Instructions for using IF97 functions for industrial use with backward equations, placed as a macro in workbook (version 2.1.0.0 from 23 May 2023).

Calculations of thermodynamic properties of water and steam are programmed according to:

"Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam", release authorized by IAPWS in Lucerne, Switzerland, 26 - 31 August 2007.

Allowed input data range (in pressure and temperature) is: **0 to 800 °C and 0.000611153 to 100 MPa** and / or **800 to 2000 °C and 0.000611153 to 50 MPa**.

According to this text, complete basic equations for all regions and backward equations for regions 1 and 2 are programmed here. Backward equations for region 3 are programmed according to: "Revised Suplementary Release on Backward Equations for the Functions T(p,h), v(p,h) and T(p,s), v(p,s) for Region 3 of the IAPWS Industrial Formulation 1997 for the T hermodynamic Properties of Water and Steam", elease authorized in Kyoto, Japan, 29 August - 3 September 2004. Backward equations for region 5 are not yet available, so they cannot be calculated here.

Program also further calculates:

Dynamic Viscosity according to "Relase on the IAPWS Formulation 2008 for the Viscosity of Ordinary Water Substance", release authorized by IAPWS in Berlin, Germany, 7 - 12 September 2008.

Allowed input data range for viscosity calculation is: **0 to 800 °C and 0.000611153 to 100 MPa** and / or **800 to 900 °C and 0.000611153 to 50 MPa.**

Smaller viscosity calculation range than source text is due to fact that this program calculates water and steam properties for industrial purposes. Therefore, recommendation from paragraph 3 on page 8 from "Relase on the IAPWS Formulation 2008 ..." is used in viscosity calculation. This means that equation (10) is simplified by using $\mu_1 = 1$ and values needed for viscosity calculation are calculated according to IAPWS-IF97. In this case, it follows from paragraph 3 that the uncertainties caused by this are smaller than the uncertainties in the viscosity calculation, except for small region near critical point described by equation (13):

$$372.76°C < t < 377.62°C \text{ and } 245.8\ kg/m^3 < \rho < 405.3\ kg/m^3$$

Thermal conductivity acc. to "Relase on the IAPS Formulation 2011 for the Thermal Concuctivity of Ordinary Water Substance", release authorized by IAPWS in Plzeň, Czech Republic, 4 - 9 September 2011

Allowed input data range for thermal conductivity calculation is: **0 to 800 °C and 0.000611153 to 100 MPa** and / or **800 to 900 °C and 0.000611153 to 50 MPa.**

Smaller thermal conducticity calculation range than source text is due to fact that this program calculates water and steam properties for industrial purposes. Therefore, recommendation from paragraph 3 on pages 11 to 14 from "Relase on the IAPWS Formulation 2011 ..." is used in thermal conductivity calculation. This means that more simplifications are used in con ductivity calculations (see source text for details). According to paragraph 3.3, uncertainties caused by this are smaller than uncertainties of IAPWS-IF95 calculation, so Figure 1 on page 5 of source text can be used to determine uncertainty in conductivity calculation, except for a small area near critical point where uncertainties become larger.

I did not find a definition of this small region in source text, but according to my tests, in pressure values it is approximately from 21.6 MPa to pressure of critical point, i.e. to 22.064 MPa, when thermal conductivity of saturated water is smaller than conductivity of saturated steam. Dependence of thermal conductivity around critical points for supercritical temperatures is described, for example, in M. L. Huber et al: "New International Formulation for the Thermal Conductivity of H_2O", on line published for example 23.8.2012 in: J. Phys. Chem. Ref. Data, Vol. 41, No. 3, 2012. Although this text describes region for t emperatures just above critical point, it suggests that thermal conductivity for temperatures from critical point (373.946 °C) downwards will follow a similar course.

Program control:

For proper function it is necessary to have macros enabled in Excel - if macros are not enabled there will be #NAME? error messages in cells with macro references. Excel from 2007 onwards may (depending on macro settings in security centre) ask for macros to be enabled in bar above sheet that appears there when file is opened and macros need to be enabled here. In order for Excel to ask for macros to be enabled when file is opened, you need to have "Disable all macros with notification" option selected in macro security. It is also possible to have "Enable all macros (..." selected in macro setti ngs, but this is not recommended due to viruses. To access macro settings, go to File - Options - Trust Center - Trust Center Settings... - Macro Settings. Administrator rights may be required.

When macros are enabled and working, you can use Excel's bar Formulas - "fx Insert Function" (or fx button - left next to row of formulas) to select category " Programs L. Ruffer" in window that opens from drop-down list "Or select a category" and there will be among others 4 functions related to IF97:

IF97_IAPWS(P;THS;WhatIsInTHS;Output); SatCurveIF97(TP;WhatIsInTP;Dryness;Output); SatP_IF97(Temp) and SatT_IF97(P).

