KCE
ThermoFluidProperties

Property Library for the Industrial Formulation IAPWS-IF97 for Water and Steam

FluidPRIME
with LibIF97_Stud
for Mathcad Prime®

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Property Library for the Industrial Formulation IAPWS-IF97 for Water and Steam

LibIF97_Stud

FluidPRIME for Mathcad Prime®

Contents

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0. Package Contents

Zip file "CD_FluidPRIME_LibIF97_Stud.zip" includes the following files:

FluidPRIME_LibIF97_Stud_Docu.pdf	- User's Guide
Functions_LibIF97_Stud.mcdx	- Mathcad Prime® worksheet with all functions
LibIF97_Stud.msi	- MSI installer
setup.exe	- Setup installer

1. Program Functions

1.1 Range of Validity

The International Association for the Properties of Water and Steam IAPWS issued the

"Release on the IAPWS Industrial Formulation 1997
for the Thermodynamic Properties of Water and Steam IAPWS-IF97"

in September 1997 [1], [2]. It will be abbreviated as IAPWS-IF97. This industrial standard must be applied worldwide in acceptance and guarantees calculations of facilities and plants working with water or steam.

Figure 1.1 shows the entire range of validity for the equation set of the Industrial Formulation IAPWS-IF97. It includes temperatures from 0 °C to 800 °C at pressures from 0.00611 bar to 1000 bar and temperatures to 2000 °C for pressures to 500 bar.

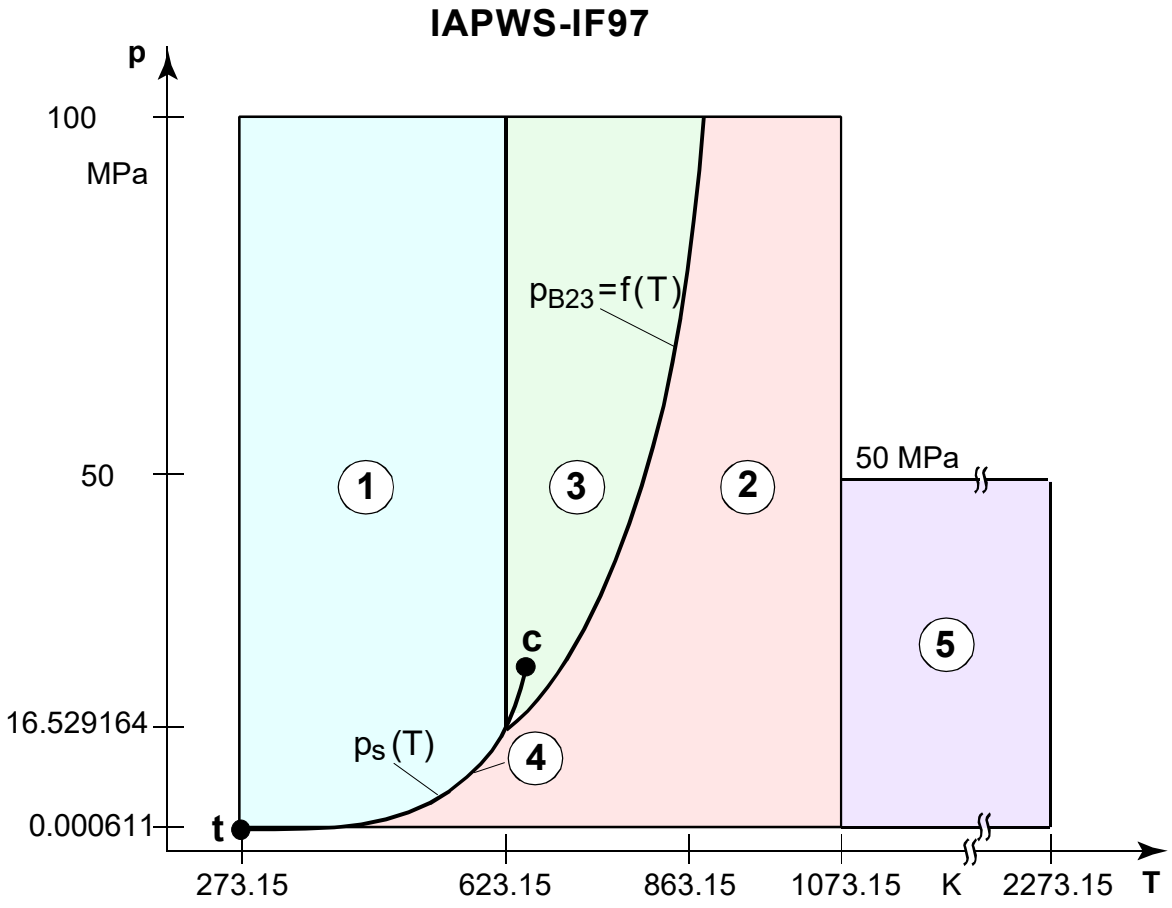


Figure 1.1 Entire Range of Validity of the IAPWS-IF97

The range of validity is divided into five calculation regions. Each of the calculation regions contains its own equations of state. They are described in detail in the official Release of the IAPWS [1] and in the publication of *Kretzschmar* and *Wagner* [2].

The sub-programs of the LibIF97_Stud library are valid in Regions 1,2, and 4.

1.2 Functions

Functional Dependence	Function Name	Property or Function	Unit of the Result	References
c_p = f(p,t,x)	cp_ptx_97_Stud	Specific isobaric heat capacity	kJ/(kg·K)	[1], [2]
η = f(p,t,x)	eta_ptx_97_Stud	Dynamic viscosity	Pa s = kg/(m s)	[1], [2], [5]
h = f(p,t,x)	h_ptx_97_Stud	Specific enthalpy	kJ/kg	[1], [2], [7]
λ = f(p,t,x)	lambda_ptx_97_stud	Heat conductivity	W/(m·K)	[1], [2], [4]
p_s = f(t)	ps_t_97_Stud	Vapor pressure	bar	[1], [2], [8]
s = f(p,t,x)	s_ptx_97_stud	Specific entropy	kJ/(kg·K)	[1], [2], [7]
t = f(p,h)	t_ph_97_Stud	Backward function: Temperature from pressure and enthalpy	°C	[1], [2], [7]
t = f(p,s)	t_ps_97_Stud	Backward function: Temperature from pressure and entropy	°C	[1], [2], [7]
v = f(p,t,x)	v_ptx_97_Stud	Specific volume	m^3/kg	[1], [2]
x = f(p,h)	x_ph_97_Stud	Backward function: Vapor fraction from pressure and enthalpy	kg/kg	[1], [2], [7]
x = f(p,s)	x_ps_97_Stud	Backward function: Vapor fraction from pressure and entropy	kg/kg	[1], [2], [7]

Units: t in °C
p in bar
x in kg saturated steam/kg wet steam

Range of validity of the property library

Temperature: from 0 °C to 350 °C
Pressure: from 0.00611 bar to 1000 bar

Details on the vapor fraction *x* and on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms.
For this purpose the following fixed details on the vapor fraction x are to be considered:

Single-phase region

If the state point to be calculated is located in the single-phase region (liquid or superheated steam) -> x = –1 must be entered as a pro-forma value.

Wet-steam region

If the state point to be calculated is located in the wet steam region
-> a value for *x* between 0 and 1 (*x* = 0 for saturated liquid, *x* = 1 for saturated steam) must be entered.

In this case, the backward functions result in the appropriate value between 0 and 1 for *x*.

When calculating wet steam either the given value for *t* and *p* = -1 or the given value for *p* and *t* = -1 and
in both cases the value for *x* between 0 and 1 must be entered.

If *p* and *t* and *x* are entered as given values, the program considers *p* and *t* to be appropriate to represent the vapor pressure curve.
If this is not the case the calculation for the property of the chosen function results in –1.

Wet steam region of the IAPWS-IF97: Temperature from 0 °C to 350 °C
Pressure from 0.00611 bar to 15.29164 bar

Note.

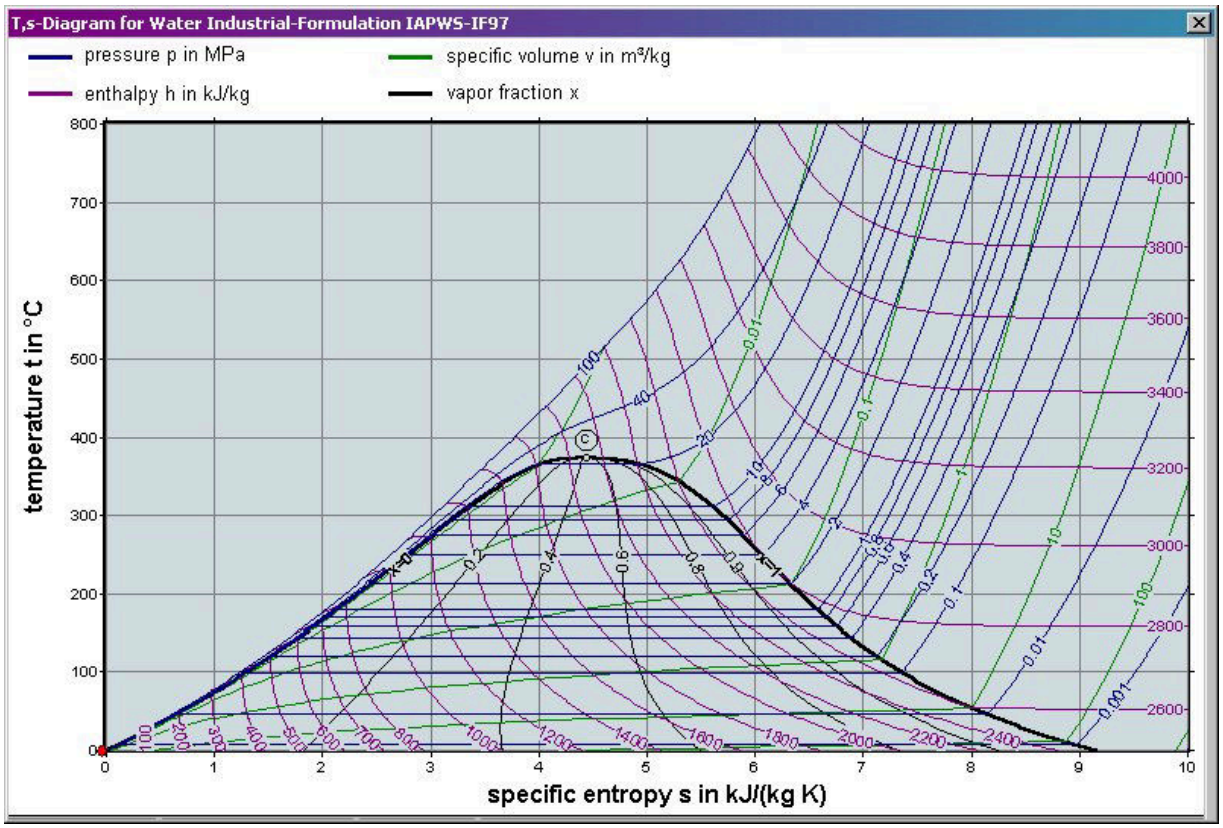
If the calculation results in –1, the values entered represent a state point beyond the range of validity of IAPWS-IF97.

