

HELP MANUAL for “STEAM”

*Microsoft Excel? application developed by Bjorn Teislev, TEISLEVenergy
Beta version August 1998 – rev. 0 October 2000 – rev. 1 January 2002 – rev. 2 July 2004
A special reduced version was introduced (in versions freeware V0 nad commercial V1 and
V2 – see below) April 2005. This full version (V4) was introduced January 2007.*

OVERVIEW

This application is based on an implementation of the International Steam Tables (Properties of Water and Steam in SI-Units, Springer-Verlag 1989, 4th Edition) – developed by Dr. Bjorn Teislev – originally for use related to Supercritical Steam Processes.

The original software was in the form of “stand alone” programmes using the Power Basic? language and specifically optimised for use in the high-pressure range up to about 400 atmospheres.

In 1996, the software was reprogrammed using the Visual Basic? language and based on this a Microsoft Office Excel? application – “STEAM” – was developed in 1998, including all the facilities for the high-pressure range.

The highly specialised iteration algorithms – necessary in the vicinity of the critical point (374.15°C and 221.2 bar) – somewhat slows the calculations and increases the size of the programme and in 1995 a reduced version was launched.

This application has three levels (all including the facilities listed below for the temperature range up to about 800°C):

?? A freeware version, which is limited to the pressure range 0 – 10 (bar)

?? A student version, which is limited to the pressure range 0 – 40 (bar)

?? A professional version, which is limited to the pressure range 0 – 165 (bar)

“STEAM” adds several useful thermodynamic and thermo physical functions to the Excel spreadsheet “vocabulary”:

A. General functions for liquid and vapour water

H2O_v(p, T) - specific volume (m³/kg) at pressure p (Pa) and temperature T (K)

H2O_h(p, T) - specific enthalpy (J/kg) at pressure p (Pa) and temperature T (K)

H2O_s(p, T) - specific entropy (J/kgK) at pressure p (Pa) and temperature T (K)

H2O_visc(T, v) - dynamic viscosity (kg/ms) at temperature T (K) and specific volume v (m³/kg)

H2O_cond(T, v) - thermal conductivity (W/mK) at temperature T (K) and specific volume v (m³/kg)

B. Functions at the saturation line

H2O_pSAT(T) - saturation pressure (Pa) at temperature T (K)

H2O_TSAT(T) - saturation temperature T (K) at pressure (Pa)

H2O_vlSAT(T) - saturated liquid specific volume (m³/kg) at temperature T (K)

H2O_vvSAT(T) - saturated vapour specific volume (m³/kg) at temperature T (K)

H2O_hlSAT(T) - saturated liquid specific enthalpy (J/kg) at temperature T (K)

H2O_hvSAT(T) - saturated vapour specific enthalpy (J/kg) at temperature T (K)

H2O_slSAT(T) - saturated liquid specific entropy (J/kgK) at temperature T (K)

H2O_svSAT(T) - saturated vapour specific entropy (J/kgK) at temperature T (K)

H2O_surf(T) - saturated liquid/vapour interface surface tension (N/m) at temperature T (K)

The functions above use the SI unit system. Temperatures are stated as degree Kelvin (K) and furthermore, the reference point for enthalpy and entropy is saturated liquid at the triple point temperature 273,16 (K) and corresponding pressure 611,2 (Pa)

Installing “STEAM”

In this reduced version, the software is – quite simply – installed by copying the complete sub-directory “STEAM” to the C:\ root directory. The sub-directory contains the 2 files:

?? **STEAM.xla**, which is the actual Add-in

?? **STEAMHELP.hlp**, which is the help file

Similarly, the software is removed by simply deleting the subdirectory “STEAM”. When the software is activated, it will remain available until de-activated.

This implies, that software which uses special Add-ins, when distributed to customers, etc. to use on other computers will naturally only recognise the special functions available from the Add-in, if the Add-in is installed on the specific computer.

Therefore, the abovementioned sub-directory “STEAM” should be installed on the computer using this installation guide.

Activation of Add-in

In Excel, click on the menu sub-item “Add-Ins” under main menu-item “Tools” after which a window listing available Add-ins will pop up – but the Add-in for this application will not be shown (because we have located it in a directory not directly found by Excel).

Therefore, click the button “Browse” and find the file “STEAM.xla”, which we just placed in C:\STEAM. Double-click on the file and you will be returned to Excel and note, that a new Add-in – “STEAM” – has appeared on the list. Click “OK” and the H2O facilities are now available.