Function IF97_IAPWS calculates thermodynamic properties based on setting variable Output: when **Output = "T"** calculates temperature [°C]; for **"H"** calculates enthalpy [kJ/kg]; **"U"** = internal energy [kJ/kg]; **"S"** = entropy [kJ/kgK]; **"Cp"** = specific heat at const. pressure [kJ/kgK]; **"Cv"** = specific heat at const. volume [kJ/kgK]; **"W"** = speed of sound [m/s]; **"Mi"** = dynamic viscosity [Pa.s]; **"Lam"** = thermal conductivity [W/Km]; **"X"** = dryness (0 is water and 1 is steam) [--] and when content of variable **Output is different** from previous specific volume is calculated [m^3/kg].
Calculation is always from abs. pressure [MPa] which enters in variable **P** and in variable **THS** enters second input variable which is defined by content of variable **WhatIsInTHS**: for **"H"** enters and is calculated from enthalpy [kJ/kg]; for **"S"** enters and is calculated from entropy [kJ/kgK]; for **"K"** enters and is calculated from temperature [°K] and when content of variable **WhatIsInTHS is different** it is entered and calculated from temperature [°C]. Calculations from enthalpy and entropy can either be iterations from basic equations - if **"H"** or **"S"** is entered in **WhatIsInTHS**, or in regions 1, 2 and 3 from backward equations and in regions 4 and 5 from basic equations (there are no backward equations) if **"HZ"** or **"SZ"** is entered in **WhatIsInTHS**.

Function SatCurveIF97 calculates thermodyn. properties on saturation curve based on setting variable Output: when **Output = "H"** calculates enthalpy [kJ/kg]; for **"U"** internal energy [kJ/kg]; **"S"** = entropy [kJ/kgK]; **"Cp"** = specific heat at const. pressure [kJ/kgK]; **"Cv"** = spec. heat at const. volume [kJ/kgK]; **"W"** = speed of sound [m/s]; **"Mi"** = dyn. viscosity [Pa.s]; **"Lam"** = thermal conductivity [W/Km] and when content of variable **Output is different** calculates specific volume [m^3/kg].
Input value for calculation is in variable **TP**, what is entered is defined by content of variable **WhatIsInTP** as follows: for **"P"** enters and is calculated from abs. pressure [MPa]; for **"K"** enters and is calculated from temperature [°K] and when content of variable **WhatIsInTP is different** it is entered and calculated from temperature [°C]. Variable **Dryness** determines dryness of mixture which will be calculated as follows: when **Dryness <= 0** so calculates for saturated water; when **Dryness is between 0 and 1** it is calculated for a mixture with a composition according to variable Dryness and when **Dryness >= 1** calculates for saturated steam.

Function SatP_IF97 calculates absolute saturation pressure [MPa] for specified temperature [°C].

Function SatT_IF97 calculates absolute saturation temperature [°C] for specified absolute pressure [MPa].

Note: to use IF97 functions, open this example in Excel, delete both sheets "IF9X Check calc. and manual" and either use prep ared blank sheet or move necessary sheets here from another open Excel workbook.
(It is possible that after moving sheets here formulas in them will need to be modified for this workbook.)

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Checking calculation and example of using IF95 functions - basic equations

To check calculations except for dynamic viscosity and thermal conductivity, data from "Revised Release on the IAPWS Industrial Formulation 1997 …" from the year 2007; specifically for region 1 from table 5, region 2 from table 15, region 3 from table 33 and for region 5 from table 42 are used. Calculation of dynamic viscosity and thermal conductivity is for information only, check data are in separate tables.

