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**Property Library for
Octamethylcyclotetrasiloxane (D4)
 $\text{C}_8\text{H}_{24}\text{O}_4\text{Si}_4$**

**FluidEXL *Graphics*
with LibD4
for Excel[®]**

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Property Library for the Calculation of Octamethylcyclotetrasiloxane (D4)

FluidEXL *Graphics* LibD4

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0. Package Contents

0.1 Zip files for 32-bit Office®

The following zip files are delivered for your computer running a 32-bit Office® version.

English zip file "CD_FluidEXL_Graphics_LibD4_Eng.zip" including the following files:

FluidEXL_Graphics_Eng_Setup.exe	- Self-extracting and self-installing program for FluidEXL <i>Graphics</i>
FluidEXL_Graphics_Eng.xla	- English Add-In FluidEXL <i>Graphics</i> for Excel
LibD4.hlp	- Help file for the LibD4 property library
LibD4.dll	- Dynamic link library with functions for water and steam
FluidEXL_Graphics_LibD4_Docu_Eng.pdf	- User's Guide

German zip file "CD_FluidEXL_Graphics_LibD4.zip" including the following files:

FluidEXL_Graphics_Setup.exe	- Self-extracting and self-installing program for FluidEXL <i>Graphics</i>
FluidEXL_Graphics.xla	- German Add-In FluidEXL <i>Graphics</i> for Excel
LibD4.hlp	- Help file for the LibD4 property library
LibD4.dll	- Dynamic link library with functions for the LibD4 property library
FluidEXL_Graphics_LibD4_Docu_Eng.pdf	- User's Guide

0.2 Zip files for 64-bit Office®

The following zip files are delivered for your computer running a 64-bit Office® version.

English zip file "CD_FluidEXL_Graphics_LibD4_Eng.zip" including the following files and folders:

Files:

FluidEXL_Graphics_LibD4_Docu_Eng.pdf	- User's Guide
FluidEXL_Graphics_Eng.xla	- English Add-In FluidEXL <i>Graphics</i> for Excel
FluidEXL_Graphics_Eng_64_Setup.msi	- Self-extracting and self-installing program
LibD4.dll	- Dynamic link library for use in Windows® programs
LibD4_Eng.hlp	- English help file for the LibD4 library
Setup.exe	- Self-extracting and self-installing program for FluidEXL <i>Graphics</i>

Folders:

vcredist_x64	- Folder containing the "Microsoft Visual C++ 2010 x64 Redistributable Pack"
WindowsInstaller3_1	- Folder containing the "Microsoft Windows Installer"

German zip file "CD_FluidEXL_Graphics_LibD4.zip" including the following files and folders:

Files:

FluidEXL_Graphics_LibD4_Docu_Eng.pdf	- User's Guide
FluidEXL_Graphics.xla	- German Add-In FluidEXL <i>Graphics</i> for Excel
FluidEXL_Graphics_64_Setup.msi	- Self-extracting and self-installing program
LibD4.dll	- Dynamic link library for use in Windows® programs
LibD4_Eng.hlp	- German help file for the LibD4 library
Setup.exe	- Self-extracting and self-installing program for FluidEXL <i>Graphics</i>

Folders:

vcredist_x64

- Folder containing the "Microsoft Visual C++ 2010 x64 Redistributable Pack"

WindowsInstaller3_1

- Folder containing the "Microsoft Windows Installer"

1. Property Functions

1.1 Calculation Programs

"D4" means Octamethylcyclotetrasiloxane ($C_8H_{24}O_4Si_4$)

Functional Dependence	Function Name	Call from Fortran program	Call in DLL LibD4 as parameter	Property or Function	Unit of the result
$a = f(p, t, x)$	a_ptx_D4	APTxD4(P,T,X)	C_APTxD4(PR,P,T,X)	Thermal diffusivity	m^2/s
$c_p = f(p, t, x)$	cp_ptx_D4	CPPTxD4(P,T,X)	C_CPPTxD4(CP,P,T,X)	Specific isobaric heat capacity	$kJ/(kg \cdot K)$
$c_v = f(p, t, x)$	cv_ptx_D4	CVPTxD4(P,T,X)	C_CVPTxD4(CV,P,T,X)	Specific isochoric heat capacity	$kJ/(kg \cdot K)$
$\left(\frac{\partial p}{\partial T}\right)_v = f(p, t, x)$	dpdtv_ptx_D4	DPDVTxD4(P,T,X)	C_DPDVTxD4(DPDT,P,T,X)	Derivative of pressure with respect to temperature (at constant specific volume)	kPa/K
$\left(\frac{\partial p}{\partial v}\right)_T = f(p, t, x)$	dpdvt_ptx_D4	DPDVTxD4(P,T,X)	C_DPDVTxD4(DPDV,P,T,X)	Derivative of pressure with respect to specific volume (at constant temperature)	$kPa/(m^3/kg)$
$\eta = f(p, t, x)$	eta_ptx_D4	ETAPTxD4(P,T,X)	C_ETAPTxD4(ETA,P,T,X)	Dynamic viscosity	$Pa \cdot s$
$h = f(p, t, x)$	h_ptx_D4	HPTxD4(P,T,X)	C_HPTxD4(H,P,T,X)	Specific enthalpy	kJ/kg
$\kappa = f(p, t, x)$	kappa_ptx_D4	KAPPAPTxD4(P,T,X)	C_KAPPAPTxD4(KAPPA,P,T,X)	Isentropic exponent	-
$\lambda = f(p, t, x)$	lamda_ptx_D4	LAMPTxD4(P,T,X)	C_LAMPTxD4(LAM,P,T,X)	Thermal conductivity	$W/(m \cdot K)$
$\nu = f(p, t, x)$	nu_ptx_D4	NUPTxD4(P,T,X)	C_NUPTxD4(NUE,P,T,X)	Kinematic viscosity	m^2/s
$Pr = f(p, t, x)$	Pr_ptx_D4	PRPTxD4(P,T,X)	C_PRPTxD4(PR,P,T,X)	Prandtl-number	-
$p_s = f(t)$	ps_t_D4	PSTD4(T)	C_PSTD4(PS,T)	Vapor pressure from temperature	bar
$\rho = f(p, t, x)$	rho_ptx_D4	RHOPTxD4(P,T,X)	C_RHOPTxD4(RHO,P,T,X)	Density	kg/m^3
$s = f(p, t, x)$	s_ptx_D4	SPTxD4(P,T,X)	C_SPTxD4(S,P,T,X)	Specific entropy	$kJ/(kg \cdot K)$
$t = f(p, h)$	t_ph_D4	TPHD4(P,H)	C_TPHD4(T,P,H)	Backward function: Temperature from pressure and enthalpy	$^{\circ}C$
$t = f(p, s)$	t_ps_D4	TPSD4(P,S)	C_TPSD4(T,P,S)	Backward function: Temperature from pressure and entropy	$^{\circ}C$
$t_s = f(p)$	ts_p_D4	TSPD4(P)	C_TSPD4(TS,P)	Saturation temperature from pressure	$^{\circ}C$
$u = f(p, t, x)$	u_ptx_D4	UPTxD4(P,T,X)	C_UPTxD4(U,P,T,X)	Specific internal energy	kJ/kg
$v = f(p, t, x)$	v_ptx_D4	VPTxD4(P,T,X)	C_VPTxD4(V,P,T,X)	Specific volume	m^3/kg

