Water (IAPWS Formulation 1995 for General and Scientific Use)

1 Temperature Scale

International Temperature Scale of 1990 (ITS-90)

2 Libraries and Single Shot Programs

Library for UNIX	libdiapws95.a
Library for Windows	diapws95.lib/ diapws95.dll
Single shot program for UNIX	diapws95-ss
Single shot program for Windows	diapws95-ss.exe

3 Fundamental Constants

Molecular formula	H_2O
Molar mass	$M = 18.015268$ g/mol
Gas constant	$R = 461.5181$ J/(kg·K)
Critical temperature	$T_c = 647.0960$ K (373.9460 °C)
Critical pressure	$P_c = 22.0640$ MPa
Critical specific volume	$v_c = 0.003106$ m^3/kg
Triple-point temperature	$T_t = 273.160$ K (0.010 °C)
Triple-point pressure	$P_t = 0.6117$ kPa

4 Reference State

The specific internal energy and the specific entropy of the saturated liquid at the triple point temperature $T_t = 273.16$ K are 0 J/kg and 0 J/(kg·K), respectively.

5 Valid Range of Equation of State

Upper limit of temperature	$T_{max} = 1273$ K
Lower limit of temperature	T_{min} = temperature on the melting line
Upper limit of pressure	$P_{max} = 1000$ MPa

6 References

Equation of state and Melting pressure:

W. Wagner and A. Pruß, The IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use, J. Phys. Chem. Ref. Data, 31, 2, pp.387-535, (2002).

Transport properties:

The current version of this library has not supported the calculation of the transport properties yet.

7 Available Functions and Valid Range of Parameters

All functions listed below have the return value and argument(s) in single precision. The functions with the return value and argument(s) in double precision begin with "D" prefix, for instance, double precision functions corresponding to PST and HPT in single precision are DPST and DHPT, respectively.

Function	Return value and Argument(s)	Valid range of argument(s)
AIPPT(P,T)	N/A	
AJTPT(P,T)	AJTPT: Joule-Thomson coefficient [K/Pa] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
AKPD(P)	AKPD: Isentropic exponent of saturated liquid [-] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
AKPDD(P)	AKPDD: Isentropic exponent of saturated vapor [-] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
AKPT(P,T)	AKPT: Isentropic exponent [-] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
AKTD(T)	AKTD: Isentropic exponent of saturated liquid [-] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
AKTDD(T)	AKTDD: Isentropic exponent of saturated vapord [-] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
ALAPP(P)	N/A	
ALAPT(T)	N/A	
ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
ALMPD(P)	N/A	
ALMPDD(P)	N/A	
ALMPT(P,T)	N/A	
ALMTD(T)	N/A	
ALMTDD(T)	N/A	
AMUPD(P)	N/A	
AMUPDD(P)	N/A	
AMUPT(P,T)	N/A	
AMUTD(T)	N/A	
AMUTDD(T)	N/A	
BPPT(P,T)	BPPT: Volumetric coefficient of expansion [1/K] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
BSPT(P,T)	BSPT: Isentropic compressibility [1/Pa] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
BTPT(P,T)	BTPT: Isothermal compressibility [1/Pa] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
BVPT(P,T)	BVPT: Pressure coefficient [1/K] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
CPPD(P)	CPPD: Isobaric heat capacity of saturated liquid [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
CPPDD(P)	CPPDD: Isobaric heat capacity of saturated vapor [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
CPPT(P,T)	CPPT: Isobaric heat capacity [J/(kg·K)] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
CPTD(T)	CPTD: Isobaric heat capacity of saturated liquid [J/(kg·K)] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
CPTDD(T)	CPTDD: Isobaric heat capacity of saturated vapor [J/(kg·K)] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$