	Input values		Output values										
	Pressure	Temperature	Specific volume	Specific density	Specific enthalpy	Specific internal energy	Specific entropy	Specific isobaric heat capacity	Specific isochoric heat capacity	Isentropic exponent	Speed of sound	Dynamic viscosity	Thermal conductivity
	P [MPa]	T [K]	v [m^3/kg]	ρ [kg/m^3]	h [kJ/kg]	u [kJ/kg]	s [kJ/kgK]	c_p [kJ/kgK]	c_v [kJ/kgK]	kapa [--]	w [m/s]	mi [μPa.s]	lam [mW/Km]
region 1	3	300	0,100 215 168E-2	0,997 852 940E+3	0,115 331 273E+3	0,112 324 818E+3	0,392 294 792E+0	0,417 301 218E+1	0,412 120 160E+1	0,756 132 220E+3	0,150 773 921E+4	853,5	611,1
	80	300	0,971 180 894E-3	0,102 967 429E+4	0,184 142 828E+3	0,106 448 356E+3	0,368 563 852E+0	0,401 008 987E+1	0,391 736 606E+1	0,343 938 651E+2	0,163 469 054E+4	855,9	649,2
	3	500	0,120 241 800E-2	0,831 657 541E+3	0,975 542 239E+3	0,971 934 985E+3	0,258 041 912E+1	0,465 580 682E+1	0,322 139 223E+1	0,426 742 799E+3	0,124 071 337E+4	118,0	639,8
region 2	0,0035	300	0,394 913 866E+2	0,253 219 774E-1	0,254 991 145E+4	0,241 169 160E+4	0,852 238 967E+1	0,191 300 162E+1	0,144 132 662E+1	0,132 481 456E+1	0,427 920 172E+3	9,760	18,6
	0,0035	700	0,923 015 898E+2	0,108 340 496E-1	0,333 568 375E+4	0,301 262 819E+4	0,101 749 996E+2	0,208 141 274E+1	0,161 978 333E+1	0,128 494 429E+1	0,644 289 068E+3	25,56	57,7
	30	700	0,542 946 619E-2	0,184 180 169E+3	0,263 149 474E+4	0,246 861 076E+4	0,517 540 298E+1	0,103 505 092E+2	0,297 553 837E+1	0,141 678 269E+1	0,480 386 523E+3	31,92	166,6
region 3	0,255 837 018E+2	650	0,200 000 000E-2	0,500 000 000E+3	0,186 343 019E+4	0,181 226 279E+4	0,405 427 273E+1	0,138 935 718E+2	0,319 131 787E+1	0,492 519 764E+1	0,502 005 553E+3	57,80	413,9
	0,222 930 643E+2	650	0,500 000 000E-2	0,200 000 000E+3	0,237 512 401E+4	0,226 365 868E+4	0,485 438 792E+1	0,446 579 341E+2	0,404 118 076E+1	0,131 906 278E+1	0,383 444 594E+3	29,90	269,6
	0,783 095 639E+2	750	0,200 000 000E-2	0,500 000 000E+3	0,225 868 845E+4	0,210 206 932E+4	0,446 971 906E+1	0,634 165 360E+1	0,271 701 677E+1	0,369 468 579E+1	0,760 696 041E+3	61,93	384,4
region 5	0,5	1 500	0,138 455 090E+1	0,722 255 860E+0	0,521 976 855E+4	0,452 749 310E+4	0,965 408 875E+1	0,261 609 445E+1	0,215 337 784E+1	0,121 485 600E+1	0,917 068 690E+3	---	---
	30	1 500	0,230 761 299E-1	0,433 348 227E+2	0,516 723 514E+4	0,447 495 124E+4	0,772 970 133E+1	0,272 724 317E+1	0,219 274 829E+1	0,124 544 481E+1	0,928 548 002E+3	---	---
	30	2 000	0,311 385 219E-1	0,321 145 623E+2	0,657 122 604E+4	0,563 707 038E+4	0,853 640 523E+1	0,288 569 882E+1	0,239 589 436E+1	0,121 958 005E+1	0,106 736 948E+4	---	---

Checking calculation and example of using IF97 functions - basic equation in region 4, saturation line

Data from "Release on the IAPWS Industrial Formulation 1997 …" from tables 35 and 36 are used to check calculation.

	Input values	Output values	Input values	Output values
	Temperature	Saturation pressure	Pressure	Satur. temperature
	T [K]	Ps [MPa]	P [MPa]	Ts [K]
region 4	300	0,353 658 941E-2	0,1	0,372 755 919E+3
	500	0,263 889 776E+1	1	0,453 035 632E+3
	600	0,123 443 146E+2	10	0,584 149 488E+3

Checking calculation and example using functions for dynamic viscosity

Data fit to range of equations for industrial use from literature listed in manual, table 4, are used for checking.

Input values		Output values	
Pressure	Temperature	Dynamic viscosity	Specific density
P [MPa]	T [K]	mi [μPa.s]	ρ [kg/m^3]
0,222 016 620E+1	298,15	889,735100	0,998 000 000E+3
0,196 909 406E+0	433,15	14,538324	0,100 000 000E+1
0,402 230 487E+0	873,15	32,619287	0,100 000 000E+1
0,336 075 594E+2	873,15	35,802262	0,100 000 000E+3

Checking calculation and example using functions for thermal conductivity

Data fit to range of equations for industrial use from literature listed in manual, tables 7, 8 and 9, are used for checking.

	Input values		Output values	
	Pressure	Temperature	Thermal conductivity	Specific density
	P [MPa]	T [K]	lam [mW/Km]	ρ [kg/m^3]
region 1	20	620	0,481 485 195E+3	---
	50	620	0,545 038 940E+3	---
region 2	0,3	650	0,522 311 024E+2	---
	50	800	0,177 709 914E+3	---
region 3	0,219 840 627E+2	647,35	0,366 879 411E+3	0,222 000 000E+3
	0,221 321 600E+2	647,35	0,124 182 415E+4	0,322 000 000E+3

Checking calculation and example of using IF97 functions - calculation by iterations from P and H

To check calculations except for dynamic viscosity and thermal conductivity, data from "Revised Release on the IAPWS Industrial Formulation 1997 …" from the year 2007; specifically for region 1 from table 5, region 2 from table 15, region 3 from table 33 and for region 5 from table 42 are used. Calculation of dynamic viscosity and thermal conductivity is for information only, check data are in separate tables.