Functional Dependence	Function Name	Call from Fortran program	Call in DLL LibD4 as parameter	Property or Function	Unit of the result
$w = f(p, t, x)$	w_ptx_D4	WPTXD4(P,T,X)	C_WPTXD4(W,P,T,X)	Isentropic speed of sound	m/s
$x = f(p, h)$	x_ph_D4	XPHD4(P,H)	C_XPHD4(X,P,H)	Backward function: Vapor fraction from pressure and enthalpy	kg/kg
$x = f(p, s)$	x_ps_D4	XPSD4(P,S)	C_XPSD4(X,P,S)	Backward function: Vapor fraction from pressure and entropy	kg/kg
$Z = f(p, t, x)$	Z_ptx_D4	ZPTXD4(P,T,X)	C_ZPTXD4(Z,P,T,X)	Compression factor	-

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

Range of validity

Temperature range: from $t = 26.85^\circ\text{C}$ to 399.85°C
 Pressure range: from $p = 0.00001$ bar to 300 bar

Reference state

$h = 0$ kJ/kg and $s = 0$ kJ/(kg K) at $t_B = 175.354^\circ\text{C}$ on the boiling curve ($x = 0$; $p_s = p_N = 1.01325$ bar)

Details on the vapor fraction x

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. Here the backward functions will also result in $x = -1$.

Wet-steam region

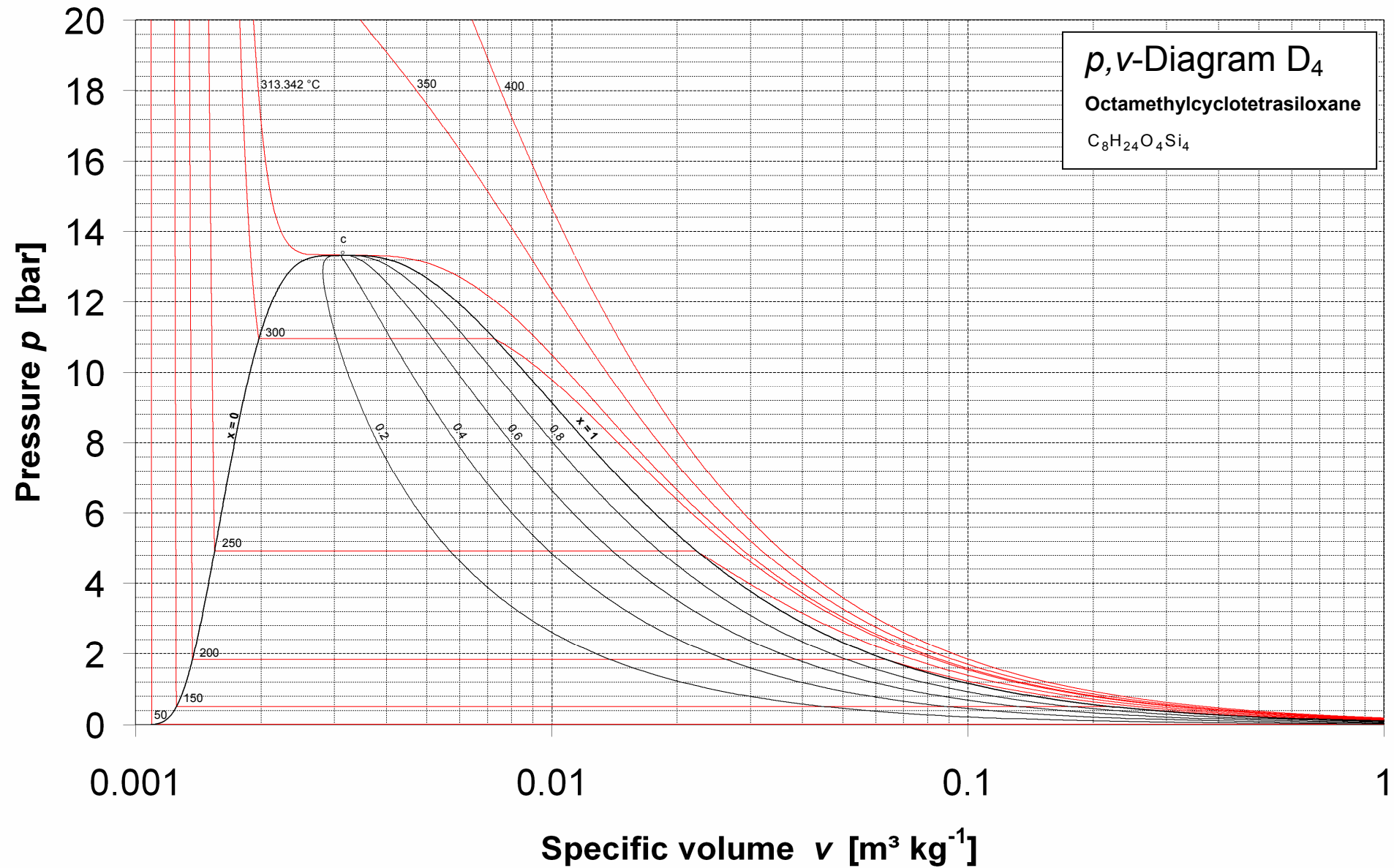
When calculating wet steam, a value between 0 and 1 ($x = 0$ for saturated liquid, $x = 1$ for saturated steam) must be entered. In this case, the backward functions result in the appropriate value between 0 and 1 for x . It is adequate to enter either the given value for t and $p = -1000$, or the given value for p and $t = -1000$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1000 .