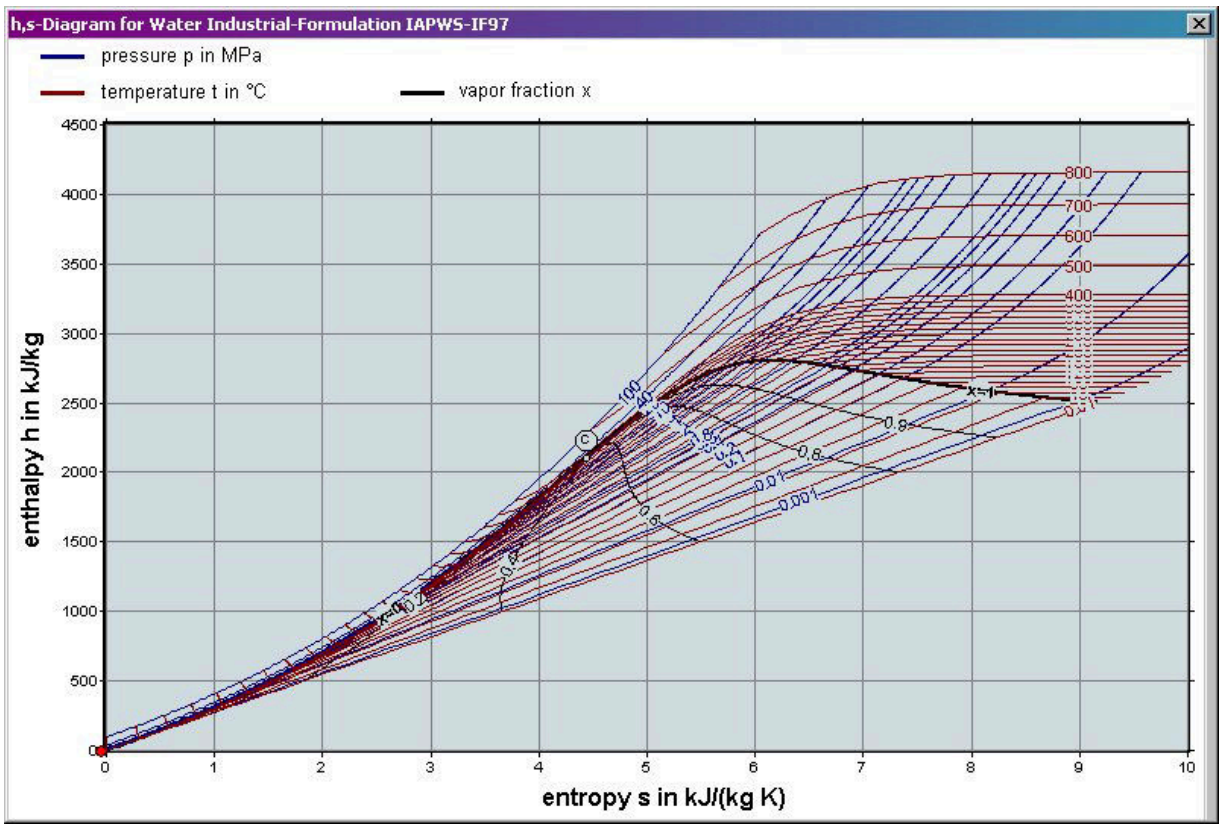
1.3 Thermodynamic Diagrams

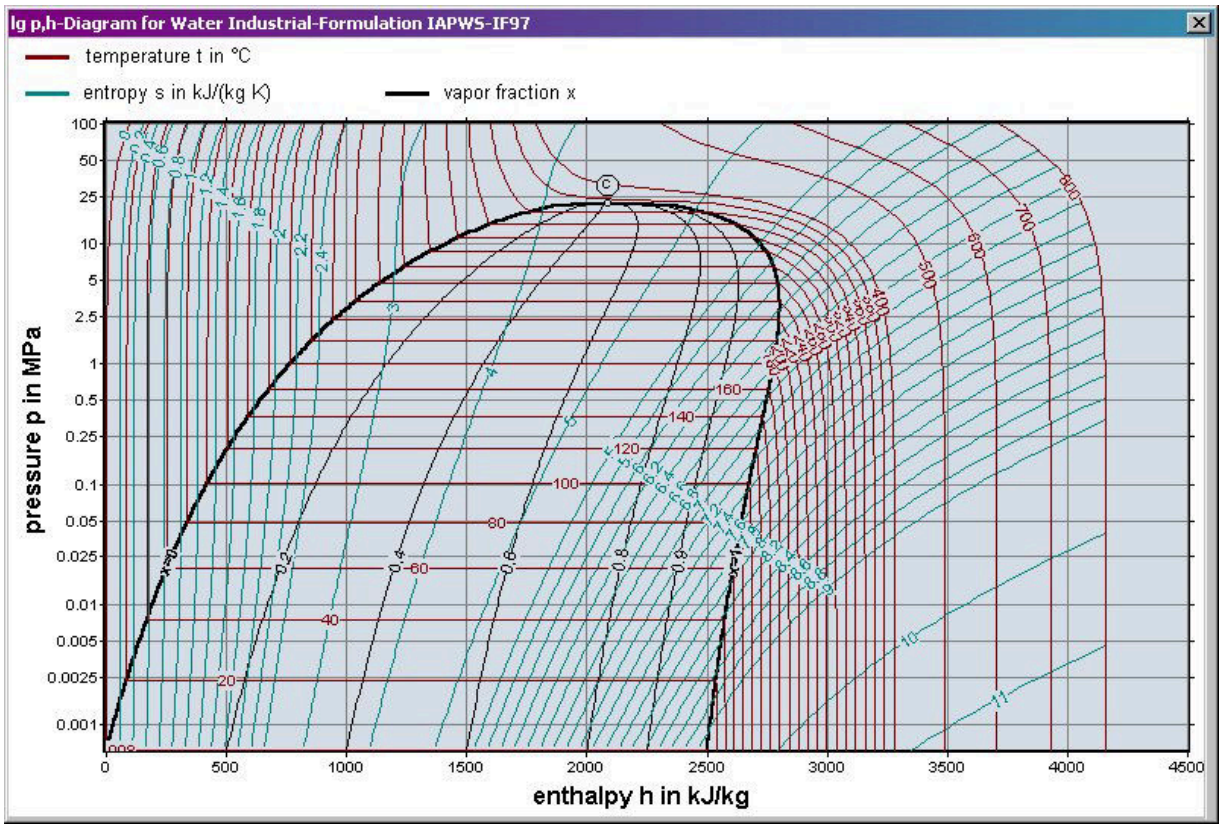
FluidEXL*Graphics*Stud enables the user to represent the calculated properties in the following thermodynamic diagrams:

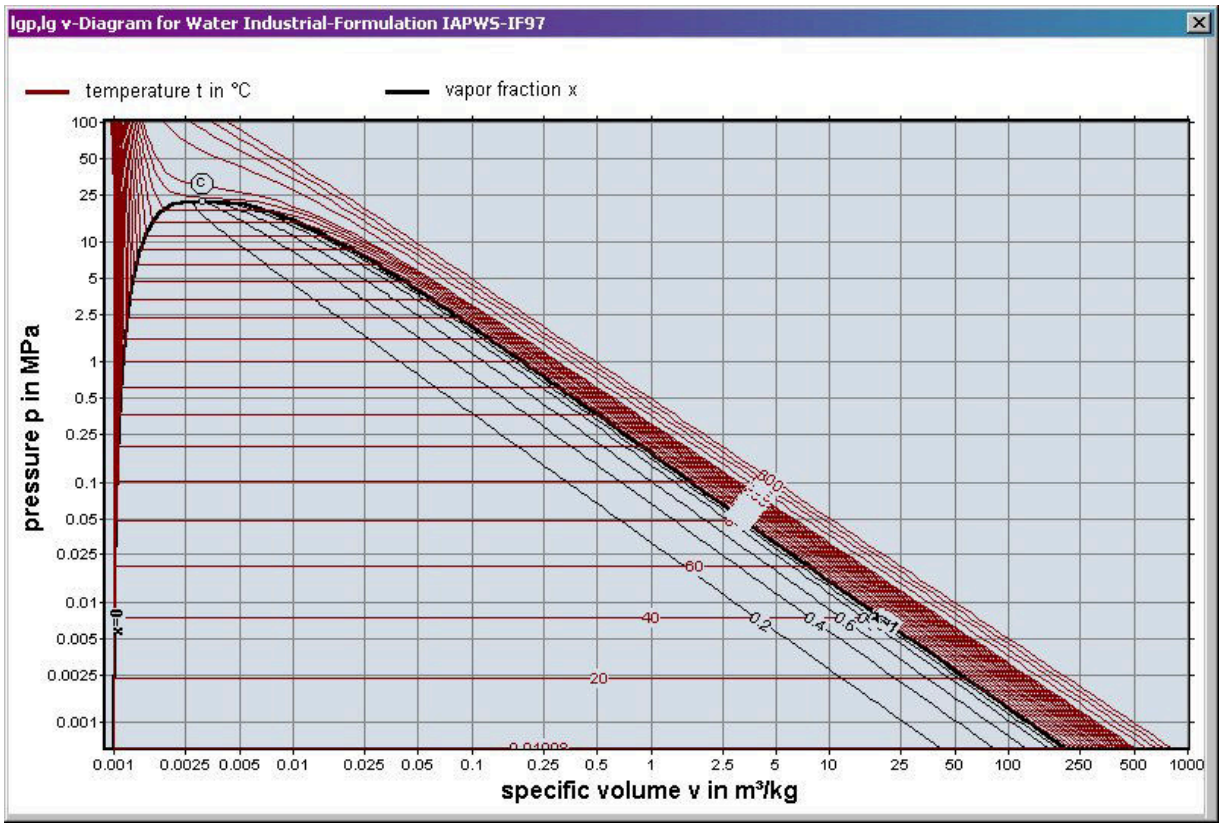
- *T-s* diagram
- *T-h* diagram
- *h-s* diagram
- *T-log(v)* diagram
- *log(p)-h* diagram
- *log(p)-s* diagram
- *log(p)-log(v)* diagram
- *h-log(v)* diagram
- *log(p)-T* diagram
- *s-log(v)*-diagram
- *p-T* diagram

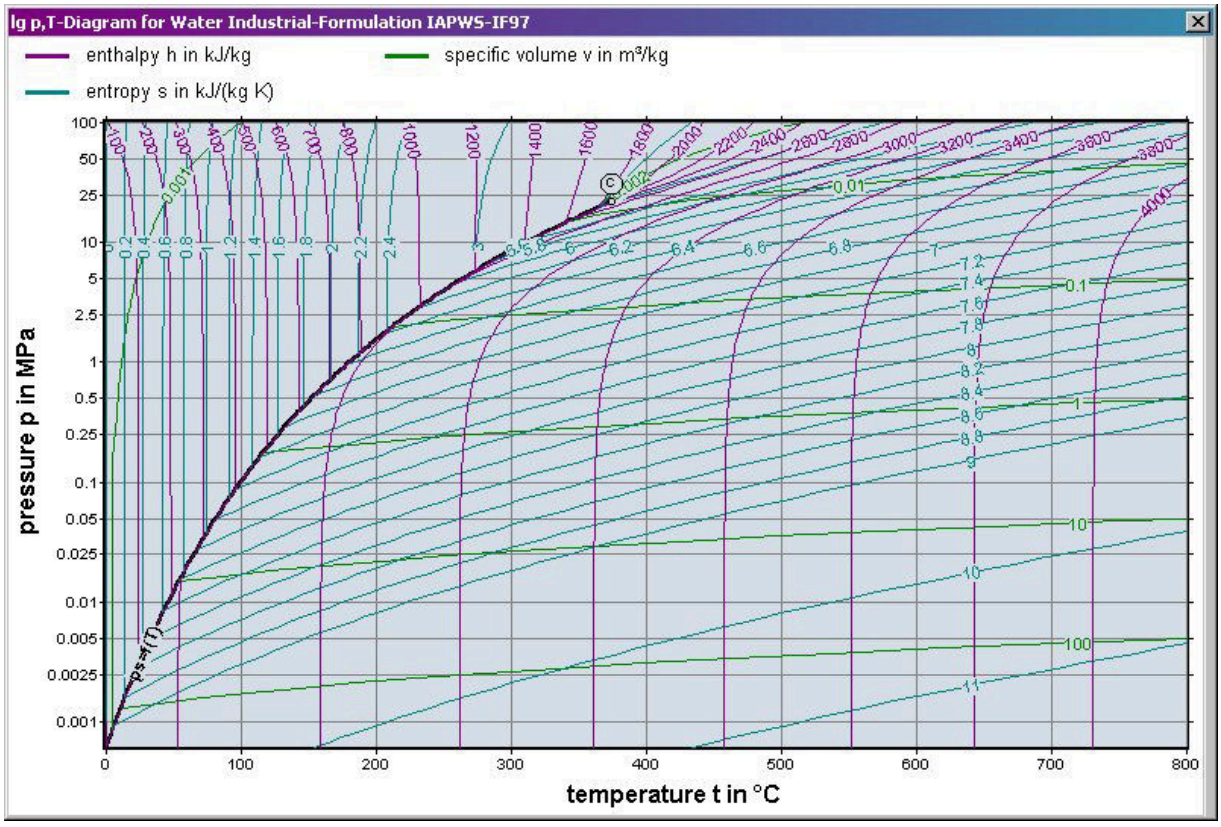
The diagrams, in which the calculated state point will be displayed, are shown on the following pages.

