $u_f$                      | $u_g$  | $h_f$                      | $h_{fg}$ | $h_g$  | $s_f$                       | $s_g$ | $p$             |

Properties of Saturated Water & Steam continued:  
Pressures from the triple point to the critical point

| Pressure<br>bar | Temp.<br>°C | Specific volume<br>m <sup>3</sup> /kg |         | Spec. int. energy<br>kJ/kg |        | Specific enthalpy<br>kJ/kg |          |        | Specific entropy<br>kJ/kg K |       | Pressure<br>bar |
|-----------------|-------------|---------------------------------------|---------|----------------------------|--------|----------------------------|----------|--------|-----------------------------|-------|-----------------|
| $p$             | $T$         | $v_f$                                 | $v_g$   | $u_f$                      | $u_g$  | $h_f$                      | $h_{fg}$ | $h_g$  | $s_f$                       | $s_g$ | $p$             |
| <b>26.0</b>     | 226.05      | 0.001201                              | 0.0769  | 968.6                      | 2602.4 | 971.7                      | 1830.7   | 2802.3 | 2.574                       | 6.241 | <b>26.0</b>     |
| <b>26.5</b>     | 227.07      | 0.001203                              | 0.0755  | 973.3                      | 2602.5 | 976.5                      | 1826.1   | 2802.5 | 2.583                       | 6.234 | <b>26.5</b>     |
| <b>27.0</b>     | 228.08      | 0.001205                              | 0.0741  | 977.9                      | 2602.7 | 981.2                      | 1821.5   | 2802.7 | 2.592                       | 6.226 | <b>27.0</b>     |
| <b>27.5</b>     | 229.07      | 0.001207                              | 0.0727  | 982.5                      | 2602.8 | 985.9                      | 1816.9   | 2802.8 | 2.601                       | 6.219 | <b>27.5</b>     |
| <b>28.0</b>     | 230.06      | 0.001209                              | 0.0714  | 987.1                      | 2602.9 | 990.5                      | 1812.4   | 2802.9 | 2.611                       | 6.212 | <b>28.0</b>     |
| <b>28.5</b>     | 231.02      | 0.001211                              | 0.0702  | 991.6                      | 2603.0 | 995.0                      | 1808.0   | 2803.0 | 2.619                       | 6.206 | <b>28.5</b>     |
| <b>29.0</b>     | 231.98      | 0.001213                              | 0.0690  | 996.0                      | 2603.1 | 999.5                      | 1803.6   | 2803.1 | 2.628                       | 6.199 | <b>29.0</b>     |
| <b>29.5</b>     | 232.92      | 0.001215                              | 0.0678  | 1000.4                     | 2603.1 | 1004.0                     | 1799.2   | 2803.1 | 2.637                       | 6.192 | <b>29.5</b>     |
| <b>30</b>       | 233.85      | 0.001217                              | 0.06667 | 1004.7                     | 2603.2 | 1008.4                     | 1794.8   | 2803.2 | 2.645                       | 6.186 | <b>30</b>       |
| <b>32</b>       | 237.46      | 0.001224                              | 0.06248 | 1021.5                     | 2603.2 | 1025.4                     | 1777.7   | 2803.1 | 2.679                       | 6.160 | <b>32</b>       |
| <b>34</b>       | 240.90      | 0.001231                              | 0.05876 | 1037.7                     | 2603.1 | 1041.8                     | 1761.0   | 2802.9 | 2.710                       | 6.136 | <b>34</b>       |
| <b>36</b>       | 244.18      | 0.001238                              | 0.05545 | 1053.1                     | 2602.8 | 1057.6                     | 1744.8   | 2802.4 | 2.740                       | 6.113 | <b>36</b>       |
| <b>38</b>       | 247.33      | 0.001245                              | 0.05247 | 1068.1                     | 2602.3 | 1072.8                     | 1728.9   | 2801.7 | 2.769                       | 6.091 | <b>38</b>       |
| <b>40</b>       | 250.35      | 0.001252                              | 0.04978 | 1082.5                     | 2601.7 | 1087.5                     | 1713.3   | 2800.8 | 2.797                       | 6.070 | <b>40</b>       |
| <b>42</b>       | 253.26      | 0.001259                              | 0.04733 | 1096.4                     | 2601.0 | 1101.7                     | 1698.1   | 2799.8 | 2.823                       | 6.049 | <b>42</b>       |
| <b>44</b>       | 256.07      | 0.001266                              | 0.04510 | 1109.9                     | 2600.1 | 1115.5                     | 1683.1   | 2798.6 | 2.849                       | 6.029 | <b>44</b>       |
| <b>46</b>       | 258.78      | 0.001273                              | 0.04306 | 1123.0                     | 2599.2 | 1128.9                     | 1668.4   | 2797.3 | 2.874                       | 6.010 | <b>46</b>       |
| <b>48</b>       | 261.40      | 0.001280                              | 0.04118 | 1135.8                     | 2598.1 | 1141.9                     | 1653.9   | 2795.8 | 2.898                       | 5.992 | <b>48</b>       |
| <b>50</b>       | 263.94      | 0.001286                              | 0.03945 | 1148.2                     | 2597.0 | 1154.6                     | 1639.6   | 2794.2 | 2.921                       | 5.974 | <b>50</b>       |
| <b>52</b>       | 266.40      | 0.001293                              | 0.03784 | 1160.3                     | 2595.7 | 1167.0                     | 1625.5   | 2792.5 | 2.943                       | 5.956 | <b>52</b>       |
| <b>54</b>       | 268.79      | 0.001299                              | 0.03635 | 1172.1                     | 2594.4 | 1179.1                     | 1611.6   | 2790.7 | 2.965                       | 5.939 | <b>54</b>       |
| <b>56</b>       | 271.12      | 0.001306                              | 0.03496 | 1183.6                     | 2593.0 | 1190.9                     | 1597.8   | 2788.8 | 2.986                       | 5.922 | <b>56</b>       |
| <b>58</b>       | 273.38      | 0.001312                              | 0.03366 | 1194.9                     | 2591.5 | 1202.5                     | 1584.2   | 2786.7 | 3.007                       | 5.906 | <b>58</b>       |
| <b>60</b>       | 275.58      | 0.001319                              | 0.03245 | 1206.0                     | 2589.9 | 1213.9                     | 1570.7   | 2784.6 | 3.027                       | 5.890 | <b>60</b>       |
| <b>62</b>       | 277.73      | 0.001326                              | 0.03131 | 1216.8                     | 2588.3 | 1225.0                     | 1557.4   | 2782.4 | 3.047                       | 5.875 | <b>62</b>       |
| <b>64</b>       | 279.83      | 0.001332                              | 0.03024 | 1227.4                     | 2586.5 | 1235.9                     | 1544.1   | 2780.1 | 3.067                       | 5.859 | <b>64</b>       |
| <b>66</b>       | 281.87      | 0.001339                              | 0.02923 | 1237.8                     | 2584.8 | 1246.7                     | 1531.0   | 2777.7 | 3.085                       | 5.844 | <b>66</b>       |
| <b>68</b>       | 283.87      | 0.001345                              | 0.02828 | 1248.1                     | 2582.9 | 1257.2                     | 1518.0   | 2775.2 | 3.104                       | 5.829 | <b>68</b>       |
| <b>70</b>       | 285.83      | 0.001352                              | 0.02738 | 1258.1                     | 2581.0 | 1267.6                     | 1505.0   | 2772.6 | 3.122                       | 5.815 | <b>70</b>       |
| <b>72</b>       | 287.74      | 0.001358                              | 0.02653 | 1268.0                     | 2579.0 | 1277.8                     | 1492.2   | 2770.0 | 3.140                       | 5.800 | <b>72</b>       |
| <b>74</b>       | 289.61      | 0.001365                              | 0.02572 | 1277.8                     | 2577.0 | 1287.9                     | 1479.4   | 2767.3 | 3.157                       | 5.786 | <b>74</b>       |
| <b>76</b>       | 291.45      | 0.001371                              | 0.02495 | 1287.4                     | 2574.9 | 1297.8                     | 1466.7   | 2764.5 | 3.174                       | 5.772 | <b>76</b>       |
| <b>78</b>       | 293.25      | 0.001378                              | 0.02422 | 1296.8                     | 2572.7 | 1307.6                     | 1454.0   | 2761.6 | 3.191                       | 5.759 | <b>78</b>       |
| <b>80</b>       | 295.01      | 0.001384                              | 0.02352 | 1306.1                     | 2570.5 | 1317.2                     | 1441.4   | 2758.7 | 3.208                       | 5.745 | <b>80</b>       |
| <b>82</b>       | 296.74      | 0.001391                              | 0.02286 | 1315.3                     | 2568.2 | 1326.7                     | 1428.9   | 2755.7 | 3.224                       | 5.732 | <b>82</b>       |
| <b>84</b>       | 298.43      | 0.001398                              | 0.02223 | 1324.4                     | 2565.9 | 1336.2                     | 1416.4   | 2752.6 | 3.240                       | 5.718 | <b>84</b>       |
| <b>86</b>       | 300.10      | 0.001404                              | 0.02162 | 1333.4                     | 2563.5 | 1345.5                     | 1404.0   | 2749.4 | 3.256                       | 5.705 | <b>86</b>       |
| <b>88</b>       | 301.74      | 0.001411                              | 0.02104 | 1342.2                     | 2561.0 | 1354.7                     | 1391.5   | 2746.2 | 3.271                       | 5.692 | <b>88</b>       |
| <b>90</b>       | 303.35      | 0.001418                              | 0.02049 | 1351.0                     | 2558.5 | 1363.8                     | 1379.2   | 2742.9 | 3.287                       | 5.679 | <b>90</b>       |
| <b>92</b>       | 304.93      | 0.001425                              | 0.01996 | 1359.7                     | 2556.0 | 1372.8                     | 1366.8   | 2739.6 | 3.302                       | 5.666 | <b>92</b>       |
| <b>94</b>       | 306.48      | 0.001431                              | 0.01945 | 1368.2                     | 2553.3 | 1381.7                     | 1354.5   | 2736.1 | 3.317                       | 5.654 | <b>94</b>       |
| <b>96</b>       | 308.01      | 0.001438                              | 0.01895 | 1376.7                     | 2550.7 | 1390.5                     | 1342.1   | 2732.6 | 3.331                       | 5.641 | <b>96</b>       |
| <b>98</b>       | 309.52      | 0.001445                              | 0.01848 | 1385.1                     | 2548.0 | 1399.3                     | 1329.8   | 2729.1 | 3.346                       | 5.628 | <b>98</b>       |
| <b>100</b>      | 311.00      | 0.001452                              | 0.01803 | 1393.4                     | 2545.2 | 1407.9                     | 1317.5   | 2725.5 | 3.360                       | 5.616 | <b>100</b>      |
| <b>105</b>      | 314.60      | 0.001470                              | 0.01696 | 1413.9                     | 2538.0 | 1429.3                     | 1286.8   | 2716.1 | 3.396                       | 5.585 | <b>105</b>      |
| <b>110</b>      | 318.08      | 0.001488                              | 0.01599 | 1433.9                     | 2530.4 | 1450.3                     | 1256.0   | 2706.3 | 3.430                       | 5.554 | <b>110</b>      |
| <b>115</b>      | 321.43      | 0.001507                              | 0.01509 | 1453.6                     | 2522.5 | 1471.0                     | 1225.1   | 2696.1 | 3.464                       | 5.524 | <b>115</b>      |
| <b>120</b>      | 324.68      | 0.001526                              | 0.01426 | 1473.0                     | 2514.3 | 1491.3                     | 1194.1   | 2685.4 | 3.496                       | 5.494 | <b>120</b>      |
| <b>125</b>      | 327.81      | 0.001546                              | 0.01350 | 1492.2                     | 2505.6 | 1511.5                     | 1162.8   | 2674.3 | 3.529                       | 5.464 | <b>125</b>      |
| <b>130</b>      | 330.85      | 0.001566                              | 0.01278 | 1511.1                     | 2496.5 | 1531.4                     | 1131.3   | 2662.7 | 3.561                       | 5.434 | <b>130</b>      |
| <b>135</b>      | 333.80      | 0.001588                              | 0.01211 | 1529.8                     | 2487.0 | 1551.2                     | 1099.3   | 2650.6 | 3.592                       | 5.403 | <b>135</b>      |
| <b>140</b>      | 336.67      | 0.001610                              | 0.01149 | 1548.4                     | 2477.1 | 1571.0                     | 1067.0   | 2637.9 | 3.623                       | 5.373 | <b>140</b>      |
| <b>145</b>      | 339.45      | 0.001633                              | 0.01090 | 1566.9                     | 2466.7 | 1590.6                     | 1034.1   | 2624.7 | 3.654                       | 5.342 | <b>145</b>      |
| $p$             | $T$         | $v_f$                                 | $v_g$   | $u_f$                      | $u_g$  | $h_f$                      | $h_{fg}$ | $h_g$  | $s_f$                       | $s_g$ | $p$             |

