ThermoFluidProperties

Property Library for Seawater Calculated from the IAPWS Industrial Formulation 2013

LibSeaWa

Prof. Hans-Joachim Kretzschmar
Dr. Sebastian Herrmann
Dr. Matthias Kunick
Thomas Gubsch
Tobias Göpfert

Property Functions of LibSeaWa

Functional Dependence	Function Name in Excel®	Call as Fortran Program	Property or Function	Unit of Result	Reference	Page
$a = \mathrm{f}(p,t,\xi)$	a_ptXI_SeaWa	= A_PTXI_SEAWA(P,T,XI)	Thermal diffusivity	m²/s	[1], [2], [16]	3/2
$a_\mathrm{l} = \mathrm{f}(t,\xi)$	al_tXI_SeaWa	= AL_TXI_SEAWA(T,XI)	Thermal diffusivity of liquid	m²/s	[1], [2], [16]	3/3
$a_\mathrm{sl} = \mathrm{f}(p_\mathrm{s},t_\mathrm{s},\xi_\mathrm{sl})$	asl_pstsXisl_SeaWa	= ASL_PSTSXISL_SEAWA(PS,TS,XISL)	Thermal diffusivity of saturated liquid	m²/s	[1], [2], [16]	3/4
$a_\mathrm{sv} = \mathrm{f}(p_\mathrm{s},t_\mathrm{s},\xi_\mathrm{sl})$	asv_pstsXisl_SeaWa	= ASV_PSTSXISL_SEAWA(PS,TS,XISL)	Thermal diffusivity of saturated vapor	m²/s	[1], [2], [16]	3/5
$\alpha_\mathrm{l} = \mathrm{f}(p,t,\xi)$	alphal_ptXi_SeaWa	= ALPHAL_PTXI_SEAWA(P,T,XI)	Thermal expansion coefficient of subcooled iquid	1/K	[1], [16]	3/6
$\alpha_\mathrm{sl} = \mathrm{f}(p_\mathrm{s},t_\mathrm{s},\xi_\mathrm{sl})$	alphasl_pstsXisl_SeaWa	= ALPHASL_PSTSXISL_SEAWA(PS,TS,XISL)	Thermal expansion coefficient of saturated liquid	1/K	[1], [16]	3/7
$\beta_\mathrm{l} = \mathrm{f}(p,t,\xi)$	betal_ptXi_SeaWa	= BETAL_PTXI_SEAWA(P,T,XI)	Haline contraction coefficient of subcooled liquid	kg/kg	[1], [16]	3/8
$\beta_\mathrm{sl} = \mathrm{f}(p,t,\xi_\mathrm{sl})$	betasl_pstsXisl_SeaWa	= BETASL_PSTSXISL_SEAWA(PS,TS,XISL)	Haline contraction coefficient of saturated liquid	kg/kg	[1], [16]	3/9
$\beta_\mathrm{Isl} = \mathrm{f}(p,t,\xi)$	betaIsl_ptXi_SeaWa	= BETAISL_PTXI_SEAWA(P,T,XI)	Isentropic temperature-pressure coefficient of subcooled liquid	K/kPa	[1], [16]	3/10
$\beta_\mathrm{Issl} = \mathrm{f}(p,t,\xi_\mathrm{sl})$	betaIssl_pstsXisl_SeaWa	= BETAISSL_PSTSXISL_SEAWA(PS,TS,XISL)	Isentropic temperature-pressure coefficient of saturated liquid	K/kPa	[1], [16]	3/11
$c_p = \mathrm{f}(p,t,\xi)$	cp_ptXI_SeaWa	= CP_PTXI_SEAWA(P,T,XI)	Specific isobaric heat capacity	kJ/(kg·K)	[1], [2], [16]	3/12
$c_{p\_\mathrm{l}} = \mathrm{f}(p,t,\xi)$	cpl_ptXI_SeaWa	= CPL_PTXI_SEAWA(P,T,XI)	Specific isobaric heat capacity of subcooled liquid	kJ/(kg·K)	[1], [2], [16]	3/13
$c_{p\_\mathrm{sl}} = \mathrm{f}(p_\mathrm{s},t_\mathrm{s},\xi_\mathrm{sl})$	cpsl_pstsXIsl_SeaWa	= CPSL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific isobaric heat capacity of saturated liquid	kJ/(kg·K)	[1], [2], [16]	3/14