Wet steam region: Temperature range from $t = 26.85^\circ\text{C}$ to $t_c = 313.342^\circ\text{C}$
 Pressure range from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

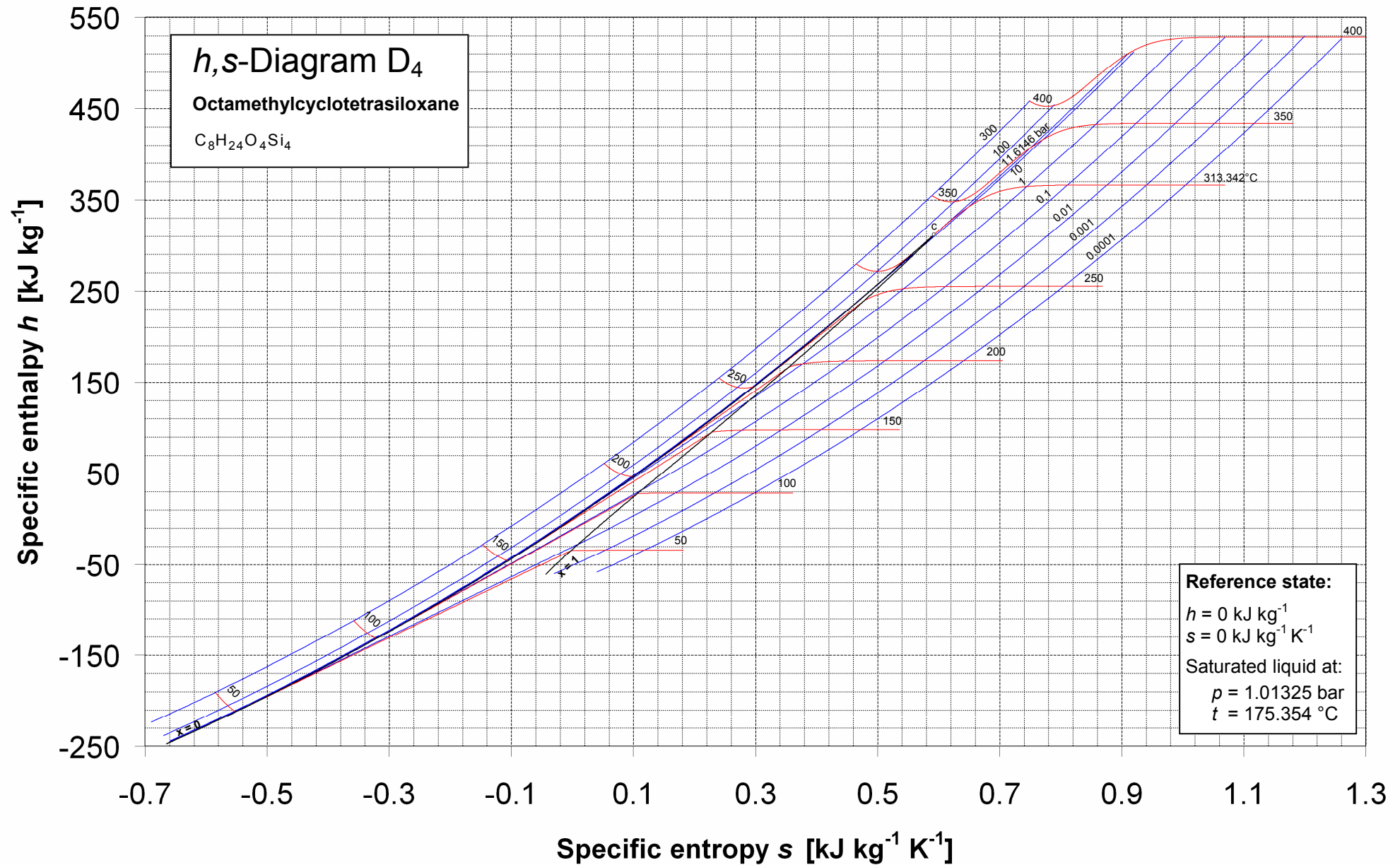
Hint:

If the calculation results in -1000 (except for x), the values entered represent a state point beyond the range of validity of LibD4. For further information on each function and its range of validity see Chapter 3. The same information may also be accessed via the online help pages.