Properties of Saturated Water & Steam continued:  
Pressures from the triple point to the critical point

| Pressure<br>bar | Temp.<br>°C   | Specific volume<br>m <sup>3</sup> /kg |                | Spec. int. energy<br>kJ/kg |               | Specific enthalpy<br>kJ/kg |            |               | Specific entropy<br>kJ/kg K |              | Pressure<br>bar |
|-----------------|---------------|---------------------------------------|----------------|----------------------------|---------------|----------------------------|------------|---------------|-----------------------------|--------------|-----------------|
| $p$             | $T$           | $v_f$                                 | $v_g$          | $u_f$                      | $u_g$         | $h_f$                      | $h_{fg}$   | $h_g$         | $s_f$                       | $s_g$        | $p$             |
| <b>150</b>      | 342.16        | 0.001657                              | 0.01034        | 1585.4                     | 2455.7        | 1610.3                     | 1000.5     | 2610.8        | 3.685                       | 5.311        | <b>150</b>      |
| <b>155</b>      | 344.79        | 0.001683                              | 0.00981        | 1603.9                     | 2444.2        | 1630.0                     | 966.2      | 2596.3        | 3.715                       | 5.279        | <b>155</b>      |
| <b>160</b>      | 347.35        | 0.001710                              | 0.00931        | 1622.5                     | 2432.0        | 1649.9                     | 931.1      | 2581.0        | 3.746                       | 5.247        | <b>160</b>      |
| <b>165</b>      | 349.86        | 0.001739                              | 0.00883        | 1641.2                     | 2419.1        | 1669.9                     | 894.9      | 2564.8        | 3.777                       | 5.213        | <b>165</b>      |
| <b>170</b>      | 352.29        | 0.001770                              | 0.00837        | 1660.2                     | 2405.4        | 1690.3                     | 857.4      | 2547.7        | 3.808                       | 5.179        | <b>170</b>      |
| <b>175</b>      | 354.67        | 0.001804                              | 0.00793        | 1679.4                     | 2390.7        | 1711.0                     | 818.5      | 2529.5        | 3.840                       | 5.143        | <b>175</b>      |
| <b>180</b>      | 356.99        | 0.001840                              | 0.00750        | 1699.1                     | 2374.9        | 1732.2                     | 777.8      | 2510.0        | 3.872                       | 5.106        | <b>180</b>      |
| <b>185</b>      | 359.26        | 0.001881                              | 0.00709        | 1719.3                     | 2357.9        | 1754.1                     | 734.9      | 2489.0        | 3.905                       | 5.067        | <b>185</b>      |
| <b>190</b>      | 361.47        | 0.001926                              | 0.00668        | 1740.3                     | 2339.1        | 1776.9                     | 689.2      | 2466.0        | 3.940                       | 5.026        | <b>190</b>      |
| <b>195</b>      | 363.63        | 0.001977                              | 0.00627        | 1762.3                     | 2318.4        | 1800.9                     | 639.8      | 2440.7        | 3.976                       | 4.981        | <b>195</b>      |
| <b>200</b>      | 365.75        | 0.002038                              | 0.00586        | 1785.9                     | 2294.8        | 1826.6                     | 585.4      | 2412.1        | 4.015                       | 4.931        | <b>200</b>      |
| <b>205</b>      | 367.81        | 0.002111                              | 0.00544        | 1811.7                     | 2267.3        | 1855.0                     | 523.8      | 2378.9        | 4.057                       | 4.875        | <b>205</b>      |
| <b>210</b>      | 369.83        | 0.002207                              | 0.00499        | 1841.6                     | 2233.5        | 1888.0                     | 450.4      | 2338.4        | 4.107                       | 4.808        | <b>210</b>      |
| <b>215</b>      | 371.79        | 0.002349                              | 0.00448        | 1879.5                     | 2187.4        | 1930.0                     | 353.6      | 2283.6        | 4.171                       | 4.719        | <b>215</b>      |
| <b>220</b>      | 373.71        | 0.002703                              | 0.00364        | 1951.6                     | 2092.4        | 2011.1                     | 161.5      | 2172.6        | 4.294                       | 4.544        | <b>220</b>      |
| <b>220.64</b>   | <b>373.95</b> | <b>0.003106</b>                       | <b>0.00311</b> | <b>2018.1</b>              | <b>2018.1</b> | <b>2086.6</b>              | <b>0.0</b> | <b>2086.6</b> | <b>4.410</b>                | <b>4.410</b> | <b>220.64</b>   |
| $p$             | $T$           | $v_f$                                 | $v_g$          | $u_f$                      | $u_g$         | $h_f$                      | $h_{fg}$   | $h_g$         | $s_f$                       | $s_g$        | $p$             |



# SPECIFIC ENTHALPY OF WATER AND STEAM

|                   |        | kJ/kg  |        |        |        |        |        |        |        |        |        |        |        |                    |        |        |        |        |  |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------|--------|--------|--------|--------|--|
| Pressure<br>(bar) | 0.1    | 0.5    | 1      | 5      | 10     | 20     | 40     | 60     | 80     | 100    | 150    | 200    | 220.64 | 250                | 300    | 400    | 500    | 1000   |  |
| Temp (°C)         |        |        |        |        |        |        |        |        |        |        |        |        |        | Critical<br>Isobar |        |        |        |        |  |
| <b>0.01</b>       | 0      | 0.1    | 0.1    | 0.5    | 1      | 2      | 4.1    | 6.1    | 8.1    | 10.1   | 15.1   | 20.1   | 22.1   | 25                 | 29.9   | 39.6   | 49.2   | 95.4   |  |
| <b>25</b>         | 104.8  | 104.9  | 104.9  | 105.3  | 105.8  | 106.7  | 108.5  | 110.4  | 112.2  | 114.1  | 118.6  | 123.2  | 125.1  | 127.8              | 132.3  | 141.3  | 150.2  | 194.1  |  |
| <b>50</b>         | 2592.0 | 209.4  | 209.4  | 209.8  | 210.2  | 211.1  | 212.8  | 214.5  | 216.2  | 217.9  | 222.2  | 226.5  | 228.3  | 230.8              | 235.1  | 243.6  | 252.0  | 293.9  |  |
| <b>75</b>         | 2639.8 | 314.0  | 314.1  | 314.4  | 314.8  | 315.6  | 317.2  | 318.8  | 320.5  | 322.1  | 326.1  | 330.1  | 331.8  | 334.2              | 338.2  | 346.2  | 354.3  | 394.3  |  |
| <b>100</b>        | 2687.5 | 2682.4 | 2675.8 | 419.5  | 419.8  | 420.6  | 422.1  | 423.6  | 425.1  | 426.6  | 430.4  | 434.2  | 435.7  | 438.0              | 441.7  | 449.3  | 456.9  | 495.1  |  |
| <b>125</b>        | 2735.2 | 2731.5 | 2726.7 | 525.3  | 525.6  | 526.3  | 527.7  | 529.1  | 530.5  | 531.8  | 535.3  | 538.8  | 540.3  | 542.4              | 545.9  | 553.0  | 560.1  | 596.3  |  |
| <b>150</b>        | 2783.0 | 2780.2 | 2776.6 | 632.2  | 632.5  | 633.1  | 634.4  | 635.6  | 636.9  | 638.1  | 641.3  | 644.4  | 645.8  | 647.7              | 650.9  | 657.4  | 664.0  | 697.9  |  |
| <b>175</b>        | 2831.2 | 2828.9 | 2826.1 | 741.1  | 741.1  | 741.6  | 742.7  | 743.7  | 744.8  | 745.9  | 748.6  | 751.4  | 752.6  | 754.2              | 757.1  | 763.0  | 768.9  | 800.2  |  |
| <b>200</b>        | 2879.6 | 2877.8 | 2875.5 | 852.5  | 852.5  | 852.5  | 853.3  | 854.1  | 854.9  | 855.8  | 858.0  | 860.3  | 861.2  | 862.6              | 865.0  | 870.0  | 875.2  | 903.4  |  |
| <b>225</b>        | 2928.4 | 2926.8 | 2924.9 | 967.1  | 967.1  | 967.1  | 967.1  | 967.6  | 968.1  | 968.7  | 970.1  | 971.7  | 972.4  | 973.4              | 975.2  | 979.0  | 983.2  | 1007.6 |  |
| <b>250</b>        | 2977.4 | 2976.1 | 2974.5 | 1085.8 | 1085.8 | 1085.8 | 1085.8 | 1085.7 | 1085.7 | 1085.8 | 1086.1 | 1086.7 | 1087.0 | 1087.4             | 1088.4 | 1090.7 | 1093.5 | 1113.1 |  |
| <b>275</b>        | 3026.9 | 3025.8 | 3024.4 | 1210.9 | 1210.9 | 1210.9 | 1210.9 | 1210.9 | 1210.0 | 1209.3 | 1207.8 | 1206.7 | 1206.4 | 1206.0             | 1205.7 | 1205.8 | 1206.8 | 1220.2 |  |
| <b>300</b>        | 3076.7 | 3075.8 | 3074.5 | 1343.3 | 1343.3 | 1343.3 | 1343.3 | 1343.3 | 1343.3 | 1343.3 | 1338.3 | 1334.4 | 1333.0 | 1331.3             | 1328.9 | 1325.6 | 1324.0 | 1329.1 |  |
| <b>325</b>        | 3126.9 | 3126.1 | 3125.0 | 1485.6 | 1485.6 | 1485.6 | 1485.6 | 1485.6 | 1485.6 | 1485.6 | 1485.6 | 1475.2 | 1471.7 | 1467.3             | 1461.1 | 1452.2 | 1446.4 | 1440.3 |  |
| <b>350</b>        | 3177.5 | 3176.8 | 3175.8 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1646.0 | 1635.6 | 1623.9             | 1608.8 | 1588.8 | 1576.1 | 1554.0 |  |
| <b>375</b>        | 3228.5 | 3227.9 | 3227.0 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4 | 1849.4             | 1849.4 | 1849.4 | 1849.4 | 1849.4 |  |
| <b>400</b>        | 3279.9 | 3279.3 | 3278.6 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8 | 2178.8             | 2178.8 | 2178.8 | 2178.8 | 2178.8 |  |
| <b>425</b>        | 3331.8 | 3331.2 | 3330.5 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6 | 2578.6             | 2578.6 | 2578.6 | 2578.6 | 2578.6 |  |
| <b>450</b>        | 3384.0 | 3383.5 | 3382.8 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6 | 2978.6             | 2978.6 | 2978.6 | 2978.6 | 2978.6 |  |
| <b>475</b>        | 3436.6 | 3436.2 | 3435.6 | 3436.6 | 3436.2 | 3435.6 | 3436.6 | 3436.2 | 3435.6 | 3436.6 | 3436.2 | 3435.6 | 3436.6 | 3436.2             | 3435.6 | 3436.6 | 3436.2 | 3435.6 |  |
| <b>500</b>        | 3489.7 | 3489.3 | 3488.7 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6 | 3836.6             | 3836.6 | 3836.6 | 3836.6 | 3836.6 |  |
| <b>550</b>        | 3597.1 | 3596.8 | 3596.3 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6 | 4236.6             | 4236.6 | 4236.6 | 4236.6 | 4236.6 |  |
| <b>600</b>        | 3706.3 | 3706.0 | 3705.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6 | 4636.6             | 4636.6 | 4636.6 | 4636.6 | 4636.6 |  |
| <b>650</b>        | 3817.2 | 3816.9 | 3816.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6 | 5036.6             | 5036.6 | 5036.6 | 5036.6 | 5036.6 |  |
| <b>700</b>        | 3929.9 | 3929.7 | 3929.4 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6 | 5436.6             | 5436.6 | 5436.6 | 5436.6 | 5436.6 |  |
| <b>750</b>        | 4044.4 | 4044.2 | 4043.9 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6 | 5836.6             | 5836.6 | 5836.6 | 5836.6 | 5836.6 |  |
| <b>800</b>        | 4160.6 | 4160.4 | 4160.2 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6 | 6236.6             | 6236.6 | 6236.6 | 6236.6 | 6236.6 |  |