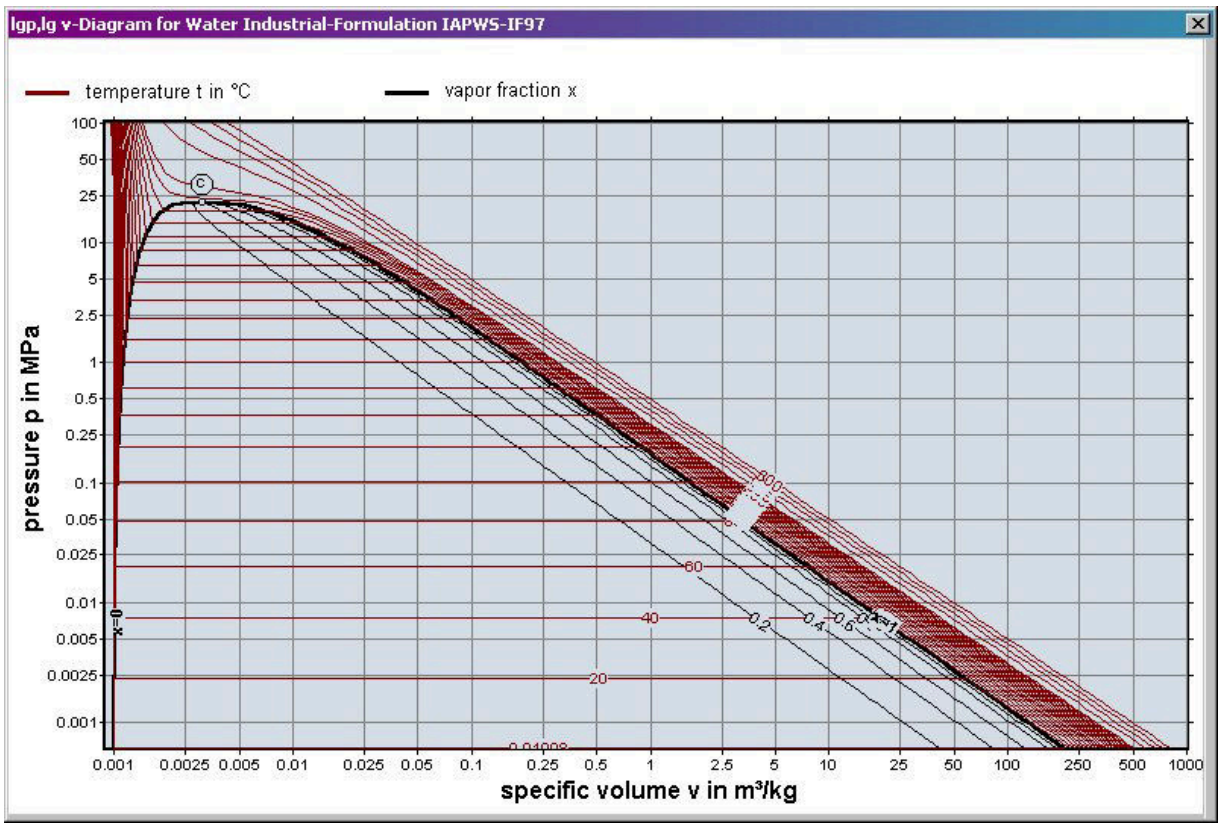


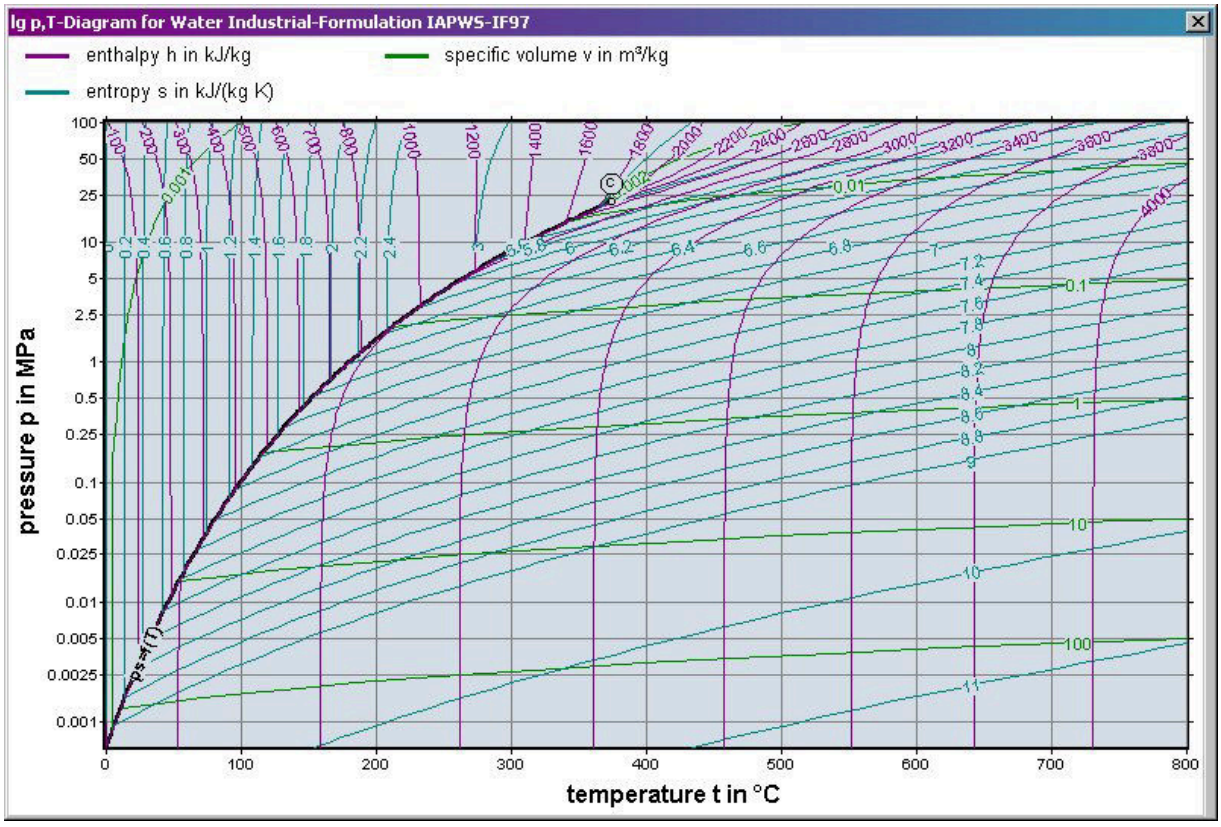

h,s-Diagram for Water Industrial-Formulation IAPWS-IF97
pressure p in MPa
temperature t in °C
vapor fraction x
enthalpy h in kJ/kg
entropy s in kJ/(kg K)

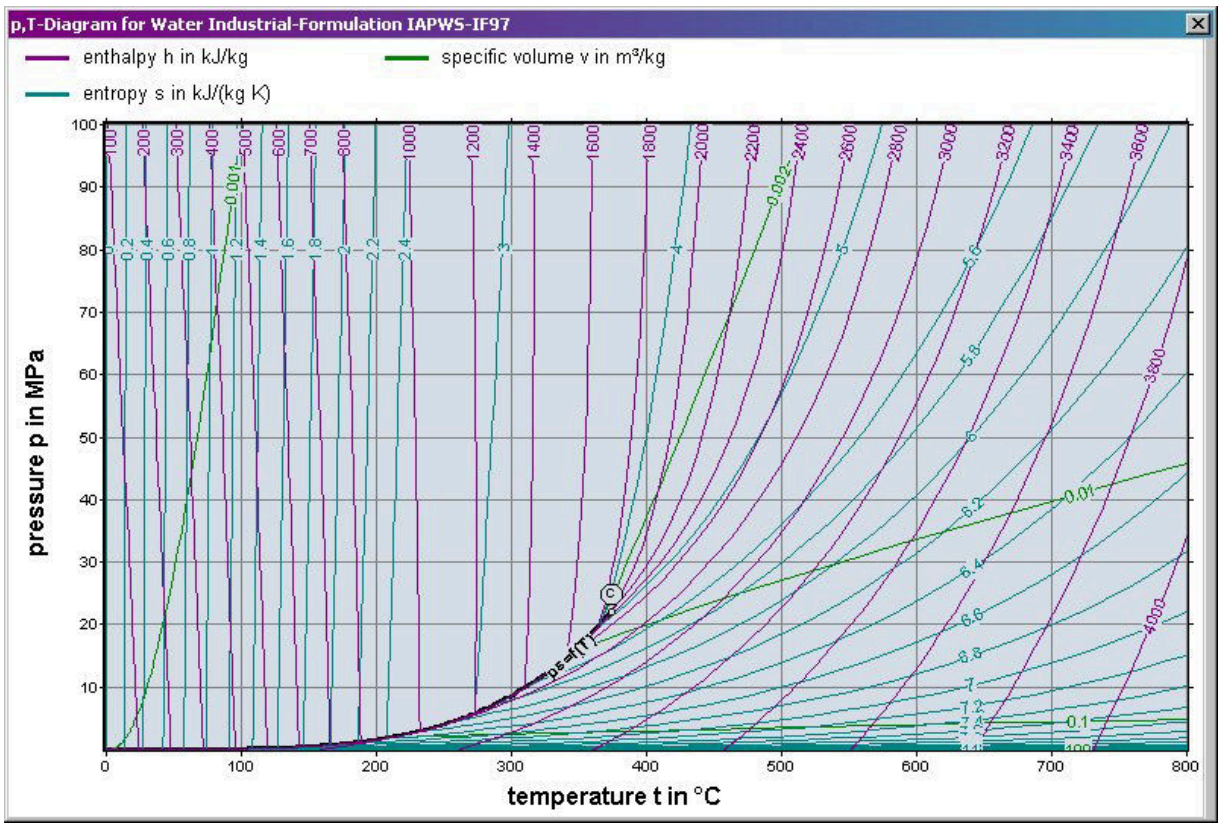

lg p,h-Diagram for Water Industrial-Formulation IAPWS-IF97
temperature t in °C
entropy s in kJ/(kg K)
vapor fraction x
pressure p in MPa
enthalpy h in kJ/kg