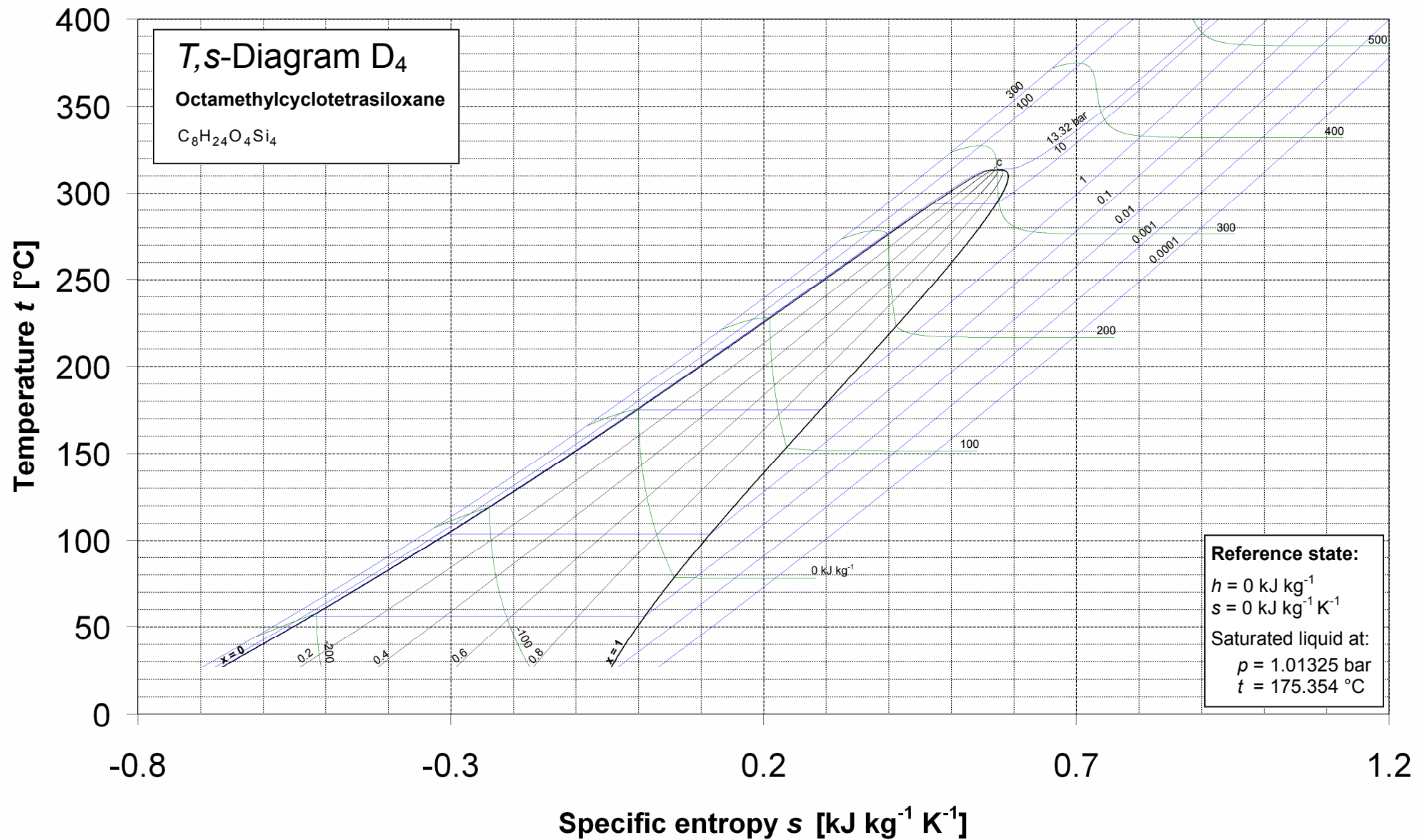
1.2 p,v -Diagram



1.3 h,s -Diagram



1.4 T,s-Diagram



2. Application of FluidEXL^{Graphics} in Excel[®]

The FluidEXL^{Graphics} Add-In has been developed to calculate thermodynamic properties in Excel more conveniently. Within Excel[®], it enables the direct call of functions relating to Octamethylcyclotetrasiloxane from the LibD4 property library. Furthermore, the program enables representation of the calculated values in various thermodynamic diagrams.

2.1 Installing FluidEXL^{Graphics}

If FluidEXL^{Graphics} has not yet been installed or if there is a version installed which has been delivered before April 2010, please complete the initial installation procedure described below.

If FluidEXL^{Graphics} has already been installed in a version which has been delivered after April 2010, you simply need to copy the files which belong to the LibD4 library. In this case, follow the subsection "Adding the LibD4 Library" on page 2/11.

Installing FluidEXL^{Graphics} for 32-bit Windows[®]

Complete the following steps for initial installation of FluidEXL^{Graphics}.

Before you begin, it is best to uninstall any trial version or full version of FluidEXL^{Graphics} delivered before April 2010.

After you have downloaded and extracted the zip-file

"CD_FluidEXL_Graphics_LibD4_Eng.zip" (for English version of Windows[®])

"CD_FluidEXL_Graphics_LibD4.zip" (for German version of Windows)

you will see the folder

CD_FluidEXL_Graphics_LibD4_Eng (for English version of Windows)

CD_FluidEXL_Graphics_LibD4 (for German version of Windows)

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:

FluidEXL_Graphics_Eng_Setup.exe (for English version of Windows)

FluidEXL_Graphics_Setup.exe (for German version of Windows)

FluidEXL_Graphics_Eng.xla (for English version of Windows)

FluidEXL_Graphics.xla (for German version of Windows)

LibD4.dll

LibD4_Eng.hlp.

In order to run the installation of FluidEXL^{Graphics}, double-click the file

FluidEXL_Graphics_Eng_Setup.exe (for English version of Windows)

FluidEXL_Graphics_Setup.exe (for German version of Windows).

Installation may start with a window noting that all Windows programs should be closed. When this is the case, the installation can be continued. Click the "Continue" button.

In the following dialog box, "Choose Destination Location", the default path offered automatically for the installation of FluidEXL^{Graphics} is

C:\Program Files\FuildEXL_Graphics_Eng (for English version of Windows)

C:\Programme\FuildEXL_Graphics (for German version of Windows).

By clicking the "Browse..." button, you can change the installation directory before installation (see figure below).



Image 2.1: Choose Destination Location

Finally, click on "Next" to continue installation; click "Next" again in the "Start Installation" window which follows in order to start the installation of FluidEXL *Graphics*.

After FluidEXL *Graphics* has been installed, the sentence "FluidEXL Graphics English has been successfully installed." will be shown. Confirm this by clicking the "Finish" button.

The installation of FluidEXL *Graphics* has been completed.

During the installation process the following files

Advapi32.dll	LC.dll
DFORMD.dll	Msvcp60.dll
Dforrt.dll	Msvcrt.dll
UNWISE.EXE	UNWISE.INI
INSTALL_EXL.LOG	
FluidEXL_Graphics_Eng.xla	(for English version of Windows)
FluidEXL_Graphics.xla	(for German version of Windows)

have been copied into the chosen destination folder, in the standard case

C:\Program Files\FuildEXL_Graphics_Eng	(for English version of Windows)
C:\Programme\FuildEXL_Graphics	(for German version of Windows).

In addition, the two subdirectories \Formulation97 and \FLuft have been compiled in the destination folder and FluidGraph.ocx has been registered as OLE-control in Windows.

In the next step, the files

FluidEXL_Graphics_Eng.xla	(for English version of Windows)
FluidEXL_Graphics.xla	(for German version of Windows)
LibD4.dll	
LibD4_Eng.hlp	

in the extracted zip-folder

CD_FluidEXL_Graphics_LibD4_Eng	(for English version of Windows)
CD_FluidEXL_Graphics_LibD4	(for German version of Windows)

must be copied into the chosen destination folder (the standard being

C:\Program Files\FluidEXL_Graphics_Eng (for English version of Windows)
 C:\Programme\FluidEXL_Graphics (for German version of Windows))

using an appropriate program such as Explorer or Norton Commander.

Installing FluidEXL *Graphics* for 64-bit Windows®

In this section, the installation of FluidEXL *Graphics* for a 64-bit Windows® version is described.

Before you begin, it is best to uninstall any trial version or full version of FluidEXL *Graphics* delivered before June 2010.