	Input values		Output values										
	Pressure	Specific enthalpy	Specific volume	Specific density	Temperature	Specific internal energy	Specific entropy	Specific isobaric heat capacity	Specific isochoric heat capacity	Isentropic exponent	Speed of sound	Dynamic viscosity	Thermal conductivity
	P [MPa]	h [kJ/kg]	v [m^3/kg]	ρ [kg/m^3]	[K]	u [kJ/kg]	s [kJ/kgK]	c_p [kJ/kgK]	c_v [kJ/kgK]	kapa [--]	w [m/s]	mi [μPa.s]	lam [mW/Km]
region 1	3	0,115 331 273E+3	0,100 215 168E-2	0,997 852 940E+3	0,300 000 000E+3	0,112 324 818E+3	0,392 294 792E+0	0,417 301 218E+1	0,412 120 160E+1	0,756 132 220E+3	0,150 773 921E+4	853,5	611,1
	80	0,184 142 828E+3	0,971 180 894E-3	0,102 967 429E+4	0,300 000 000E+3	0,106 448 356E+3	0,368 563 853E+0	0,401 008 987E+1	0,391 736 606E+1	0,343 938 651E+2	0,163 469 054E+4	855,9	649,2
	3	0,975 542 239E+3	0,120 241 800E-2	0,831 657 541E+3	0,500 000 000E+3	0,971 934 985E+3	0,258 041 912E+1	0,465 580 682E+1	0,322 139 223E+1	0,426 742 799E+3	0,124 071 337E+4	118,0	639,8
region 2	0,0035	0,254 991 145E+4	0,394 913 866E+2	0,253 219 774E-1	0,300 000 000E+3	0,241 169 160E+4	0,852 238 967E+1	0,191 300 162E+1	0,144 132 662E+1	0,132 481 456E+1	0,427 920 172E+3	9,760	18,6
	0,0035	0,333 568 375E+4	0,923 015 898E+2	0,108 340 496E-1	0,700 000 000E+3	0,301 262 819E+4	0,101 749 996E+2	0,208 141 274E+1	0,161 978 333E+1	0,128 494 429E+1	0,644 289 068E+3	25,56	57,7
	30	0,263 149 474E+4	0,542 946 619E-2	0,184 180 169E+3	0,700 000 000E+3	0,246 861 076E+4	0,517 540 298E+1	0,103 505 092E+2	0,297 553 837E+1	0,141 678 269E+1	0,480 386 523E+3	31,92	166,6
region 3	0,255 837 018E+2	0,186 343 019E+4	0,200 000 000E-2	0,500 000 000E+3	0,650 000 000E+3	0,181 226 279E+4	0,405 427 273E+1	0,138 935 718E+2	0,319 131 787E+1	0,492 519 764E+1	0,502 005 553E+3	57,80	413,9
	0,222 930 643E+2	0,237 512 401E+4	0,500 000 000E-2	0,200 000 000E+3	0,650 000 000E+3	0,226 365 868E+4	0,485 438 792E+1	0,446 579 341E+2	0,404 118 076E+1	0,131 906 278E+1	0,383 444 594E+3	29,90	269,6
	0,783 095 639E+2	0,225 868 845E+4	0,200 000 000E-2	0,500 000 000E+3	0,750 000 000E+3	0,210 206 932E+4	0,446 971 906E+1	0,634 165 360E+1	0,271 701 677E+1	0,369 468 579E+1	0,760 696 041E+3	61,93	384,4
region 5	0,5	0,521 976 855E+4	0,138 455 090E+1	0,722 255 860E+0	0,150 000 000E+4	0,452 749 310E+4	0,965 408 875E+1	0,261 609 445E+1	0,215 337 784E+1	0,121 485 600E+1	0,917 068 690E+3	---	---
	30	0,516 723 514E+4	0,230 761 299E-1	0,433 348 227E+2	0,150 000 000E+4	0,447 495 124E+4	0,772 970 133E+1	0,272 724 317E+1	0,219 274 829E+1	0,124 544 481E+1	0,928 548 002E+3	---	---
	30	0,657 122 604E+4	0,311 385 219E-1	0,321 145 623E+2	0,200 000 000E+4	0,563 707 038E+4	0,853 640 523E+1	0,288 569 882E+1	0,239 589 436E+1	0,121 958 005E+1	0,106 736 948E+4	---	---

Checking calculation and example of using IF97 functions - calculation by iterations from P and S

To check calculations except for dynamic viscosity and thermal conductivity, data from "Revised Release on the IAPWS Industrial Formulation 1997 …" from the year 2007; specifically for region 1 from table 5, region 2 from table 15, region 3 from table 33 and for region 5 from table 42 are used. Calculation of dynamic viscosity and thermal conductivity is for information only, check data are in separate tables.

