' water97\_v13: A collection of Visual Basic functions

' for calculating properties of water and steam.

'

' Source: IAPWS-IF97. For details see

' http://www.cheresources.com/iapwsif97.shtml

'

' Version 1.3, 02/10/02: documentation updated

'

' Version 1.2, 02/06/01: starting value for iteration in densreg3 for

' supercritical temperatures changed from 500 to 600

'

'

' Version 1.1, 01/29/01: mistake in calculation of partial derivatives

' for thermal conductivity corrected

'

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'

'

Public Const rgas\_water As Double = 461.526 'gas constant in J/(kg K)

Public Const tc\_water As Double = 647.096 'critical temperature in K

Public Const pc\_water As Double = 220.64 'critical pressure in bar

Public Const dc\_water As Double = 322# 'critical density in kg/m\*\*3

Private ireg1(1 To 34) As Integer

Private jreg1(1 To 34) As Integer

Private nreg1(1 To 34) As Double

Private j0reg2(1 To 9) As Integer

Private n0reg2(1 To 9) As Double

Private ireg2(1 To 43) As Integer

Private jreg2(1 To 43) As Integer

Private nreg2(1 To 43) As Double

Private ireg3(1 To 40) As Integer

Private jreg3(1 To 40) As Integer

Private nreg3(1 To 40) As Double

Private nreg4(1 To 10) As Double

Private nbound(1 To 5) As Double

Private n0visc(0 To 3) As Double

Private ivisc(1 To 19) As Integer

Private jvisc(1 To 19) As Integer

Private nvisc(1 To 19) As Double

Private n0thcon(0 To 3) As Double

Private nthcon(0 To 4, 0 To 5) As Double

'

'

'

Sub InitFieldsreg1()

'

' Initialize coefficients and exponents for region 1

'

ireg1(1) = 0

ireg1(2) = 0

ireg1(3) = 0

ireg1(4) = 0

ireg1(5) = 0

ireg1(6) = 0

ireg1(7) = 0

ireg1(8) = 0

ireg1(9) = 1

ireg1(10) = 1

ireg1(11) = 1

ireg1(12) = 1

ireg1(13) = 1

ireg1(14) = 1

ireg1(15) = 2

ireg1(16) = 2

ireg1(17) = 2

ireg1(18) = 2

ireg1(19) = 2

ireg1(20) = 3

ireg1(21) = 3

ireg1(22) = 3

ireg1(23) = 4

ireg1(24) = 4

ireg1(25) = 4

ireg1(26) = 5

ireg1(27) = 8

ireg1(28) = 8

ireg1(29) = 21

ireg1(30) = 23

ireg1(31) = 29

ireg1(32) = 30

ireg1(33) = 31

ireg1(34) = 32

'

jreg1(1) = -2

jreg1(2) = -1

jreg1(3) = 0

jreg1(4) = 1

jreg1(5) = 2

jreg1(6) = 3

jreg1(7) = 4

jreg1(8) = 5

jreg1(9) = -9

jreg1(10) = -7

jreg1(11) = -1

jreg1(12) = 0

jreg1(13) = 1

jreg1(14) = 3

jreg1(15) = -3

jreg1(16) = 0

jreg1(17) = 1

jreg1(18) = 3

jreg1(19) = 17

jreg1(20) = -4

jreg1(21) = 0

jreg1(22) = 6

jreg1(23) = -5

jreg1(24) = -2

jreg1(25) = 10

jreg1(26) = -8

jreg1(27) = -11

jreg1(28) = -6

jreg1(29) = -29

jreg1(30) = -31

jreg1(31) = -38

jreg1(32) = -39

jreg1(33) = -40

jreg1(34) = -41

'

nreg1(1) = 0.14632971213167

nreg1(2) = -0.84548187169114

nreg1(3) = -3.756360367204

nreg1(4) = 3.3855169168385

nreg1(5) = -0.95791963387872

nreg1(6) = 0.15772038513228

nreg1(7) = -0.016616417199501

nreg1(8) = 8.1214629983568E-04

nreg1(9) = 2.8319080123804E-04

nreg1(10) = -6.0706301565874E-04

nreg1(11) = -0.018990068218419

nreg1(12) = -0.032529748770505

nreg1(13) = -0.021841717175414

nreg1(14) = -5.283835796993E-05

nreg1(15) = -4.7184321073267E-04

nreg1(16) = -3.0001780793026E-04

nreg1(17) = 4.7661393906987E-05

nreg1(18) = -4.4141845330846E-06

nreg1(19) = -7.2694996297594E-16

nreg1(20) = -3.1679644845054E-05

nreg1(21) = -2.8270797985312E-06

nreg1(22) = -8.5205128120103E-10

nreg1(23) = -2.2425281908E-06

nreg1(24) = -6.5171222895601E-07

nreg1(25) = -1.4341729937924E-13

nreg1(26) = -4.0516996860117E-07

nreg1(27) = -1.2734301741641E-09

nreg1(28) = -1.7424871230634E-10

nreg1(29) = -6.8762131295531E-19

nreg1(30) = 1.4478307828521E-20

nreg1(31) = 2.6335781662795E-23

nreg1(32) = -1.1947622640071E-23

nreg1(33) = 1.8228094581404E-24

nreg1(34) = -9.3537087292458E-26

'

End Sub

'

'

'

Sub InitFieldsreg2()

'

' Initialize coefficients and exponents for region 2

'

j0reg2(1) = 0

j0reg2(2) = 1

j0reg2(3) = -5

j0reg2(4) = -4

j0reg2(5) = -3

j0reg2(6) = -2

j0reg2(7) = -1

j0reg2(8) = 2

j0reg2(9) = 3

'

n0reg2(1) = -9.6927686500217

n0reg2(2) = 10.086655968018

n0reg2(3) = -0.005608791128302

n0reg2(4) = 0.071452738081455

n0reg2(5) = -0.40710498223928

n0reg2(6) = 1.4240819171444

n0reg2(7) = -4.383951131945

n0reg2(8) = -0.28408632460772

n0reg2(9) = 0.021268463753307

'

ireg2(1) = 1

ireg2(2) = 1

ireg2(3) = 1

ireg2(4) = 1

ireg2(5) = 1

ireg2(6) = 2

ireg2(7) = 2

ireg2(8) = 2

ireg2(9) = 2

ireg2(10) = 2

ireg2(11) = 3

ireg2(12) = 3

ireg2(13) = 3

ireg2(14) = 3

ireg2(15) = 3

ireg2(16) = 4

ireg2(17) = 4

ireg2(18) = 4

ireg2(19) = 5

ireg2(20) = 6

ireg2(21) = 6

ireg2(22) = 6

ireg2(23) = 7

ireg2(24) = 7

ireg2(25) = 7

ireg2(26) = 8

ireg2(27) = 8

ireg2(28) = 9

ireg2(29) = 10

ireg2(30) = 10

ireg2(31) = 10

ireg2(32) = 16

ireg2(33) = 16

ireg2(34) = 18

ireg2(35) = 20

ireg2(36) = 20

ireg2(37) = 20

ireg2(38) = 21

ireg2(39) = 22

ireg2(40) = 23

ireg2(41) = 24

ireg2(42) = 24

ireg2(43) = 24

'

jreg2(1) = 0

jreg2(2) = 1

jreg2(3) = 2

jreg2(4) = 3

jreg2(5) = 6

jreg2(6) = 1

jreg2(7) = 2

jreg2(8) = 4

jreg2(9) = 7

jreg2(10) = 36

jreg2(11) = 0

jreg2(12) = 1

jreg2(13) = 3

jreg2(14) = 6

jreg2(15) = 35

jreg2(16) = 1

jreg2(17) = 2

jreg2(18) = 3

jreg2(19) = 7

jreg2(20) = 3

jreg2(21) = 16

jreg2(22) = 35

jreg2(23) = 0

jreg2(24) = 11

jreg2(25) = 25

jreg2(26) = 8

jreg2(27) = 36

jreg2(28) = 13

jreg2(29) = 4

jreg2(30) = 10

jreg2(31) = 14

jreg2(32) = 29

jreg2(33) = 50

jreg2(34) = 57

jreg2(35) = 20

jreg2(36) = 35

jreg2(37) = 48

jreg2(38) = 21

jreg2(39) = 53

jreg2(40) = 39

jreg2(41) = 26

jreg2(42) = 40

jreg2(43) = 58

'