Functional Dependence	Function Name in Excel®	Call as Fortran Program	Property or Function	Unit of Result	Reference	Page
$c_{p\_sv} = f(p_s, t_s, \xi_{sl})$	cpsv_pstsXisl_SeaWa	= CPSV_PSTSXISL_SEAWA(PS,TS,XISL)	Specific isobaric heat capacity of saturated vapor	kJ/(kg·K)	[1], [2], [16]	3/15
$\eta = f(p, t, \xi)$	eta_ptXI_SeaWa	= ETA_PTXI_SEAWA(P,T,XI)	Dynamic viscosity	Pa·s	[1], [2], [16]	3/16
$\eta_l = f(t, \xi)$	etal_tXI_SeaWa	= ETAL_TXI_SEAWA(T,XI)	Dynamic viscosity of subcooled liquid	Pa·s	[1], [2], [16]	3/17
$\eta_{sl} = f(p_s, t_s, \xi_{sl})$	etasl_pstsXIsl_SeaWa	= ETASL_PSTSXISL_SEAWA(PS,TS,XISL)	Dynamic viscosity of saturated liquid	Pa·s	[1], [2], [16]	3/18
$\eta_{sv} = f(p_s, t_s, \xi_{sl})$	etasv_pstsXisl_SeaWa	= ETASV_PSTSXISL_SEAWA(PS,TS,XISL)	Dynamic viscosity of saturated vapor	Pa·s	[1], [2], [16]	3/19
$f_l = f(p, t, \xi)$	fl_ptXI_SeaWa	= FL_PTXI_SEAWA(P,T,XI)	Specific Helmholtz energy of l subcooled iquid	kJ/kg	[1], [16]	3/20
$f_{sl} = f(p_s, t_s, \xi_{sl})$	fsl_pstsXIsl_SeaWa	= FSL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific Helmholtz energy of saturated liquid	kJ/kg	[1], [16]	3/21
$\phi_l = f(p, t, \xi)$	phil_ptXI_SeaWa	= PHIL_PTXI_SEAWA(P,T,XI)	Osmotic coefficient of liquid	[-]	[1], [16]	3/22
$\phi_{sl} = f(p_s, t_s, \xi_{sl})$	phisl_pstsXIsl_SeaWa	= PHISL_PSTSXISL_SEAWA(PS,TS,XISL)	Osmotic coefficient of saturated liquid	[-]	[1], [16]	3/23
$h = f(p, t, \xi)$	h_ptXI_SeaWa	= H_PTXI_SEAWA(P,T,XI)	Specific enthalpy	kJ/kg	[1], [2], [16]	3/24
$h_l = f(p, t, \xi)$	hl_ptXI_SeaWa	= HL_PTXI_SEAWA(P,T,XI)	Specific enthalpy of subcooled liquid	kJ/kg	[1], [2], [16]	3/25
$h_{sl} = f(p_s, t_s, \xi_{sl})$	hsl_pstsXisl_SeaWa	= HSL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific enthalpy of saturated liquid	kJ/kg	[1], [2], [16]	3/26
$h_{sv} = f(p_s, t_s, \xi_{sl})$	hsv_pstsXisl_SeaWa	= HSV_PSTSXISL_SEAWA(PS,TS,XISL)	Specific enthalpy of saturated steam	kJ/kg	[1], [2], [16]	3/27
$\kappa = f(p, t, \xi)$	kappa_ptXI_SeaWa	= KAPPA_PTXI_SEAWA(P,T,XI)	Isentropic exponent	[-]	[1], [16]	3/28
$\kappa_l = f(p, t, \xi)$	kappal_ptXI_SeaWa	= KAPPAL_PTXI_SEAWA(P,T,XI)	Isentropic exponent of subcooled liquid	[-]	[1], [16]	3/29
Functional Dependence	Function Name in Excel®	Call as Fortran Program	Property or Function	Unit of Result	Reference	Page