After you have downloaded and extracted the zip-file

"CD_FluidEXL_Graphics_LibD4_Eng.zip" (for English version of Windows)
 "CD_FluidEXL_Graphics_LibD4.zip" (for German version of Windows)

you will see the folder

CD_FluidEXL_Graphics_LibD4_Eng (for English version of Windows)
 CD_FluidEXL_Graphics_LibD4 (for German version of Windows)

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

FluidEXL_Graphics_LibD4_Docu_Eng.pdf
 FluidEXL_Graphics_Eng.xla (for English version of Windows)
 FluidEXL_Graphics.xla (for German version of Windows)
 FluidEXL_Graphics_Eng_Setup_64.msi (for English version of Windows)
 FluidEXL_Graphics_Setup_64.msi (for German version of Windows)
 LibD4.dll
 LibD4_Eng.hlp
 Setup.exe

and the folders

vcredist_x64
 WindowsInstaller3_1.

In order to run the installation of FluidEXL *Graphics*, double-click the file

Setup.exe.

If the "Microsoft Visual C++ 2010 x64 Redistributable Pack" is not running on your computer yet, installation will start with a window noting that the "Visual C++ 2010 runtime library (x64)" will be installed on your machine (see Figure 2.2).

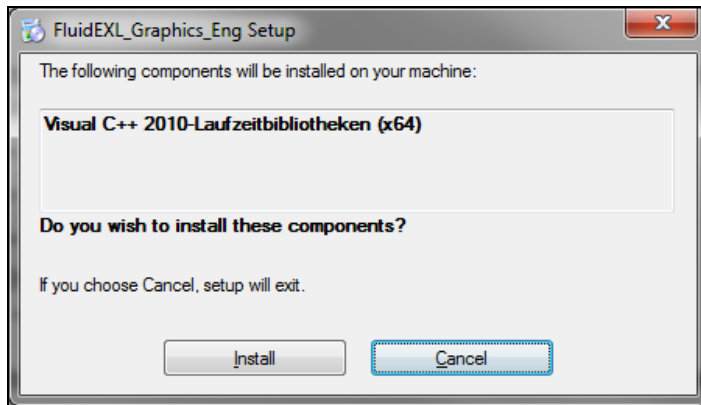


Figure 2.2: Installing the "Visual C++ 2010 runtime library (x64)"

Click on "Install" to continue.

In the following window you are required to accept the Microsoft® license terms to install the "Microsoft Visual C++ 2010 x64 Redistributable Pack" by ticking the box next to "I have read and accept the license terms" (see Figure 2.3).

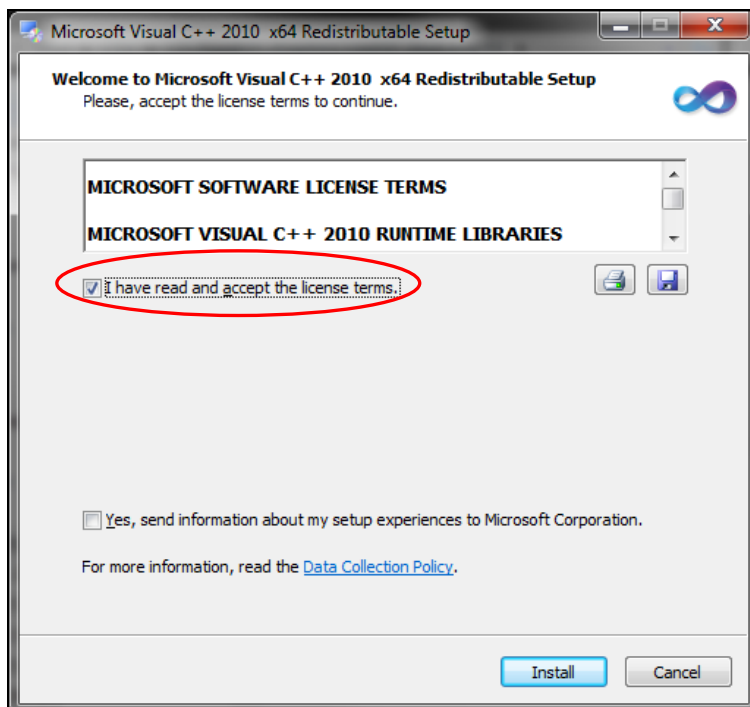


Figure 2.3: Accepting the license terms

Now click on "Install" to continue installation.

After the "Microsoft Visual C++ 2010 x64 Redistributable Pack" has been installed, you will see the sentence "Microsoft Visual C++ 2010 x64 Redistributable has been installed." Confirm this by clicking "Finish."

Now the installation of FluidEXL^{Graphics} starts with a window noting that the installer will guide you through the installation. Click the "Next >" button to continue.

In the following dialog box (see Figure 2.4), "Select Installation Folder," the default path offered automatically for the installation of FluidEXL^{Graphics} is

C:\Program Files\FluidEXL_Graphics_Eng	(for English version of Windows)
C:\Programme\FluidEXL_Graphics	(for German version of Windows).

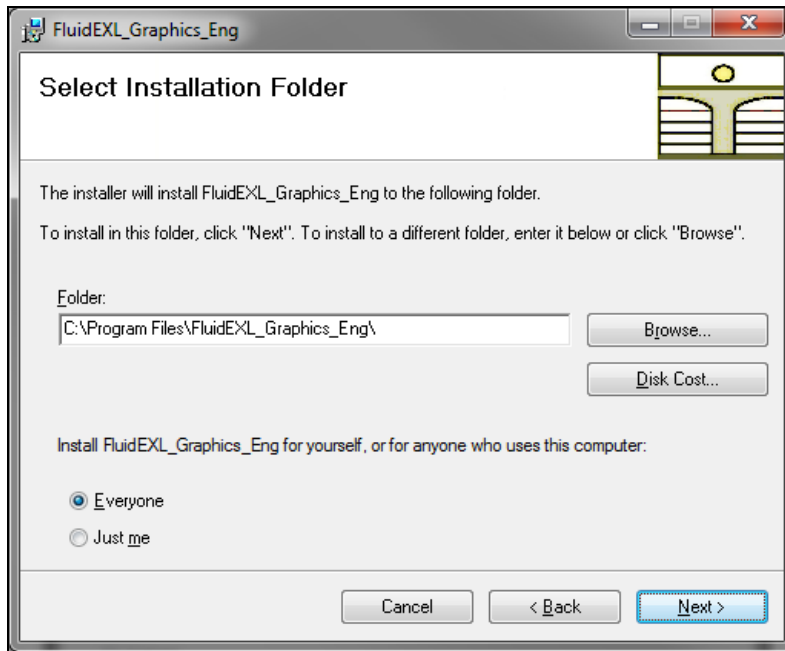


Figure 2.4: Choosing the Installation Folder of FluidEXL *Graphics*

Finally, click on "Next >" to continue installation; click "Next >" again in the "Confirm Installation" window which follows in order to start the installation of FluidEXL *Graphics*.