	Input values		Output values										
	Pressure	Specific entropy	Specific volume	Specific density	Specific enthalpy	Specific internal energy	Temperature	Specific isobaric heat capacity	Specific isochoric heat capacity	Isentropic exponent	Speed of sound	Dynamic viscosity	Thermal conductivity
	P [MPa]	s [kJ/kgK]	v [m^3/kg]	ρ [kg/m^3]	h [kJ/kg]	u [kJ/kg]	[K]	c_p [kJ/kgK]	c_v [kJ/kgK]	kapa [--]	w [m/s]	mi [μPa.s]	lam [mW/Km]
region 1	3	0,392 294 792E+0	0,100 215 168E-2	0,997 852 940E+3	0,115 331 273E+3	0,112 324 818E+3	0,300 000 000E+3	0,417 301 218E+1	0,412 120 160E+1	0,756 132 221E+3	0,150 773 921E+4	853,5	611,1
	80	0,368 563 852E+0	0,971 180 894E-3	0,102 967 429E+4	0,184 142 828E+3	0,106 448 356E+3	0,300 000 000E+3	0,401 008 987E+1	0,391 736 606E+1	0,343 938 651E+2	0,163 469 054E+4	855,9	649,2
	3	0,258 041 912E+1	0,120 241 800E-2	0,831 657 541E+3	0,975 542 239E+3	0,971 934 985E+3	0,500 000 000E+3	0,465 580 682E+1	0,322 139 223E+1	0,426 742 799E+3	0,124 071 337E+4	118,0	639,8
region 2	0,0035	0,852 238 967E+1	0,394 913 866E+2	0,253 219 774E-1	0,254 991 145E+4	0,241 169 160E+4	0,300 000 000E+3	0,191 300 162E+1	0,144 132 662E+1	0,132 481 456E+1	0,427 920 172E+3	9,760	18,6
	0,0035	0,101 749 996E+2	0,923 015 898E+2	0,108 340 496E-1	0,333 568 375E+4	0,301 262 819E+4	0,700 000 000E+3	0,208 141 274E+1	0,161 978 333E+1	0,128 494 429E+1	0,644 289 068E+3	25,56	57,7
	30	0,517 540 298E+1	0,542 946 620E-2	0,184 180 169E+3	0,263 149 475E+4	0,246 861 076E+4	0,700 000 000E+3	0,103 505 092E+2	0,297 553 837E+1	0,141 678 269E+1	0,480 386 523E+3	31,92	166,6
region 3	0,255 837 018E+2	0,405 427 273E+1	0,200 000 000E-2	0,500 000 000E+3	0,186 343 019E+4	0,181 226 279E+4	0,650 000 000E+3	0,138 935 718E+2	0,319 131 787E+1	0,492 519 763E+1	0,502 005 553E+3	57,80	413,9
	0,222 930 643E+2	0,485 438 792E+1	0,500 000 000E-2	0,200 000 000E+3	0,237 512 401E+4	0,226 365 868E+4	0,650 000 000E+3	0,446 579 341E+2	0,404 118 076E+1	0,131 906 278E+1	0,383 444 594E+3	29,90	269,6
	0,783 095 639E+2	0,446 971 906E+1	0,200 000 000E-2	0,500 000 000E+3	0,225 868 845E+4	0,210 206 932E+4	0,750 000 000E+3	0,634 165 360E+1	0,271 701 677E+1	0,369 468 579E+1	0,760 696 041E+3	61,93	384,4
region 5	0,5	0,965 408 875E+1	0,138 455 090E+1	0,722 255 860E+0	0,521 976 855E+4	0,452 749 310E+4	0,150 000 000E+4	0,261 609 445E+1	0,215 337 784E+1	0,121 485 600E+1	0,917 068 690E+3	---	---
	30	0,772 970 133E+1	0,230 761 300E-1	0,433 348 227E+2	0,516 723 514E+4	0,447 495 124E+4	0,150 000 000E+4	0,272 724 317E+1	0,219 274 829E+1	0,124 544 481E+1	0,928 548 002E+3	---	---
	30	0,853 640 523E+1	0,311 385 219E-1	0,321 145 623E+2	0,657 122 604E+4	0,563 707 038E+4	0,200 000 000E+4	0,288 569 882E+1	0,239 589 436E+1	0,121 958 005E+1	0,106 736 948E+4	---	---

Checking calculation and example of using IF97 functions - calculation from backward equations from P and H

To check calculations except for dynamic viscosity and thermal conductivity, data from "Revised Release on the IAPWS Industrial Formulation 1997 …" from the year 2007; specifically for region 1 from table 7, for region 2 from table 24 are used and for region 3, data from "Revised Supplementary Release on Backward Equations …" from the year 2004; from table 5 are used.

Calculation of dynamic viscosity and thermal conductivity is for information only, check data are in separate tables.