Deactivation of Add-in

In Excel, click on the menu sub-item “Add-Ins” under main menu-item “Tools” after which a window listing available Add-ins will pop up – remove the selection for “STEAM” and click “OK”. The H2O facilities are no longer available, but may – naturally – be revoked any time you wish by marking it on the Add-in list.

Complete removal of “STEAM” from the computer

First Deactivate the Add-in and then delete the sub-directory C:\STEAM. Next time you start Excel, you will note, that “STEAM” is still on the Add-in list. It can be removed from this list by marking it and accept the Error-message (which asks if it should be removed from the list).

Furthermore

If some problem should arise or you want further information on the commercial versions of this software, please contact:

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Using “STEAM”

The functions made available through the Excel Add-in “STEAM” are used exactly like any other Excel? function (direct cell calculation, copy/move cell ranges, etc.) and some examples are given – using the following functions:

General functions for liquid and vapour water

H2O_v(p, T) - specific volume (m³/kg) at pressure p (Pa) and temperature T (K)

H2O_h(p, T) - specific enthalpy (J/kg) at pressure p (Pa) and temperature T (K)

H2O_s(p, T) - specific entropy (J/kgK) at pressure p (Pa) and temperature T (K)

H2O_visc(T, v) - dynamic viscosity (kg/ms) at temperature T (K) and specific volume v (m³/kg)

H2O_cond(T, v) - thermal conductivity (W/mK) at temperature T (K) and specific volume v (m³/kg)

Functions at the saturation line

H2O_pSAT(T) - saturation pressure (Pa) at temperature T (K)

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H2O_vlSAT(T) - saturated liquid specific volume (m³/kg) at temperature T (K)
H2O_vvSAT(T) - saturated vapour specific volume (m³/kg) at temperature T (K)
H2O_hlSAT(T) - saturated liquid specific enthalpy (J/kg) at temperature T (K)
H2O_hvSAT(T) - saturated vapour specific enthalpy (J/kg) at temperature T (K)
H2O_slSAT(T) - saturated liquid specific entropy (J/kgK) at temperature T (K)
H2O_svSAT(T) - saturated vapour specific entropy (J/kgK) at temperature T (K)
H2O_surf(T) - saturated liquid/vapour interface surface tension (N/m) at temperature T (K)

Consider Water Substance at a pressure of 8 (bar), which can be handled by all three versions of “STEAM”.

First we will calculate the saturation properties using the functions now implemented in Excel? :

The steam saturation temperature at 8 bar (= 8e5 Pa) is now calculated by writing **=H2O_TSAT (8e5)** and striking “Enter”. The result is 443,56 (K) – i.e. 170,41 (C) - which is identical to the tabulated value from The International Steam Tables.

This may be checked by using the inverse function to calculate the saturation pressure at 443,56 (K). We write **=H2O_pSAT (443,56)** and strike “Enter”. The result is 800000,6 (Pa) – which is quite close! We further calculate:

=H2O_vlSAT (443,56) and the result: 0,0011150 (m³/kg)

=H2O_vvSAT (443,56) and the result: 0,24028 (m³/kg)

=H2O_hlSAT (443,56) and the result: 720,92 (kJ/kg)

=H2O_hvSAT (443,56) and the result: 2767,46 (kJ/kg)

=H2O_slSAT (443,56) and the result: 2,0457 (kJ/kgK)

=H2O_svSAT (443,56) and the result: 6,6596 (kJ/kgK)

=H2O_surf (443,56) and the result: 0,04432 (N/m)

These values are identical to the tabulated values. Next we maintain the pressure (8 bar) and increase the temperature to 400 (C). We get:

=H2O_v (8e5; 673,15) and the result: 0,3842 (m³/kg)

=H2O_h (8e5; 673,15) and the result: 3267,5 (kJ/kg)

=H2O_s (8e5; 673,15) and the result: 7,5729 (kJ/kgK)

and using the specific volume just calculated:

=H2O_visc (673,15;0, 3248) and the result: 24,43e-6 (kg/ms)

=H2O_cond (673,15;0, 3248) and the result: 55,27e-3 (W/mK)

These values are also identical to the values tabulated in The International Steam Tables.

Steam V3 Facilities

The STEAM version 3 has all the facilities of the previous versions – however, the range is now expanded up to 500 bar and 800 C. Therefore, this version handles the Supercritical Range quite well and by employing new algorithms (as compared to the previous versions for the high pressure range), also quite fast.

Furthermore, STEAM now has its own item on the main Excel Menu-bar, where – apart from access to the Help Manual – further specialized applications may later be included.