After FluidEXL *Graphics* has been installed, you will see the sentence

"FluidEXL Graphics English has been successfully installed."

"FluidEXL Graphics wurde erfolgreich installiert."

Confirm this by clicking the "Close" button.

During the installation process the following files

capt_ico_big.ico	libmmd.dll
libifcoremd.dll	LC.dll
libiomp5md.dll	

will have been copied into the destination folder chosen, the standard being

C:\Program Files\FuildEXL_Graphics_Eng	(for English version of Windows)
C:\Programme\FuildEXL_Graphics	(for German version of Windows).

In addition, the two subdirectories \FORMULATION97 and \FLuft will have been created in the destination folder.

In the next step, the following files

FluidEXL_Graphics_Eng.xla	(for English version of Windows)
FluidEXL_Graphics.xla	(for German version of Windows)
LibD4.dll	
LibD4_Eng.hlp	

which can be found in your CD folder must be copied into the chosen destination folder (the standard being

C:\Program Files\FuildEXL_Graphics_Eng	(for English version of Windows)
C:\Programme\FuildEXL_Graphics	(for German version of Windows))

using an appropriate program such as Explorer or Norton Commander.

2.2 Registering FluidEXL^{Graphics} as Add-In in Excel[®]

Registering FluidEXL^{Graphics} as Add-In in Excel[®], versions 2003 or earlier

After the installation of FluidEXL^{Graphics}, the program must be registered as an Add-In in Excel[®]. In order to do so, start Excel and carry out the following steps:

- Click "Tools" in the upper Menu bar in Excel
- Here, click on "Add-Ins..." in the menu

After a short delay, the dialog box "Add-Ins" will appear

- Click "Browse..."
- In the following dialog box, chose your destination folder (the standard being
 C:\Program Files\FuildEXL_Graphics_Eng (for English version of Windows)
 C:\Programme\FuildEXL_Graphics (for German version of Windows))
- Here select the file
 "FluidEXL_Graphics_Eng.xla" (for English version of Windows) or
 "FluidEXL_Graphics.xla" (for German version of Windows)
 and afterwards click "OK".

Now, the entry

"FluidEXL Graphics Eng" (for English version of Windows)
 "FluidEXL Graphics" (for German version of Windows)

will appear in your list of Add-Ins.

Note:

As long as the check box next to the file name

*"FluidEXL Graphics Eng" (for English version of Windows) or
 "FluidEXL Graphics" (for German version of Windows),*

is checked, this Add-In will be loaded automatically every time you start Excel until you unmark the box by clicking on it again.

- In order to register FluidEXL^{Graphics} as an Add-In click "OK" in the "Add-Ins" dialog box.

Now, the new FluidEXL^{Graphics} menu bar will appear in the upper menu area of your Excel screen, marked with a red circle in the next figure.

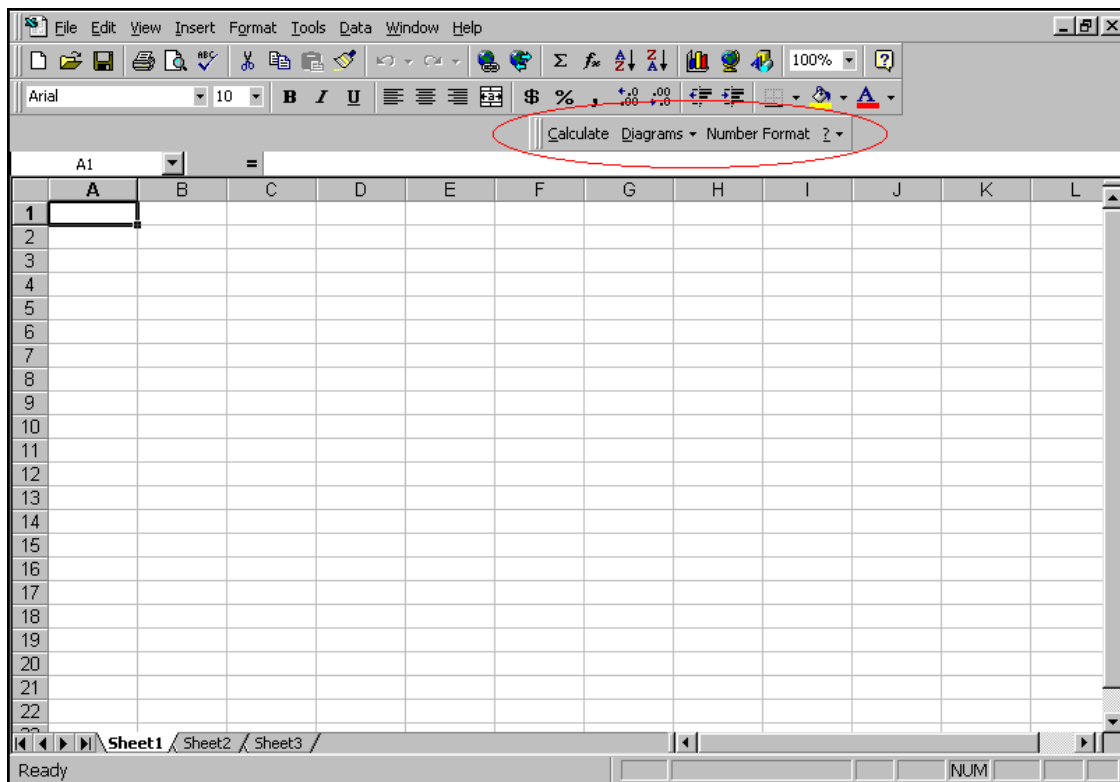


Figure 2.5: Menu bar of FluidEXLGraphics

Registering FluidEXL^{Graphics} as Add-In in Excel[®] 2007 (or later versions)

After installation in Windows[®], FluidEXL^{Graphics} must be registered in Excel[®] as from version 2007 as an Add-In. For this, start Excel and carry out the following steps:

- Click the Windows Office button in the upper left hand corner of Excel
- Click on the "Excel Options" button in the menu which then appears (see Figure 2.6)

