

International Steam Tables – IAPWS-IF97

developed by

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Overview:

The "International Steam Tables - IAPWS-IF97" app has been developed by active members of the International Association for the Properties of Water and Steam (IAPWS) at the Zittau/Goerlitz University of Applied Sciences. The research group at the Department of Technical Thermodynamics in Zittau participated in the development of the "Industrial Formulation IAPWS-IF97 for the Properties of Water and Steam" and developed four supplementary standards for backward equations.

The "International Steam Tables - IAPWS-IF97" app is available on the App Store:

<http://itunes.apple.com/de/app/international-steam-tables/id502937992?mt=8&ls=1> .

This universal app can be used on iPhone, iPad, and iPod touch, and is designed for comfortable use. The calculations of the thermodynamic properties are based on the Industrial Formulation IAPWS-IF97 and cover its full range of validity. In addition, transport properties, thermodynamic derivatives, and backward functions can be calculated. This app is intended to be used by students and engineers in their daily work.

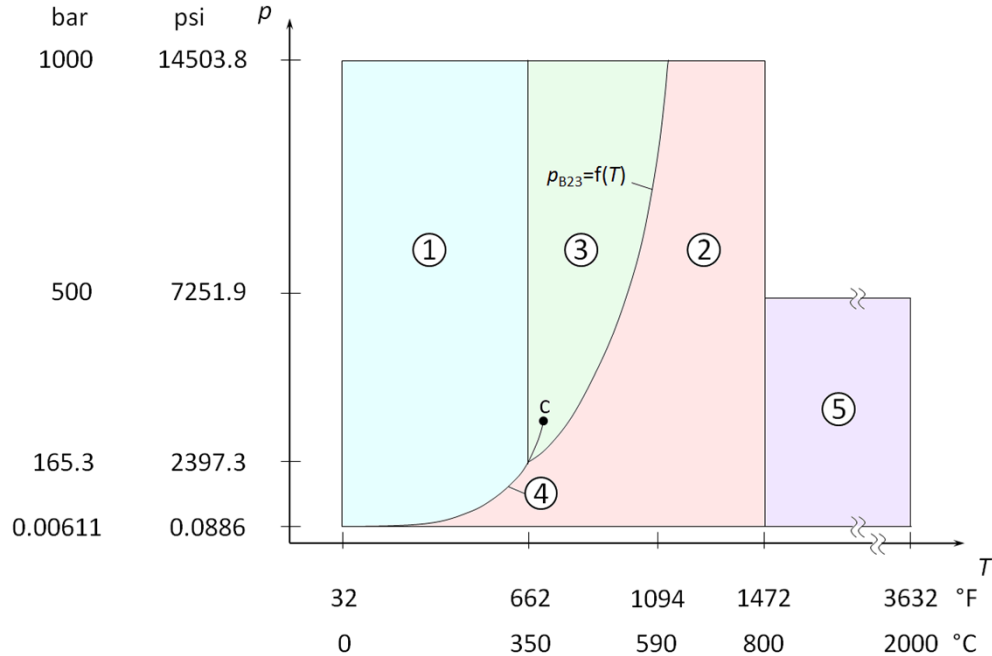
For more detailed information on the features of the "International Steam Tables - IAPWS-IF97" app refer to the User's Guide below.

International Steam Tables – IAPWS-IF97

User's Guide

1. IAPWS-IF97 Range of Validity

This application is based on the Industrial Formulation IAPWS-IF97 [1], supplementary backward equations [2,3,4,5] and the latest standards for transport properties [6,7]. A comprehensive description of the entire equation set is given in [8]. The range of validity and the calculation regions are illustrated in this p - T diagram:



Temperature: $0\text{ °C} \leq t \leq 800\text{ °C}$ $32\text{ °F} \leq t \leq 1472\text{ °F}$
 Pressure: $0.00611\text{ bar} \leq p \leq 1000\text{ bar}$ $0.0886\text{ psi} \leq p \leq 14503.77\text{ psi}$

High-temperature region 5:
 $800\text{ °C} < t \leq 2000\text{ °C}^a$ $1472\text{ °F} < t \leq 3632\text{ °F}^a$
 $0.00611\text{ bar} \leq p \leq 500\text{ bar}$ $0.0886\text{ psi} \leq p \leq 7251.89\text{ psi}$