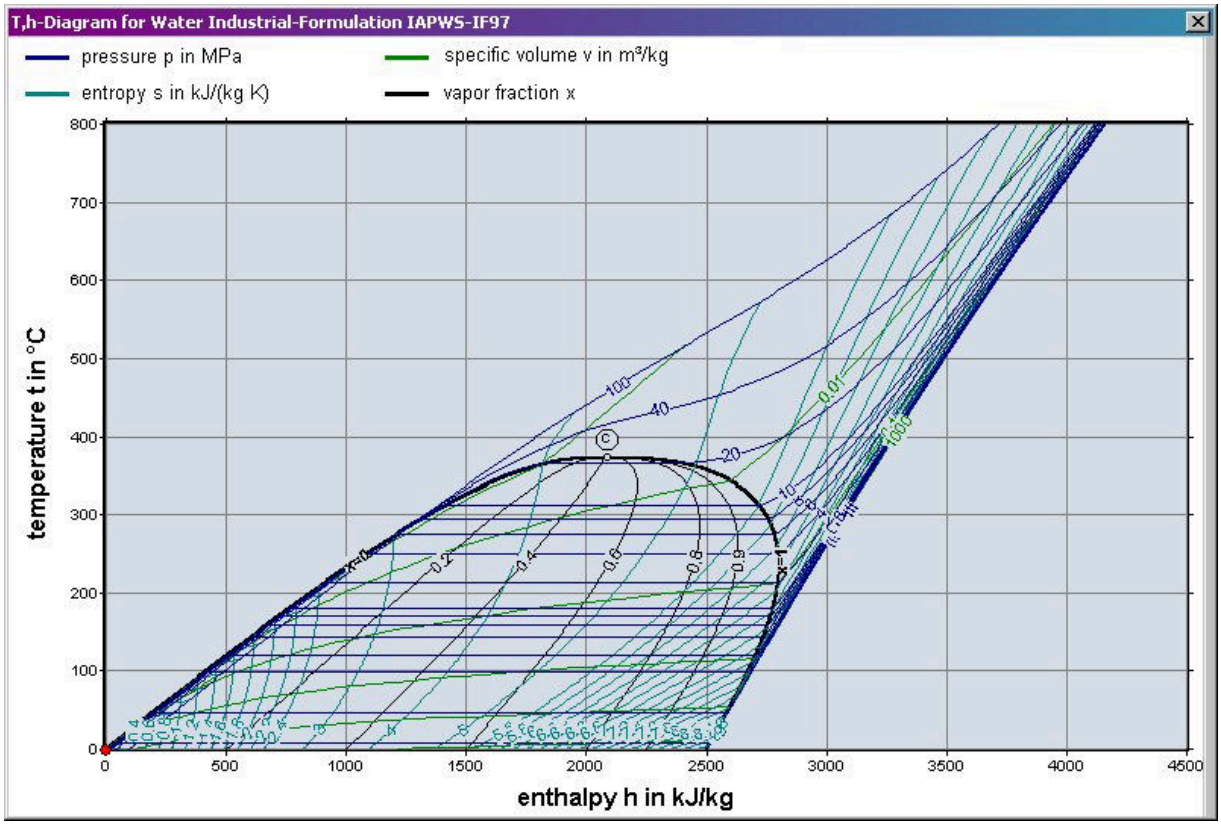

lgp,lg v-Diagram for Water Industrial-Formulation IAPWS-IF97
temperature t in °C
vapor fraction x
pressure p in MPa
specific volume v in m³/kg
x=0
C

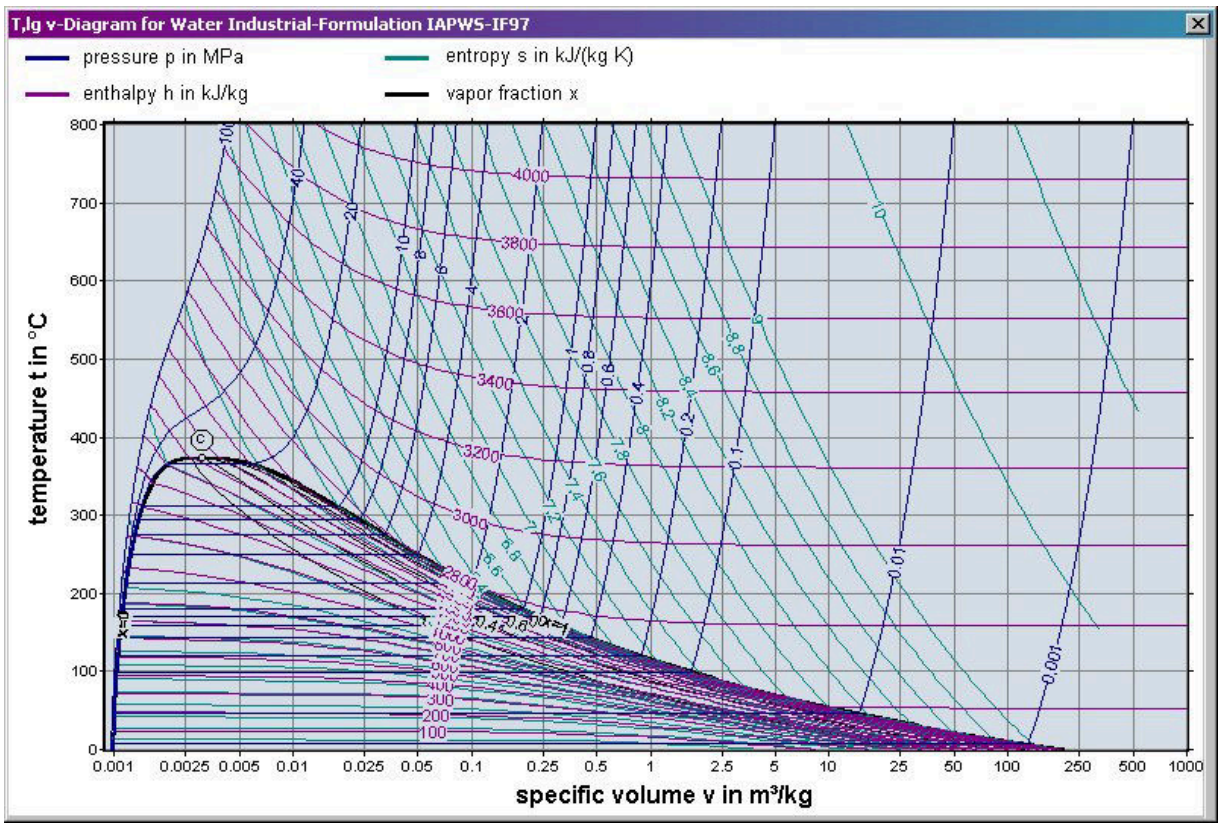

lg p,T-Diagram for Water Industrial-Formulation IAPWS-IF97
enthalpy h in kJ/kg
specific volume v in m³/kg
entropy s in kJ/(kg K)
pressure p in MPa
temperature t in °C
ps=f(T)
C

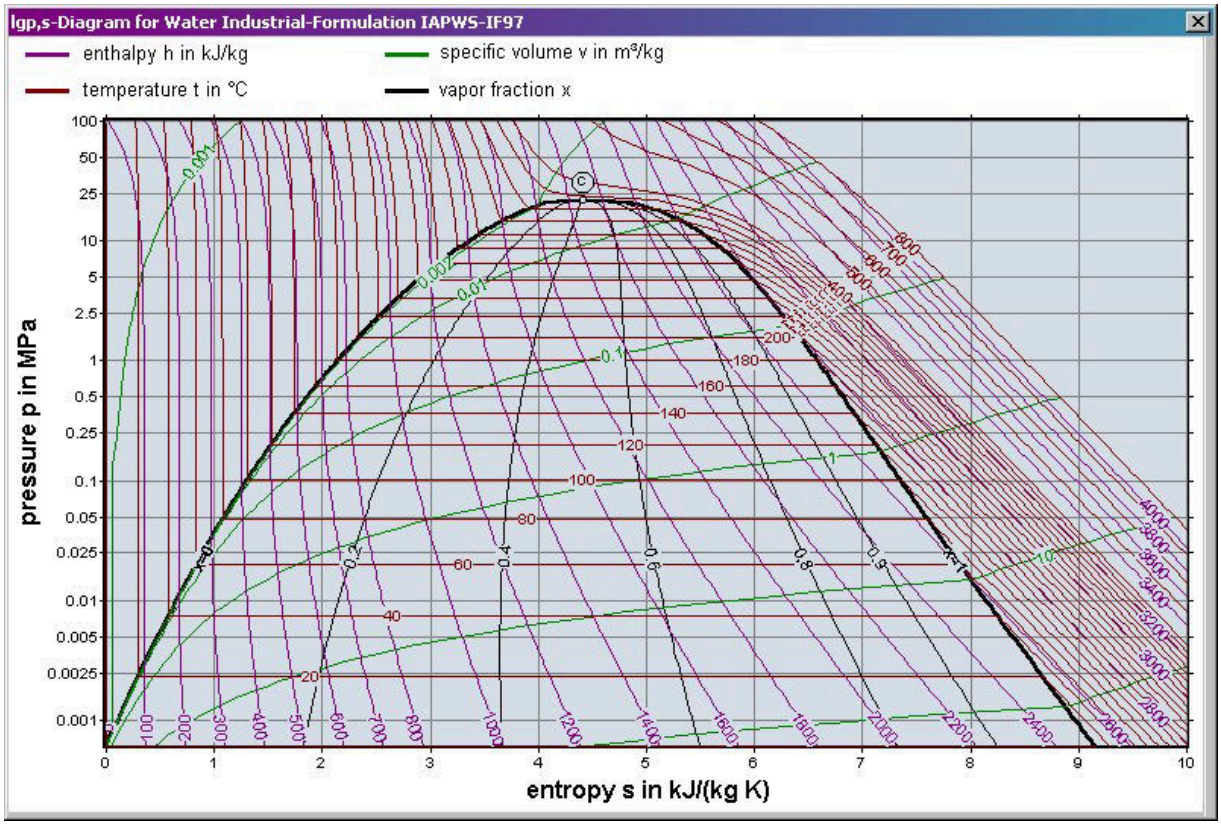

lgp,lg v-Diagram for Water Industrial-Formulation IAPWS-IF97
temperature t in °C
vapor fraction x
pressure p in MPa
specific volume v in m³/kg
C
x=0
x=1
800
60
40
20
0.2
0.4
0.6
0.8