# SPECIFIC ENTROPY OF WATER AND STEAM

kJ/kg K

| Pressure<br>(bar) | 0.1                | 0.5    | 1      | 5      | 10     | 20     | 40     | 60     | 80     | 100    | 150    | 200    | 220.64 | 250    | 300    | 400     | 500     | 1000    |
|-------------------|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|
| Temp (°C)         | Critical<br>Isobar |        |        |        |        |        |        |        |        |        |        |        |        |        |        |         |         |         |
| <b>0.01</b>       | 0.0000             | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0004 | -0.0001 | -0.0009 | -0.0084 |
| <b>25</b>         | 0.3672             | 0.3672 | 0.3672 | 0.3671 | 0.3670 | 0.3667 | 0.3662 | 0.3657 | 0.3651 | 0.3646 | 0.3632 | 0.3619 | 0.3613 | 0.3605 | 0.3591 | 0.3561  | 0.3532  | 0.3371  |
| <b>50</b>         | 8.1741             | 0.7038 | 0.7038 | 0.7036 | 0.7034 | 0.7029 | 0.7020 | 0.7010 | 0.7001 | 0.6992 | 0.6969 | 0.6946 | 0.6937 | 0.6923 | 0.6901 | 0.6855  | 0.6810  | 0.6587  |
| <b>75</b>         | 8.3167             | 1.0158 | 1.0157 | 1.0155 | 1.0152 | 1.0145 | 1.0133 | 1.0120 | 1.0108 | 1.0096 | 1.0065 | 1.0035 | 1.0022 | 1.0004 | 0.9975 | 0.9916  | 0.9858  | 0.9579  |
| <b>100</b>        | 8.4489             | 7.6953 | 7.3610 | 1.3069 | 1.3065 | 1.3057 | 1.3042 | 1.3026 | 1.3011 | 1.2996 | 1.2958 | 1.2920 | 1.2905 | 1.2883 | 1.2847 | 1.2775  | 1.2705  | 1.2375  |
| <b>125</b>        | 8.5726             | 7.8225 | 7.4932 | 1.5813 | 1.5808 | 1.5799 | 1.5780 | 1.5762 | 1.5743 | 1.5725 | 1.5680 | 1.5635 | 1.5617 | 1.5591 | 1.5548 | 1.5464  | 1.5381  | 1.4999  |
| <b>150</b>        | 8.6892             | 7.9413 | 7.6148 | 1.8418 | 1.8412 | 1.8401 | 1.8379 | 1.8357 | 1.8335 | 1.8313 | 1.8260 | 1.8208 | 1.8186 | 1.8156 | 1.8106 | 1.8008  | 1.7912  | 1.7475  |
| <b>175</b>        | 8.7997             | 8.0531 | 7.7284 | 6.9427 | 2.0905 | 2.0892 | 2.0865 | 2.0839 | 2.0813 | 2.0788 | 2.0725 | 2.0664 | 2.0639 | 2.0604 | 2.0545 | 2.0431  | 2.0321  | 1.9824  |
| <b>200</b>        | 8.9049             | 8.1592 | 7.8356 | 7.0610 | 6.6955 | 2.3298 | 2.3267 | 2.3235 | 2.3205 | 2.3174 | 2.3100 | 2.3027 | 2.2998 | 2.2956 | 2.2888 | 2.2755  | 2.2628  | 2.2064  |
| <b>225</b>        | 9.0053             | 8.2602 | 7.9374 | 7.1702 | 6.8165 | 6.4160 | 2.5612 | 2.5573 | 2.5536 | 2.5499 | 2.5409 | 2.5322 | 2.5287 | 2.5237 | 2.5156 | 2.5000  | 2.4853  | 2.4210  |
| <b>250</b>        | 9.1015             | 8.3568 | 8.0346 | 7.2724 | 6.9265 | 6.5475 | 2.7935 | 2.7886 | 2.7839 | 2.7792 | 2.7680 | 2.7573 | 2.7530 | 2.7471 | 2.7373 | 2.7187  | 2.7013  | 2.6277  |
| <b>275</b>        | 9.1938             | 8.4495 | 8.1277 | 7.3692 | 7.0286 | 6.6631 | 6.2312 | 3.0222 | 3.0159 | 3.0097 | 2.9951 | 2.9814 | 2.9760 | 2.9685 | 2.9563 | 2.9336  | 2.9128  | 2.8276  |
| <b>300</b>        | 9.2827             | 8.5386 | 8.2172 | 7.4614 | 7.1246 | 6.7684 | 6.3639 | 6.0703 | 5.7937 | 3.2488 | 3.2279 | 3.2091 | 3.2018 | 3.1919 | 3.1760 | 3.1473  | 3.1218  | 3.0219  |
| <b>325</b>        | 9.3684             | 8.6246 | 8.3034 | 7.5497 | 7.2158 | 6.8662 | 6.4797 | 6.2137 | 5.9851 | 5.7596 | 3.4793 | 3.4495 | 3.4385 | 3.4241 | 3.4017 | 3.3634  | 3.3308  | 3.2117  |
| <b>350</b>        | 9.4513             | 8.7076 | 8.3866 | 7.6346 | 7.3029 | 6.9583 | 6.5843 | 6.3357 | 6.1321 | 5.9459 | 5.4437 | 3.7290 | 3.7069 | 3.6804 | 3.6436 | 3.5871  | 3.5431  | 3.3979  |
| <b>375</b>        | 9.5315             | 8.7880 | 8.4671 | 7.7164 | 7.3864 | 7.0457 | 6.6809 | 6.4441 | 6.2561 | 6.0911 | 5.7050 | 5.2275 | 4.7985 | 4.0344 | 3.9313 | 3.8290  | 3.7642  | 3.5816  |
| <b>400</b>        | 9.6094             | 8.8659 | 8.5452 | 7.7955 | 7.4669 | 7.1292 | 6.7714 | 6.5432 | 6.3658 | 6.2141 | 5.8819 | 5.5525 | 5.4001 | 5.1400 | 4.4757 | 4.1145  | 4.0029  | 3.7639  |
| <b>425</b>        | 9.6849             | 8.9416 | 8.6209 | 7.8722 | 7.5447 | 7.2093 | 6.8570 | 6.6352 | 6.4655 | 6.3229 | 6.0229 | 5.7514 | 5.6384 | 5.4707 | 5.1473 | 4.5044  | 4.2746  | 3.9455  |
| <b>450</b>        | 9.7584             | 9.0151 | 8.6946 | 7.9465 | 7.6200 | 7.2866 | 6.9386 | 6.7219 | 6.5579 | 6.4219 | 6.1434 | 5.9043 | 5.8098 | 5.6759 | 5.4421 | 4.9448  | 4.5896  | 4.1271  |
| <b>475</b>        | 9.8300             | 9.0867 | 8.7663 | 8.0188 | 7.6931 | 7.3613 | 7.0169 | 6.8041 | 6.6445 | 6.5135 | 6.2505 | 6.0324 | 5.9487 | 5.8331 | 5.6404 | 5.2556  | 4.9097  | 4.3089  |
| <b>500</b>        | 9.8998             | 9.1566 | 8.8361 | 8.0892 | 7.7641 | 7.4337 | 7.0922 | 6.8826 | 6.7266 | 6.5995 | 6.3480 | 6.1446 | 6.0682 | 5.9642 | 5.7956 | 5.4744  | 5.1762  | 4.4900  |
| <b>550</b>        | 10.0344            | 9.2913 | 8.9709 | 8.2249 | 7.9008 | 7.5725 | 7.2355 | 7.0307 | 6.8799 | 6.7585 | 6.5230 | 6.3389 | 6.2715 | 6.1816 | 6.0402 | 5.7857  | 5.5563  | 4.8405  |
| <b>600</b>        | 10.1631            | 9.4201 | 9.0998 | 8.3543 | 8.0310 | 7.7043 | 7.3705 | 7.1693 | 7.0221 | 6.9045 | 6.6796 | 6.5075 | 6.4455 | 6.3637 | 6.2373 | 6.0170  | 5.8245  | 5.1581  |
| <b>650</b>        | 10.2866            | 9.5436 | 9.2234 | 8.4784 | 8.1557 | 7.8302 | 7.4988 | 7.3001 | 7.1556 | 7.0408 | 6.8233 | 6.6593 | 6.6008 | 6.5242 | 6.4074 | 6.2078  | 6.0373  | 5.4315  |
| <b>700</b>        | 10.4055            | 9.6625 | 9.3424 | 8.5977 | 8.2755 | 7.9509 | 7.6214 | 7.4246 | 7.2821 | 7.1693 | 6.9572 | 6.7990 | 6.7431 | 6.6702 | 6.5598 | 6.3740  | 6.2178  | 5.6639  |
| <b>750</b>        | 10.5202            | 9.7773 | 9.4572 | 8.7128 | 8.3909 | 8.0670 | 7.7390 | 7.5438 | 7.4028 | 7.2916 | 7.0836 | 6.9297 | 6.8756 | 6.8054 | 6.6997 | 6.5236  | 6.3775  | 5.8642  |
| <b>800</b>        | 10.6311            | 9.8882 | 9.5681 | 8.8240 | 8.5024 | 8.1790 | 7.8523 | 7.6582 | 7.5184 | 7.4085 | 7.2037 | 7.0531 | 7.0004 | 6.9322 | 6.8300 | 6.6612  | 6.5225  | 6.0406  |