nreg2(1) = -1.7731742473213E-03

nreg2(2) = -0.017834862292358

nreg2(3) = -0.045996013696365

nreg2(4) = -0.057581259083432

nreg2(5) = -0.05032527872793

nreg2(6) = -3.3032641670203E-05

nreg2(7) = -1.8948987516315E-04

nreg2(8) = -3.9392777243355E-03

nreg2(9) = -0.043797295650573

nreg2(10) = -2.6674547914087E-05

nreg2(11) = 2.0481737692309E-08

nreg2(12) = 4.3870667284435E-07

nreg2(13) = -3.227767723857E-05

nreg2(14) = -1.5033924542148E-03

nreg2(15) = -0.040668253562649

nreg2(16) = -7.8847309559367E-10

nreg2(17) = 1.2790717852285E-08

nreg2(18) = 4.8225372718507E-07

nreg2(19) = 2.2922076337661E-06

nreg2(20) = -1.6714766451061E-11

nreg2(21) = -2.1171472321355E-03

nreg2(22) = -23.895741934104

nreg2(23) = -5.905956432427E-18

nreg2(24) = -1.2621808899101E-06

nreg2(25) = -0.038946842435739

nreg2(26) = 1.1256211360459E-11

nreg2(27) = -8.2311340897998

nreg2(28) = 1.9809712802088E-08

nreg2(29) = 1.0406965210174E-19

nreg2(30) = -1.0234747095929E-13

nreg2(31) = -1.0018179379511E-09

nreg2(32) = -8.0882908646985E-11

nreg2(33) = 0.10693031879409

nreg2(34) = -0.33662250574171

nreg2(35) = 8.9185845355421E-25

nreg2(36) = 3.0629316876232E-13

nreg2(37) = -4.2002467698208E-06

nreg2(38) = -5.9056029685639E-26

nreg2(39) = 3.7826947613457E-06

nreg2(40) = -1.2768608934681E-15

nreg2(41) = 7.3087610595061E-29

nreg2(42) = 5.5414715350778E-17

nreg2(43) = -9.436970724121E-07

'

End Sub

'

'

'

Sub InitFieldsreg3()

'

' Initialize coefficients and exponents for region 3

'

ireg3(1) = 0

ireg3(2) = 0

ireg3(3) = 0

ireg3(4) = 0

ireg3(5) = 0

ireg3(6) = 0

ireg3(7) = 0

ireg3(8) = 0

ireg3(9) = 1

ireg3(10) = 1

ireg3(11) = 1

ireg3(12) = 1

ireg3(13) = 2

ireg3(14) = 2

ireg3(15) = 2

ireg3(16) = 2

ireg3(17) = 2

ireg3(18) = 2

ireg3(19) = 3

ireg3(20) = 3

ireg3(21) = 3

ireg3(22) = 3

ireg3(23) = 3

ireg3(24) = 4

ireg3(25) = 4

ireg3(26) = 4

ireg3(27) = 4

ireg3(28) = 5

ireg3(29) = 5

ireg3(30) = 5

ireg3(31) = 6

ireg3(32) = 6

ireg3(33) = 6

ireg3(34) = 7

ireg3(35) = 8

ireg3(36) = 9

ireg3(37) = 9

ireg3(38) = 10

ireg3(39) = 10

ireg3(40) = 11

'

jreg3(1) = 0

jreg3(2) = 0

jreg3(3) = 1

jreg3(4) = 2

jreg3(5) = 7

jreg3(6) = 10

jreg3(7) = 12

jreg3(8) = 23

jreg3(9) = 2

jreg3(10) = 6

jreg3(11) = 15

jreg3(12) = 17

jreg3(13) = 0

jreg3(14) = 2

jreg3(15) = 6

jreg3(16) = 7

jreg3(17) = 22

jreg3(18) = 26

jreg3(19) = 0

jreg3(20) = 2

jreg3(21) = 4

jreg3(22) = 16

jreg3(23) = 26

jreg3(24) = 0

jreg3(25) = 2

jreg3(26) = 4

jreg3(27) = 26

jreg3(28) = 1

jreg3(29) = 3

jreg3(30) = 26

jreg3(31) = 0

jreg3(32) = 2

jreg3(33) = 26

jreg3(34) = 2

jreg3(35) = 26

jreg3(36) = 2

jreg3(37) = 26

jreg3(38) = 0

jreg3(39) = 1

jreg3(40) = 26

'

nreg3(1) = 1.0658070028513

nreg3(2) = -15.732845290239

nreg3(3) = 20.944396974307

nreg3(4) = -7.6867707878716

nreg3(5) = 2.6185947787954

nreg3(6) = -2.808078114862

nreg3(7) = 1.2053369696517

nreg3(8) = -8.4566812812502E-03

nreg3(9) = -1.2654315477714

nreg3(10) = -1.1524407806681

nreg3(11) = 0.88521043984318

nreg3(12) = -0.64207765181607

nreg3(13) = 0.38493460186671

nreg3(14) = -0.85214708824206

nreg3(15) = 4.8972281541877

nreg3(16) = -3.0502617256965

nreg3(17) = 0.039420536879154

nreg3(18) = 0.12558408424308

nreg3(19) = -0.2799932969871

nreg3(20) = 1.389979956946

nreg3(21) = -2.018991502357

nreg3(22) = -8.2147637173963E-03

nreg3(23) = -0.47596035734923

nreg3(24) = 0.0439840744735

nreg3(25) = -0.44476435428739

nreg3(26) = 0.90572070719733

nreg3(27) = 0.70522450087967

nreg3(28) = 0.10770512626332

nreg3(29) = -0.32913623258954

nreg3(30) = -0.50871062041158

nreg3(31) = -0.022175400873096

nreg3(32) = 0.094260751665092

nreg3(33) = 0.16436278447961

nreg3(34) = -0.013503372241348

nreg3(35) = -0.014834345352472

nreg3(36) = 5.7922953628084E-04

nreg3(37) = 3.2308904703711E-03

nreg3(38) = 8.0964802996215E-05

nreg3(39) = -1.6557679795037E-04

nreg3(40) = -4.4923899061815E-05

'

End Sub

'

'

'

Sub InitFieldsreg4()

'

' Initialize coefficients for region 4

'

nreg4(1) = 1167.0521452767

nreg4(2) = -724213.16703206

nreg4(3) = -17.073846940092

nreg4(4) = 12020.82470247

nreg4(5) = -3232555.0322333

nreg4(6) = 14.91510861353

nreg4(7) = -4823.2657361591

nreg4(8) = 405113.40542057

nreg4(9) = -0.23855557567849

nreg4(10) = 650.17534844798

'

End Sub

'

'

'

Sub InitFieldsbound()

'

' Initialize coefficients for boundary equation

'

nbound(1) = 348.05185628969

nbound(2) = -1.1671859879975

nbound(3) = 1.0192970039326E-03

nbound(4) = 572.54459862746

nbound(5) = 13.91883977887

'

End Sub

'

'

'

Sub InitFieldsvisc()

'