$\kappa_{sl} = f(p_s, t_s, \xi_{sl})$	kappasl_pstsXisl_SeaWa	= KAPPASL_PSTSXISL_SEAWA(PS,TS,XISL)	Isentropic exponent of saturated liquid	[-]	[1], [16]	3/30
$\kappa_{sv} = f(p_s, t_s, \xi_{sl})$	kappasv_pstsXisl_SeaWa	= KAPPASV_PSTSXISL_SEAWA(PS,TS,XISL)	Isentropic exponent of saturated vapor	[-]	[1], [16]	3/31
$\kappa_{T\_l} = f(p, t, \xi)$	kappaTl_ptXI_SeaWa	= KAPPATL_PTXI_SEAWA(P,T,XI)	Isothermal compressibility of subcooled liquid	1/kPa	[1], [16]	3/32
$\kappa_{T\_sl} = f(p_s, t_s, \xi_{sl})$	kappaTsl_pstsXisl_SeaWa	= KAPPATSL_PSTSXISL_SEAWA(PS,TS,XISL)	Isothermal compressibility of saturated liquid	1/kPa	[1], [16]	3/33
$\kappa_{ls\_l} = f(p, t, \xi)$	kappaIsl_ptXI_SeaWa	= KAPPAISL_PTXI_SEAWA(P,T ,XI)	Isentropic compressibility of subcooled liquid	1/kPa	[1], [16]	3/34
$\kappa_{ls\_sl} = f(p_s, t_s, \xi_{sl})$	kappaIssl_pstsXisl_SeaWa	= KAPPAISSL_PSTSXISL_SEAWA(PS,TS,XISL)	Isentropic compressibility of saturated liquid	1/kPa	[1], [16]	3/35
$\lambda = f(p, t, \xi)$	lambda_ptXI_SeaWa	= LAMBDA_PTXI_SEAWA(P,T,XI)	Thermal conductivity	W/(m·K)	[3], [4], [15]	3/36
$\lambda_l = f(t, \xi)$	lambdal_tXI_SeaWa	= LAMBDAL_TXI_SEAWA(T,XI)	Thermal conductivity of subcooled liquid	W/(m·K)	[3], [4], [15]	3/37
$\lambda_{sl} = f(p_s, t_s, \xi_{sl})$	lambdasl_pstsXisl_SeaWa	= LAMBDASL_PSTSXISL_SEAWA(PS,TS,XISL)	Thermal conductivity of saturated liquid	W/(m·K)	[3], [4], [15]	3/38
$\lambda_{sv} = f(p_s, t_s, \xi_{sl})$	lambdasv_pstsXisl_SeaWa	= LAMBDASV_PSTSXISL_SEAWA(PS,TS,XISL)	Thermal conductivity of saturated vapor	W/(m·K)	[3], [4], [15]	3/39
$\mu_l = f(p, t, \xi)$	myl_ptXI_SeaWa	= MYL_PTXI_SEAWA(P,T,XI)	Relative chem. potential of subcooled liquid	kJ/kg	[1], [16]	3/40
$\mu_{sl} = f(p_s, t_s, \xi_{sl})$	mysl_pstsXisl_SeaWa	= MYSL_PSTSXISL_SEAWA(PS,TS,XISL)	Relative chem. potential of saturated liquid	kJ/kg	[1], [16]	3/41
$\mu_{W\_l} = f(p, t, \xi)$	mywl_ptXI_SeaWa	= MYWL_PTXI_SEAWA(P,T,XI)	Relative chem. potential of H_2O of subcooled liquid	kJ/kg	[1], [16]	3/42
$\mu_{W\_sl} = f(p_s, t_s, \xi_{sl})$	mywsl_pstsXisl_SeaWa	= MYWSL_PSTSXISL_SEAWA(PS,TS,XISL)	Relative chem. potential of H_2O of saturated liquid	kJ/kg	[1], [16]	3/43
Functional Dependence	**Function Name in Excel®**	**Call as Fortran Program**	**Property or Function**	**Unit of Result**	**Reference**	**Page**
$\mu_{Salt\_l} = f(p, t, \xi)$	mySaltl_ptXI_SeaWa	= MYSALTL_PTXI_SEAWA(P,T,XI)	Relative chem. potential of sea salt of subcooled liquid	kJ/kg	[1], [16]	3/44