	Input values		Output values										
	Pressure	Specific enthalpy	Specific volume	Specific density	Temperature	Specific internal energy	Specific entropy	Specific isobaric heat capacity	Specific isochoric heat capacity	Isentropic exponent	Speed of sound	Dynamic viscosity	Thermal conductivity
	P [MPa]	h [kJ/kg]	v [m^3/kg]	ρ [kg/m^3]	[K]	u [kJ/kg]	s [kJ/kgK]	c_p [kJ/kgK]	c_v [kJ/kgK]	kapa [--]	w [m/s]	mi [μPa.s]	lam [mW/Km]
region 1	3	500	0,105 754 769E-2	0,945 583 838E+3	0,391 798 509E+3	0,496 854 971E+3	0,151 068 431E+1	0,423 700 784E+1	0,367 125 070E+1	0,737 159 820E+3	0,152 929 559E+4	235,6	683,7
	80	500	0,101 113 765E-2	0,988 985 030E+3	0,378 108 626E+3	0,419 045 673E+3	0,130 385 120E+1	0,407 226 955E+1	0,364 006 336E+1	0,356 026 517E+2	0,169 703 698E+4	288,4	722,3
	80	1500	0,132 152 054E-2	0,756 704 092E+3	0,611 041 229E+3	0,139 419 897E+4	0,335 294 085E+1	0,473 080 617E+1	0,291 493 585E+1	0,133 250 874E+2	0,118 690 780E+4	94,59	599,2
region 2a	0,001	3000	0,246 647 089E+3	0,405 437 584E-2	0,534 433 241E+3	0,275 334 553E+4	0,102 066 242E+2	0,197 604 945E+1	0,151 444 027E+1	0,130 476 416E+1	0,567 288 536E+3	18,73	39,3
	3	3000	0,816 103 154E-1	0,122 533 530E+2	0,575 373 370E+3	0,275 515 843E+4	0,655 103 210E+1	0,253 043 864E+1	0,179 357 800E+1	0,129 022 392E+1	0,562 038 027E+3	20,09	49,3
	3	4000	0,154 358 069E+0	0,647 844 332E+1	0,101 077 577E+4	0,353 692 063E+4	0,784 738 139E+1	0,233 981 043E+1	0,185 298 743E+1	0,125 342 856E+1	0,761 859 851E+3	38,17	99,5
region 2b	5	3500	0,714 751 382E-1	0,139 908 789E+2	0,801 299 102E+3	0,314 263 094E+4	0,706 105 592E+1	0,232 407 943E+1	0,176 056 816E+1	0,127 459 580E+1	0,674 914 480E+3	29,88	74,0
	5	4000	0,925 943 965E-1	0,107 997 896E+2	0,101 531 583E+4	0,353 704 029E+4	0,761 387 636E+1	0,237 017 129E+1	0,186 635 555E+1	0,125 466 134E+1	0,762 150 278E+3	38,45	101,7
	25	3500	0,141 966 081E-1	0,704 393 608E+2	0,875 279 054E+3	0,314 508 535E+4	0,637 104 614E+1	0,295 967 578E+1	0,199 880 095E+1	0,129 633 866E+1	0,678 299 564E+3	34,63	103,9
region 2c	40	2700	0,456 357 980E-2	0,219 126 222E+3	0,743 056 411E+3	0,251 738 167E+4	0,520 154 235E+1	0,815 763 051E+1	0,275 727 879E+1	0,153 194 737E+1	0,528 816 190E+3	36,62	182,0
	60	2700	0,331 969 676E-2	0,301 232 333E+3	0,791 137 067E+3	0,250 097 171E+4	0,510 153 326E+1	0,686 102 436E+1	0,263 515 900E+1	0,185 473 385E+1	0,607 806 907E+3	45,20	236,7
	60	3200	0,498 713 692E-2	0,200 515 850E+3	0,882 756 860E+3	0,290 071 528E+4	0,570 179 540E+1	0,439 749 229E+1	0,231 256 633E+1	0,150 212 235E+1	0,670 430 749E+3	41,87	174,0
region 3a	20	1700	0,174 990 808E-2	0,571 458 587E+3	6,293 083 892E+2	0,166 503 022E+4	0,381 518 416E+1	0,962 003 925E+1	0,310 963 785E+1	0,101 460 710E+2	0,595 897 501E+3	65,61	455,9
	50	2000	0,190 807 708E-2	0,524 087 842E+3	6,905 718 338E+2	0,190 460 188E+4	0,418 710 734E+1	0,770 198 689E+1	0,288 196 158E+1	0,480 531 528E+1	0,677 086 108E+3	62,29	408,5
	100	2100	0,167 618 629E-2	0,596 592 398E+3	7,336 163 014E+2	0,193 231 440E+4	0,420 280 614E+1	0,533 989 709E+1	0,271 343 877E+1	0,519 638 893E+1	0,933 280 016E+3	72,68	461,8
region 3b	20	2500	0,667 092 274E-2	0,149 904 299E+3	6,418 418 053E+2	0,236 664 983E+4	0,506 842 641E+1	0,219 644 648E+2	0,375 280 112E+1	0,127 717 233E+1	0,412 793 360E+3	26,48	181,7
	50	2400	0,280 110 600E-2	0,357 001 841E+3	7,351 848 618E+2	0,225 991 006E+4	0,474 765 962E+1	0,952 841 214E+1	0,286 602 013E+1	0,220 095 206E+1	0,555 207 169E+3	47,37	285,3
	100	2700	0,240 415 475E-2	0,415 946 603E+3	8,420 460 876E+2	0,245 954 621E+4	0,496 544 367E+1	0,543 670 234E+1	0,255 193 468E+1	0,250 092 283E+1	0,775 409 923E+3	56,91	322,8