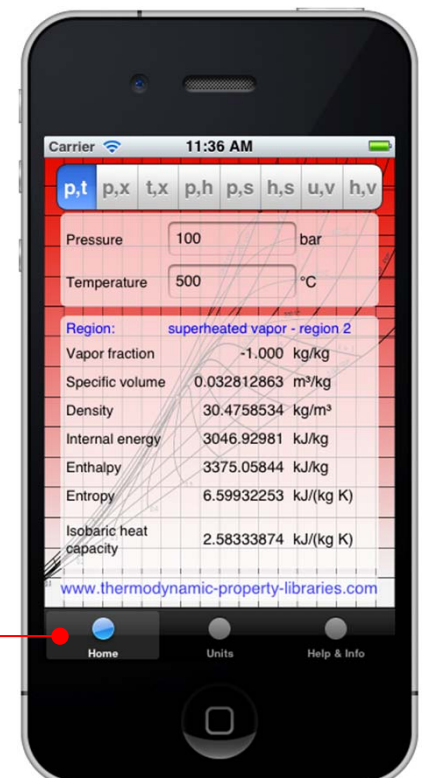
^a The upper temperature limit of the transport properties (λ , η , ν , Pr and a) is $900\text{ °C} / 1652\text{ °F}$.

2. User's Guide

2.1 Navigation within the International Steam Tables app

At the bottom of the screen you will find a tab bar to switch between three different views: **Home**, **Units** and **Help & Info**.

- Home:** Perform calculations (see Section 2.2)
- Units:** Select units (see Section 2.3)
- Help & Info:** View this manual and get additional information (see Section 3)



2.2 Calculations

To perform a calculation, carry out the following steps:

1. Tap the **Home** button on the tab bar to switch to the **Home** view
2. Select the input variables from the input button bar.

The following combinations of input variables are available:

p,t	Pressure p and temperature t
p,x	Pressure p and vapor fraction x for wet steam region
t,x	Temperature t and vapor fraction x for wet steam region
p,h	Pressure p and specific enthalpy h
p,s	Pressure p and specific entropy s
h,s	Specific enthalpy h and specific entropy s
u,v	Specific internal energy u and specific volume v
h,v	Specific enthalpy h and specific volume v

Example: choose p,t

3. Enter the values of the input variables by tapping the corresponding text boxes and typing via the keyboard which appears.

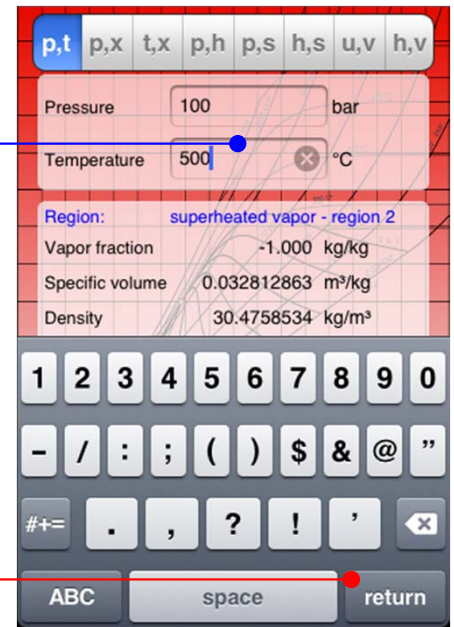
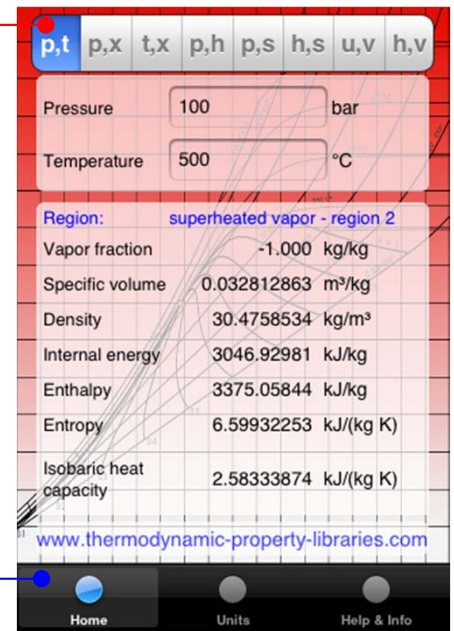
Please note that, depending on the country and language settings on your device, either a comma “,” or a dot “.” is used as decimal separator.

Tap the “return” button of the keyboard to complete input value editing.

If you want to change the input units refer to Section 2.3 of this manual.

