Water97_v13.xla – Excel Add-In for Properties of Water and Steam in SI-Units

Version 1.3 – 10 February 2002, documentation updated

Version 1.2 – 6 February 2001, numerical values in densreg3 adjusted

Version 1.1 – 29 January 2001, error in the calculation of thermal conductivity (partial derivatives) corrected.

Version 1.0 – 27 August 2000

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Introduction

Water97_v13.xla is an Add-In for MS Excel which provides a set of functions for calculating thermodynamic and transport properties of water and steam using the industrial standard IAPWS-IF97. For more information about IAPWS-IF97, underlying equations and references see

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

Installation

The functions are provided as an Add-In file (water97_v13.xla) for MS Excel. After downloading and decompressing the archive file which contains "water97_v13.xla" you may load "water97_v13.xla" in Excel every time you need it by going to Tools...Add-ins or by simply double clicking on "water97_v13.xla" in Explorer. The water property functions are then available just like built-in functions. In the function Wizard list they can be found under User Defined. See also the documentation for MS Excel for more information about add-in files.

Reference of available functions

Functions are available for calculating the following properties in the single-phase state for temperatures 273.15 K $\leq T \leq$ 1073.15 K and pressures $0 < p \leq$ 1000 bar

- density
- specific internal energy
- specific enthalpy
- specific entropy
- specific isobaric heat capacity
- specific isochoric heat capacity
- dynamic viscosity
- thermal conductivity

Additionally there are functions for calculating the boiling point temperature as a function of pressure and

the vapor pressure as a function of temperature as well as above eight properties for the saturated liquid and vapor state both as a function of temperature and pressure between 273.16 K or 611.657 Pa and 647.096 K or 220.64 bar (critical point).

1. Density in single-phase state

a) Usage: densW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: density in kg/m^3

d) Range of validity: $273.15\ K \leq T \leq 1073.15\ K$ and $0 < p \leq 1000$ bar

e)Error: densW = -1, temperature and/or pressure outside range

f) Example: density of water at 1 bar and 20 °C
formula in worksheet cell: =densW(20+273.15; 1)

2. Specific internal energy in single-phase state

a) Usage: energyW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: specific internal energy in kJ/kg

d) Range of validity: $273.15\ K \leq T \leq 1073.15\ K$ and $0 < p \leq 1000$ bar

e)Error: energyW = -1, temperature and/or pressure outside range

f) Example: specific internal energy of water at 10 bar and 400 K
formula in worksheet cell: =energyW(400; 10)

3. Specific enthalpy in single-phase state

a) Usage: enthalpyW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: specific enthalpy in kJ/kg

d) Range of validity: $273.15\ K \leq T \leq 1073.15\ K$ and $0 < p \leq 1000$ bar

e)Error: enthalpyW = -1, temperature and/or pressure outside range

f) Example: specific enthalpy of water at 10 bar and 400 K
formula in worksheet cell: =enthalpyW(400; 10)

4. Specific entropy in single-phase state

a) Usage: entropyW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: specific entropy in kJ/(kg K)

d) Range of validity: 273.15 K ≤ T ≤ 1073.15 K and 0 < p ≤ 1000 bar

e)Error: entropyW = -1, temperature and/or pressure outside range

f) Example: specific entropy of water at 10 bar and 400 K
formula in worksheet cell: =entropyW(400; 10)

5. Specific isobaric heat capacity in single-phase state

a) Usage: cpW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: specific isobaric heat capacity in kJ/(kg K)

d) Range of validity: 273.15 K ≤ T ≤ 1073.15 K and 0 < p ≤ 1000 bar

e)Error: cpW = -1, temperature and/or pressure outside range

f) Example: specific isobaric heat capacity of steam at 1 bar and 120 °C
formula in worksheet cell: =cpW(120+273.15; 1)

6. Specific isochoric heat capacity in single-phase state

a) Usage: cvW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: specific isochoric heat capacity in kJ/(kg K)

d) Range of validity: 273.15 K ≤ T ≤ 1073.15 K and 0 < p ≤ 1000 bar

e)Error: cvW = -1, temperature and/or pressure outside range

f) Example: specific isochoric heat capacity of steam at 1 bar and 120 °C
formula in worksheet cell: =cvW(120+273.15; 1)

7. Dynamic viscosity in single-phase state

a) Usage: viscW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: dynamic viscosity in Pa s

d) Range of validity: 273.15 K ≤ T ≤ 1073.15 K and 0 < p ≤ 1000 bar

e)Error: viscW = -1, temperature and/or pressure outside range

f) Example: dynamic viscosity of water at 1 bar and 20 °C
formula in worksheet cell: =viscW(20+273.15; 1)

8. Thermal conductivity in single-phase state

a) Usage: thconW(T; P)

b) Argument(s): T temperature in K
P pressure in bar

c) Unit: thermal conductivity in W/(m K)

d) Range of validity: 273.15 K ≤ T ≤ 1073.15 K and 0 < p ≤ 1000 bar

e)Error: thconW = -1, temperature and/or pressure outside range

f) Example: thermal conductivity of water at 1 bar and 20 °C
formula in worksheet cell: =thconW(20+273.15; 1)

9. Boiling point as a function of pressure

a) Usage: tSatW(P)

b) Argument(s): P pressure in bar

c) Unit: boiling point in K

d) Range of validity: 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: tSatW = -1, pressure outside range

f) Example: boiling point of water at 1 bar in °C
formula in worksheet cell: =tSatW(1)-273.15