Checking calculation and example of using IF97 functions - calculation from backward equations from P and S

To check calculations except for dynamic viscosity and thermal conductivity, data from "Revised Release on the IAPWS Industrial Formulation 1997 …" from the year 2007; specifically for region 1 from table 9, for region 2 from table 29 are used and for region 3, data from "Revised Supplementary Release on Backward Equations …" from the year 2004; from table 12 are used.

Calculation of dynamic viscosity and thermal conductivity is for information only, check data are in separate tables.

	Input values		Output values										
	Pressure	Specific entropy	Specific volume	Specific density	Specific enthalpy	Specific internal energy	Temperature	Specific isobaric heat capacity	Specific isochoric heat capacity	Isentropic exponent	Speed of sound	Dynamic viscosity	Thermal conductivity
	P [MPa]	s [kJ/kgK]	v [m^3/kg]	ρ [kg/m^3]	h [kJ/kg]	u [kJ/kg]	[K]	c_p [kJ/kgK]	c_v [kJ/kgK]	kapa [--]	w [m/s]	mi [μPa.s]	lam [mW/Km]
region 1	3	0,5	0,100 460 349E-2	0,995 417 601E+3	0,148 050 406E+3	0,145 036 595E+3	0,307 842 258E+3	0,417 157 882E+1	0,408 821 112E+1	0,772 678 586E+3	0,152 601 010E+4	723,7	622,8
	80	0,5	0,974 771 695E-3	0,102 588 125E+4	0,224 221 191E+3	0,146 239 456E+3	0,309 979 785E+3	0,402 123 411E+1	0,389 283 924E+1	0,352 214 387E+2	0,165 729 566E+4	705,8	662,8
	80	3	0,122 631 854E-2	0,815 448 815E+3	0,129 222 251E+4	0,119 411 703E+4	0,565 899 909E+3	0,448 347 449E+1	0,301 263 614E+1	0,179 006 372E+2	0,132 519 835E+4	107,9	650,5
region 2a	0,1	7,5	0,182 388 606E+1	0,548 279 865E+0	0,272 942 798E+4	0,254 703 938E+4	0,399 517 097E+3	0,200 873 380E+1	0,150 886 907E+1	0,131 640 921E+1	0,489 998 000E+3	13,26	26,8
	0,1	8	0,236 411 333E+1	0,422 991 567E+0	0,295 660 489E+4	0,272 019 356E+4	0,514 127 081E+3	0,198 574 968E+1	0,151 416 162E+1	0,130 660 457E+1	0,555 784 246E+3	17,88	37,4
	2,5	8	0,190 940 879E+0	0,523 722 318E+1	0,407 073 464E+4	0,359 338 244E+4	0,103 984 917E+4	0,234 979 706E+1	0,186 920 330E+1	0,125 038 438E+1	0,772 576 038E+3	39,27	103,1
region 2b	8	6	0,276 664 506E-1	0,361 448 606E+2	0,290 739 409E+4	0,268 606 249E+4	0,600 484 040E+3	0,383 976 004E+1	0,227 579 207E+1	0,127 265 391E+1	0,530 733 956E+3	21,01	63,6
	8	7,5	0,605 038 167E-1	0,165 278 829E+2	0,410 410 710E+4	0,362 007 657E+4	0,106 495 556E+4	0,242 910 574E+1	0,190 875 504E+1	0,125 331 192E+1	0,778 871 774E+3	40,52	111,0
	90	6	0,454 349 840E-2	0,220 094 718E+3	0,362 808 026E+4	0,321 916 540E+4	0,103 801 126E+4	0,363 342 981E+1	0,222 911 827E+1	0,153 875 255E+1	0,793 233 117E+3	48,97	216,5
region 2c	20	5,75	0,114 672 968E-1	0,872 045 103E+2	0,295 210 742E+4	0,272 276 149E+4	0,697 992 849E+3	0,476 888 638E+1	0,241 716 186E+1	0,129 589 195E+1	0,545 167 453E+3	26,98	94,4
	80	5,25	0,314 619 832E-2	0,317 843 918E+3	0,288 672 594E+4	0,263 503 008E+4	0,854 011 484E+3	0,545 613 741E+1	0,248 794 530E+1	0,191 881 900E+1	0,694 952 378E+3	49,11	251,0
	80	5,75	0,426 104 741E-2	0,234 684 082E+3	0,333 596 132E+4	0,299 507 753E+4	0,949 017 998E+3	0,412 883 519E+1	0,229 673 264E+1	0,158 498 381E+1	0,735 047 816E+3	46,70	207,0
region 3a	20	3,8	0,173 366 619E-2	0,576 812 311E+3	0,169 045 878E+4	0,165 578 546E+4	6,282 959 869E+2	0,929 208 390E+1	0,309 738 437E+1	0,106 713 311E+2	0,608 284 900E+3	66,27	458,9
	50	3,6	0,146 962 695E-2	0,680 444 791E+3	0,161 165 420E+4	0,153 817 285E+4	6,297 158 726E+2	0,549 271 955E+1	0,290 335 633E+1	0,123 097 275E+2	0,951 070 640E+3	81,28	529,5
	100	4,0	0,155 581 222E-2	0,642 751 091E+3	0,195 386 599E+4	0,179 828 477E+4	7,056 880 237E+2	0,511 967 708E+1	0,274 685 345E+1	0,646 916 871E+1	0,100 323 535E+4	78,01	501,0
region 3b	20	5,0	0,626 056 454E-2	0,159 730 004E+3	0,245 606 822E+4	0,233 085 693E+4	6,401 176 443E+2	0,302 448 542E+2	0,397 784 411E+1	0,127 013 571E+1	0,398 792 342E+3	26,88	210,0
	50	4,5	0,233 289 212E-2	0,428 652 484E+3	0,222 028 549E+4	0,210 364 089E+4	7,163 687 517E+2	0,932 608 468E+1	0,289 880 850E+1	0,293 248 093E+1	0,584 857 318E+3	53,25	339,4
	100	5,0	0,244 955 561E-2	0,408 237 313E+3	0,272 914 399E+4	0,248 418 843E+4	8,474 332 825E+2	0,539 674 003E+1	0,254 264 964E+1	0,243 679 868E+1	0,772 597 817E+3	56,40	317,4