# DENSITY OF WATER AND STEAM

|                | kg/m <sup>3</sup> |       |       |        |        |        |        |        |        |        |        |        |        |                 |        |        |        |        |
|----------------|-------------------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------------|--------|--------|--------|--------|
| Pressure (bar) | 0.1               | 0.5   | 1     | 5      | 10     | 20     | 40     | 60     | 80     | 100    | 150    | 200    | 220.64 | 250             | 300    | 400    | 500    | 1000   |
| Temp (°C)      |                   |       |       |        |        |        |        |        |        |        |        |        |        | Critical Isobar |        |        |        |        |
| <b>0.01</b>    | 999.8             | 999.8 | 999.8 | 1000.0 | 1000.3 | 1000.8 | 1001.8 | 1002.8 | 1003.8 | 1004.8 | 1007.3 | 1009.7 | 1010.7 | 1012.2          | 1014.5 | 1019.2 | 1023.8 | 1045.3 |
| <b>25</b>      | 997.0             | 997.0 | 997.0 | 997.2  | 997.5  | 997.9  | 998.8  | 999.7  | 1000.6 | 1001.5 | 1003.7 | 1005.8 | 1006.7 | 1008.0          | 1010.1 | 1014.3 | 1018.4 | 1037.9 |
| <b>50</b>      | 0.0673            | 988.0 | 988.0 | 988.2  | 988.4  | 988.9  | 989.7  | 990.6  | 991.5  | 992.3  | 994.4  | 996.5  | 997.4  | 998.6           | 1000.7 | 1004.7 | 1008.7 | 1027.4 |
| <b>75</b>      | 0.0624            | 974.8 | 974.8 | 975.0  | 975.2  | 975.7  | 976.6  | 977.5  | 978.3  | 979.2  | 981.3  | 983.5  | 984.4  | 985.6           | 987.7  | 991.8  | 995.8  | 1014.6 |
| <b>100</b>     | 0.0582            | 0.293 | 0.590 | 958.5  | 958.8  | 959.2  | 960.2  | 961.1  | 962.0  | 962.9  | 965.2  | 967.4  | 968.4  | 969.6           | 971.8  | 976.1  | 980.3  | 999.8  |
| <b>125</b>     | 0.0545            | 0.274 | 0.550 | 939.2  | 939.4  | 939.9  | 940.9  | 941.9  | 942.9  | 943.9  | 946.4  | 948.8  | 949.8  | 951.2           | 953.5  | 958.1  | 962.5  | 983.1  |
| <b>150</b>     | 0.0512            | 0.257 | 0.516 | 917.0  | 917.3  | 917.9  | 919.0  | 920.1  | 921.2  | 922.3  | 925.0  | 927.7  | 928.8  | 930.3           | 932.9  | 937.9  | 942.7  | 964.8  |
| <b>175</b>     | 0.0484            | 0.243 | 0.487 | 2.503  | 892.4  | 893.0  | 894.3  | 895.6  | 896.8  | 898.1  | 901.1  | 904.1  | 905.4  | 907.1           | 909.9  | 915.5  | 920.9  | 945.0  |
| <b>200</b>     | 0.0458            | 0.230 | 0.460 | 2.353  | 4.850  | 865.0  | 866.5  | 868.0  | 869.5  | 870.9  | 874.5  | 878.0  | 879.4  | 881.3           | 884.6  | 890.9  | 897.0  | 923.7  |
| <b>225</b>     | 0.0435            | 0.218 | 0.437 | 2.223  | 4.550  | 9.63   | 835.1  | 836.9  | 838.7  | 840.4  | 844.7  | 848.8  | 850.5  | 852.8           | 856.6  | 864.0  | 870.9  | 901.0  |
| <b>250</b>     | 0.0414            | 0.207 | 0.416 | 2.108  | 4.300  | 8.97   | 798.9  | 801.2  | 803.5  | 805.7  | 811.0  | 816.1  | 818.1  | 820.9           | 825.6  | 834.3  | 842.4  | 876.7  |
| <b>275</b>     | 0.0395            | 0.198 | 0.396 | 2.006  | 4.070  | 8.43   | 18.31  | 759.1  | 762.2  | 765.1  | 772.2  | 778.7  | 781.3  | 784.8           | 790.6  | 801.4  | 811.1  | 850.8  |
| <b>300</b>     | 0.0378            | 0.189 | 0.379 | 1.913  | 3.880  | 7.97   | 16.99  | 27.63  | 41.2   | 715.3  | 725.6  | 734.7  | 738.2  | 743.0           | 750.7  | 764.4  | 776.5  | 823.2  |
| <b>325</b>     | 0.0362            | 0.181 | 0.363 | 1.830  | 3.700  | 7.57   | 15.93  | 25.39  | 36.5   | 50.3   | 664.9  | 679.8  | 685.3  | 692.4           | 703.4  | 722.0  | 737.6  | 793.7  |
| <b>350</b>     | 0.0348            | 0.174 | 0.348 | 1.754  | 3.540  | 7.21   | 15.04  | 23.67  | 33.4   | 44.6   | 87.1   | 600.6  | 612.0  | 625.5           | 643.9  | 671.9  | 693.2  | 762.3  |
| <b>375</b>     | 0.0334            | 0.167 | 0.335 | 1.684  | 3.390  | 6.90   | 14.28  | 22.27  | 31.0   | 40.7   | 71.9   | 130.3  | 210.0  | 505.5           | 558.2  | 609.3  | 641.2  | 728.8  |
| <b>400</b>     | 0.0322            | 0.161 | 0.322 | 1.620  | 3.260  | 6.61   | 13.62  | 21.09  | 29.1   | 37.8   | 63.8   | 100.5  | 121.9  | 166.5           | 357.4  | 523.3  | 577.8  | 692.9  |
| <b>425</b>     | 0.0310            | 0.155 | 0.311 | 1.561  | 3.140  | 6.35   | 13.03  | 20.07  | 27.5   | 35.5   | 58.3   | 87.1   | 101.8  | 126.8           | 188.7  | 394.1  | 497.7  | 654.7  |
| <b>450</b>     | 0.0300            | 0.150 | 0.300 | 1.506  | 3.030  | 6.11   | 12.49  | 19.17  | 26.2   | 33.6   | 54.1   | 78.6   | 90.3   | 109.0           | 148.4  | 270.9  | 402.0  | 614.2  |
| <b>475</b>     | 0.0290            | 0.145 | 0.290 | 1.454  | 2.920  | 5.90   | 12.01  | 18.37  | 25.0   | 31.9   | 50.8   | 72.4   | 82.4   | 97.8            | 128.1  | 210.0  | 315.2  | 571.7  |
| <b>500</b>     | 0.0280            | 0.140 | 0.280 | 1.407  | 2.820  | 5.69   | 11.57  | 17.65  | 23.9   | 30.5   | 48.0   | 67.6   | 76.4   | 89.7            | 115.1  | 177.8  | 257.1  | 528.3  |
| <b>550</b>     | 0.0263            | 0.132 | 0.263 | 1.320  | 2.650  | 5.33   | 10.79  | 16.39  | 22.1   | 28.0   | 43.6   | 60.3   | 67.7   | 78.5            | 98.3   | 143.2  | 195.4  | 444.6  |
| <b>600</b>     | 0.0248            | 0.124 | 0.248 | 1.244  | 2.490  | 5.01   | 10.12  | 15.32  | 20.6   | 26.1   | 40.1   | 55.0   | 61.4   | 70.7            | 87.4   | 123.6  | 163.7  | 374.2  |
| <b>650</b>     | 0.0235            | 0.117 | 0.235 | 1.176  | 2.360  | 4.73   | 9.53   | 14.40  | 19.4   | 24.4   | 37.3   | 50.8   | 56.5   | 64.8            | 79.4   | 110.5  | 143.7  | 321.0  |
| <b>700</b>     | 0.0223            | 0.111 | 0.223 | 1.115  | 2.230  | 4.48   | 9.01   | 13.60  | 18.2   | 22.9   | 34.9   | 47.3   | 52.5   | 60.1            | 73.2   | 100.7  | 129.6  | 282.0  |
| <b>750</b>     | 0.0212            | 0.106 | 0.212 | 1.060  | 2.120  | 4.25   | 8.55   | 12.88  | 17.3   | 21.7   | 32.9   | 44.4   | 49.2   | 56.2            | 68.2   | 93.1   | 118.8  | 253.0  |
| <b>800</b>     | 0.020             | 0.101 | 0.202 | 1.010  | 2.020  | 4.05   | 8.14   | 12.25  | 16.4   | 20.6   | 31.1   | 41.9   | 46.4   | 52.8            | 64.0   | 86.8   | 110.2  | 230.6  |