' Initialize coefficients and exponents for viscosity

'

n0visc(0) = 1#

n0visc(1) = 0.978197

n0visc(2) = 0.579829

n0visc(3) = -0.202354

'

ivisc(1) = 0

ivisc(2) = 0

ivisc(3) = 0

ivisc(4) = 0

ivisc(5) = 1

ivisc(6) = 1

ivisc(7) = 1

ivisc(8) = 1

ivisc(9) = 2

ivisc(10) = 2

ivisc(11) = 2

ivisc(12) = 3

ivisc(13) = 3

ivisc(14) = 3

ivisc(15) = 3

ivisc(16) = 4

ivisc(17) = 4

ivisc(18) = 5

ivisc(19) = 6

'

jvisc(1) = 0

jvisc(2) = 1

jvisc(3) = 4

jvisc(4) = 5

jvisc(5) = 0

jvisc(6) = 1

jvisc(7) = 2

jvisc(8) = 3

jvisc(9) = 0

jvisc(10) = 1

jvisc(11) = 2

jvisc(12) = 0

jvisc(13) = 1

jvisc(14) = 2

jvisc(15) = 3

jvisc(16) = 0

jvisc(17) = 3

jvisc(18) = 1

jvisc(19) = 3

'

nvisc(1) = 0.5132047

nvisc(2) = 0.3205656

nvisc(3) = -0.7782567

nvisc(4) = 0.1885447

nvisc(5) = 0.2151778

nvisc(6) = 0.7317883

nvisc(7) = 1.241044

nvisc(8) = 1.476783

nvisc(9) = -0.2818107

nvisc(10) = -1.070786

nvisc(11) = -1.263184

nvisc(12) = 0.1778064

nvisc(13) = 0.460504

nvisc(14) = 0.2340379

nvisc(15) = -0.4924179

nvisc(16) = -0.0417661

nvisc(17) = 0.1600435

nvisc(18) = -0.01578386

nvisc(19) = -0.003629481

'

End Sub

'

'

'

Sub InitFieldsthcon()

'

' Initialize coefficients and exponents for thermal conductivity

'

n0thcon(0) = 1#

n0thcon(1) = 6.978267

n0thcon(2) = 2.599096

n0thcon(3) = -0.998254

'

nthcon(0, 0) = 1.3293046

nthcon(0, 1) = -0.40452437

nthcon(0, 2) = 0.2440949

nthcon(0, 3) = 0.018660751

nthcon(0, 4) = -0.12961068

nthcon(0, 5) = 0.044809953

nthcon(1, 0) = 1.7018363

nthcon(1, 1) = -2.2156845

nthcon(1, 2) = 1.6511057

nthcon(1, 3) = -0.76736002

nthcon(1, 4) = 0.37283344

nthcon(1, 5) = -0.1120316

nthcon(2, 0) = 5.2246158

nthcon(2, 1) = -10.124111

nthcon(2, 2) = 4.9874687

nthcon(2, 3) = -0.27297694

nthcon(2, 4) = -0.43083393

nthcon(2, 5) = 0.13333849

nthcon(3, 0) = 8.7127675

nthcon(3, 1) = -9.5000611

nthcon(3, 2) = 4.3786606

nthcon(3, 3) = -0.91783782

nthcon(3, 4) = 0#

nthcon(3, 5) = 0#

nthcon(4, 0) = -1.8525999

nthcon(4, 1) = 0.9340469

nthcon(4, 2) = 0#

nthcon(4, 3) = 0#

nthcon(4, 4) = 0#

nthcon(4, 5) = 0#

'

End Sub

'

'

'

Private Function gammareg1(tau, pi)

'

' Fundamental equation for region 1

'

Call InitFieldsreg1

gammareg1 = 0

For i = 1 To 34

gammareg1 = gammareg1 + nreg1(i) \* (7.1 - pi) ^ ireg1(i) \* (tau - 1.222) ^ jreg1(i)

Next i

'

End Function

'

'

'

Private Function gammapireg1(tau, pi)

'

' First derivative of fundamental equation in pi for region 1

'

Call InitFieldsreg1

gammapireg1 = 0

For i = 1 To 34

gammapireg1 = gammapireg1 - nreg1(i) \* ireg1(i) \* (7.1 - pi) ^ (ireg1(i) - 1) \* (tau - 1.222) ^ jreg1(i)

Next i

'

End Function

'

'

'

Private Function gammapipireg1(tau, pi)

'

' Second derivative of fundamental equation in pi for region 1

'

Call InitFieldsreg1

gammapipireg1 = 0

For i = 1 To 34

gammapipireg1 = gammapipireg1 + nreg1(i) \* ireg1(i) \* (ireg1(i) - 1) \* (7.1 - pi) ^ (ireg1(i) - 2) \* (tau - 1.222) ^ jreg1(i)

Next i

'

End Function

'

'

'

Private Function gammataureg1(tau, pi)

'

' First derivative of fundamental equation in tau for region 1

'

Call InitFieldsreg1

gammataureg1 = 0

For i = 1 To 34

gammataureg1 = gammataureg1 + nreg1(i) \* (7.1 - pi) ^ ireg1(i) \* jreg1(i) \* (tau - 1.222) ^ (jreg1(i) - 1)

Next i

'

End Function

'

'

'

Private Function gammatautaureg1(tau, pi)

'

' Second derivative of fundamental equation in tau for region 1

'

Call InitFieldsreg1

gammatautaureg1 = 0

For i = 1 To 34

gammatautaureg1 = gammatautaureg1 + nreg1(i) \* (7.1 - pi) ^ ireg1(i) \* jreg1(i) \* (jreg1(i) - 1) \* (tau - 1.222) ^ (jreg1(i) - 2)

Next i

'

End Function '

'

'

'

Private Function gammapitaureg1(tau, pi)

'

' Second derivative of fundamental equation in pi and tau for region 1

'

Call InitFieldsreg1

gammapitaureg1 = 0

For i = 1 To 34

gammapitaureg1 = gammapitaureg1 - nreg1(i) \* ireg1(i) \* (7.1 - pi) ^ (ireg1(i) - 1) \* jreg1(i) \* (tau - 1.222) ^ (jreg1(i) - 1)

Next i

'

End Function

'

'

'

Private Function gamma0reg2(tau, pi)

'

' Ideal-gas part of fundamental equation for region 2

'

Call InitFieldsreg2

gamma0reg2 = Log(pi)

For i = 1 To 9

gamma0reg2 = gamma0reg2 + n0reg2(i) \* tau ^ j0reg2(i)

Next i

'

End Function

'

'

'

Private Function gamma0pireg2(tau, pi)

'

' First derivative in pi of ideal-gas part of fundamental equation for region 2

'

gamma0pireg2 = 1 / pi

'

End Function

'

'

'

Private Function gamma0pipireg2(tau, pi)

'

' Second derivative in pi of ideal-gas part of fundamental equation for region 2

'

gamma0pipireg2 = -1 / pi ^ 2

'

End Function

'

'

'

Private Function gamma0taureg2(tau, pi)

'

' First derivative in tau of ideal-gas part of fundamental equation for region 2

'

Call InitFieldsreg2

gamma0taureg2 = 0

For i = 1 To 9

gamma0taureg2 = gamma0taureg2 + n0reg2(i) \* j0reg2(i) \* tau ^ (j0reg2(i) - 1)

Next i

'

End Function

'

'

'

Private Function gamma0tautaureg2(tau, pi)

'

' Second derivative in tau of ideal-gas part of fundamental equation for region 2

'

Call InitFieldsreg2

gamma0tautaureg2 = 0

For i = 1 To 9

gamma0tautaureg2 = gamma0tautaureg2 + n0reg2(i) \* j0reg2(i) \* (j0reg2(i) - 1) \* tau ^ (j0reg2(i) - 2)

Next i

'

End Function

'

'

'

Private Function gamma0pitaureg2(tau, pi)

'

' Second derivative in pi and tau of ideal-gas part of fundamental equation for region 2

'

Call InitFieldsreg2

gamma0pitaureg2 = 0

'

End Function

'

'

'

Private Function gammarreg2(tau, pi)

'

' Residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammarreg2 = 0

For i = 1 To 43

gammarreg2 = gammarreg2 + nreg2(i) \* pi ^ ireg2(i) \* (tau - 0.5) ^ jreg2(i)

Next i

'

End Function

'

'

'

Private Function gammarpireg2(tau, pi)