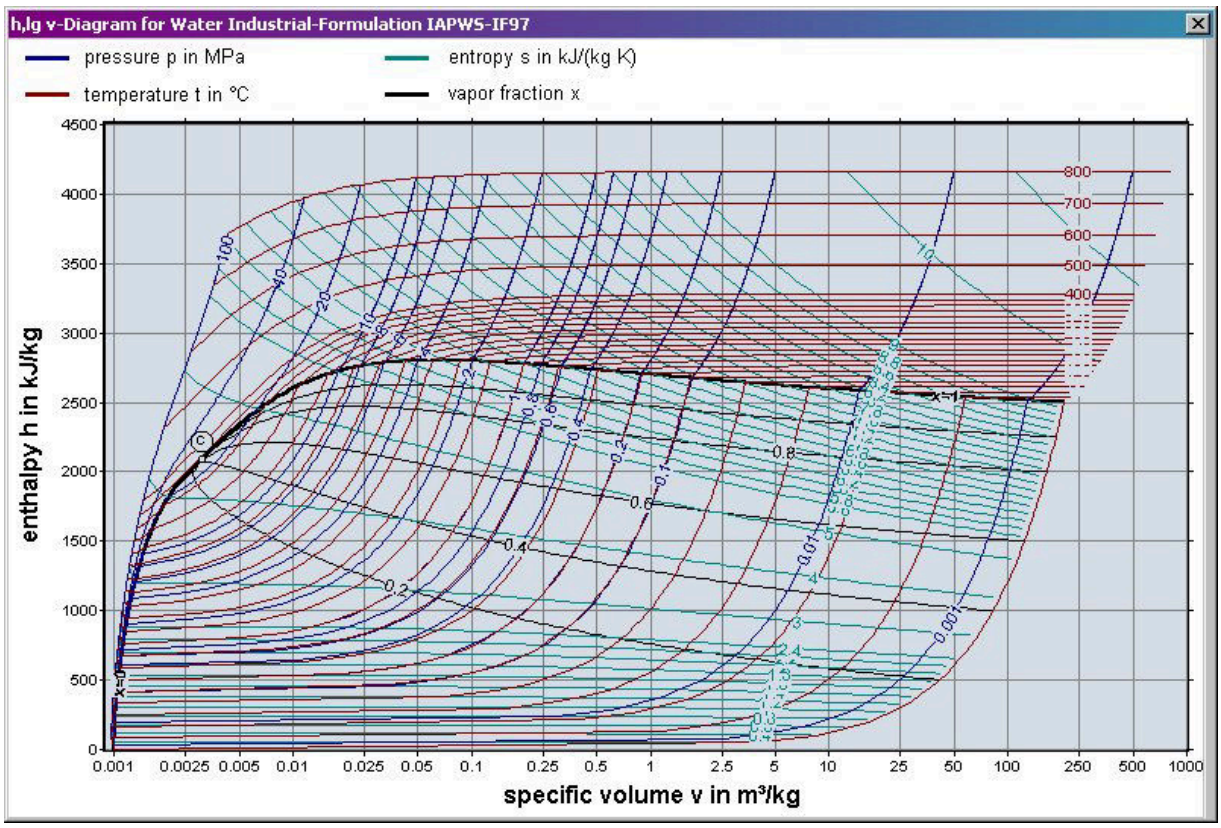

lg p,T-Diagram for Water Industrial-Formulation IAPWS-IF97
enthalpy h in kJ/kg
specific volume v in m³/kg
entropy s in kJ/(kg K)
pressure p in MPa
temperature t in °C
C
ps=f(T)
0.01
0.1
1
10
100

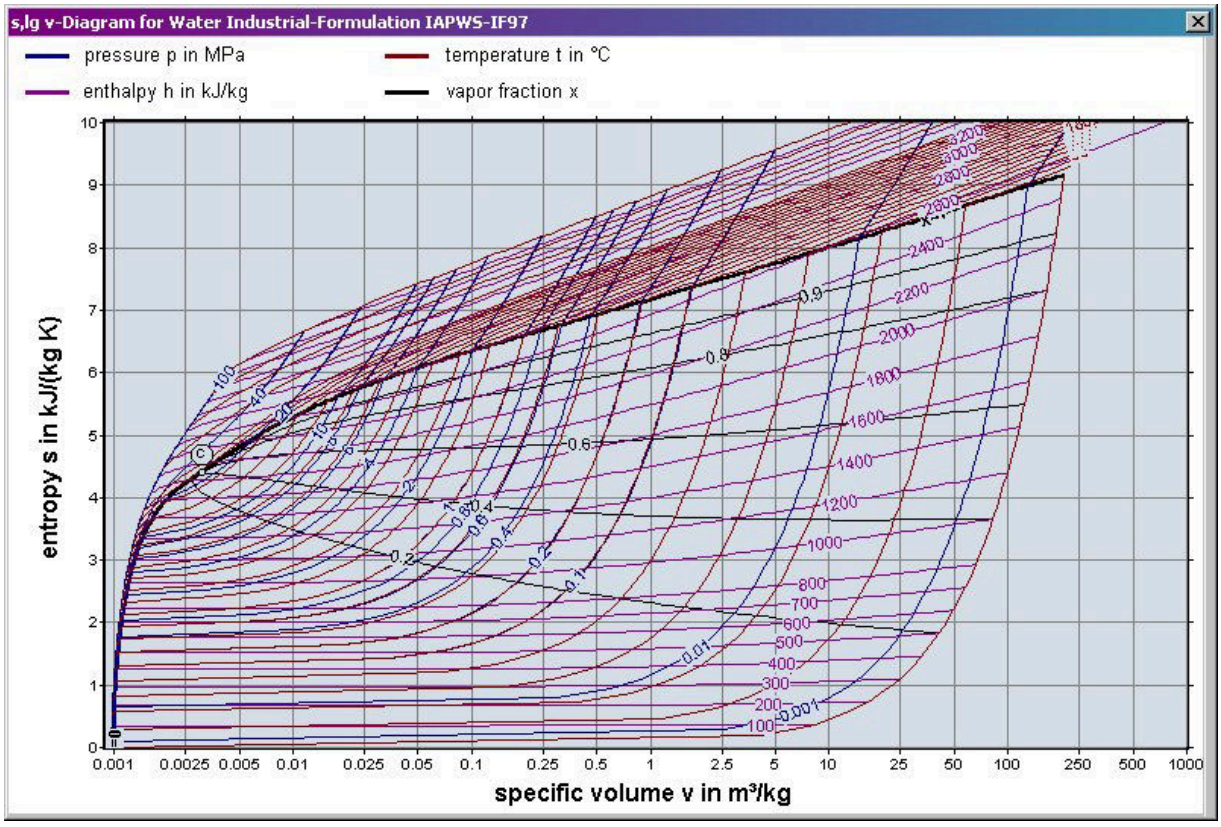

p,T-Diagram for Water Industrial-Formulation IAPWS-IF97
enthalpy h in kJ/kg
specific volume v in m³/kg
entropy s in kJ/(kg K)
pressure p in MPa
temperature t in °C
p=f(T)
C


T,h-Diagram for Water Industrial-Formulation IAPWS-IF97
pressure p in MPa
specific volume v in m³/kg
entropy s in kJ/(kg K)
vapor fraction x
temperature t in °C
enthalpy h in kJ/kg
x=0
x=1
C


T,lg v-Diagram for Water Industrial-Formulation IAPWS-IF97
pressure p in MPa
entropy s in kJ/(kg K)
enthalpy h in kJ/kg
vapor fraction x
temperature t in °C
specific volume v in m³/kg


lgp,s-Diagram for Water Industrial-Formulation IAPWS-IF97
enthalpy h in kJ/kg
specific volume v in m³/kg
temperature t in °C
vapor fraction x
pressure p in MPa
entropy s in kJ/(kg K)


h,lg v-Diagram for Water Industrial-Formulation IAPWS-IF97
pressure p in MPa
entropy s in kJ/(kg K)
temperature t in °C
vapor fraction x
enthalpy h in kJ/kg
specific volume v in m³/kg


s,lg v-Diagram for Water Industrial-Formulation IAPWS-IF97
pressure p in MPa
temperature t in °C
enthalpy h in kJ/kg
vapor fraction x
entropy s in kJ/(kg K)
specific volume v in m³/kg

2 Application of FluidPRIME in Mathcad Prime®

FluidPRIME has been developed to calculate thermodynamic properties in Mathcad Prime® more conveniently. Within Mathcad Prime, it enables the direct call of functions relating to humid air from the LibIF97 property library.

2.1 Installing FluidPRIME

In this section, the installation of FluidPRIME LibIF97_Stud is described.
After you have downloaded and extracted the zip-file "CD_FluidPRIME_LibIF97_Stud.zip", you will see the folder

CD_FluidPRIME_LibIF97_Stud

in your Windows Explorer, Norton Commander etc.

Now, open this folder by double-clicking on it.

Within this folder you will see the following files and a folders:

FluidPRIME_LibIF97_Stud_Docu.pdf
Functions_LibIF97_Stud.mcdx
LibIF97_Stud.msi
setup.exe

In order to run the installation of FluidPRIME double-click the file

setup.exe.

Note: If you get an error message during the installation, please double click

LibIF97_Stud.msi

instead of the setup.exe for the installation.
The steps trough the install assistent are similiary on both the .exe and the .msi file.

After opening the installer-file you get the start window of the setup wizard (Figure 1.1).
Please confirm with "Next".

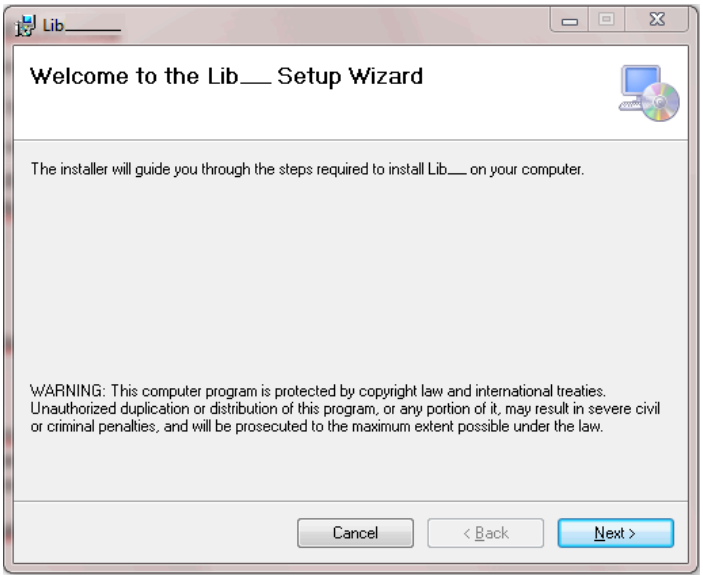


Figure 2.1: Setup Wizard

In Figure 2.2 you can see a note window that will inform you additionally to the next steps.

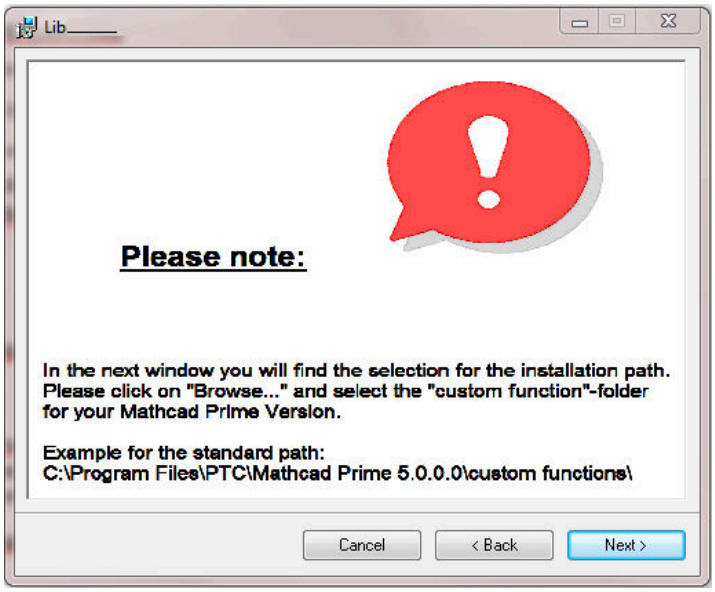


Figure 2.2: Note Window

Click on the "Next" button to get the "Select Installation Folder"-window (Figure 2.3).