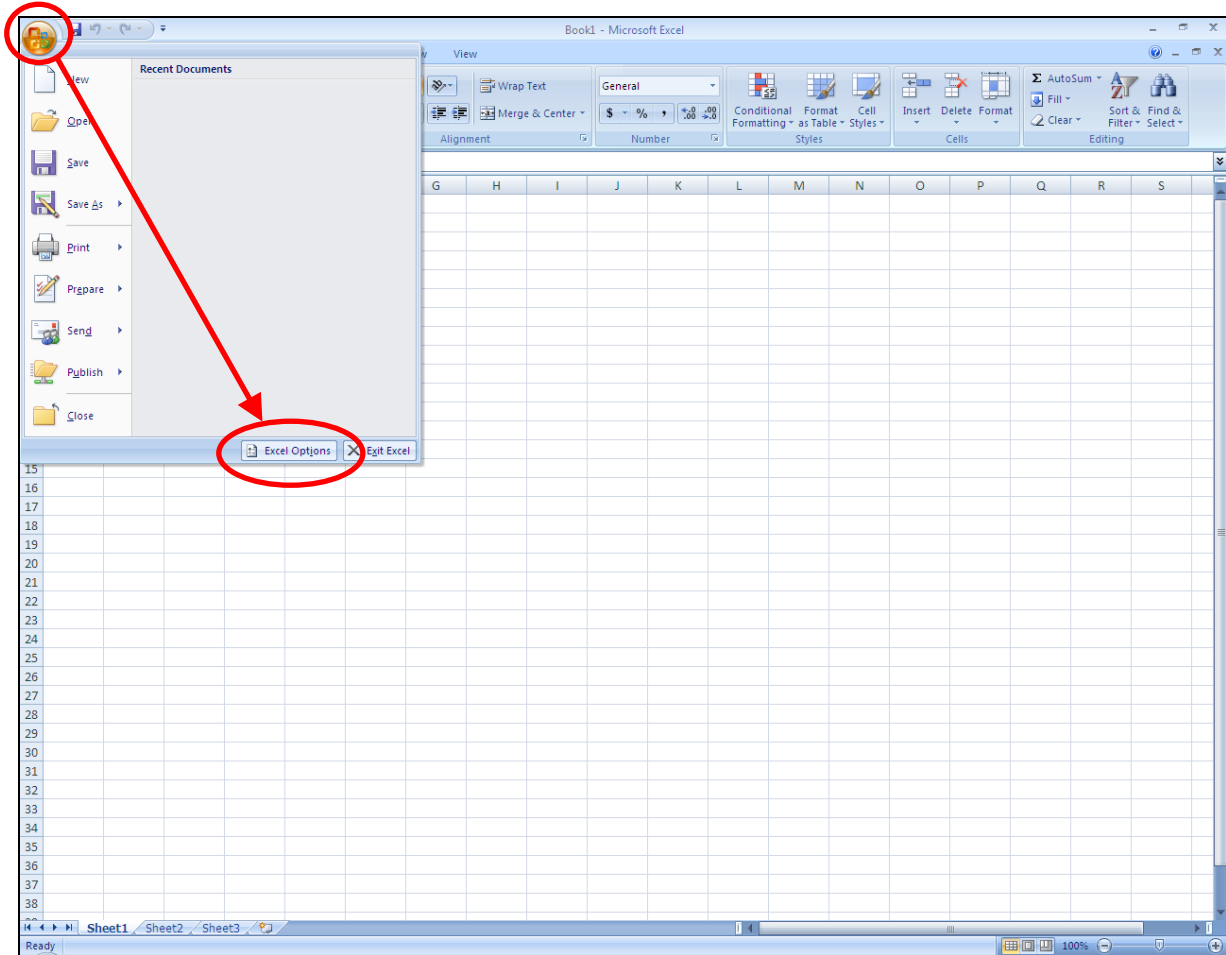


Figure 2.6: Registering FluidEXL^{Graphics} as Add-In in Excel 2007

- Click on "Add-Ins" in the next menu

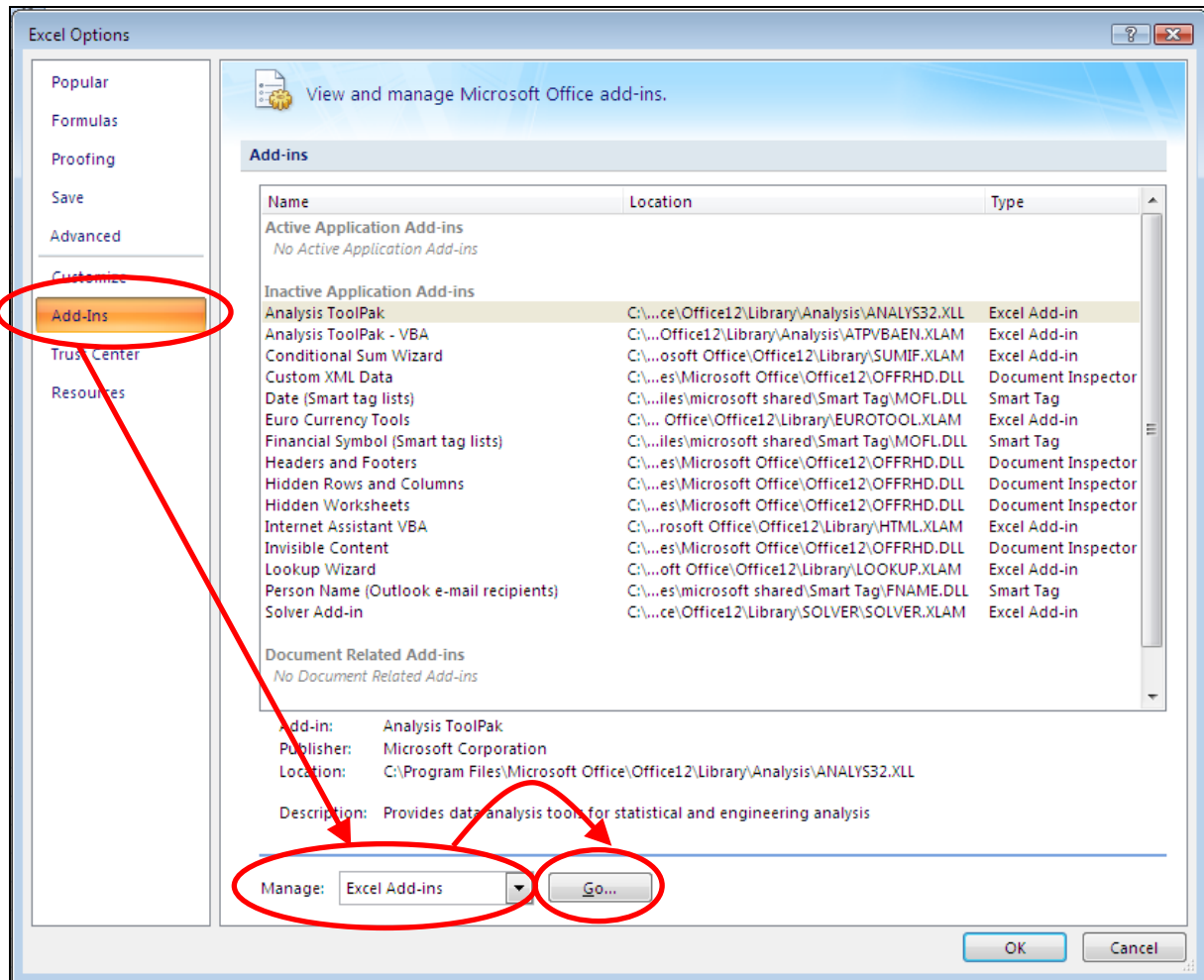


Figure 2.7: Dialog window "Add-Ins"

- Should it not be shown in the list automatically, select "Excel Add-ins" (found next to "Manage:" in the lower area of the menu)
- Then click the "Go..." button
- Click "Browse" in the following window and locate the destination folder, generally
C:\Program Files\FluidEXL_Graphics_Eng (for English version of Windows)
C:\Programme\FluidEXL_Graphics (for German version of Windows);
within that folder click on the file named
"FluidEXL_Graphics_Eng.xla" (for English version of Windows)
"FluidEXL_Graphics.xla" (for German version of Windows)
and then hit "OK".

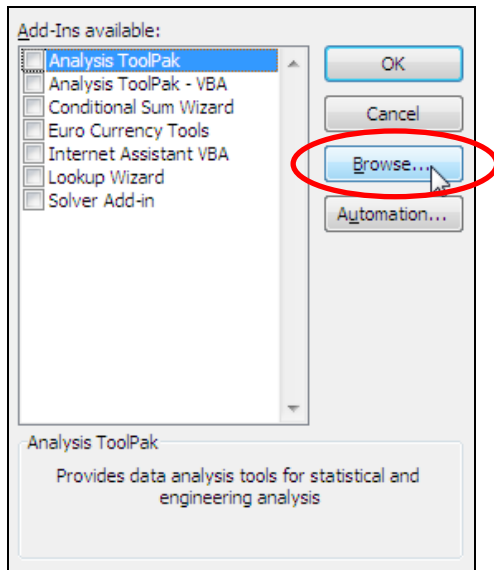


Figure 2.8: Dialog window "Add-Ins available"

- Now, "FluidEXL Graphics Eng" will be shown in your list of Add-Ins.
(If a check-mark is situated in the box next to the name "FluidEXL Graphics", this Add-In will automatically be loaded whenever Excel starts. This will continue to occur unless the check-mark is removed from the box by clicking on it.)