Example: - enter a pressure p of 100 bar
- enter a temperature t of 500 °C

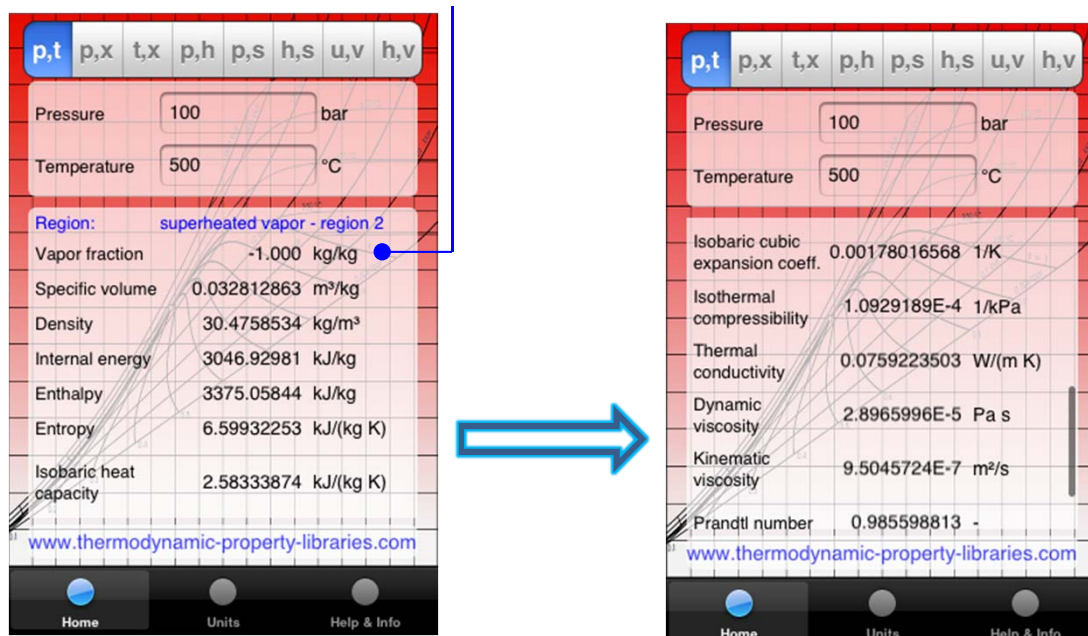
4. Results are shown in the scrollable output view. The calculated properties are shown in this table:



Pressure	p
Saturation pressure	p_s
Temperature	t
Saturation temperature	t_s
Vapor fraction	$x = \frac{m''}{m}$
Specific volume	v
Density	$\rho = 1/v$
Specific internal energy	u
Specific enthalpy	$h = u + p \cdot v$
Specific entropy	s
Specific isobaric heat capacity	$c_p = \left(\frac{\partial h}{\partial T} \right)_p$
Specific isochoric heat capacity	$c_v = \left(\frac{\partial u}{\partial T} \right)_v$

Isentropic exponent	$\kappa = -\frac{v}{p} \left(\frac{\partial p}{\partial v} \right)_s$
Speed of sound	$w = v \sqrt{-\left(\frac{\partial p}{\partial v} \right)_s}$
Isobaric cubic expansion coefficient	$\alpha_v = \frac{1}{v} \left(\frac{\partial v}{\partial T} \right)_p$
Isothermal compressibility	$\kappa_T = -\frac{1}{v} \left(\frac{\partial v}{\partial p} \right)_T$
Thermal conductivity	λ
Dynamic viscosity	η
Kinematic viscosity	$\nu = \eta / \rho$
Prandtl number	$Pr = \frac{\eta \cdot c_p}{\lambda}$
Thermal diffusivity	$a = \frac{\lambda}{\rho \cdot c_p}$

Scroll down in the output view to see more calculated properties:



Using the values for v , s , c_p , α_v and κ_T , all thermodynamic derivatives can be calculated. The procedure to obtain all thermodynamic derivatives from these properties is described in [8].

Remarks on results:

- If the input values are outside the range of validity (see Section 1), the values of the properties will appear as **-1**. Note that the upper temperature limit of the transport properties (λ , η , ν , Pr and a) is 900 °C / 1652 °F
- If input values correspond to a state point in the wet steam region but not exactly to a saturated liquid or saturated vapor state the value **-1** will be shown for the following properties:

Specific isobaric heat capacity c_p
Specific isochoric heat capacity c_v
Isentropic exponent κ
Speed of sound w
Isobaric cubic expansion coefficient α_v
Isothermal compressibility κ_T
Thermal conductivity λ
Dynamic viscosity η
Kinematic viscosity ν
Prandtl number Pr
Thermal diffusivity a

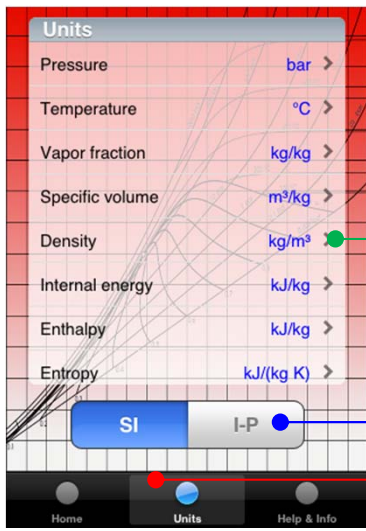
- The vapor fraction x is not defined in the single phase regions (1, 2, 3 and 5 of IAPWS-IF97) and will be set to **-1** in these regions.