Function	Return value and Argument(s)	Valid range of argument(s)
CRP(A)	CRP: Critical Constants $A = 'H'$: specific enthalpy, 2084.256 kJ/kg $A = 'P'$: pressure, 22.0640 MPa (220.640 bar) $A = 'S'$: specific entropy, 4.4070 kJ/(kg·K) $A = 'T'$: temperature, 647.0960 K (373.9460 ° C) $A = 'V'$: specific volume, 0.003106 m^3/kg	'H', 'P', 'S', 'T', and 'V'
CVPD(P)	CVPD: Isochoric heat capacity of saturated liquid [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
CVPDD(P)	CVPDD: Isochoric heat capacity of saturated vapor [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
CVPT(P, T)	CVPT: Isochoric heat capacity [J/(kg·K)] P: Pressure [Pa], [bar] T: Temperature [K], [° C]	$P_t \le P \le P_{max}$ TMLP(P) $\le T \le T_{max}$
CVTD(T)	CVTD: Isochoric heat capacity of saturated liquid [J/(kg·K)] T: Temperature [K], [° C]	$T_t \le T \le T_c$
CVTDD(T)	CVTDD: Isochoric heat capacity of saturated vapor [J/(kg·K)] T: Temperature [K], [° C]	$T_t \le T \le T_c$
EPSPD(P)	N/A	
EPSPDD(P)	N/A	
EPSPT(P, T)	N/A	
EPSTD(T)	N/A	
EPSTDD(T)	N/A	
FC(A)	FC: Fundamental constants $A = 'M'$: Molar mass, 18.015268 g/mol $A = 'R'$: Gas constant, 461.5181 J/(kg·K)	'M' and 'R'
GAMPD(P)	GAMPD: Heat capacity ratio of saturated liquid [-] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
GAMPDD(P)	GAMPDD: Heat capacity ratio of saturated vapor [-] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
GAMPT(P, T)	GAMPT: Heat capacity ratio [-] P: Pressure [Pa], [bar] T: Temperature [K], [° C]	$P_t \le P \le P_{max}$ TMLP(P) $\le T \le T_{max}$
GAMTD(T)	GAMTD: Heat capacity ratio of saturated liquid [-] T: Temperature [K], [° C]	$T_t \le T \le T_c$
GAMTDD(T)	GAMTDD: Heat capacity ratio of saturated vapor [-] T: Temperature [K], [° C]	$T_t \le T \le T_c$
HPD(P)	HPD: Specific enthalpy of saturated liquid [J/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
HPDD(P)	HPDD: Specific enthalpy of saturated vapor [J/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
HPS(P, S)	HPS: Specific enthalpy [J/kg] P: Pressure [Pa], [bar] S: Specific entropy [J/(kg·K]	$P_t \le P \le P_{max}$ SPT(P, TMLP(P)) $\le S \le$ SPT(P, T_{max})
HPT(P, T)	HPT: Specific enthalpy [J/kg] P: Pressure [Pa], [bar] T: Temperature [K], [° C]	$P_t \le P \le P_{max}$ TMLP(P) $\le T \le T_{max}$
HPX(P, X)	HPX: Specific enthalpy [J/kg] P: Pressure [Pa], [bar] X: Dryness fraction [-]	$P_t \le P \le P_c$ $0 \le X \le 1.0$
HTD(T)	HTD: Specific enthalpy of saturated liquid [J/kg] T: Temperature [K], [° C]	$T_t \le T \le T_c$
HTDD(T)	HTDD: Specific enthalpy of saturated vapor [J/kg] T: Temperature [K], [° C]	$T_t \le T \le T_c$
HTX(T, X)	HTX: Specific enthalpy [J/kg] T: Temperature [K], [° C] X: Dryness fraction [-]	$T_t \le T \le T_c$ $0 \le X \le 1.0$
IDENTF(A)	IDENTF : Package Identification (CHARACTER*20) $A = 'C'$: Molecular formula, H_2O $A = 'S'$: Substance name, Water $A = 'V'$: Version number, 13.1	'C', 'S', and 'V'
PLDT(T)	N/A	
PMLT(T)	PMLT: Pressure on melting curve [Pa], [bar] T: Temperature [K], [° C]	$T_t \le T \le T_{max}$
PRPD(P)	N/A	