'

' First derivative in pi of residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammarpireg2 = 0

For i = 1 To 43

gammarpireg2 = gammarpireg2 + nreg2(i) \* ireg2(i) \* pi ^ (ireg2(i) - 1) \* (tau - 0.5) ^ jreg2(i)

Next i

'

End Function

'

'

'

Private Function gammarpipireg2(tau, pi)

'

' Second derivative in pi of residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammarpipireg2 = 0

For i = 1 To 43

gammarpipireg2 = gammarpipireg2 + nreg2(i) \* ireg2(i) \* (ireg2(i) - 1) \* pi ^ (ireg2(i) - 2) \* (tau - 0.5) ^ jreg2(i)

Next i

'

End Function

'

'

'

Private Function gammartaureg2(tau, pi)

'

' First derivative in tau of residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammartaureg2 = 0

For i = 1 To 43

gammartaureg2 = gammartaureg2 + nreg2(i) \* pi ^ ireg2(i) \* jreg2(i) \* (tau - 0.5) ^ (jreg2(i) - 1)

Next i

'

End Function

'

'

'

Private Function gammartautaureg2(tau, pi)

'

' Second derivative in tau of residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammartautaureg2 = 0

For i = 1 To 43

gammartautaureg2 = gammartautaureg2 + nreg2(i) \* pi ^ ireg2(i) \* jreg2(i) \* (jreg2(i) - 1) \* (tau - 0.5) ^ (jreg2(i) - 2)

Next i

'

End Function

'

'

'

Private Function gammarpitaureg2(tau, pi)

'

' Second derivative in pi and tau of residual part of fundamental equation for region 2

'

Call InitFieldsreg2

gammarpitaureg2 = 0

For i = 1 To 43

gammarpitaureg2 = gammarpitaureg2 + nreg2(i) \* ireg2(i) \* pi ^ (ireg2(i) - 1) \* jreg2(i) \* (tau - 0.5) ^ (jreg2(i) - 1)

Next i

'

End Function

'

'

'

Private Function fireg3(tau, delta)

'

' Fundamental equation for region 3

'

Call InitFieldsreg3

fireg3 = nreg3(1) \* Log(delta)

For i = 2 To 40

fireg3 = fireg3 + nreg3(i) \* delta ^ ireg3(i) \* tau ^ jreg3(i)

Next i

'

End Function

'

'

'

Private Function fideltareg3(tau, delta)

'

' First derivative in delta of fundamental equation for region 3

'

Call InitFieldsreg3

fideltareg3 = nreg3(1) / delta

For i = 2 To 40

fideltareg3 = fideltareg3 + nreg3(i) \* ireg3(i) \* delta ^ (ireg3(i) - 1) \* tau ^ jreg3(i)

Next i

'

End Function

'

'

'

Private Function fideltadeltareg3(tau, delta)

'

' Second derivative in delta of fundamental equation for region 3

'

Call InitFieldsreg3

fideltadeltareg3 = -nreg3(1) / delta ^ 2

For i = 2 To 40

fideltadeltareg3 = fideltadeltareg3 + nreg3(i) \* ireg3(i) \* (ireg3(i) - 1) \* delta ^ (ireg3(i) - 2) \* tau ^ jreg3(i)

Next i

'

End Function

'

'

'

Private Function fitaureg3(tau, delta)

'

' First derivative in tau of fundamental equation for region 3

'

Call InitFieldsreg3

fitaureg3 = 0

For i = 2 To 40

fitaureg3 = fitaureg3 + nreg3(i) \* delta ^ ireg3(i) \* jreg3(i) \* tau ^ (jreg3(i) - 1)

Next i

'

End Function

'

'

'

Private Function fitautaureg3(tau, delta)

'

' Second derivative in tau of fundamental equation for region 3

'

Call InitFieldsreg3

fitautaureg3 = 0

For i = 2 To 40

fitautaureg3 = fitautaureg3 + nreg3(i) \* delta ^ ireg3(i) \* jreg3(i) \* (jreg3(i) - 1) \* tau ^ (jreg3(i) - 2)

Next i

'

End Function

'

'

'

Private Function fideltataureg3(tau, delta)

'

' Second derivative in delta and tau of fundamental equation for region 3

'

Call InitFieldsreg3

fideltataureg3 = 0

For i = 2 To 40

fideltataureg3 = fideltataureg3 + nreg3(i) \* ireg3(i) \* delta ^ (ireg3(i) - 1) \* jreg3(i) \* tau ^ (jreg3(i) - 1)

Next i

'

End Function

'

'

'

Private Function psivisc(tau, delta)

'

' Reduced dynamic viscosity

'

Call InitFieldsvisc

psi0 = 0

psi1 = 0

For i = 0 To 3

psi0 = psi0 + n0visc(i) \* tau ^ i

Next i

psi0 = 1 / (tau ^ 0.5 \* psi0)

For i = 1 To 19

psi1 = psi1 + nvisc(i) \* (delta - 1#) ^ ivisc(i) \* (tau - 1#) ^ jvisc(i)

Next i

psi1 = Exp(delta \* psi1)

psivisc = psi0 \* psi1

'

End Function

'

'

'

Private Function lambthcon(temperature, pressure, tau, delta)

'

' Reduced thermal conductivity

'

Call InitFieldsthcon

lamb0 = 0

lamb1 = 0

For i = 0 To 3

lamb0 = lamb0 + n0thcon(i) \* tau ^ i

Next i

lamb0 = 1 / (tau ^ 0.5 \* lamb0)

For i = 0 To 4

For j = 0 To 5

lamb1 = lamb1 + nthcon(i, j) \* (tau - 1#) ^ i \* (delta - 1#) ^ j

Next j

Next i

lamb1 = Exp(delta \* lamb1)

'

' v1.1: calculation of lamb2 corrected

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

taus = 1386# / temperature

pis = pressure / 165.3

dpidtau = (647.226 \* 165.3 \* (gammapitaureg1(taus, pis) \* 1386# - gammapireg1(taus, pis) \* temperature)) / (221.15 \* temperature ^ 2 \* gammapipireg1(taus, pis))

ddeltadpi = -(22115000# \* gammapipireg1(taus, pis)) / (317.763 \* rgas\_water \* temperature \* gammapireg1(taus, pis) ^ 2)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

taus = 540# / temperature

pis = pressure / 10#

dpidtau = (647.226 \* 10# \* ((gamma0pitaureg2(taus, pis) + gammarpitaureg2(taus, pis)) \* 540# - (gamma0pireg2(taus, pis) + gammarpireg2(taus, pis)) \* temperature)) / (221.15 \* temperature ^ 2 \* (gamma0pipireg2(taus, pis) + gammarpipireg2(taus, pis)))

ddeltadpi = -(22115000# \* (gamma0pipireg2(taus, pis) + gammarpipireg2(taus, pis))) / (317.763 \* rgas\_water \* temperature \* (gamma0pireg2(taus, pis) + gammarpireg2(taus, pis)) ^ 2)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

taus = 647.096 / temperature

deltas = delta \* 317.763 / 322#

dpidtau = (647.226 \* rgas\_water \* (delta \* 317.763) ^ 2 \* (fideltareg3(taus, deltas) - (647.096 / temperature) \* fideltataureg3(taus, deltas))) / (22115000# \* 322#)

ddeltadpi = (22115000# \* 322#) / (317.763 \* delta \* 317.763 \* rgas\_water \* temperature \* (2 \* fideltareg3(taus, deltas) + (delta \* 317.763 / 322#) \* fideltadeltareg3(taus, deltas)))

Else

' outside range

dpidtau = 0

ddeltadpi = 0

End If

lamb2 = 0.0013848 / psivisc(tau, delta) \* (tau \* delta) ^ (-2) \* dpidtau ^ 2 \* (delta \* ddeltadpi) ^ 0.4678 \* delta ^ 0.5 \* Exp(-18.66 \* (1 / tau - 1) ^ 2 - (delta - 1) ^ 4)

lambthcon = lamb0 \* lamb1 + lamb2

'