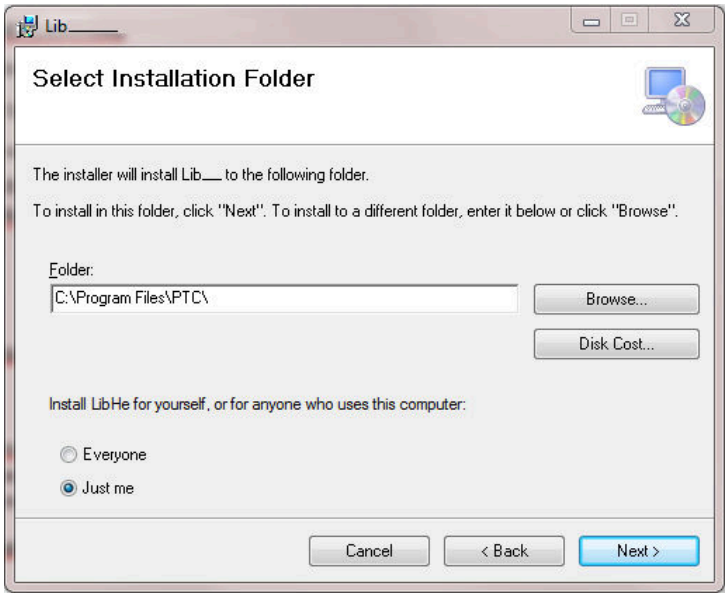


Figure 2.3: Select Installation Folder

Please click on "Browse…" to get another window where you can select the installation path.

You will get the standard path:

C:\Program Files\PTC\

Now select your Mathcad Prime® version folder. For example

C:\Program Files\PTC\Mathcad Prime 5.0.0.0 (Version 5.0.0.0)

or

C:\Program Files\PTC\Mathcad Prime 7.0.0.0 (Version 7.0.0.0).

On the next step you have to choose the "Custom Functions" folder, so that your final installation path looks like

C:\Program Files\PTC\Mathcad Prime 7.0.0.0\Custom Functions\

or

C:\Program Files\PTC\Mathcad Prime 7.0.0.0\Custom Functions\

that you can also see in Figure 2.4.

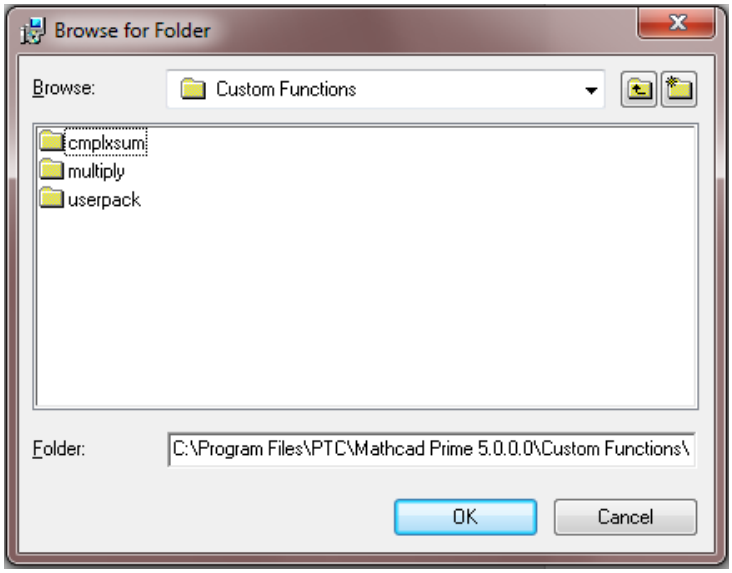


Figure 2.4: "Browse for Folder"-window with the full installation path

Please confirm with "OK" and continue in the further window (Figure 2.5) with "Next".

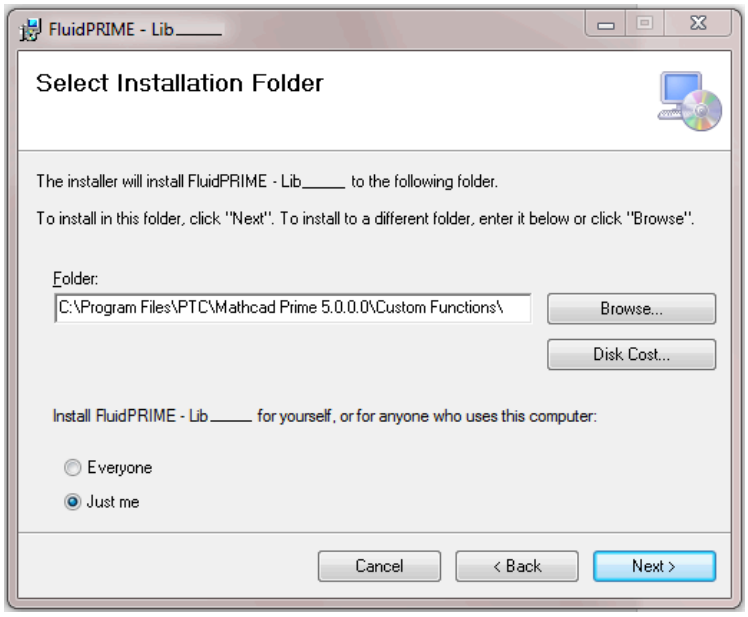


Figure 2.5: "Select Installation Folder"-window

To start the installation you have to click "Next".

After a few moments, you get a message that the installation was successful and you can exit the setup with "Close".

The installation of FluidPRIME with the library LibIF97_Stud is finished.

Note:

The underscore after "Lib" in the figures before, is representative of the name of the library to be installed.

2.2 Licensing the LibIF97 Property Library

Within the installation that was shown in chapter 2.1 the licensing key has been registered on your computer automatically.

2.3 Example: Calculation of the Enthalpy *h* = f(*p*,*t*,*x*) for Water and Steam

Now we will calculate, step by step, the specific enthalpy *h* as a function of pressure *p*, temperature *t* and vapor fraction *x* for water and steam from the Industrial Formulation IAPWS-IF97, using FluidPRIME.

- Start Mathcad Prime.
- Type "*p*:" and enter the value for the pressure *p* in bar.
  (Range of validity of the IF97: p = 0.00611 ... 1000 bar)

  e. g.: Enter "p: 100 bar" for the first operand
- Type "*t*:" and enter the value for the temperature *t* in °C.
  (Range of validity of the IF97: 0 °C … 2000.00 °C for $p \leq 100$ bar
  0 °C … 800.00 °C for 100 bar < $p \leq$ 1000 bar)

  e. g.: Enter "t: 400 °C" for the second operand
- Type "x:" and enter the value for the vapor fraction *x* in $kg_{sat.\ steam}$ / $kg_{wet\ steam}$.
  Since the wet steam region is calculated automatically by the subprograms, the following fixed details on the vapor fraction *x* are to be considered when the value for *x* is entered:

  <u>Single-phase region</u>

  If the state point to be calculated is located in the single-phase region (liquid or superheated steam) $x = -1$ must be entered as a pro-forma value.

  <u>Wet-steam region</u>

  If the state point to be calculated is located in the wet steam region, a value for *x* between 0 and 1 (x = 0 for saturated water, x = 1 for saturated steam) must be entered.

  When calculating wet steam either the given value for *t* and $p = -1$ bar or the given value for *p* and $t = -1$ °C and in both cases the value for *x* between 0 and 1 must be entered.

  If *p* and *t* and *x* are entered as given values, the program considers *p* and *t* to be appropriate to represent the vapor pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in –1.

  Wet steam region of the IAPWS-IF97: t_t = 0 °C ... t_c = 373.946 °C
  p_t = 0.00611 bar ... p_c = 220.64 bar

  e. g.: Enter "*x*: –1" for the third operand
- Confirm your entry by pressing the "ENTER" key.
- To insert units you can type it directly behind the value or you can use the units menu to search for the desired units (see Figure 2.6, marked red).

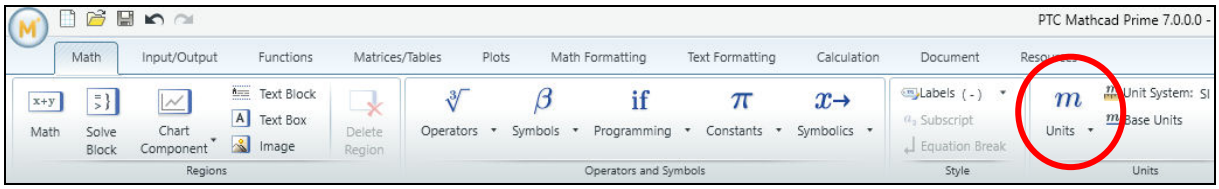


Figure 2.6: Mathcad Prime® menu bar with the units function

- Your Mathcad Prime calculation window should look like Figure 2.7.

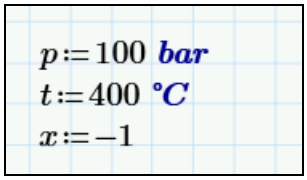


Figure 2.7: Example Mathcad Prime® sheet after input of the given parameters

- Now, open the file Functions_LibIF97_Stud.mcdx. In this Mathcad Prime® worksheet you can find all functions of the library (see Figure 2.8).

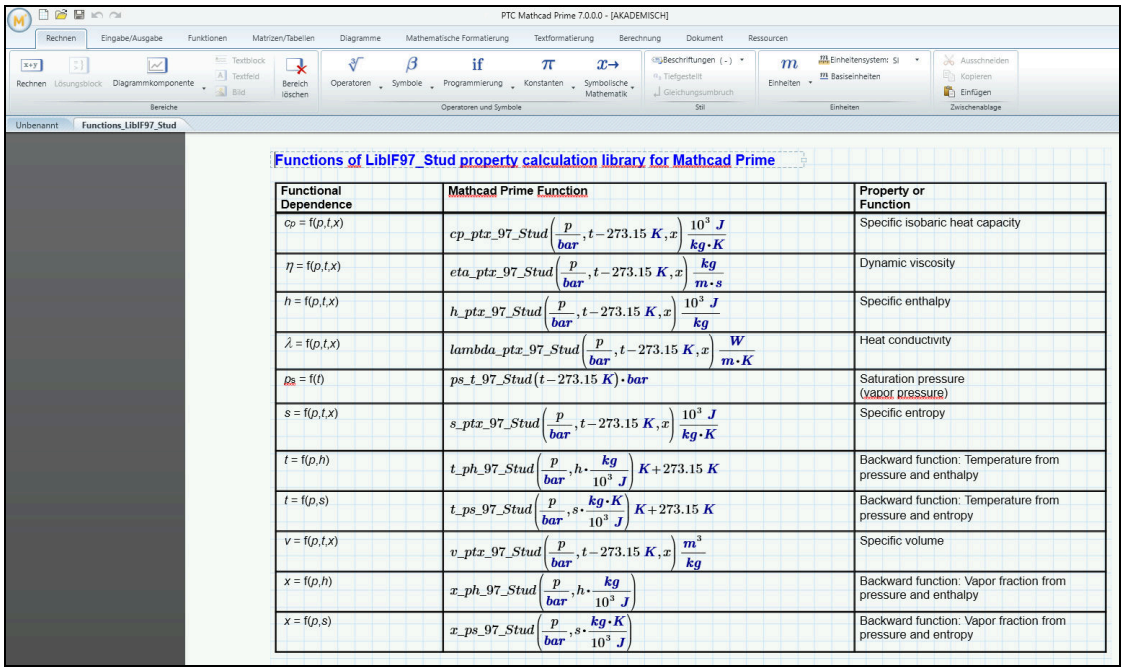


Figure 2.8: Mathcad Prime® worksheet with LibIF97_Stud-Functions

- Find the function
  h_ptx_IF97_Stud
  and mark the corresponding table cell.
- Copy the marked function and paste it into your example worksheet.
- Click it the function and type "h:" in front of it.
- Your Mathcad Prime calculation window should look like Figure 2.9.

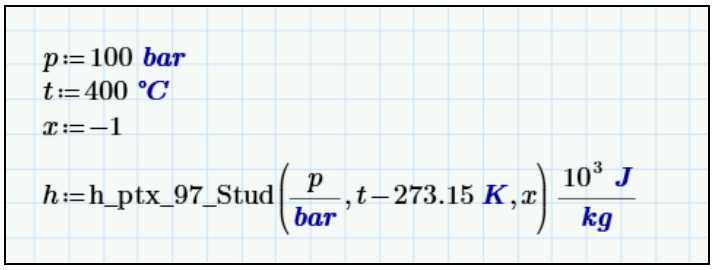


Figure 2.9: Example Mathcad Prime® sheet

- To see the result, you have to type the following command on the next line in the Mathcad Prime window:
  "h=".