Function	Return value and Argument(s)	Valid range of argument(s)
PRPDD(P)	N/A	
PRPT(P,T)	N/A	
PRTD(T)	N/A	
PRTDD(T)	N/A	
PSBT(T)	N/A	
PST(T)	PST: Saturation pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
PSTD(T)	N/A	
PSTDD(T)	N/A	
SIGP(P)	N/A	
SIGT(T)	N/A	
SPD(P)	SPD: Specific entropy of saturated Liquid [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
SPDD(P)	SPDD: Specific entropy of saturated vapor [J/(kg·K)] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
SPT(P,T)	SPT: Specific entropy [J/(kg·K)] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
SPX(P,X)	SPX: Specific entropy [J/(kg·K)] P: Pressure [Pa], [bar] X: Dryness fraction [-]	$P_t \le P \le P_c$ $0 \le X \le 1.0$
STD(T)	STD: Specific entropy of saturated liquid [J/(kg·K)] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
STDD(T)	STDD: Specific entropy of saturated vapor [J/(kg·K)] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
STX(T,X)	STX: Specific entropy [J/(kg·K)] T: Temperature [K], [$^\circ$C] X: Dryness fraction [-]	$T_t \le T \le T_c$ $0 \le X \le 1.0$
TLDP(P)	N/A	
TMLP(P)	TMLP: Temperature on melting-line [K], [$^\circ$C] P: Pressure [Pa], [bar]	$P_t \le P \le P_{max}$
TPH(P,H)	TPH: Temperature [K], [$^\circ$C] P: Pressure [Pa], [bar] H: Specific enthalpy [J/kg]	$P_t \le P \le P_{max}$ HPT$(P,$TMLP$(P)) \le H \le$ HPT(P,T_{max})
TPH2(P,H)	N/A	
TPS(P,S)	TPS: Temperature [K], [$^\circ$C] P: Pressure [Pa], [bar] S: Specific entropy [J/(kg·K)]	$P_t \le P \le P_{max}$ SPT$(P,$TMLP$(P)) \le S \le$ SPT(P,T_{max})
TPS2(P,S)	N/A	
TPSEUP(P)	N/A	
TPV(P,V)	TPV: Temperature [K], [$^\circ$C] P: Pressure [Pa], [bar] V: Specific volume [m^3/kg]	$P_t \le P \le P_{max}$ VPT$(P,$TMLP$(P)) \le V \le$ VPT(P,T_{max})
TRPL(A)	TRPL: Properties at Triple Point $A = $'P': Pressure, 0.6117 KPa $A = $'T': Temperature, 273.160 K (0.010 $^\circ$C)	'P' and 'T'
TSBP(P)	N/A	
TSP(P)	TSP: Saturation temperature [K], [$^\circ$C] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
TSPD(P)	N/A	
TSPDD(P)	N/A	
UPD(P)	UPD: Specific internal energy of saturated liquid [J/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
UPDD(P)	UPDD: Specific internal energy of saturated vapor [J/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
UPS(P,S)	UPS: Specific internal energy [J/kg] P: Pressure [Pa], [bar] S: Specific entropy [J/(kg·K)]	$P_t \le P \le P_{max}$ SPT$(P,$TMLP$(P)) \le S \le$ SPT(P,T_{max})
UPT(P,T)	UPT: Specific internal energy [J/kg] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ TMLP$(P) \le T \le T_{max}$
UPX(P,X)	UPX: Specific internal energy [J/kg] P: Pressure [Pa], [bar] X: Dryness fraction [-]	$P_t \le P \le P_c$ $0 \le X \le 1.0$