End Function

'

'

'

Public Function pSatW(temperature)

'

' saturation pressure of water

' pSatW in bar

' temperature in K

'

' pSatW = -1: temperature outside range

'

'

If temperature < 273.15 Or temperature > 647.096 Then

pSatW = -1#

Else

Call InitFieldsreg4

del = temperature + nreg4(9) / (temperature - nreg4(10))

aco = del ^ 2 + nreg4(1) \* del + nreg4(2)

bco = nreg4(3) \* del ^ 2 + nreg4(4) \* del + nreg4(5)

cco = nreg4(6) \* del ^ 2 + nreg4(7) \* del + nreg4(8)

pSatW = (2 \* cco / (-bco + (bco ^ 2 - 4 \* aco \* cco) ^ 0.5)) ^ 4 \* 10

End If

'

End Function

'

'

'

Public Function tSatW(pressure)

'

' saturation temperature of water

' tSatW in K

' pressure in bar

'

' tSatW = -1: pressure outside range

'

'

If pressure < 0.00611213 Or pressure > 220.64 Then

tSatW = -1#

Else

Call InitFieldsreg4

bet = (0.1 \* pressure) ^ 0.25

eco = bet ^ 2 + nreg4(3) \* bet + nreg4(6)

fco = nreg4(1) \* bet ^ 2 + nreg4(4) \* bet + nreg4(7)

gco = nreg4(2) \* bet ^ 2 + nreg4(5) \* bet + nreg4(8)

dco = 2 \* gco / (-fco - (fco ^ 2 - 4 \* eco \* gco) ^ 0.5)

tSatW = 0.5 \* (nreg4(10) + dco - ((nreg4(10) + dco) ^ 2 - 4 \* (nreg4(9) + nreg4(10) \* dco)) ^ 0.5)

End If

'

End Function

'

'

'

Private Function pBound(temperature)

'

' boundary pressure between regions 2 and 3

' pBound in bar

' temperature in K

'

' pBound = -1: temperature outside range

'

'

If temperature < 623.15 Or temperature > 863.15 Then

pBound = -1#

Else

Call InitFieldsbound

pBound = (nbound(1) + nbound(2) \* temperature + nbound(3) \* temperature ^ 2) \* 10#

End If

'

End Function

'

'

'

Private Function tBound(pressure)

'

' boundary temperature between regions 2 and 3

' tBound in K

' pressure in bar

'

' tBound = -1: pressure outside range

'

'

If pressure < 165.292 Or pressure > 1000# Then

tBound = -1#

Else

Call InitFieldsbound

tBound = nbound(4) + ((0.1 \* pressure - nbound(5)) / nbound(3)) ^ 0.5

End If

'

End Function

'

'

'

Private Function volreg1(temperature, pressure)

'

' specific volume in region 1

' volreg1 in m^3/kg

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

volreg1 = rgas\_water \* temperature \* pi \* gammapireg1(tau, pi) / (pressure \* 100000#)

'

End Function

'

'

'

Private Function energyreg1(temperature, pressure)

'

' specific internal energy in region 1

' energyreg1 in kJ/kg

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

energyreg1 = 0.001 \* rgas\_water \* temperature \* (tau \* gammataureg1(tau, pi) - pi \* gammapireg1(tau, pi))

'

End Function

'

'

'

Private Function entropyreg1(temperature, pressure)

'

' specific entropy in region 1

' entropyreg1 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

entropyreg1 = 0.001 \* rgas\_water \* (tau \* gammataureg1(tau, pi) - gammareg1(tau, pi))

'

End Function

'

'

'

Private Function enthalpyreg1(temperature, pressure)

'

' specific enthalpy in region 1

' enthalpyreg1 in kJ/kg

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

enthalpyreg1 = 0.001 \* rgas\_water \* temperature \* tau \* gammataureg1(tau, pi)

'

End Function

'

'

'

Private Function cpreg1(temperature, pressure)

'

' specific isobaric heat capacity in region 1

' cpreg1 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

cpreg1 = -0.001 \* rgas\_water \* tau ^ 2 \* gammatautaureg1(tau, pi)

'

End Function

'

'

'

Private Function cvreg1(temperature, pressure)

'

' specific isochoric heat capacity in region 1

' cvreg1 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 1386# / temperature

pi = 0.1 \* pressure / 16.53

cvreg1 = 0.001 \* rgas\_water \* (-tau ^ 2 \* gammatautaureg1(tau, pi) + (gammapireg1(tau, pi) - tau \* gammapitaureg1(tau, pi)) ^ 2 / gammapipireg1(tau, pi))

'

End Function

'

'

'

' Private Function spsoundreg1(temperature, pressure)

'

' speed of sound in region 1

' spsoundreg1 in m/s

' temperature in K

' pressure in bar

'

' tau = 540# / temperature

' pi = 0.1 \* pressure / 16.53

' spsoundreg1 = (rgas\_water \* temperature \* (gammapireg1(tau, pi) ^ 2 / ((gammapireg1(tau, pi) - tau \* gammapitaureg1(tau, pi)) ^ 2 / (tau ^ 2 \* gammatautaureg1(tau, pi)) - gammapipireg1(tau, pi)))) ^ 0.5

'

' End Function

'

'

'

Private Function volreg2(temperature, pressure)

'

' specific volume in region 2

' volreg2 in m^3/kg

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

volreg2 = rgas\_water \* temperature \* pi \* (gamma0pireg2(tau, pi) + gammarpireg2(tau, pi)) / (pressure \* 100000#)

'

End Function

'

'

'

Private Function energyreg2(temperature, pressure)

'

' specific internal energy in region 2

' energyreg2 in kJ/kg

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

energyreg2 = 0.001 \* rgas\_water \* temperature \* (tau \* (gamma0taureg2(tau, pi) + gammartaureg2(tau, pi)) - pi \* (gamma0pireg2(tau, pi) + gammarpireg2(tau, pi)))

'

End Function

'

'

'

Private Function entropyreg2(temperature, pressure)

'

' specific entropy in region 2

' entropyreg2 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

entropyreg2 = 0.001 \* rgas\_water \* (tau \* (gamma0taureg2(tau, pi) + gammartaureg2(tau, pi)) - (gamma0reg2(tau, pi) + gammarreg2(tau, pi)))

'

End Function

'

'

'

Private Function enthalpyreg2(temperature, pressure)

'

' specific enthalpy in region 2

' enthalpyreg2 in kJ/kg

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

enthalpyreg2 = 0.001 \* rgas\_water \* temperature \* tau \* (gamma0taureg2(tau, pi) + gammartaureg2(tau, pi))

'

End Function

'

'

'

Private Function cpreg2(temperature, pressure)

'

' specific isobaric heat capacity in region 2

' cpreg2 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

cpreg2 = -0.001 \* rgas\_water \* tau ^ 2 \* (gamma0tautaureg2(tau, pi) + gammartautaureg2(tau, pi))

'

End Function

'

'

'

Private Function cvreg2(temperature, pressure)

'

' specific isochoric heat capacity in region 2

' cvreg2 in kJ/(kg K)

' temperature in K

' pressure in bar

'

tau = 540# / temperature

pi = 0.1 \* pressure

cvreg2 = 0.001 \* rgas\_water \* (-tau ^ 2 \* (gamma0tautaureg2(tau, pi) + gammartautaureg2(tau, pi)) - (1 + pi \* gammarpireg2(tau, pi) - tau \* pi \* gammarpitaureg2(tau, pi)) ^ 2 / (1 - pi ^ 2 \* gammarpipireg2(tau, pi)))

'

End Function

'

'

'

' Private Function spsoundreg2(temperature, pressure)

'

' speed of sound in region 2

' spsoundreg2 in m/s

' temperature in K

' pressure in bar

'