Checking calculation and example of using IF97 functions - equations for saturation line

Data for checking the program from "Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use" from the year 2009; table 8 on page 14 are used as input.
These data were used because there are no such data in IF97, and with the understanding that values calculated using IF97 equations will not exactly match IF95 values.

Values calculated by equations IF97 :

	T = 275 °K	T = 450 °K	T = 625 °K
Specific density ρ' [kg/m^3]	0,999 888 397E+3	0,890 346 801E+3	0,567 062 014E+3
Specific density ρ'' [kg/m^3]	0,550 647 310E-2	0,481 150 942E+1	0,118 308 455E+3
Specific enthalpy h' [kJ/kg]	0,775 955 758E+1	0,749 293 340E+3	0,168 627 331E+4
Specific enthalpy h'' [kJ/kg]	0,250 429 111E+4	0,277 441 019E+4	0,255 065 140E+4
Specific entropy s' [kJ/kgK]	0,283 088 058E-1	0,210 894 620E+1	0,380 191 134E+1
Specific entropy s'' [kJ/kgK]	0,910 661 682E+1	0,660 922 243E+1	0,518 491 640E+1

Original table 8 on page 14 in IF95 :

Thermodynamic property values in the two-phase region for selected values of temperature

	T = 275 °K	T = 450 °K	T = 625 °K
Specific density ρ' [kg/m^3]	0,999 887 406E+3	0,890 341 250E+3	0,567 090 385E+3
Specific density ρ'' [kg/m^3]	0,550 664 919E-2	0,481 200 360E+1	0,118 290 280E+3
Specific enthalpy h' [kJ/kg]	0,775 972 202E+1	0,749 161 585E+3	0,168 626 976E+4
Specific enthalpy h'' [kJ/kg]	0,250 428 995E+4	0,277 441 078E+4	0,255 071 625E+4
Specific entropy s' [kJ/kgK]	0,283 094 670E-1	0,210 865 845E+1	0,380 194 683E+1
Specific entropy s'' [kJ/kgK]	0,910 660 121E+1	0,660 921 221E+1	0,518 506 121E+1

Deviations [%] of values calculated according to IF97 from values in IF95 :

(IF95 values are taken as 100%)

	T = 275 °K	T = 450 °K	T = 625 °K
Specific density ρ' [%]	-0,0001	-0,0006	0,0050
Specific density ρ'' [%]	0,0032	0,0103	-0,0154
Specific enthalpy h' [%]	0,0021	-0,0176	-0,0002
Specific enthalpy h'' [%]	0,0000	0,0000	0,0025
Specific entropy s' [%]	0,0023	-0,0136	0,0009
Specific entropy s'' [%]	-0,0002	-0,0002	0,0028