  You will now see the result h=3.097 x 10^6 m^2/s^{-1}. The corresponding unit is kJ/kg (see table of the property functions in Chapter 1). In Mathcad Prime® the final unit (given behind the function call) changed to base units. To display the result in the unit you have chosen, you can change the unit after the result value.

In the next figure you can see the calculated value.

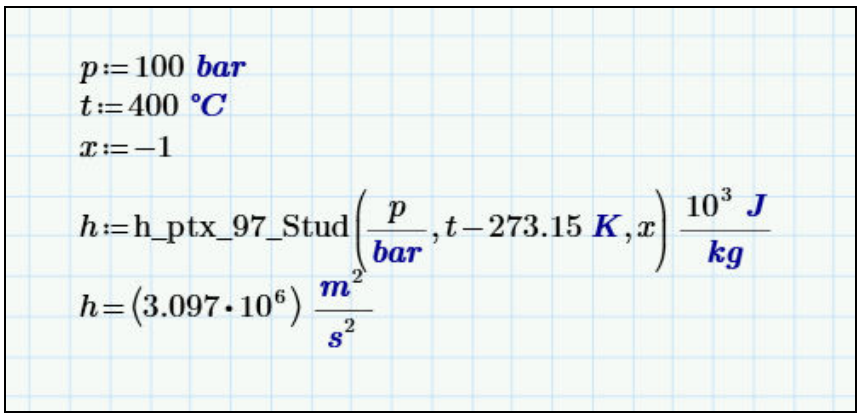


Figure 2.10: Example Mathcad Prime® sheet with finished calculation

2.4 Removing FluidPRIME

To remove FluidPRIME with the library LibIF97_Stud from your hard drive, carry out the following steps:

- Click "Start" in the lower task bar of your desktop, then "Settings" and then "Control Panel".
- Now, double click on "Add or Remove Programs".
- In the list box of the "Add or Remove Programs" window that appears select "FluidPRIME_LibIF97_Stud" by clicking on it and click the "Add/Remove…" button.
- In the following dialog box click "Yes" and wait until the windows is closing.
- Finally, close the "Add or Remove Programs" and "Control Panel" windows.

Now FluidPRIME with the library LibIF97_Stud has been removed.

KCE ThermoFluidProperties

KCE-ThermoFluidProperties
www.thermofluidprop.com

Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

Property Libraries for Calculating Heat Cycles, Boilers, Turbines and Refrigerators

Water and Steam

Library LibIF97

- Industrial Formulation IAPWS-IF97 (Revision 2007)
- Supplementary Standards IAPWS-IF97-S01, -S03rev, -S04, and -S05
- IAPWS Revised Advisory Note No. 3 on Thermo-dynamic Derivatives (2008)

Library LibIF97_META

- Industrial Formulation IAPWS-IF97 (Revision 2007) for metastable steam

Humid Combustion Gas Mixtures

Library LibHuGas

Model: Ideal mixture of the real fluids:

CO_2 - Span, Wagner H_2O - IAPWS-95
O_2 - Schmidt, Wagner N_2 - Span et al.
Ar - Tegeler et al.

and of the ideal gases:

SO_2, CO, Ne
(Scientific Formulation of Bücker et al.)

Consideration of:

- Dissociation from VDI 4670
- Poynting effect

Humid Air

Library LibHuAir

Model: Ideal mixture of the real fluids:

- Dry air from Lemmon et al.
- Steam, water and ice from IAPWS-IF97 and IAPWS-06

Consideration of:

- Condensation and freezing of steam
- Dissociation from VDI 4670
- Poynting effect from ASHRAE RP-1485

Extremely Fast Property Calculations

Spline-Based Table Look-up Method (SBTL)

Library LibSBTL_IF97
Library LibSBTL_95
Library LibSBTL_HuAir

For steam, water, humid air, carbon dioxide and other fluids and mixtures according IAPWS Guideline 2015 for Computational Fluid Dynamics (CFD), real-time and non-stationary simulations

Carbon Dioxide Including Dry Ice

Library LibCO2

Formulation of Span and Wagner (1996)

Seawater

Library LibSeaWa

IAPWS Industrial Formulation 2013

Ice

Library LibICE

Ice from IAPWS-06, Melting and sublimation pressures from IAPWS-08, Water from IAPWS-IF97, Steam from IAPWS-95 and -IF97

Ideal Gas Mixtures

Library LibIdGasMix

Model: Ideal mixture of the ideal gases:

Ar	NO	He	Propylene
Ne	H_2O	F_2	Propane
N_2	SO_2	NH_3	Iso-Butane
O_2	H_2	Methane	n-Butane
CO	H_2S	Ethane	Benzene
CO_2	OH	Ethylene	Methanol
Air			

Consideration of:

- Dissociation from the VDI Guideline 4670

Library LibIDGAS

Model: Ideal gas mixture from VDI Guideline 4670

Consideration of:

- Dissociation from the VDI Guideline 4670

Humid Air

Library ASHRAE LibHuAirProp

Model: Virial equation from ASHRAE Report RP-1485 for real mixture of the real fluids:
- Dry air
- Steam

Consideration of:

- Enhancement of the partial saturation pressure of water vapor at elevated total pressures

www.ashrae.org/bookstore

Dry Air Including Liquid Air

Library LibRealAir

Formulation of Lemmon et al. (2000)

Refrigerants

Ammonia

Library LibNH3

Formulation of Tillner-Roth et al. (1993)

R134a

Library LibR134a

Formulation of Tillner-Roth and Baehr (1994)

Iso-Butane

Library LibButane_Iso

Formulation of Bücker and Wagner (2006)

n-Butane

Library LibButane_n

Formulation of Bücker and Wagner (2006)

Mixtures for Absorption Processes

Ammonia/Water Mixtures

Library LibAmWa

IAPWS Guideline 2001 of Tillner-Roth and Friend (1998)

Helmholtz energy equation for the mixing term

(also useable for calculating the Kalina Cycle)

Water/Lithium Bromide Mixtures

Library LibWaLi

Formulation of Kim and Infante Ferreira (2004)

Gibbs energy equation for the mixing term

Liquid Coolants

Liquid Secondary Refrigerants

Library LibSecRef

Liquid solutions of water with

$C_2H_6O_2$	Ethylene glycol
$C_3H_8O_2$	Propylene glycol
C_2H_5OH	Ethanol
CH_3OH	Methanol
$C_3H_8O_3$	Glycerol
K_2CO_3	Potassium carbonate
$CaCl_2$	Calcium chloride
$MgCl_2$	Magnesium chloride
NaCl	Sodium chloride
$C_2H_3KO_2$	Potassium acetate
$CHKO_2$	Potassium formate
LiCl	Lithium chloride
NH_3	Ammonia

Formulation of the International Institute of Refrigeration (IIR 2010)

Ethanol

Library LibC2H5OH

Formulation of
Schroeder et al. (2014)

Methanol

Library LibCH3OH

Formulation of
de Reuck and Craven (1993)

Propane

Library LibPropane

Formulation of
Lemmon et al. (2009)

Siloxanes as ORC Working Fluids

Octamethylcyclotetrasiloxane $C_8H_{24}O_4Si_4$ **Library LibD4**

Decamethylcyclopentasiloxane $C_{10}H_{30}O_5Si_5$ **Library LibD5**

Tetradecamethylhexasiloxane $C_{14}H_{42}O_5Si_6$ **Library LibMD4M**

Hexamethyldisiloxane $C_6H_{18}OSi_2$ **Library LibMM**

Formulation of Colonna et al. (2006)

Dodecamethylcyclohexasiloxane $C_{12}H_{36}O_6Si_6$ **Library LibD6**

Decamethyltetrasiloxane $C_{10}H_{30}O_3Si_4$ **Library LibMD2M**

Dodecamethylpentasiloxane $C_{12}H_{36}O_4Si_5$ **Library LibMD3M**

Octamethyltrisiloxane $C_8H_{24}O_2Si_3$ **Library LibMDM**

Formulation of Colonna et al. (2008)

Nitrogen and Oxygen

**Libraries
LibN2 and LibO2**

Formulations of Span et al. (2000)
and Schmidt and Wagner (1985)

Hydrogen

Library LibH2

Formulation of
Leachman et al. (2009)

Helium

Library LibHe

Formulation of
Arp et al. (1998)

Hydrocarbons

Decane $C_{10}H_{22}$ **Library LibC10H22**

Isopentane C_5H_{12} **Library LibC5H12_Iso**

Neopentane C_5H_{12} **Library LibC5H12_Neo**

Isohexane C_6H_{14} **Library LibC6H14**

Toluene C_7H_8 **Library LibC7H8**

Formulation of Lemmon and Span (2006)

Further Fluids

Carbon monoxide **CO** **Library LibCO**

Carbonyl sulfide **COS** **Library LibCOS**

Hydrogen sulfide H_2S **Library LibH2S**

Nitrous oxide N_2O **Library LibN2O**

Sulfur dioxide SO_2 **Library LibSO2**

Acetone C_3H_6O **Library LibC3H6O**

Formulation of Lemmon and Span (2006)

KCE
ThermoFluidProperties

For more information please contact:

KCE-ThermoFluidProperties UG & Co. KG
Prof. Dr. Hans-Joachim Kretzschmar
Wallotstr. 3
01307 Dresden, Germany

Internet: www.thermofluidprop.com
Email: info@thermofluidprop.com
Phone: +49-351-27597860
Mobile: +49-172-7914607
Fax: +49-3222-1095810

The following thermodynamic and transport properties can be calculated[a]:

Thermodynamic Properties

- Vapor pressure p_s
- Saturation temperature T_s
- Density ρ
- Specific volume v
- Enthalpy h
- Internal energy u
- Entropy s
- Exergy e
- Isobaric heat capacity c_p
- Isochoric heat capacity c_v
- Isentropic exponent κ
- Speed of sound w
- Surface tension σ

Transport Properties

- Dynamic viscosity η
- Kinematic viscosity ν
- Thermal conductivity λ
- Prandtl number Pr
- Thermal diffusivity a

Backward Functions

- T, v, s (p,h)
- T, v, h (p,s)
- p, T, v (h,s)
- p, T (v,h)
- p, T (v,u)

Thermodynamic Derivatives

- Partial derivatives used in process modeling can be calculated.