# SPECIFIC INTERNAL ENERGY OF WATER AND STEAM

| Pressure<br>(bar) | kJ/kg  |        |        |        |        |        |        |        |        |        |        |        |        |                    |        |        |        |        |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------|--------|--------|--------|--------|
|                   | 0.1    | 0.5    | 1      | 5      | 10     | 20     | 40     | 60     | 80     | 100    | 150    | 200    | 220.64 | 250                | 300    | 400    | 500    | 1000   |
| Temp (°C)         |        |        |        |        |        |        |        |        |        |        |        |        |        | Critical<br>Isobar |        |        |        |        |
| <b>0.01</b>       | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.0    | 0.1    | 0.1    | 0.1    | 0.2    | 0.2    | 0.3    | 0.3    | 0.3                | 0.3    | 0.3    | 0.3    | -0.2   |
| <b>25</b>         | 104.8  | 104.8  | 104.8  | 104.8  | 104.7  | 104.7  | 104.5  | 104.4  | 104.2  | 104.1  | 103.7  | 103.3  | 103.2  | 102.9              | 102.6  | 101.9  | 101.1  | 97.7   |
| <b>50</b>         | 2443.3 | 209.3  | 209.3  | 209.3  | 209.2  | 209.0  | 208.7  | 208.4  | 208.2  | 207.9  | 207.1  | 206.4  | 206.2  | 205.8              | 205.1  | 203.7  | 202.5  | 196.6  |
| <b>75</b>         | 2479.5 | 314.0  | 314.0  | 313.9  | 313.8  | 313.6  | 313.1  | 312.7  | 312.3  | 311.9  | 310.8  | 309.8  | 309.4  | 308.8              | 307.8  | 305.9  | 304.1  | 295.8  |
| <b>100</b>        | 2515.5 | 2511.5 | 2506.2 | 418.9  | 418.8  | 418.5  | 417.9  | 417.4  | 416.8  | 416.2  | 414.8  | 413.5  | 412.9  | 412.2              | 410.9  | 408.4  | 405.9  | 395.1  |
| <b>125</b>        | 2551.6 | 2548.7 | 2545.0 | 524.7  | 524.5  | 524.2  | 523.4  | 522.7  | 522.0  | 521.2  | 519.5  | 517.8  | 517.1  | 516.1              | 514.4  | 511.2  | 508.2  | 494.6  |
| <b>150</b>        | 2587.9 | 2585.7 | 2582.9 | 631.6  | 631.4  | 630.9  | 630.0  | 629.1  | 628.2  | 627.3  | 625.1  | 622.9  | 622.0  | 620.8              | 618.7  | 614.8  | 611.0  | 594.3  |
| <b>175</b>        | 2624.5 | 2622.8 | 2620.6 | 2601.6 | 740.0  | 739.4  | 738.2  | 737.0  | 735.9  | 734.8  | 732.0  | 729.3  | 728.2  | 726.7              | 724.1  | 719.3  | 714.6  | 694.4  |
| <b>200</b>        | 2661.3 | 2660.0 | 2658.2 | 2643.3 | 2622.2 | 850.1  | 848.6  | 847.2  | 845.7  | 844.3  | 840.8  | 837.5  | 836.1  | 834.2              | 831.1  | 825.1  | 819.4  | 795.1  |
| <b>225</b>        | 2698.5 | 2697.4 | 2695.9 | 2683.9 | 2667.3 | 2628.5 | 962.3  | 960.5  | 958.6  | 956.8  | 952.4  | 948.1  | 946.4  | 944.1              | 940.2  | 932.7  | 925.8  | 896.6  |
| <b>250</b>        | 2736.1 | 2735.1 | 2733.9 | 2723.8 | 2710.4 | 2680.2 | 1080.8 | 1078.2 | 1075.8 | 1073.4 | 1067.6 | 1062.2 | 1060.0 | 1057.0             | 1052.0 | 1042.7 | 1034.2 | 999.1  |
| <b>275</b>        | 2774.0 | 2773.2 | 2772.1 | 2763.6 | 2752.3 | 2727.8 | 2668.9 | 1203.0 | 1199.5 | 1196.2 | 1188.3 | 1181.0 | 1178.1 | 1174.2             | 1167.7 | 1155.9 | 1145.2 | 1102.7 |
| <b>300</b>        | 2812.3 | 2811.6 | 2810.6 | 2803.2 | 2793.6 | 2773.2 | 2726.2 | 2668.4 | 2592.3 | 1329.4 | 1317.6 | 1307.1 | 1303.1 | 1297.6             | 1288.9 | 1273.3 | 1259.6 | 1207.6 |
| <b>325</b>        | 2850.9 | 2850.3 | 2849.5 | 2843.0 | 2834.7 | 2817.2 | 2778.3 | 2733.1 | 2679.2 | 2611.6 | 1463.0 | 1445.8 | 1439.5 | 1431.2             | 1418.4 | 1396.7 | 1378.6 | 1314.3 |
| <b>350</b>        | 2890.0 | 2889.4 | 2888.7 | 2883.0 | 2875.7 | 2860.5 | 2827.4 | 2790.4 | 2748.3 | 2699.6 | 2520.9 | 1612.7 | 1599.6 | 1583.9             | 1562.2 | 1529.3 | 1503.9 | 1422.8 |
| <b>375</b>        | 2929.5 | 2929.0 | 2928.3 | 2923.2 | 2916.7 | 2903.3 | 2874.7 | 2843.4 | 2808.9 | 2770.7 | 2650.4 | 2449.1 | 2232.6 | 1799.9             | 1738.1 | 1677.0 | 1638.6 | 1533.6 |
| <b>400</b>        | 2969.3 | 2968.9 | 2968.3 | 2963.7 | 2957.9 | 2945.9 | 2920.7 | 2893.7 | 2864.6 | 2833.1 | 2740.6 | 2617.9 | 2551.9 | 2428.5             | 2068.9 | 1854.9 | 1787.8 | 1646.8 |
| <b>425</b>        | 3009.6 | 3009.2 | 3008.7 | 3004.5 | 2999.2 | 2988.5 | 2966.1 | 2942.4 | 2917.2 | 2890.4 | 2815.0 | 2723.5 | 2679.3 | 2607.8             | 2452.8 | 2097.5 | 1960.2 | 1762.9 |
| <b>450</b>        | 3050.3 | 3049.9 | 3049.4 | 3045.6 | 3040.9 | 3031.1 | 3011.0 | 2989.9 | 2967.8 | 2944.5 | 2880.7 | 2807.2 | 2773.4 | 2721.2             | 2618.9 | 2364.2 | 2160.3 | 1881.9 |
| <b>475</b>        | 3091.4 | 3091.0 | 3090.6 | 3087.1 | 3082.8 | 3073.9 | 3055.7 | 3036.7 | 3017.0 | 2996.5 | 2941.3 | 2879.7 | 2852.1 | 2810.5             | 2732.7 | 2549.7 | 2361.4 | 2003.6 |
| <b>500</b>        | 3132.9 | 3132.6 | 3132.2 | 3129.0 | 3125.0 | 3116.9 | 3100.3 | 3083.1 | 3065.4 | 3047.0 | 2998.4 | 2945.3 | 2922.0 | 2887.3             | 2824.0 | 2681.6 | 2528.1 | 2126.9 |
| <b>550</b>        | 3217.2 | 3217.0 | 3216.6 | 3213.9 | 3210.5 | 3203.6 | 3189.5 | 3175.2 | 3160.5 | 3145.4 | 3106.2 | 3064.7 | 3046.9 | 3020.8             | 2974.5 | 2875.0 | 2769.5 | 2371.0 |
| <b>600</b>        | 3303.3 | 3303.1 | 3302.8 | 3300.4 | 3297.5 | 3291.5 | 3279.4 | 3267.2 | 3254.7 | 3242.0 | 3209.3 | 3175.3 | 3160.9 | 3140.0             | 3103.4 | 3026.8 | 2947.1 | 2597.9 |
| <b>650</b>        | 3391.2 | 3391.0 | 3390.7 | 3388.6 | 3386.0 | 3380.8 | 3370.3 | 3359.6 | 3348.9 | 3337.9 | 3310.1 | 3281.4 | 3269.3 | 3251.9             | 3221.7 | 3159.5 | 3095.6 | 2798.9 |
| <b>700</b>        | 3480.8 | 3480.6 | 3480.4 | 3478.5 | 3476.2 | 3471.6 | 3462.4 | 3453.0 | 3443.6 | 3434.0 | 3409.8 | 3385.1 | 3374.7 | 3359.9             | 3334.3 | 3282.0 | 3228.7 | 2976.1 |
| <b>750</b>        | 3572.2 | 3572.0 | 3571.8 | 3570.2 | 3568.1 | 3564.0 | 3555.8 | 3547.5 | 3539.1 | 3530.7 | 3509.4 | 3487.7 | 3478.7 | 3465.8             | 3443.6 | 3398.6 | 3353.1 | 3135.2 |
| <b>800</b>        | 3665.3 | 3665.2 | 3665.0 | 3663.6 | 3661.7 | 3658.0 | 3650.6 | 3643.2 | 3635.7 | 3628.2 | 3609.2 | 3590.1 | 3582.1 | 3570.7             | 3551.2 | 3511.8 | 3472.2 | 3281.7 |

## TRANSPORT PROPERTIES OF SATURATED WATER & STEAM

| Temp.<br>°C   | Specific volume<br>m <sup>3</sup> /kg |                | Isobaric specific<br>heat capacity<br>kJ/kg K |              | Thermal conductivity<br>W/m K |               | Dynamic viscosity<br>kg/s m |                   | Prandtl number<br>$= \mu c_p / \lambda$ |              | Temp.<br>°C   |
|---------------|---------------------------------------|----------------|---|--------------|-------------------------------|---------------|-----------------------------|-------------------|---|--------------|---------------|
|               | $v_f$                                 | $v_g$          | $c_{p_f}$                                     | $c_{p_g}$    | $\lambda_f$                   | $\lambda_g$   | $\mu_f / 10^{-3}$           | $\mu_g / 10^{-6}$ | $Pr_f$                                  | $Pr_g$       |               |
| <b>0.01</b>   | <b>0.00100</b>                        | <b>206.2</b>   | <b>4.217</b>                                  | <b>1.854</b> | <b>0.569</b>                  | <b>0.0173</b> | <b>1.755</b>                | <b>8.8</b>        | <b>13.02</b>                            | <b>0.942</b> | <b>0.01</b>   |
| 10            | 0.00100                               | 106.4          | 4.193   | 1.860        | 0.587                         | 0.0185        | 1.301                       | 9.1               | 9.29                                    | 0.915        | 10            |
| 20            | 0.00100                               | 57.8           | 4.182   | 1.866        | 0.603                         | 0.0191        | 1.002                       | 9.4               | 6.95                                    | 0.918        | 20            |
| 30            | 0.00100                               | 32.9           | 4.179   | 1.885        | 0.618                         | 0.0198        | 0.797                       | 9.7               | 5.39                                    | 0.923        | 30            |
| 40            | 0.00101                               | 19.5           | 4.179   | 1.885        | 0.632                         | 0.0204        | 0.651                       | 10.1              | 4.31                                    | 0.930        | 40            |
| 50            | 0.00101                               | 12.05          | 4.181   | 1.899        | 0.643                         | 0.0210        | 0.544                       | 10.4              | 3.53                                    | 0.939        | 50            |
| 60            | 0.00102                               | 7.68           | 4.185   | 1.915        | 0.653                         | 0.0217        | 0.462                       | 10.7              | 2.96                                    | 0.947        | 60            |
| 70            | 0.00102                               | 5.05           | 4.190   | 1.936        | 0.662                         | 0.0224        | 0.400                       | 11.1              | 2.53                                    | 0.956        | 70            |
| 80            | 0.00103                               | 3.41           | 4.197   | 1.962        | 0.670                         | 0.0231        | 0.350                       | 11.4              | 2.19                                    | 0.966        | 80            |
| 90            | 0.00104                               | 2.36           | 4.205   | 1.992        | 0.676                         | 0.0240        | 0.311                       | 11.7              | 1.93                                    | 0.976        | 90            |
| 100           | 0.00104                               | 1.673          | 4.216   | 2.028        | 0.681                         | 0.0249        | 0.278                       | 12.1              | 1.723                                   | 0.986        | 100           |
| 125           | 0.00107                               | 0.770          | 4.254   | 2.147        | 0.687                         | 0.0272        | 0.219                       | 13.3              | 1.358                                   | 1.047        | 125           |
| 150           | 0.00109                               | 0.392          | 4.310   | 2.314        | 0.687                         | 0.0300        | 0.180                       | 14.4              | 1.133                                   | 1.110        | 150           |
| 175           | 0.00112                               | 0.217          | 4.389   | 2.542        | 0.679                         | 0.0334        | 0.153                       | 15.6              | 0.990                                   | 1.185        | 175           |
| 200           | 0.00116                               | 0.127          | 4.497   | 2.843        | 0.665                         | 0.0375        | 0.133                       | 16.7              | 0.902                                   | 1.270        | 200           |
| 225           | 0.00120                               | 0.0783         | 4.648   | 3.238        | 0.644                         | 0.0427        | 0.1182                      | 17.9              | 0.853                                   | 1.36         | 225           |
| 250           | 0.00125                               | 0.0500         | 4.867   | 3.772        | 0.616                         | 0.0495        | 0.1065                      | 19.1              | 0.841                                   | 1.45         | 250           |
| 275           | 0.00132                               | 0.0327         | 5.202   | 4.561        | 0.582                         | 0.0587        | 0.0972                      | 20.2              | 0.869                                   | 1.56         | 275           |
| 300           | 0.00140                               | 0.0216         | 5.762   | 5.863        | 0.541                         | 0.0719        | 0.0897                      | 21.4              | 0.955                                   | 1.74         | 300           |
| 325           | 0.00153                               | 0.0142         | 6.861   | 8.440        | 0.493                         | 0.0929        | 0.0790                      | 23.0              | 1.100                                   | 2.09         | 325           |
| 350           | 0.00174                               | 0.00880        | 10.10   | 17.15        | 0.437                         | 0.1343        | 0.0648                      | 25.8              | 1.50                                    | 3.29         | 350           |
| 360           | 0.00190                               | 0.00694        | 14.6  | 25.1         | 0.400                         | 0.168         | 0.0582                      | 27.5              | 2.11                                    | 3.89         | 360           |
| <b>374.15</b> | <b>0.00317</b>                        | <b>0.00317</b> | $\infty$                                      | $\infty$     | <b>0.24</b>                   | <b>0.24</b>   | <b>0.045</b>                | <b>45.0</b>       | $\infty$                                | $\infty$     | <b>374.15</b> |

## TRANSPORT PROPERTIES OF STEAM

| Temp.<br>°C | Isobaric sp.<br>heat capacity<br>kJ/kg K<br>$c_p$ | Thermal<br>conductivity<br>W/m K<br>$\lambda$ | Dynamic<br>viscosity<br>kg/s m<br>$\mu/10^{-6}$ | Prandtl number<br>$Pr = \mu c_p / \lambda$ |
|-------------|---|---|---|--|
| 100         | 2.028   | 0.0245  | 12.1  | 0.986                                      |
| 200         | 1.979   | 0.0331  | 16.2  | 0.968                                      |
| 300         | 2.010   | 0.0434  | 20.4  | 0.946                                      |
| 400         | 2.067   | 0.0548  | 24.6  | 0.928                                      |
| 500         | 2.132   | 0.0673  | 28.8  | 0.912                                      |
| 600         | 2.201   | 0.0805  | 32.9  | 0.898                                      |
| 700         | 2.268   | 0.0942  | 36.8  | 0.887                                      |
| 800         | 2.332   | 0.1080  | 40.6  | 0.876                                      |

Values for water at atmospheric pressure between 0°C and 100°C are given with sufficient accuracy by the saturated values in the previous table.