' tau = 540# / temperature

' pi = 0.1 \* pressure

' spsoundreg2 = (rgas\_water \* temperature \* (1 + 2 \* pi \* gammarpireg2(tau, pi) + pi ^ 2 \* gammarpireg2(tau, pi) ^ 2) / ((1 - pi ^ 2 \* gammarpipireg2(tau, pi)) + (1 + pi \* gammarpireg2(tau, pi) - tau \* pi \* gammarpitaureg2(tau, pi)) ^ 2 / (tau ^ 2 \* (gamma0tautaureg2(tau, pi) + gammartautaureg2(tau, pi))))) ^ 0.5

'

' End Function

'

'

'

Private Function pressreg3(temperature, density)

'

' pressure in region 3

' pressreg3 in bar

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

pressreg3 = density \* rgas\_water \* temperature \* delta \* fideltareg3(tau, delta) / 100000#

'

End Function

'

'

'

Private Function energyreg3(temperature, density)

'

' specific internal energy in region 3

' energyreg3 in kJ/kg

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

energyreg3 = 0.001 \* rgas\_water \* temperature \* tau \* fitaureg3(tau, delta)

'

End Function

'

'

'

Private Function entropyreg3(temperature, density)

'

' specific entropy in region 3

' entropyreg3 in kJ/(kg K)

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

entropyreg3 = 0.001 \* rgas\_water \* (tau \* fitaureg3(tau, delta) - fireg3(tau, delta))

'

End Function

'

'

'

Private Function enthalpyreg3(temperature, density)

'

' specific enthalpy in region 3

' enthalpyreg3 in kJ/kg

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

enthalpyreg3 = 0.001 \* rgas\_water \* temperature \* (tau \* fitaureg3(tau, delta) + delta \* fideltareg3(tau, delta))

'

End Function

'

'

'

Private Function cpreg3(temperature, density)

'

' specific isobaric heat capacity in region 3

' cpreg3 in kJ/(kg K)

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

cpreg3 = 0.001 \* rgas\_water \* (-tau ^ 2 \* fitautaureg3(tau, delta) + (delta \* fideltareg3(tau, delta) - delta \* tau \* fideltataureg3(tau, delta)) ^ 2 / (2 \* delta \* fideltareg3(tau, delta) + delta ^ 2 \* fideltadeltareg3(tau, delta)))

'

End Function

'

'

'

Private Function cvreg3(temperature, density)

'

' specific isochoric heat capacity in region 3

' cvreg3 in kJ/(kg K)

' temperature in K

' density in kg/m^3

'

tau = tc\_water / temperature

delta = density / dc\_water

cvreg3 = 0.001 \* rgas\_water \* (-tau ^ 2 \* fitautaureg3(tau, delta))

'

End Function

'

'

'

' Private Function spsoundreg3(temperature, density)

'

' speed of sound in region 3

' spsoundreg3 in m/s

' temperature in K

' density in kg/m^3

'

' tau = tc\_water / temperature

' delta = density / dc\_water

' spsoundreg3 = (rgas\_water \* temperature \* (2 \* delta \* fideltareg3(tau, delta) + delta ^ 2 \* fideltadeltareg3(tau, delta) - (delta \* fideltareg3(tau, delta) - delta \* tau \* fideltataureg3(tau, delta)) ^ 2 / (tau ^ 2 \* fitautaureg3(tau, delta)))) ^ 0.5

'

' End Function

'

'

'

Private Function densreg3(temperature, pressure)

'

' Determine density in region 3 iteratively using Newton method

' densreg3 in kg/m^3

' temperature in K

' pressure in bar

'

' densreg3 = -2: not converged

'

If temperature < tc\_water And pressure < pSatW(temperature) Then

densold = 100#

Else

densold = 600#

End If

tau = tc\_water / temperature

'

For j = 1 To 1000

delta = densold / dc\_water

derivprho = rgas\_water \* temperature / dc\_water \* (2 \* densold \* fideltareg3(tau, delta) + densold ^ 2 / dc\_water \* fideltadeltareg3(tau, delta))

densnew = densold + (pressure \* 100000# - rgas\_water \* temperature \* densold ^ 2 / dc\_water \* fideltareg3(tau, delta)) / derivprho

diffdens = Abs(densnew - densold)

If diffdens < 0.000005 Then

densreg3 = densnew

Exit Function

End If

densold = densnew

Next j

densreg3 = -2#

'

End Function

'

'

'

Public Function densW(temperature, pressure)

'

' density of water or steam

' densW in kg/m^3

' temperature in K

' pressure in bar

'

' densW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

densW = 1 / volreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

densW = 1 / volreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

densW = densreg3(temperature, pressure)

Else

' outside range

densW = -1#

End If

'

End Function

'

'

'

Public Function energyW(temperature, pressure)

'

' specific internal energy of water or steam

' energyW in kJ/kg

' temperature in K

' pressure in bar

'

' energyW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

energyW = energyreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

energyW = energyreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

density = densreg3(temperature, pressure)

energyW = energyreg3(temperature, density)

Else

' outside range

energyW = -1#

End If

'

End Function

'

'

'

Public Function entropyW(temperature, pressure)

'

' specific entropy of water or steam

' entropyW in kJ/(kg K)

' temperature in K

' pressure in bar

'

' entropyW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

entropyW = entropyreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

entropyW = entropyreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

density = densreg3(temperature, pressure)

entropyW = entropyreg3(temperature, density)

Else

' outside range

entropyW = -1#

End If

'

End Function

'

'

'

Public Function enthalpyW(temperature, pressure)

'

' specific enthalpy of water or steam

' enthalpyW in kJ/kg

' temperature in K

' pressure in bar

'

' enthalpyW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

enthalpyW = enthalpyreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

enthalpyW = enthalpyreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

density = densreg3(temperature, pressure)

enthalpyW = enthalpyreg3(temperature, density)

Else

' outside range

enthalpyW = -1#

End If

'

End Function

'

'

'

Public Function cpW(temperature, pressure)

'

' specific isobaric heat capacity of water or steam

' cpW in kJ/(kg K)

' temperature in K

' pressure in bar

'

' cpW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

cpW = cpreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

cpW = cpreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

density = densreg3(temperature, pressure)

cpW = cpreg3(temperature, density)

Else

' outside range

cpW = -1#

End If

'

End Function

'

'

'

Public Function cvW(temperature, pressure)

'

' specific isochoric heat capacity of water or steam

' cvW in kJ/(kg K)

' temperature in K

' pressure in bar

'

' cvW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

cvW = cvreg1(temperature, pressure)

ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

cvW = cvreg2(temperature, pressure)

ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

density = densreg3(temperature, pressure)

cvW = cvreg3(temperature, density)

Else

' outside range

cvW = -1#

End If

'

End Function

'

'

'

' Public Function spsoundW(temperature, pressure)

'

' speed of sound in water or steam

' spsoundW in m/s

' temperature in K

' pressure in bar

'

' spsoundW = -1: temperature and/or pressure outside range

'

' If temperature >= 273.15 And temperature <= 623.15 And pressure >= pSatW(temperature) And pressure <= 1000# Then

' region 1

' spsoundW = spsoundreg1(temperature, pressure)

' ElseIf (temperature >= 273.15 And temperature <= 623.15 And pressure > 0 And pressure <= pSatW(temperature)) Or (temperature >= 623.15 And temperature <= 863.15 And pressure > 0 And pressure <= pBound(temperature)) Or (temperature >= 863.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000#) Then

' region 2

' spsoundW = spsoundreg2(temperature, pressure)

' ElseIf temperature >= 623.15 And temperature <= tBound(pressure) And pressure >= pBound(temperature) And pressure <= 1000# Then

' region 3

' density = densreg3(temperature, pressure)

' spsoundW = spsoundreg3(temperature, density)

' Else

' outside range

' spsoundW = -1#

' End If

'

' End Function

'

'

'

Public Function viscW(temperature, pressure)

'

' dynamic viscosity of water or steam

' viscW in Pa s

' temperature in K

' pressure in bar

'