[a] Not all of these property functions are available in all property libraries.

www.thermofluidprop.com

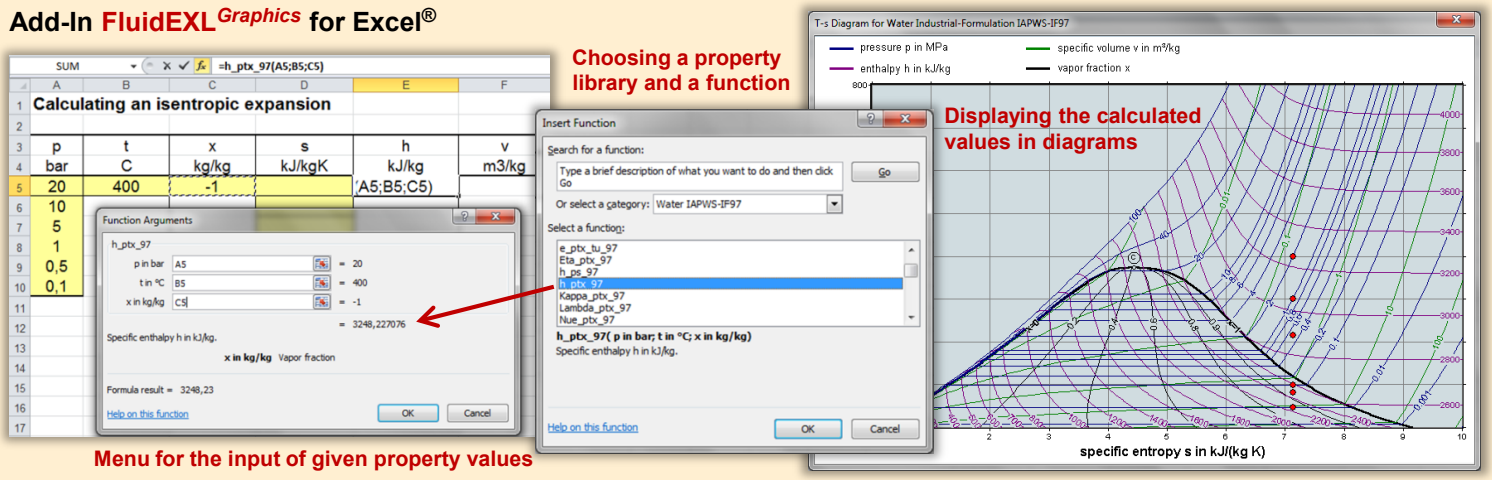
KCE ThermoFluidProperties

KCE-ThermoFluidProperties
www.thermofluidprop.com

Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

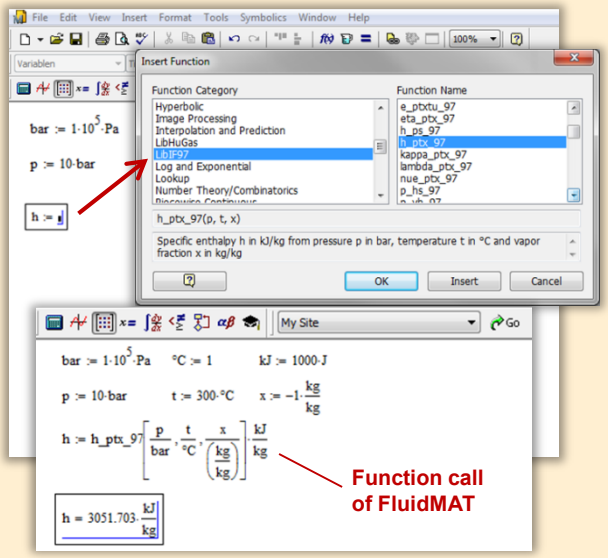
Property Software for Calculating Heat Cycles, Boilers, Turbines and Refrigerators

Add-In FluidEXL*Graphics* for Excel®



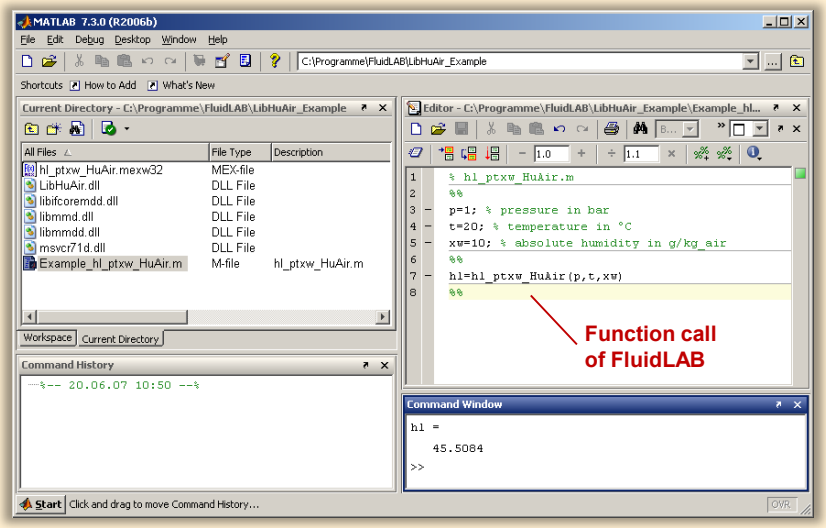
Add-On FluidMAT for Mathcad®
Add-On FluidPRIME for Mathcad Prime®

The property libraries can be used in Mathcad® and Mathcad Prime®.



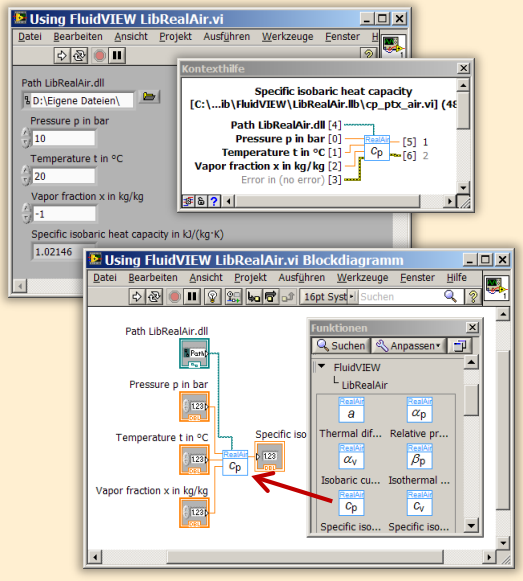
Add-On FluidLAB for MATLAB® and SIMULINK®

Using the Add-In FluidLAB the property functions can be called in MATLAB® and SIMULINK®.



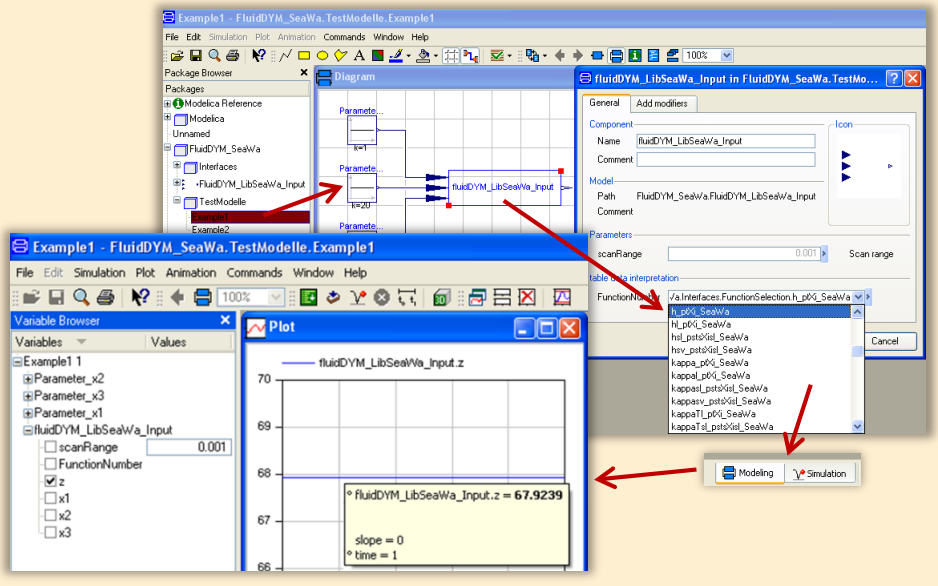
Add-On FluidVIEW for LabVIEW™

The property functions can be calculated in LabVIEW™.

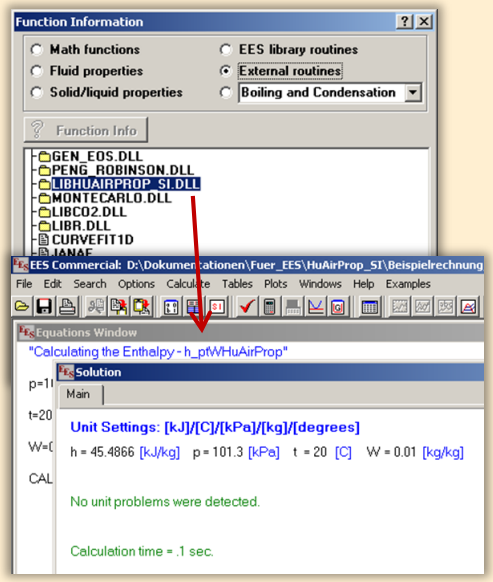


Add-On FluidDYM for DYMOLA® (Modelica) and SimulationX®

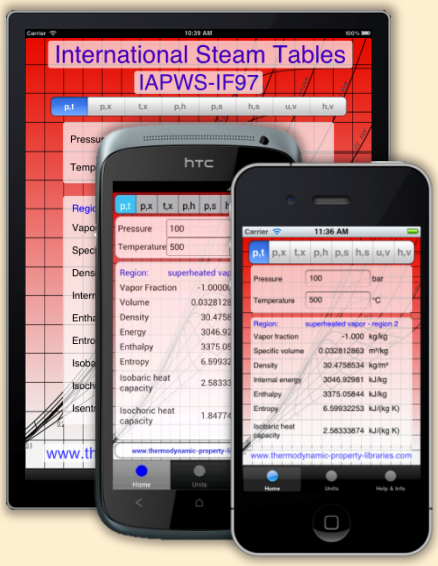
The property functions can be called in DYMOLA® and SimulationX®.



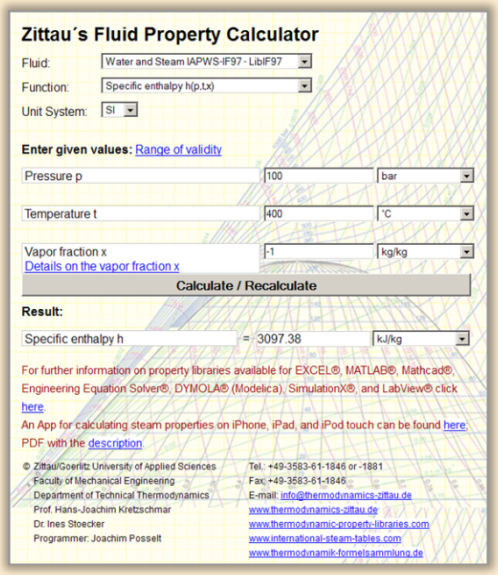
Add-On FluidEES for Engineering Equation Solver®



App International Steam Tables for iPhone, iPad, iPod touch, Android Smartphones and Tablets



Online Property Calculator at www.thermofluidprop.com



Property Software for Pocket Calculators

FluidCasio


fx 9750 G II


CFX 9850 fx-GG20


CFX 9860 G Graph 85


ALGEBRA FX 2.0

FluidHP


HP 48


HP 49

FluidTI


TI Nspire CX CAS
TI Nspire CAS


TI 83
TI 84
TI 89


TI Voyage 200


TI 92

For more information please contact:

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Mobile: +49-172-7914607
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- Saturation temperature T_s
- Density ρ
- Specific volume v
- Enthalpy h
- Internal energy u
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[a] Not all of these property functions are available in all property libraries.

www.thermofluidprop.com

4. References

[1] IAPWS,R7-97(2012): Revised Release on the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.
Available at the IAPWS website http://www.iapws.org.

[2] Kretzschmar, H.-J., Wagner, W.:
International Steam Tables, 3rd. Ed.
Springer-Verlag, Berlin (2019).

[3] IAPWS, AN3-07: Revised Advisory Note No. 3: Calculation of Thermodynamic Derivatives for Water and Steam from the IAPWS Formulations (2014).
Available at the IAPWS website http://www.iapws.org.

[4] IAPWS, R15-11: Release on the IAPWS Formulation 2011 for the Thermal Conductivity of Ordinary Water Substance (2011).
Available at the IAPWS website http://www.iapws.org.

[5] IAPWS, R12-08: Release on the IAPWS Formulation 2008 for the Viscosity of Ordinary Water Substance (2008).
Available at the IAPWS website http://www.iapws.org.