$\mu_{\mathrm{Salt\_sl}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}}$	mySaltsl_pstsXisl_SeaWa	= MYSALTSL_PSTSXISL_SEAWA(PS,TS,XISL)	Relative chem. potential of sea salt of saturated liquid	kJ/kg	[1], [16]	3/45
$v = \mathrm{f}(p,t,\xi)$	ny_ptXI_SeaWa	= NY_PTXI_SEAWA(P,T,XI)	Kinematic viscosity	m²/s	[1], [2], [16]	3/46
$v_{\mathrm{l}} = \mathrm{f}(t,\xi)$	nyl_tXI_SeaWa	= NYL_TXI_SEAWA(T,XI)	Kinematic viscosity of subcooled liquid	m²/s	[1], [2], [16]	3/47
$v_{\mathrm{sl}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	nysl_pstsXIsl_SeaWa	= NYSL_PSTSXISL_SEAWA(PS,TS,XISL)	Kinematic viscosity of saturated liquid	m²/s	[1], [2], [16]	3/48
$v_{\mathrm{sv}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	nysv_pstsXisl_SeaWa	= NYSV_PSTSXISL_SEAWA(PS,TS,XISL)	Kinematic viscosity of saturated vapor	m²/s	[1], [2], [16]	3/49
$p_{\mathrm{s}} = \mathrm{f}(t_{\mathrm{s}},\xi_{\mathrm{sl}})$	ps_tsXisl_SeaWa	= PS_TSXISL_SEAWA(TS,XISL)	Boiling pressure	bar	[1], [2], [4], [16]	3/50
$p_{\mathrm{mel}} = \mathrm{f}(t,\xi)$	pmel_tXi_SeaWa	= PMEL_TXI_SEAWA(T,XI)	Freezing pressure	bar	[1], [4], [5], [16]	3/51
$p_{\mathrm{tr}} = \mathrm{f}(\xi)$	ptr_Xi_SeaWa	= PTR_XI_SEAWA(T,XI)	Triple point pressure	bar	[1], [4], [5], [16]	3/52
$\mathrm{Pr} = \mathrm{f}(p,t,\xi)$	Pr_ptXI_SeaWa	= PR_PTXI_SEAWA(P,T,XI)	Prandtl Number	[-]	[1], [2], [3], [16]	3/53
$\mathrm{Pr}_{\mathrm{l}} = \mathrm{f}(t,\xi)$	Prl_tXI_SeaWa	= PRL_TXI_SEAWA(T,XI)	Prandtl Number of subcooled liquid	[-]	[1], [2], [3], [16]	3/54
$\mathrm{Pr}_{\mathrm{sl}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	Prsl_pstsXisl_SeaWa	= PRSL_PSTSXISL_SEAWA(PS,TS,XISL)	Prandtl Number of saturated liquid	[-]	[1], [2], [3], [16]	3/55
$\mathrm{Pr}_{\mathrm{sv}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	Prsv_pstsXisl_SeaWa	= PRSV_PSTSXISL_SEAWA(PS,TS,XISL)	Prandtl Number of saturated vapor	[-]	[1], [2], [3], [16]	3/56
$\rho = \mathrm{f}(p,t,\xi)$	rho_ptXI_SeaWa	= RHO_PTXI_SEAWA(P,T,XI)	Density	kg/m³	[1], [2], [16]	3/57
$\rho_{\mathrm{l}} = \mathrm{f}(p,t,\xi)$	rhol_ptXI_SeaWa	= RHOL_PTXI_SEAWA(P,T,XI)	Density of subcooled liquid	kg/m³	[1], [2], [16]	3/58
Functional Dependence	**Function Name in Excel®**	**Call as Fortran Program**	**Property or Function**	**Unit of Result**	**Reference**	**Page**
$\rho_{\mathrm{sl}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	rhosl_pstsXisl_SeaWa	= RHOSL_PSTSXISL_SEAWA(PS,TS,XISL)	Density of saturated liquid	kg/m³	[1], [2], [16]	3/59
$\rho_{\mathrm{sv}} = \mathrm{f}(p_{\mathrm{s}},t_{\mathrm{s}},\xi_{\mathrm{sl}})$	rhosv_pstsXisl_SeaWa	= RHOSV_PSTSXISL_SEAWA(PS,TS,XISL)	Density of saturated vapor	kg/m³	[1], [2], [16]	3/60