10. Vapor pressure

a) Usage: pSatW(T)

b) Argument(s): T temperature in K

c) Unit: vapor pressure in bar

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K

e)Error: pSatW = -1, temperature outside range

f) Example: vapor pressure of water at 100 °C
formula in worksheet cell: =pSatW(373.15)

11. Density in saturation state

a) Usage: densSatLiqTW(T), density of boiling water as a function of temperature
densSatLiqPW(P), density of boiling water as a function of pressure
densSatVapTW(T), density of saturated steam as a function of temperature
densSatVapPW(P), density of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: density in kg/m^3

d) Range of validity: $273.16\ K \leq T \leq 647.096\ K$ or $611.657\ Pa \leq p \leq 220.64$ bar

e)Error: densSatxxxxW = -1, temperature or pressure outside range

f) Example: density of boiling water at 1 bar
formula in worksheet cell: =densSatLiqPW(1)

12. Specific internal energy in saturation state

a) Usage: energySatLiqTW(T), specific internal energy of boiling water as a function of temperature
energySatLiqPW(P), specific internal energy of boiling water as a function of pressure
energySatVapTW(T), specific internal energy of saturated steam as a function of temperature
energySatVapPW(P), specific internal energy of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: specific internal energy in kJ/kg

d) Range of validity: $273.16\ K \leq T \leq 647.096\ K$ or $611.657\ Pa \leq p \leq 220.64$ bar

e)Error: energySatxxxxW = -1, temperature or pressure outside range

f) Example: specific internal energy of saturated steam at 100 °C
formula in worksheet cell: =energySatVapTW(100+273.15)

13. Specific enthalpy in saturation state

a) Usage: enthalpySatLiqTW(T), specific enthalpy of boiling water as a function of temperature
enthalpySatLiqPW(P), specific enthalpy of boiling water as a function of pressure
enthalpySatVapTW(T), specific enthalpy of saturated steam as a function of temperature
enthalpySatVapPW(P), specific enthalpy of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: specific enthalpy in kJ/kg

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K or 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: enthalpySatxxxxW = -1, temperature or pressure outside range

f) Example: specific enthalpy of saturated steam at 100 °C
formula in worksheet cell: =enthalpySatVapTW(100+273.15)

14. Specific entropy in saturation state

a) Usage: entropySatLiqTW(T), specific entropy of boiling water as a function of temperature
entropySatLiqPW(P), specific entropy of boiling water as a function of pressure
entropySatVapTW(T), specific entropy of saturated steam as a function of temperature
entropySatVapPW(P), specific entropy of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: specific entropy in kJ/(kg K)

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K or 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: entropySatxxxxW = -1, temperature or pressure outside range

f) Example: specific entropy of saturated steam at 100 °C
formula in worksheet cell: =entropySatVapTW(100+273.15)

15. Specific isobaric heat capacity in saturation state

a) Usage: cpSatLiqTW(T), specific isobaric heat capacity of boiling water as a function of temperature
cpSatLiqPW(P), specific isobaric heat capacity of boiling water as a function of pressure
cpSatVapTW(T), specific isobaric heat capacity of saturated steam as a function of temperature
cpSatVapPW(P), specific isobaric heat capacity of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: specific isobaric heat capacity in kJ/(kg K)

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K or 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: cpSatxxxxW = -1, temperature or pressure outside range

f) Example: specific isobaric heat capacity of boiling water at 100 °C
formula in worksheet cell: =cpSatLiqTW(100+273.15)

16. Specific isochoric heat capacity in saturation state

a) Usage: cvSatLiqTW(T), specific isochoric heat capacity of boiling water as a function of temperature
cvSatLiqPW(P), specific isochoric heat capacity of boiling water as a function of pressure
cvSatVapTW(T), specific isochoric heat capacity of saturated steam as a function of temperature
cvSatVapPW(P), specific isochoric heat capacity of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: specific isochoric heat capacity in kJ/(kg K)

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K or 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: cvSatxxxxW = -1, temperature or pressure outside range

f) Example: specific isochoric heat capacity of saturated steam at 500 mbar
formula in worksheet cell: =cvSatVapPW(0.5)

17. Dynamic viscosity in saturation state

a) Usage: viscSatLiqTW(T), dynamic viscosity of boiling water as a function of temperature
viscSatLiqPW(P), dynamic viscosity of boiling water as a function of pressure
viscSatVapTW(T), dynamic viscosity of saturated steam as a function of temperature
viscSatVapPW(P), dynamic viscosity of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: dynamic viscosity in Pa s

d) Range of validity: 273.16 K ≤ T ≤ 647.096 K or 611.657 Pa ≤ p ≤ 220.64 bar

e)Error: viscSatxxxxW = -1, temperature or pressure outside range

f) Example: dynamic viscosity of boiling water at 1 bar
formula in worksheet cell: =viscSatLiqPW(1)

18. Thermal conductivity in saturation state

a) Usage: thconSatLiqTW(T), thermal conductivity of boiling water as a function of temperature
thconSatLiqPW(P), thermal conductivity of boiling water as a function of pressure
thconSatVapTW(T), thermal conductivity of saturated steam as a function of temperature
thconSatVapPW(P), thermal conductivity of saturated steam as a function of pressure

b) Argument(s): T temperature in K or P pressure in bar

c) Unit: thermal conductivity in W/(m K)

d) Range of validity: 273.16 K $\leq$ T $\leq$ 647.096 K or 611.657 Pa $\leq$ p $\leq$ 220.64 bar

e)Error: thconSatxxxxW = -1, temperature or pressure outside range

f) Example: thermal conductivity of boiling water at 1 bar
formula in worksheet cell: =thconSatLiqPW(1)