' viscW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000# Then

density = densW(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscW = 0.000055071 \* psivisc(tau, delta)

Else

' outside range

viscW = -1#

End If

'

End Function

'

'

'

Public Function thconW(temperature, pressure)

'

' thermal conductivity of water or steam

' thconW in W/(m K)

' temperature in K

' pressure in bar

'

' thconW = -1: temperature and/or pressure outside range

'

If temperature >= 273.15 And temperature <= 1073.15 And pressure > 0 And pressure <= 1000# Then

density = densW(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

thconW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

Else

' outside range

thconW = -1#

End If

'

End Function

'

'

'

Public Function densSatLiqTW(temperature)

'

' density of saturated liquid water as a function of temperature

' densSatLiqTW in kg/m^3

' temperature in K

'

' densSatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

densSatLiqTW = 1 / volreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

densSatLiqTW = densreg3(temperature, pressure)

Else

' outside range

densSatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function densSatVapTW(temperature)

'

' density of saturated steam as a function of temperature

' densSatVapTW in kg/m^3

' temperature in K

'

' densSatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

densSatVapTW = 1 / volreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

densSatVapTW = densreg3(temperature, pressure)

Else

' outside range

densSatVapTW = -1#

End If

'

End Function

'

'

'

Public Function densSatLiqPW(pressure)

'

' density of saturated liquid water as a function of pressure

' densSatLiqPW in kg/m^3

' pressure in bar

'

' densSatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

densSatLiqPW = 1 / volreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

densSatLiqPW = densreg3(temperature, pressure)

Else

' outside range

densSatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function densSatVapPW(pressure)

'

' density of saturated steam as a function of pressure

' densSatVapPW in kg/m^3

' pressure in bar

'

' densSatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

densSatVapPW = 1 / volreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

densSatVapPW = densreg3(temperature, pressure)

Else

' outside range

densSatVapPW = -1#

End If

'

End Function

'

'

'

Public Function energySatLiqTW(temperature)

'

' specific internal energy of saturated liquid water as a function of temperature

' energySatLiqTW in kJ/kg

' temperature in K

'

' energySatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

energySatLiqTW = energyreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

energySatLiqTW = energyreg3(temperature, density)

Else

' outside range

energySatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function energySatVapTW(temperature)

'

' specific internal energy of saturated steam as a function of temperature

' energySatVapTW in kJ/kg

' temperature in K

'

' energySatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

energySatVapTW = energyreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

energySatVapTW = energyreg3(temperature, density)

Else

' outside range

energySatVapTW = -1#

End If

'

End Function

'

'

'

Public Function energySatLiqPW(pressure)

'

' specific internal energy of saturated liquid water as a function of pressure

' energySatLiqPW in kJ/kg

' pressure in bar

'

' energySatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

energySatLiqPW = energyreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

energySatLiqPW = energyreg3(temperature, density)

Else

' outside range

energySatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function energySatVapPW(pressure)

'

' specific internal energy of saturated steam as a function of pressure

' energySatVapPW in kJ/kg

' pressure in bar

'

' energySatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

energySatVapPW = energyreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

energySatVapPW = energyreg3(temperature, density)

Else

' outside range

energySatVapPW = -1#

End If

'

End Function

'

'

'

Public Function entropySatLiqTW(temperature)

'

' specific entropy of saturated liquid water as a function of temperature

' entropySatLiqTW in kJ/(kg K)

' temperature in K

'

' entropySatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

entropySatLiqTW = entropyreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

entropySatLiqTW = entropyreg3(temperature, density)

Else

' outside range

entropySatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function entropySatVapTW(temperature)

'

' specific entropy of saturated steam as a function of temperature

' entropySatVapTW in kJ/(kg K)

' temperature in K

'

' entropySatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

entropySatVapTW = entropyreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

entropySatVapTW = entropyreg3(temperature, density)

Else

' outside range

entropySatVapTW = -1#

End If

'

End Function

'

'

'

Public Function entropySatLiqPW(pressure)

'

' specific entropy of saturated liquid water as a function of pressure

' entropySatLiqPW in kJ/(kg K)

' pressure in bar

'

' entropySatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

entropySatLiqPW = entropyreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

entropySatLiqPW = entropyreg3(temperature, density)

Else

' outside range

entropySatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function entropySatVapPW(pressure)

'

' specific entropy of saturated steam as a function of pressure

' entropySatVapPW in kJ/(kg K)

' pressure in bar

'

' entropySatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

entropySatVapPW = entropyreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

entropySatVapPW = entropyreg3(temperature, density)

Else

' outside range

entropySatVapPW = -1#

End If

'

End Function

'

'

'

Public Function enthalpySatLiqTW(temperature)

'

' specific enthalpy of saturated liquid water as a function of temperature

' enthalpySatLiqTW in kJ/kg

' temperature in K

'

' enthalpySatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

enthalpySatLiqTW = enthalpyreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

enthalpySatLiqTW = enthalpyreg3(temperature, density)

Else

' outside range

enthalpySatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function enthalpySatVapTW(temperature)

'

' specific enthalpy of saturated steam as a function of temperature

' enthalpySatVapTW in kJ/kg

' temperature in K

'

' enthalpySatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

enthalpySatVapTW = enthalpyreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

enthalpySatVapTW = enthalpyreg3(temperature, density)

Else

' outside range

enthalpySatVapTW = -1#

End If

'

End Function

'

'

'

Public Function enthalpySatLiqPW(pressure)

'

' specific enthalpy of saturated liquid water as a function of pressure

' enthalpySatLiqPW in kJ/kg

' pressure in bar

'

' enthalpySatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

enthalpySatLiqPW = enthalpyreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

enthalpySatLiqPW = enthalpyreg3(temperature, density)

Else

' outside range

enthalpySatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function enthalpySatVapPW(pressure)

'

' specific enthalpy of saturated steam as a function of pressure

' enthalpySatVapPW in kJ/kg

' pressure in bar

'

' enthalpySatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

enthalpySatVapPW = enthalpyreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

enthalpySatVapPW = enthalpyreg3(temperature, density)

Else

' outside range

enthalpySatVapPW = -1#

End If

'

End Function

'

'

'

Public Function cpSatLiqTW(temperature)

'

' specific isobaric heat capacity of saturated liquid water as a function of temperature

' cpSatLiqTW in kJ/(kg K)

' temperature in K

'

' cpSatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

cpSatLiqTW = cpreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

cpSatLiqTW = cpreg3(temperature, density)

Else

' outside range

cpSatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function cpSatVapTW(temperature)

'

' specific isobaric heat capacity of saturated steam as a function of temperature

' cpSatVapTW in kJ/(kg K)

' temperature in K

'

' cpSatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

cpSatVapTW = cpreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

cpSatVapTW = cpreg3(temperature, density)

Else

' outside range

cpSatVapTW = -1#

End If

'

End Function

'

'

'

Public Function cpSatLiqPW(pressure)

'

' specific isobaric heat capacity of saturated liquid water as a function of pressure

' cpSatLiqPW in kJ/(kg K)

' pressure in bar

'

' cpSatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

cpSatLiqPW = cpreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

cpSatLiqPW = cpreg3(temperature, density)

Else

' outside range

cpSatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function cpSatVapPW(pressure)

'

' specific isobaric heat capacity of saturated steam as a function of pressure

' cpSatVapPW in kJ/(kg K)

' pressure in bar

'

' cpSatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

cpSatVapPW = cpreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

cpSatVapPW = cpreg3(temperature, density)

Else

' outside range

cpSatVapPW = -1#

End If

'

End Function

'

'

'

Public Function cvSatLiqTW(temperature)

'

' specific isochoric heat capacity of saturated liquid water as a function of temperature

' cvSatLiqTW in kJ/(kg K)

' temperature in K

'

' cvSatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

cvSatLiqTW = cvreg1(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

cvSatLiqTW = cvreg3(temperature, density)

Else

' outside range

cvSatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function cvSatVapTW(temperature)