$s = f(p,t,\xi)$	s_ptXI_SeaWa	= S_PTXI_SEAWA(P,T,XI)	Specific entropy	kJ/(kg·K)	[1], [2], [16]	3/61
$s_l = f(p,t,\xi)$	sl_ptXI_SeaWa	= SL_PTXI_SEAWA(P,T,XI)	Specific entropy of subcooled liquid	kJ/(kg·K)	[1], [2], [16]	3/62
$s_{sl} = f(p_s,t_s,\xi_{sl})$	ssl_pstsXisl_SeaWa	= SSL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific entropy of saturated liquid	kJ/(kg·K)	[1], [2], [16]	3/63
$s_{sv} = f(p_s,t_s,\xi_{sl})$	ssv_pstsXisl_SeaWa	= SSV_PSTSXISL_SEAWA(PS,TS,XISL)	Specific entropy of saturated vapor	kJ/(kg·K)	[1], [2], [16]	3/64
$t_s = f(p_s,\xi_{sl})$	ts_psXisl_SeaWa	= TS_PSXISL_SEAWA(PS,XISL)	Boiling temperature	°C	[1], [2], [4], [16]	3/65
$t_{mel} = f(p,\xi)$	tmel_pXi_SeaWa	= TMEL_PXI_SEAWA(P,XI)	Freezing temperature	°C	[1], [4], [5], [16]	3/66
$t_{tr} = f(\xi)$	ttr_Xi_SeaWa	= TTR_XI_SEAWA(T,XI)	Triple point temperature	°C	[1], [4], [5], [16]	3/67
$\mathrm{Region} = f(p,t,\xi)$	Region_ptXI_SeaWa	= REGION_PTXI_SEAWA(P,T,XI)	Region	[-]	[1], [2], [4], [16]	3/68
$\mathrm{Region} = f(p,h,\xi)$	Region_phXI_SeaWa	= REGION_PHXI_SEAWA(P,H,XI)	Region	[-]	[1], [2], [4], [16]	3/69
$\mathrm{Region} = f(p,s,\xi)$	Region_psXI_SeaWa	= REGION_PSXI_SEAWA(P,S,XI)	Region	[-]	[1], [2], [4], [16]	3/70
$t = f(p,h,\xi)$	t_phXI_SeaWa	= T_PHXI_SEAWA(P,H,XI)	Backward function: Temperature from pressure and specific enthalpy	°C	[1], [2], [4], [16]	3/71
$t = f(p,s,\xi)$	t_psXI_SeaWa	= T_PSXI_SEAWA(P,S,XI)	Backward function: Temperature from pressure and specific entropy	°C	[1], [2], [4], [16]	3/72
Functional Dependence	**Function Name in Excel®**	**Call as Fortran Program**	**Property or Function**	**Unit of Result**	**Reference**	**Page**
$u = f(p,t,\xi)$	u_ptXI_SeaWa	= U_PTXI_SEAWA(P,T,XI)	Specific internal energy	kJ/kg	[1], [2], [16]	3/73
$u_l = f(p,t,\xi)$	ul_ptXI_SeaWa	= UL_PTXI_SEAWA(P,T,XI)	Specific internal energy of subcooled liquid	kJ/kg	[1], [2], [16]	3/74
$u_{sl} = f(p_s,t_s,\xi_{sl})$	usl_pstsXisl_SeaWa	= USL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific internal energy of saturated liquid	kJ/kg	[1], [2], [16]	3/75