Function	Return value and Argument(s)	Valid range of argument(s)
UTD(T)	UTD: Specific internal energy of saturated liquid [J/kg] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
UTDD(T)	UTDD: Specific internal energy of saturated vapor [J/kg] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
UTX(T, X)	UTX: Specific internal energy [J/kg] T: Temperature [K], [$^\circ$C] X: Dryness fraction [-]	$T_t \le T \le T_c$ $0 \le X \le 1.0$
VPD(P)	VPD: Specific volume of saturated liquid [m^3/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
VPDD(P)	VPDD: Specific volume of saturated vapor [m^3/kg] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
VPS(P, S)	VPS: Specific volume [m^3/kg] P: Pressure [Pa], [bar] S: Specific entropy [J/(kg·K)]	$P_t \le P \le P_{max}$ $\mathrm{SPT}(P, \mathrm{TMLP}(P))$ $\le S \le \mathrm{SPT}(P, T_{max})$
VPT(P, T)	VPT: Specific volume [m^3/kg] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ $\mathrm{TMLP}(P) \le T \le T_{max}$
VPX(P, X)	VPX: Specific volume [m^3/kg] P: Pressure [Pa], [bar] X: Dryness fraction [-]	$P_t \le P \le P_c$ $0 \le X \le 1.0$
VTD(T)	VTD: Specific volume of saturated liquid [m^3/kg] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
VTDD(T)	VTDD: Specific volume of saturated vapor [m^3/kg] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
VTX(T, X)	VTX: Specific volume [m^3/kg] T: Temperature [K], [$^\circ$C] X: Dryness fraction [-]	$T_t \le T \le T_c$ $0 \le X \le 1.0$
WPD(P)	WPD: Sound speed in saturated liquid [m/s] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
WPDD(P)	WPDD: Sound speed in saturated vapor [m/s] P: Pressure [Pa], [bar]	$P_t \le P \le P_c$
WPT(P, T)	WPT: Sound speed [m/s] P: Pressure [Pa], [bar] T: Temperature [K], [$^\circ$C]	$P_t \le P \le P_{max}$ $\mathrm{TMLP}(P) \le T \le T_{max}$
WTD(T)	WTD: Sound speed in saturated liquid [m/s] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
WTDD(T)	WTDD: Sound speed in saturated vapor [m/s] T: Temperature [K], [$^\circ$C]	$T_t \le T \le T_c$
XPH(P, H)	XPH: Dryness Fraction [-] P: Pressure [Pa], [bar] H: Specific enthalpy [J/kg]	$P_t \le P \le P_c$ $\mathrm{HPD}(P) \le H \le \mathrm{HPDD}(P)$
XPS(P, S)	XPS: Dryness Fraction [-] P: Pressure [Pa], [bar] S: Specific entropy [J/(kg·K)]	$P_t \le P \le P_c$ $\mathrm{SPD}(P) \le S \le \mathrm{SPDD}(P)$
XPU(P, U)	XPU: Dryness Fraction [-] P: Pressure [Pa], [bar] U: Specific internal energy [J/kg]	$P_t \le P \le P_c$ $\mathrm{UPD}(P) \le U \le \mathrm{UPDD}(P)$
XPV(P, V)	XPV: Dryness Fraction [-] P: Pressure [Pa], [bar] V: Specific volume [m^3/kg]	$P_t \le P \le P_c$ $\mathrm{VPD}(P) \le V \le \mathrm{VPDD}(P)$
XTH(T, H)	XTH: Dryness Fraction [-] T: Temperature [K], [$^\circ$C] H: Specific enthalpy [J/kg]	$T_t \le T \le T_c$ $\mathrm{HTD}(T) \le H \le \mathrm{HTDD}(T)$
XTS(T, S)	XTS: Dryness Fraction [-] T: Temperature [K], [$^\circ$C] S: Specific entropy [J/(kg·K)]	$T_t \le T \le T_c$ $\mathrm{STD}(T) \le S \le \mathrm{STDD}(T)$
XTU(T, U)	XTU: Dryness Fraction [-] T: Temperature [K], [$^\circ$C] U: Specific internal energy [J/kg]	$T_t \le T \le T_c$ $\mathrm{UTD}(T) \le U \le \mathrm{UTDD}(T)$
XTV(T, V)	XTV: Dryness Fraction [-] T: Temperature [K], [$^\circ$C] V: Specific volume [m^3/kg]	$T_t \le T \le T_c$ $\mathrm{VTD}(T) \le V \le \mathrm{VTDD}(T)$