'

' specific isochoric heat capacity of saturated steam as a function of temperature

' cvSatVapTW in kJ/(kg K)

' temperature in K

'

' cvSatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

cvSatVapTW = cvreg2(temperature, pressure)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

cvSatVapTW = cvreg3(temperature, density)

Else

' outside range

cvSatVapTW = -1#

End If

'

End Function

'

'

'

Public Function cvSatLiqPW(pressure)

'

' specific isochoric heat capacity of saturated liquid water as a function of pressure

' cvSatLiqPW in kJ/(kg K)

' pressure in bar

'

' cvSatLiqPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

cvSatLiqPW = cvreg1(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

cvSatLiqPW = cvreg3(temperature, density)

Else

' outside range

cvSatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function cvSatVapPW(pressure)

'

' specific isochoric heat capacity of saturated steam as a function of pressure

' cvSatVapPW in kJ/(kg K)

' pressure in bar

'

' cvSatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

cvSatVapPW = cvreg2(temperature, pressure)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

cvSatVapPW = cvreg3(temperature, density)

Else

' outside range

cvSatVapPW = -1#

End If

'

End Function

'

'

'

' Public Function spsoundSatLiqTW(temperature)

'

' speed of sound in saturated liquid water as a function of temperature

' spsoundSatLiqTW in m/s

' temperature in K

'

' spsoundSatLiqTW = -1: temperature outside range

'

' If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

' pressure = pSatW(temperature)

' spsoundSatLiqTW = spsoundreg1(temperature, pressure)

' ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

' pressure = pSatW(temperature)

' density = densreg3(temperature, pressure)

' spsoundSatLiqTW = spsoundreg3(temperature, density)

' Else

' outside range

' spsoundSatLiqTW = -1#

' End If

'

' End Function

'

'

'

' Public Function spsoundSatVapTW(temperature)

'

' speed of sound in saturated steam as a function of temperature

' spsoundSatVapTW in m/s

' temperature in K

'

' spsoundSatVapTW = -1: temperature outside range

'

' If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

' pressure = pSatW(temperature)

' spsoundSatVapTW = spsoundreg2(temperature, pressure)

' ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

' pressure = pSatW(temperature) - 0.00001

' density = densreg3(temperature, pressure)

' spsoundSatVapTW = spsoundreg3(temperature, density)

' Else

' outside range

' spsoundSatVapTW = -1#

' End If

'

' End Function

'

'

'

' Public Function spsoundSatLiqPW(pressure)

'

' speed of sound in saturated liquid water as a function of pressure

' spsoundSatLiqPW in m/s

' pressure in bar

'

' spsoundSatLiqPW = -1: pressure outside range

'

' If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

' temperature = tSatW(pressure)

' spsoundSatLiqPW = spsoundreg1(temperature, pressure)

' ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

' temperature = tSatW(pressure)

' pressure = pressure + 0.00001

' density = densreg3(temperature, pressure)

' spsoundSatLiqPW = spsoundreg3(temperature, density)

' Else

' outside range

' spsoundSatLiqPW = -1#

' End If

'

' End Function

'

'

'

' Public Function spsoundSatVapPW(pressure)

'

' speed of sound in saturated steam as a function of pressure

' spsoundSatVapPW in m/s

' pressure in bar

'

' spsoundSatVapPW = -1: pressure outside range

'

' If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

' temperature = tSatW(pressure)

' spsoundSatVapPW = spsoundreg2(temperature, pressure)

' ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

' temperature = tSatW(pressure)

' pressure = pressure - 0.00001

' density = densreg3(temperature, pressure)

' spsoundSatVapPW = spsoundreg3(temperature, density)

' Else

' outside range

' spsoundSatVapPW = -1#

' End If

'

' End Function

'

'

'

Public Function viscSatLiqTW(temperature)

'

' dynamic viscosity of saturated liquid water as a function of temperature

' viscSatLiqTW in Pa s

' temperature in K

'

' viscSatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

density = 1 / volreg1(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatLiqTW = 0.000055071 \* psivisc(tau, delta)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatLiqTW = 0.000055071 \* psivisc(tau, delta)

Else

' outside range

viscSatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function viscSatVapTW(temperature)

'

' dynamic viscosity of saturated steam as a function of temperature

' viscSatVapTW in Pa s

' temperature in K

'

' viscSatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

density = 1 / volreg2(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatVapTW = 0.000055071 \* psivisc(tau, delta)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatVapTW = 0.000055071 \* psivisc(tau, delta)

Else

' outside range

viscSatVapTW = -1#

End If

'

End Function

'

'

'

Public Function viscSatLiqPW(pressure)

'

' dynamic viscosity of saturated liquid water as a function of pressure

' viscSatLiqPW in Pa s

' pressure in bar

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' viscSatLiqPW = -1: pressure outside range

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If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 1

temperature = tSatW(pressure)

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ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatLiqPW = 0.000055071 \* psivisc(tau, delta)

Else

' outside range

viscSatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function viscSatVapPW(pressure)

'

' dynamic viscosity of saturated steam as a function of pressure

' viscSatVapPW in Pa s

' pressure in bar

'

' viscSatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

density = 1 / volreg2(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatVapPW = 0.000055071 \* psivisc(tau, delta)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure - 0.00001

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

viscSatVapPW = 0.000055071 \* psivisc(tau, delta)

Else

' outside range

viscSatVapPW = -1#

End If

'

End Function

'

'

'

Public Function thconSatLiqTW(temperature)

'

' thermal conductivity of saturated liquid water as a function of temperature

' thconSatLiqTW in W /(m K)

' temperature in K

'

' thconSatLiqTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 1

pressure = pSatW(temperature)

density = 1 / volreg1(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

thconSatLiqTW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature)

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

thconSatLiqTW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

Else

' outside range

thconSatLiqTW = -1#

End If

'

End Function

'

'

'

Public Function thconSatVapTW(temperature)

'

' thermal conductivity of saturated steam as a function of temperature

' thconSatVapTW in W /(m K)

' temperature in K

'

' thconSatVapTW = -1: temperature outside range

'

If temperature >= 273.15 And temperature <= 623.15 Then

' region 2

pressure = pSatW(temperature)

density = 1 / volreg2(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

pressure = pressure - 0.0001 \* pressure

thconSatVapTW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

ElseIf temperature > 623.15 And temperature <= tc\_water Then

' region 3

pressure = pSatW(temperature) - 0.00001

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

thconSatVapTW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

Else

' outside range

thconSatVapTW = -1#

End If

'

End Function

'

'

'

Public Function thconSatLiqPW(pressure)

'

' thermal conductivity of saturated liquid water as a function of pressure

' thconSatLiqPW in W /(m K)

' pressure in bar

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' thconSatLiqPW = -1: pressure outside range

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' region 1

temperature = tSatW(pressure)

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thconSatLiqPW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

pressure = pressure + 0.00001

density = densreg3(temperature, pressure)

delta = density / 317.763

tau = 647.226 / temperature

thconSatLiqPW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

Else

' outside range

thconSatLiqPW = -1#

End If

'

End Function

'

'

'

Public Function thconSatVapPW(pressure)

'

' thermal conductivity of saturated steam as a function of pressure

' thconSatVapPW in W /(m K)

' pressure in bar

'

' thconSatVapPW = -1: pressure outside range

'

If pressure >= pSatW(273.15) And pressure <= pSatW(623.15) Then

' region 2

temperature = tSatW(pressure)

density = 1 / volreg2(temperature, pressure)

delta = density / 317.763

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pressure = pressure - 0.0001 \* pressure

thconSatVapPW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

ElseIf pressure > pSatW(623.15) And pressure <= pc\_water Then

' region 3

temperature = tSatW(pressure)

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delta = density / 317.763

tau = 647.226 / temperature

thconSatVapPW = 0.4945 \* lambthcon(temperature, pressure, tau, delta)

Else

' outside range

thconSatVapPW = -1#

End If

'

End Function