The above values are correct for a pressure of 1 atm = 1.01325 bar but may be used with sufficient accuracy at other pressures.

## TRANSPORT PROPERTIES OF AIR

| Temp.<br>°C | Isobaric sp.<br>heat capacity<br>kJ/kg K<br>$c_p$ | Thermal<br>conductivity<br>W/m K<br>$\lambda$ | Dynamic<br>viscosity<br>kg/s m<br>$\mu/10^{-6}$ | Prandtl number<br>$Pr = \mu c_p / \lambda$ |
|-------------|---|---|---|--|
| -100        | 1.01  | 0.016   | 12  | 0.75                                       |
| 0           | 1.01  | 0.024   | 17  | 0.72                                       |
| 100         | 1.02  | 0.032   | 22  | 0.70                                       |
| 200         | 1.03  | 0.039   | 26  | 0.69                                       |
| 300         | 1.05  | 0.045   | 30  | 0.69                                       |
| 400         | 1.07  | 0.051   | 33  | 0.70                                       |
| 500         | 1.10  | 0.056   | 36  | 0.70                                       |
| 600         | 1.12  | 0.061   | 39  | 0.71                                       |
| 700         | 1.14  | 0.066   | 42  | 0.72                                       |
| 800         | 1.16  | 0.071   | 44  | 0.73                                       |

This table may be used with reasonable accuracy for values of  $c_p$ ,  $\gamma$ ,  $\mu$  and  $Pr$  of N<sub>2</sub>, O<sub>2</sub> and CO.

The above values are correct for a pressure of 1 atm = 1.01325 bar but may be used with sufficient accuracy at other pressures.

## TRANSPORT PROPERTIES OF CARBON DIOXIDE

| Temp.<br>°C | Isobaric sp.<br>heat capacity<br>kJ/kg K<br>$c_p$ | Thermal<br>conductivity<br>W/m K<br>$\lambda$ | Dynamic<br>viscosity<br>kg/s m<br>$\mu/10^{-6}$ | Prandtl number<br>$Pr = \mu c_p / \lambda$ |
|-------------|---|---|---|--|
| -50         | 0.79  | 0.011   | 11  | 0.79                                       |
| 0           | 0.83  | 0.015   | 14  | 0.78                                       |
| 100         | 0.92  | 0.022   | 18  | 0.75                                       |
| 200         | 1.00  | 0.030   | 22  | 0.73                                       |
| 300         | 1.06  | 0.038   | 26  | 0.72                                       |
| 400         | 1.11  | 0.046   | 29  | 0.71                                       |
| 500         | 1.16  | 0.053   | 32  | 0.70                                       |
| 600         | 1.20  | 0.061   | 35  | 0.69                                       |
| 700         | 1.23  | 0.069   | 38  | 0.68                                       |
| 800         | 1.25  | 0.078   | 41  | 0.67                                       |

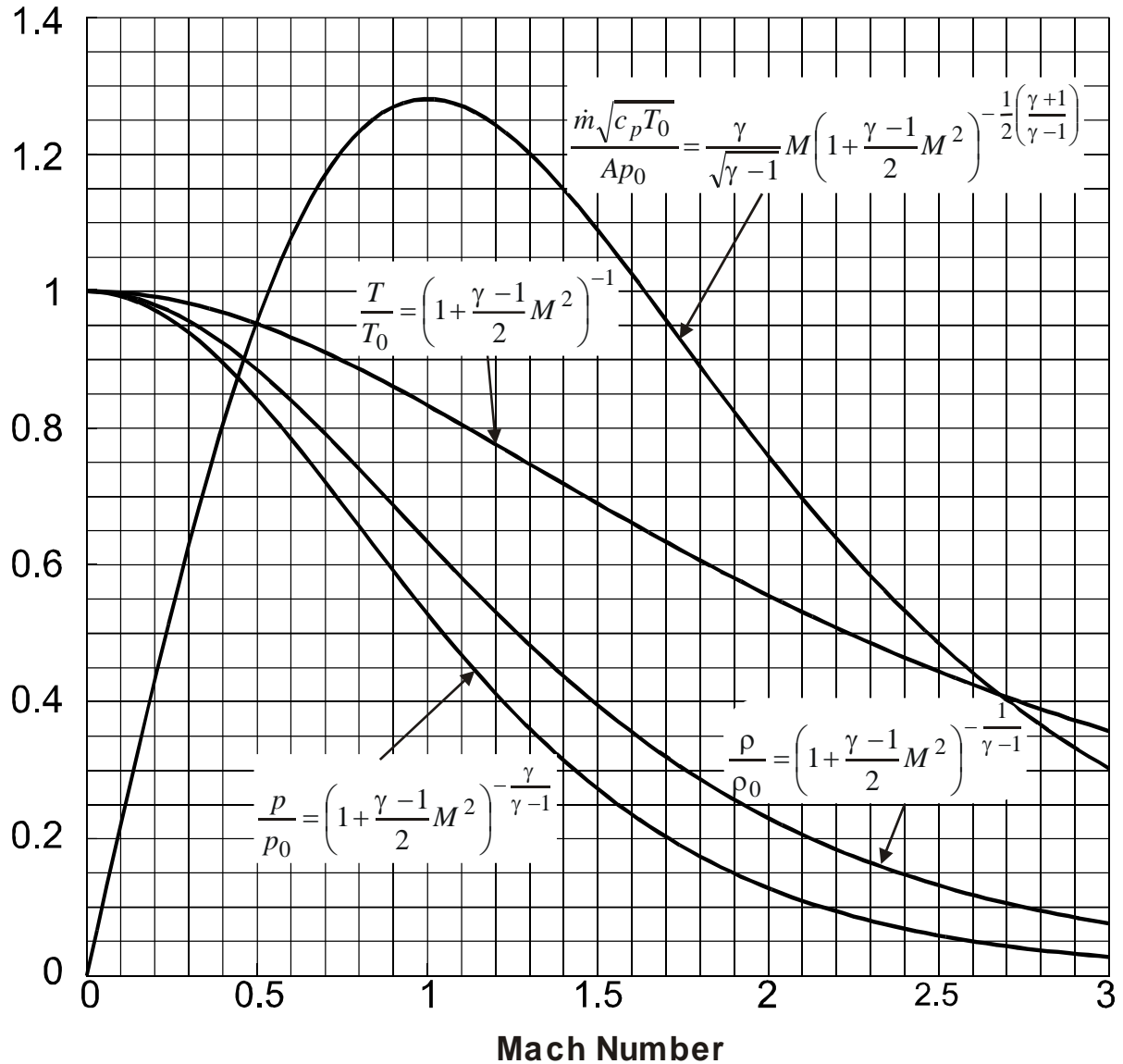
The above values are correct for a pressure of 1 atm = 1.01325 bar but may be used with sufficient accuracy at other pressures.

## TRANSPORT PROPERTIES OF HYDROGEN

| Temp.<br>°C | Isobaric sp.<br>heat capacity<br>kJ/kg K<br>$c_p$ | Thermal<br>conductivity<br>W/m K<br>$\lambda$ | Dynamic<br>viscosity<br>kg/s m<br>$\mu/10^{-6}$ | Prandtl number<br>$Pr = \mu c_p / \lambda$ |
|-------------|---|---|---|--|
| -200        | 10.6  | 0.050   | 3.3   | 0.71                                       |
| -100        | 13.1  | 0.112   | 6.2   | 0.72                                       |
| 0           | 14.2  | 0.172   | 8.4   | 0.69                                       |
| 100         | 14.5  | 0.220   | 10.3  | 0.68                                       |
| 200         | 14.5  | 0.307   | 12.1  | 0.67                                       |
| 300         | 14.5  | 0.307   | 13.8  | 0.66                                       |
| 400         | 14.6  | 0.348   | 15.4  | 0.65                                       |
| 500         | 14.7  | 0.387   | 16.9  | 0.64                                       |
| 600         | 14.8  | 0.427   | 18.3  | 0.63                                       |
| 700         | 14.9  | 0.476   | 19.9  | 0.62                                       |
| 800         | 15.1  | 0.528   | 21.1  | 0.61                                       |

The above values are correct for a pressure of 1 atm = 1.01325 bar but may be used with sufficient accuracy at other pressures.

## PERFECT GAS RELATIONS FOR COMPRESSIBLE FLOW FOR $\gamma=1.4$



Notes:

- (1)  $T_0 = \text{const.}$  in adiabatic flow with no shaft work
- (2) If flow is isentropic,  $p_0 = \text{const.}$  and  $\rho_0 = \text{const.}$  when  $T_0 = \text{const.}$

- (3) At Mach 1 and when  $\gamma=1.4$ ,  $\frac{\dot{m}\sqrt{c_p T_0}}{A p_0} = 1.281$



## PROPERTIES OF GASES AT SEA LEVEL CONDITIONS

The following data are at  $p_{sl} = 1.01325 \text{ bar}$  and  $T_{sl} = 15^\circ\text{C}$ .

|  | <i>Air</i>             | <i>CO<sub>2</sub></i> | <i>H<sub>2</sub></i> | <i>He</i>             |
|--|------------------------|-----------------------|----------------------|-----------------------|
| Density $\rho \text{ kg/m}^3$                  | 1.225                  | 1.860                 | 0.0852               | 0.1693                |
| Viscosity $\mu \text{ kg/m s}$                 | $17.9 \times 10^{-6}$  | $14.4 \times 10^{-6}$ | $8.9 \times 10^{-6}$ | $19.7 \times 10^{-6}$ |
| Kinematic viscosity $\nu \text{ m}^2/\text{s}$ | $14.64 \times 10^{-6}$ | $7.7 \times 10^{-6}$  | $104 \times 10^{-6}$ | $116 \times 10^{-6}$  |
| Speed of sound $\text{m/s}$                    | 340                    | 264                   | 1292                 | 988                   |
| Thermal conductivity $\lambda \text{ W/m K}$   | 0.0252                 | 0.0153                | 0.180                | 0.150                 |