The results are automatically updated whenever the combination of input variables is changed (via the input button bar), the values of the input variables are changed, or the units are changed (as described in Section 2.3).

Note:

If you switch from one input variable combination to another, the values previously given or calculated will be assigned to the new input values and the output will be calculated automatically. For example, if you calculate a certain state point from pressure p and temperature t and afterwards you switch to a calculation from pressure p and specific entropy s , the previously calculated value for s (from p and t) will be assigned as input value for s . This eases the calculation of thermodynamic processes in which one property is kept constant, e. g. of an isentropic expansion.

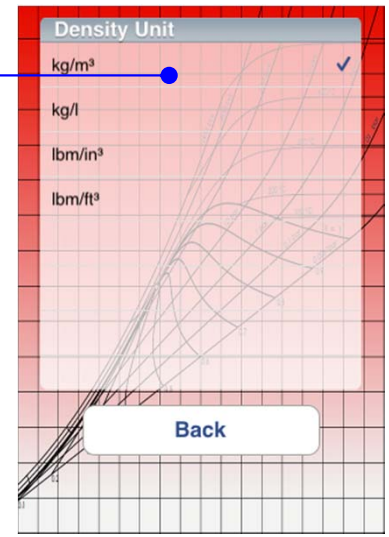
2.3 Unit Settings



1. Select the **Units** view from the tab bar controller.
2. Preselect the unit system (SI and I-P unit systems are available).
3. In order to select a unit for a certain property, tap the property in the scrollable table and select the unit from the table which then appears.

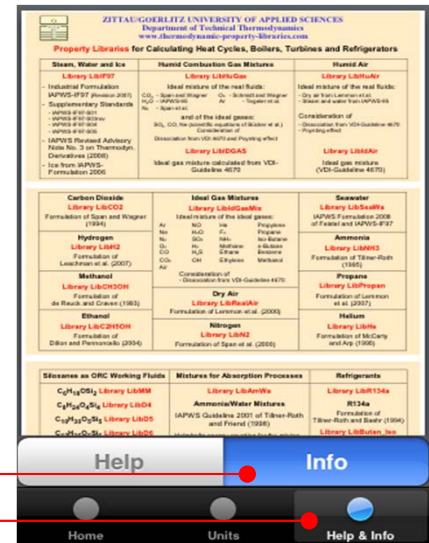
Note:

When units are changed the corresponding values are immediately converted to these new units.



3. Information

For more information on property libraries for various fluids and interfaces available for Excel®, MATLAB®, Mathcad®, EES®, Dymola®, SimulationX® or LabView®, tap the **Help & Info** button on the tab bar and tap the **Info** button at the bottom of the screen.



We recommend visiting the following websites:

For more information on **thermodynamic property libraries** for various fluids and software applications, please visit:

www.thermodynamic-property-libraries.com .

In order to **calculate thermodynamic properties of various fluids online**, please visit:

www.fluid-property-calculator.com .

For details on the **book** and the authors of the **International Steam Tables**, visit the website:

www.international-steam-tables.com .

To learn more about the **International Association for the Properties of Water and Steam (IAPWS)**, visit the official website:

www.iapws.org .

4. Contact

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5. References

- [1] IAPWS (2007), *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] IAPWS (2001), *Supplementary Release on Backward Equations for Pressure as a Function of Enthalpy and Entropy $p(h,s)$ to the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*, available at the IAPWS website <http://www.iapws.org>.
- [3] IAPWS (2004), *Revised Supplementary 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 Thermodynamic Properties of Water and Steam*, available at the IAPWS website <http://www.iapws.org>.
- [4] IAPWS (2004), *Supplementary Release on Backward Equations $p(h,s)$ for Region 3, Equations as a Function of h and s for the Region Boundaries, and an Equation $T_{sat}(h,s)$ for Region 4 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*, available at the IAPWS website <http://www.iapws.org>.
- [5] IAPWS (2005), *Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature $v(p,T)$ for Region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam*, available at the IAPWS website <http://www.iapws.org>.
- [6] IAPWS (2008), *Release on the IAPWS Formulation 2008 for the Viscosity of Ordinary Water Substance*, available at the IAPWS website <http://www.iapws.org>.
- [7] IAPWS (2011), *Release on the IAPWS Formulation 2011 for the Thermal Conductivity of Ordinary Water Substance*, available at the IAPWS website <http://www.iapws.org>.
- [8] Wagner, W., Kretschmar, H.-J., *International Steam Tables*, Springer-Verlag, Berlin (2008), see also at <http://www.international-steam-tables.com>.