$u_{sv} = f(p_s, t_s, \xi_{sl})$	usv_pstsXisl_SeaWa	= USV_PSTSXISL_SEAWA(PS,TS,XISL)	Specific internal energy of saturated vapor	kJ/kg	[1], [2], [16]	3/76
$\upsilon = f(p, t, \xi)$	v_ptXI_SeaWa	= V_PTXI_SEAWA(P,T,XI)	Specific volume	m³/kg	[1], [2], [16]	3/77
$\upsilon_l = f(p, t, \xi)$	vl_ptXI_SeaWa	= VL_PTXI_SEAWA(P,T,XI)	Specific internal energy of subcooled liquid	m³/kg	[1], [2], [16]	3/78
$\upsilon_{sl} = f(p_s, t_s, \xi_{sl})$	vsl_pstsXisl_SeaWa	= VSL_PSTSXISL_SEAWA(PS,TS,XISL)	Specific volume of saturated liquid	m³/kg	[1], [2], [16]	3/79
$\upsilon_{sv} = f(p_s, t_s, \xi_{sl})$	vsv_pstsXisl_SeaWa	= VSV_PSTSXISL_SEAWA(PS,TS,XISL)	Specific volume of saturated vapor	m³/kg	[1], [2], [16]	3/80
$w = f(p, t, \xi)$	w_ptXI_SeaWa	= W_PTXI_SEAWA(P,T,XI)	Speed of sound	m/s	[1], [16]	3/81
$w_l = f(p, t, \xi)$	wl_ptXI_SeaWa	= WL_PTXI_SEAWA(P,T,XI)	Speed of sound of liquid	m/s	[1], [16]	3/82
$w_{sl} = f(p_s, t_s, \xi_{sl})$	wsl_pstsXisl_SeaWa	= WSL_PSTSXISL_SEAWA(PS,TS,XISL)	Speed of sound of saturated liquid	m/s	[1], [16]	3/83
$w_{sv} = f(p_s, t_s, \xi_{sl})$	wsv_pstsXisl_SeaWa	= WSV_PSTSXISL_SEAWA(PS,TS,XISL)	Speed of sound of saturated vapor	m/s	[1], [16]	3/84
$x = f(p, t, \xi)$	x_ptXI_SeaWa	= X_PTXI_SEAWA(P,T,XI)	Vapor fraction	kg/kg	[1], [16]	3/85
$\xi_{sl} = f(p_s, t_s)$	Xisl_psts_SeaWa	= XISL_PSTS_SEAWA(PS,TS)	Mass fraction of sea salt in saturated liquid	kg/kg	[1], [16]	3/86
$\xi_{sv} = f(p_s, t_s)$	Xisv_psts_SeaWa	= XISV_PSTS_SEAWA(PS,TS)	Mass fraction of sea salt in saturated vapor	kg/kg	[1], [16]	3/87

Range of Validity

Pressure:	0.002 093	≤	p	≤	1000	bar
Temperature:	−12.15	≤	t	≤	220	°C
Salinity:	0	≤	ξ	≤	0.2	$kg_{salt}/kg_{mixture}$

Reference State

Property	SeaWater
Pressure	1.01325 bar
Temperature	0 °C
Salinity	0.003516504 kg/kg
Enthalpy	0 kJ/kg
Entropy	0 kJ/(kg·K)

Variable Types for Function Call

All functions and variables:	REAL*8

Property functions with deviation to the range of validity (cp. Chapter 3)