## PROPERTIES OF LIQUIDS AT SEA LEVEL CONDITIONS

The following data are at  $p_{sl} = 1.01325 \text{ bar}$  and  $T_{sl} = 15^\circ\text{C}$ .

|  | <i>Hg</i>              | <i>H<sub>2</sub>O</i> |
|--|------------------------|-----------------------|
| Density $\rho \text{ kg/m}^3$                  | 13595.1                | 1000                  |
| Viscosity $\mu \text{ kg/m s}$                 | $1.59 \times 10^{-3}$  | $1.14 \times 10^{-3}$ |
| Kinematic viscosity $\nu \text{ m}^2/\text{s}$ | $0.117 \times 10^{-6}$ | $1.14 \times 10^{-6}$ |
| Thermal conductivity $\lambda \text{ W/m K}$   | 8.36                   | 0.620                 |

## THE INTERNATIONAL STANDARD ATMOSPHERE

The sea-level condition for the international standard atmosphere is given by

$$p_{sl} = 1.01325 \text{ bar} = 760 \text{ mm Hg}$$

$$T_{sl} = 15^\circ\text{C} = 288.15 \text{ K}$$

for which

$$\rho_{sl} = 1.225 \text{ kg/m}^3$$

$$\nu_{sl} = \frac{\mu_{sl}}{\rho_{sl}} = 14.64 \times 10^{-6} \text{ m}^2/\text{s}$$

$$a_{sl} = \sqrt{\gamma RT_{sl}} = 340 \text{ m/s}$$

## PROPERTIES OF THE INTERNATIONAL STANDARD ATMOSPHERE AT ALTITUDE

| Height<br>m | $\frac{T}{T_{sl}}$ | $\frac{p}{p_{sl}}$ | $\frac{\rho}{\rho_{sl}}$ | $\frac{\nu}{\nu_{sl}}$ |
|-------------|--------------------|--------------------|--------------------------|------------------------|
| 0           | 1.0000             | 1.0000             | 1.0000                   | 1.0000                 |
| 1000        | 0.9774             | 0.8870             | 0.9075                   | 1.0826                 |
| 2000        | 0.9549             | 0.7846             | 0.8217                   | 1.1739                 |
| 3000        | 0.9324             | 0.6920             | 0.7422                   | 1.2753                 |
| 4000        | 0.9098             | 0.6085             | 0.6689                   | 1.3881                 |
| 5000        | 0.8873             | 0.5334             | 0.6012                   | 1.5138                 |
| 6000        | 0.8648             | 0.4660             | 0.5389                   | 1.6543                 |
| 7000        | 0.8423             | 0.4057             | 0.4816                   | 1.8117                 |
| 8000        | 0.8198             | 0.3519             | 0.4292                   | 1.9887                 |
| 9000        | 0.7973             | 0.3040             | 0.3813                   | 2.1881                 |
| 10000       | 0.7748             | 0.2615             | 0.3376                   | 2.4137                 |
| 11000       | 0.7523             | 0.2240             | 0.2978                   | 2.6697                 |
| 12000       | 0.7519             | 0.1915             | 0.2546                   | 3.1206                 |
| 13000       | 0.7519             | 0.1636             | 0.2176                   | 3.6514                 |
| 14000       | 0.7519             | 0.1398             | 0.1860                   | 4.2722                 |
| 15000       | 0.7519             | 0.1195             | 0.1590                   | 4.9983                 |
| 16000       | 0.7519             | 0.1022             | 0.1359                   | 5.8476                 |
| 17000       | 0.7519             | 0.0873             | 0.1162                   | 6.8408                 |
| 18000       | 0.7519             | 0.0747             | 0.0993                   | 8.0023                 |
| 19000       | 0.7519             | 0.0638             | 0.0849                   | 9.3606                 |
| 20000       | 0.7519             | 0.0546             | 0.0726                   | 10.9488                |
| 21000       | 0.7551             | 0.0467             | 0.0618                   | 12.9031                |
| 22000       | 0.7585             | 0.0399             | 0.0527                   | 15.2021                |
| 23000       | 0.7620             | 0.0342             | 0.0449                   | 17.8964                |
| 24000       | 0.7654             | 0.0293             | 0.0383                   | 21.0515                |
| 25000       | 0.7689             | 0.0252             | 0.0327                   | 24.7434                |
| 26000       | 0.7723             | 0.0216             | 0.0280                   | 29.0603                |
| 27000       | 0.7758             | 0.0186             | 0.0239                   | 34.1039                |
| 28000       | 0.7792             | 0.0160             | 0.0205                   | 39.9926                |
| 29000       | 0.7826             | 0.0137             | 0.0175                   | 46.8626                |
| 30000       | 0.7861             | 0.0118             | 0.0150                   | 54.8714                |

The speed of sound at altitude is given by

$$\frac{a}{a_{sl}} = \sqrt{\frac{T}{T_{sl}}}$$

The viscosity at altitude is given approximately by

$$\mu = \frac{1.458 \times 10^{-6} T^{3/2}}{T + 110.4} \text{ kg/m.s}$$

## PHYSICAL CONSTANTS

|                                       |   |
|---------------------------------------|---|
| Absolute zero of temperature          | -273.15°C   |
| Acceleration due to gravity, $g$      | 9.80665 m/s <sup>2</sup>                              |
| Avogadro's number, $N_A$              | 6.022x10 <sup>26</sup> kmol <sup>-1</sup>             |
| Base of natural logarithms, $e$       | 2.7182818   |
| Boltzmann's constant, $k$             | 1.381 x 10 <sup>-23</sup> J/K                         |
| Electronic charge, $e$                | -1.602 x 10 <sup>-19</sup> C                          |
| Faraday's constant, $F$               | 9.648 x 10 <sup>7</sup> C/kmol                        |
| Universal Gas constant, $\bar{R}$     | 8.3143 kJ/kmol K                                      |
| Permeability of vacuum, $\mu_0$       | 1.257 x 10 <sup>-6</sup> H/m                          |
| Permittivity of vacuum, $\epsilon_0$  | 8.854 x 10 <sup>-12</sup> F/m                         |
| Pi, $\pi$                             | 3.14159265  |
| Planck's constant, $h$                | 6.626 x 10 <sup>-34</sup> Js                          |
| Stefan-Boltzmann's constant, $\sigma$ | 5.67x10 <sup>-8</sup> W/m <sup>2</sup> K <sup>4</sup> |
| Velocity of light in vacuum, $c$      | 2.998 x 10 <sup>8</sup> m/s                           |
| Volume of perfect gas at STP          | 22.41 m <sup>3</sup> /kmol                            |

## CONVERSION OF NON-SI TO SI UNITS

| Non SI Unit              | Conversion |                         | SI Unit                    |
|--------------------------|------------|-------------------------|----------------------------|
| <b>Length</b>            |            |                         |                            |
| 1 yard (yd)              |            | = 0.9144                | m                          |
| 1 foot (ft)              | =          | 0.9144/3.0              | ≈ 0.3048 m                 |
| 1 inch (in)              | =          | 0.9144/36.0             | ≈ 0.0254 m                 |
| 1 mile (mile)            | =          | 0.9144×1760             | ≈ 1609 m                   |
| <b>Mass</b>              |            |                         |                            |
| 1 pound (lb)             |            | = 0.45359237            | kg                         |
| 1 ounce (oz)             | =          | 0.45359237/16           | ≈ 0.02835 kg               |
| 1 hundredweight (cwt)    | =          | 0.45359237×112          | ≈ 50.8 kg                  |
| 1 tonne (t)              | =          |                         | = 1000 kg                  |
| 1 ton (ton)              | =          | 0.45359237×2240         | ≈ 1016 kg                  |
| <b>Force</b>             |            |                         |                            |
| 1 dyne (dyn)             |            | =                       | 10 <sup>-5</sup> N         |
| 1 ounce (ozf)            | =          | 0.45359237×9.80665/16   | ≈ 0.278 N                  |
| 1 pound force (lbf)      | =          | 0.45359237×9.80665      | ≈ 4.45 N                   |
| 1 ton force (tonf)       | =          | 0.45359237×9.80665×2240 | ≈ 9960 N                   |
| <b>Volume</b>            |            |                         |                            |
| 1 Imperial gallon (gal)  |            | = 0.0045460916          | m <sup>3</sup>             |
| 1 pint (pt)              | =          | 0.0045460916/8          | ≈ 0.0005683 m <sup>3</sup> |
| 1 litre (l)              |            | = 0.001                 | m <sup>3</sup>             |
| <b>Dynamic Viscosity</b> |            |                         |                            |
| 1 poise (P)              |            | = 0.1                   | Ns/m <sup>2</sup>          |

## CONVERSION OF NON-SI TO SI UNITS cont.

| Non SI Unit                | Conversion |   | SI Unit           |
|----------------------------|------------|---|-------------------|
| <b>Kinematic Viscosity</b> |            |   |                   |
| 1 stokes (St)              | =          | $10^{-4}$   | m <sup>2</sup> /s |
| <b>Energy</b>              |            |   |                   |
| 1 erg                      | =          | $10^{-7}$   | J                 |
| 1 calorie (cal)            | =          | 4.1868  | J                 |
| 1 Cal (kcal)               | =          | 4186.8  | J                 |
| 1 Btu                      | =          | $4.1868 \times 0.45359237 / 1.8$  | $\approx 1055$ J  |
| <b>Power</b>               |            |   |                   |
| 1 horsepower (hp)          | =          | $550 \times \left( \frac{0.9144}{3} \right) \times 0.45359237 \times 9.80665$ | $\approx 746$ W   |
| <b>Pressure</b>            |            |   |                   |
| 1 dyn/cm <sup>2</sup>      | =          | 0.1   | Pa                |
| 1 N/m <sup>2</sup>         | =          | 1   | Pa                |
| 1 mm H <sub>2</sub> O      | =          | $1000 \times 0.001 \times 9.80665$  | = 9.80665 Pa      |
| 1 mm Hg                    | =          | $13595.1 \times 0.001 \times 9.80665$   | = 133.32 Pa       |
| 1 torr                     | =          | $101325 / 760$  | = 133.32 Pa       |
| 1 in Hg                    | =          | $13595.1 \times 9.80665 \times \frac{0.9144}{36}$                             | = 3386 Pa         |
| 1 lb/in <sup>2</sup>       | =          | $0.45359237 \times 9.80665 \times \left( \frac{36}{0.9144} \right)^2$         | = 6895 Pa         |
| 1 bar                      | =          | 100000  | Pa                |
| 1 atm                      | =          | 101325  | Pa                |
| 1 kgf/mm <sup>2</sup>      | =          | $1 \times 9.80665 \times 1000000$   | = 9806650 Pa      |

## SOURCES OF INFORMATION

Haywood, RW, "Thermodynamic Tables in SI (metric) Units", 3<sup>rd</sup> Edition, CUP.

Gas Flow Tables, CUED, 1975.

Houghton E.L., Brock A.E., "Tables for compressible flow of dry air: giving major parameters for the Mach number range 0 to 4", 3<sup>rd</sup> Edition, London, 1975

Kay, GWC, and Laby, TH, "Tables of Physical and Chemical Constants and Some Mathematic Functions" 14th Ed, Longman, 1972

US Standard Atmosphere, NOAA-S/T 76-1562, 1976

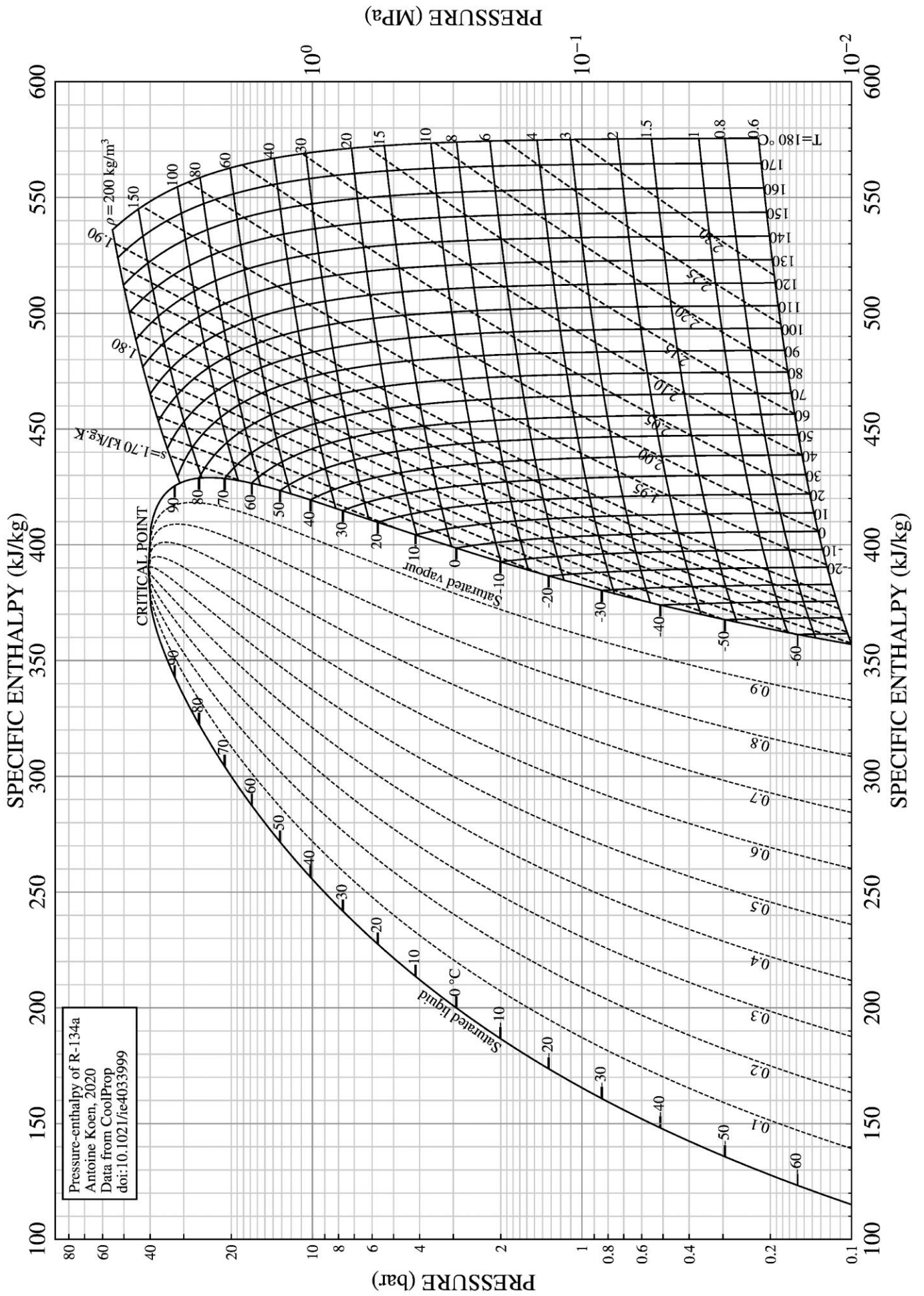
The Pressure-Enthalpy chart for the refrigerant R-134a produced by Antoine Koen, 2020.  
Data from CoolProp. doi:10.1021/ie4033999

## CRITICAL POINT DATA FOR REFRIGERANT R-134a (CH<sub>2</sub>FCF<sub>3</sub>)

Critical Temperature = 101.08 °C  
Critical Pressure = 40.603 bar  
Critical Volume = 0.0019 m<sup>3</sup>/kg  
Molecular Weight = 102.03 kg/kMol

## PROPERTIES TABLE FOR REFRIGERANT R-134a (CH<sub>2</sub>FCF<sub>3</sub>)

| Saturation Temp.<br>°C | Saturation Pressure<br>bar | Saturated                             |                      |                            |                      |                             |                      | Superheated by |          |          |          | Saturation Temp.<br>°C |
|------------------------|----------------------------|---------------------------------------|----------------------|----------------------------|----------------------|-----------------------------|----------------------|----------------|----------|----------|----------|------------------------|
|                        |                            | Specific volume<br>m <sup>3</sup> /kg |                      | Specific enthalpy<br>kJ/kg |                      | Specific entropy<br>kJ/kg K |                      | 20K            |          | 40K      |          |                        |
|                        |                            | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>h</i>       | <i>s</i> | <i>h</i> | <i>s</i> |                        |
| <i>T<sub>sat</sub></i> | <i>P<sub>sat</sub></i>     | <i>v<sub>f</sub></i>                  | <i>v<sub>g</sub></i> | <i>h<sub>f</sub></i>       | <i>h<sub>g</sub></i> | <i>s<sub>f</sub></i>        | <i>s<sub>g</sub></i> | <i>h</i>       | <i>s</i> | <i>h</i> | <i>s</i> | <i>T<sub>sat</sub></i> |
| <b>-45</b>             | 0.39                       | 0.00070                               | 0.46458              | 141.9                      | 370.8                | 0.7687                      | 1.7722               | 385.8          | 1.8348   | 401.3    | 1.8949   | <b>-45</b>             |
| <b>-40</b>             | 0.51                       | 0.00071                               | 0.36094              | 148.1                      | 374.0                | 0.7956                      | 1.7643               | 389.2          | 1.8270   | 405.0    | 1.8869   | <b>-40</b>             |
| <b>-35</b>             | 0.66                       | 0.00071                               | 0.28390              | 154.4                      | 377.2                | 0.8221                      | 1.7574               | 392.7          | 1.8201   | 408.6    | 1.8797   | <b>-35</b>             |
| <b>-30</b>             | 0.84                       | 0.00072                               | 0.22585              | 160.8                      | 380.3                | 0.8483                      | 1.7512               | 396.1          | 1.8139   | 412.3    | 1.8734   | <b>-30</b>             |
| <b>-25</b>             | 1.06                       | 0.00073                               | 0.18155              | 167.2                      | 383.4                | 0.8743                      | 1.7458               | 399.5          | 1.8085   | 416.0    | 1.8678   | <b>-25</b>             |
| <b>-20</b>             | 1.33                       | 0.00074                               | 0.14735              | 173.6                      | 386.5                | 0.8999                      | 1.7410               | 402.9          | 1.8037   | 419.7    | 1.8629   | <b>-20</b>             |
| <b>-15</b>             | 1.64                       | 0.00074                               | 0.12065              | 180.1                      | 389.6                | 0.9253                      | 1.7368               | 406.3          | 1.7995   | 423.4    | 1.8587   | <b>-15</b>             |
| <b>-10</b>             | 2.01                       | 0.00075                               | 0.09959              | 186.7                      | 392.7                | 0.9505                      | 1.7331               | 409.7          | 1.7959   | 427.0    | 1.8550   | <b>-10</b>             |
| <b>-5</b>              | 2.43                       | 0.00076                               | 0.08281              | 193.3                      | 395.6                | 0.9753                      | 1.7299               | 413.1          | 1.7927   | 430.7    | 1.8518   | <b>-5</b>              |
| <b>0</b>               | 2.93                       | 0.00077                               | 0.06933              | <b>200.0</b>               | 398.6                | <b>1.0000</b>               | 1.7270               | 416.4          | 1.7900   | 434.3    | 1.8491   | <b>0</b>               |
| <b>5</b>               | 3.50                       | 0.00078                               | 0.05840              | 206.8                      | 401.5                | 1.0244                      | 1.7245               | 419.7          | 1.7877   | 437.9    | 1.8469   | <b>5</b>               |
| <b>10</b>              | 4.15                       | 0.00079                               | 0.04947              | 213.6                      | 404.3                | 1.0486                      | 1.7222               | 422.9          | 1.7857   | 441.5    | 1.8450   | <b>10</b>              |
| <b>15</b>              | 4.88                       | 0.00080                               | 0.04212              | 220.5                      | 407.1                | 1.0726                      | 1.7202               | 426.1          | 1.7840   | 445.0    | 1.8434   | <b>15</b>              |
| <b>20</b>              | 5.72                       | 0.00082                               | 0.03602              | 227.5                      | 409.8                | 1.0965                      | 1.7183               | 429.3          | 1.7825   | 448.5    | 1.8422   | <b>20</b>              |
| <b>25</b>              | 6.65                       | 0.00083                               | 0.03093              | 234.6                      | 412.3                | 1.1202                      | 1.7165               | 432.3          | 1.7813   | 452.0    | 1.8412   | <b>25</b>              |
| <b>30</b>              | 7.70                       | 0.00084                               | 0.02666              | 241.7                      | 414.8                | 1.1438                      | 1.7148               | 435.4          | 1.7803   | 455.4    | 1.8405   | <b>30</b>              |
| <b>35</b>              | 8.87                       | 0.00086                               | 0.02305              | 249.0                      | 417.2                | 1.1672                      | 1.7130               | 438.3          | 1.7794   | 458.8    | 1.8399   | <b>35</b>              |
| <b>40</b>              | 10.17                      | 0.00087                               | 0.01999              | 256.4                      | 419.4                | 1.1906                      | 1.7112               | 441.2          | 1.7786   | 462.1    | 1.8395   | <b>40</b>              |
| <b>45</b>              | 11.60                      | 0.00089                               | 0.01736              | 263.9                      | 421.5                | 1.2140                      | 1.7093               | 444.0          | 1.7779   | 465.4    | 1.8393   | <b>45</b>              |
| <b>50</b>              | 13.18                      | 0.00091                               | 0.01511              | 271.6                      | 423.4                | 1.2374                      | 1.7073               | 446.7          | 1.7772   | 468.6    | 1.8392   | <b>50</b>              |
| <b>60</b>              | 16.82                      | 0.00095                               | 0.01148              | 287.5                      | 426.6                | 1.2846                      | 1.7022               | 451.8          | 1.7759   | 474.8    | 1.8392   | <b>60</b>              |
| <b>70</b>              | 21.16                      | 0.00101                               | 0.00871              | 304.3                      | 428.6                | 1.3329                      | 1.6953               | 456.4          | 1.7743   | 480.7    | 1.8394   | <b>70</b>              |
| <b>80</b>              | 26.33                      | 0.00108                               | 0.00654              | 322.4                      | 428.8                | 1.3834                      | 1.6848               | 460.4          | 1.7722   | 486.2    | 1.8395   | <b>80</b>              |
| <b>90</b>              | 32.45                      | 0.00119                               | 0.00481              | 342.9                      | 425.4                | 1.4393                      | 1.6665               | 463.8          | 1.7692   | 491.3    | 1.8392   | <b>90</b>              |
| <b>100</b>             | 39.73                      | 0.00148                               | 0.00345              | 373.3                      | 407.7                | 1.5183                      | 1.6105               | 466.4          | 1.7650   | 495.9    | 1.8384   | <b>100</b>             |





### Enthalpy-Entropy Diagram for Steam

Plotted from the IAPWS equations <http://www.iapws.org> (Duncan A. Simpson (2002))