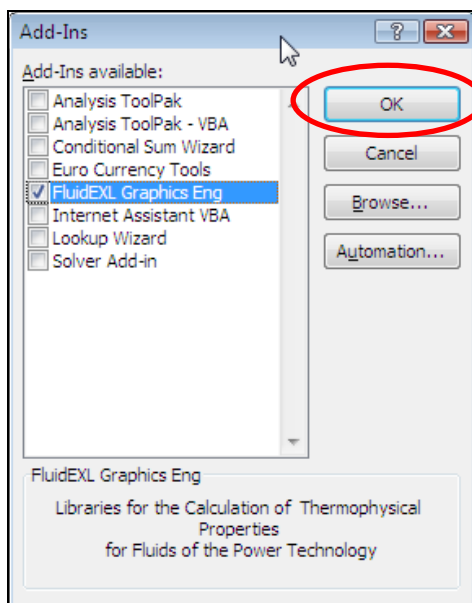


Figure 2.9: Dialog window "Add-Ins"

- In order to register the Add-In click the "OK" button in the "Add-Ins" window.

In order to use FluidEXL *Graphics* in the following example, click on the menu item "Add-Ins", shown in the next image.

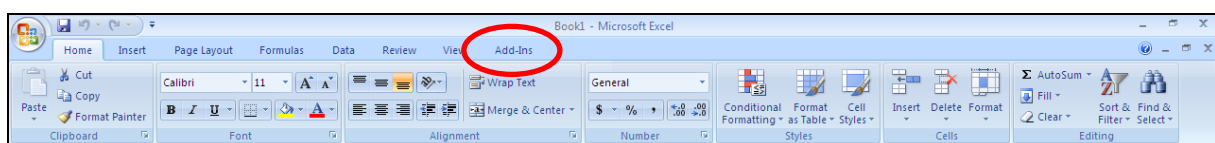


Figure 2.10: Menu item "Add-Ins"

In the upper menu region of Excel, the FluidEXL^{Graphics} menu bar will appear as indicated by the red circle in the next image.

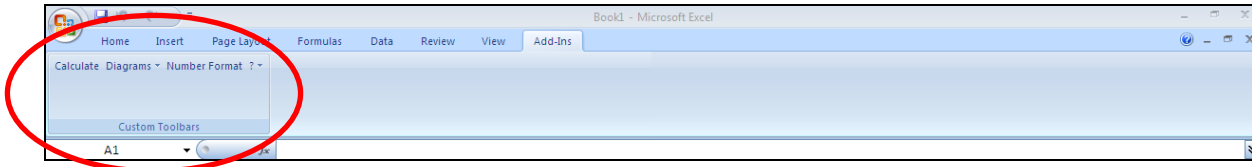


Figure 2.11: FluidEXL^{Graphics} menu bar

Installation of FluidEXL^{Graphics} in Excel (versions 2007 and later) is now finished. FluidEXL^{Graphics} can be used analogous to the description for using with earlier Excel versions.

Adding the LibD4 Library (FluidEXL^{Graphics} is already installed)

If FluidEXL^{Graphics} has already been installed in the April 2010 version, you only have to copy the following files

FluidEXL_Graphics_Eng.xla	(for English version of Windows)
FluidEXL_Graphics.xla	(for German version of Windows)
LibD4.dll	
LibD4_Eng.hlp	

provided in the extracted folder

CD_FluidEXL_Graphics_LibD4_Eng	(for English version of Windows [®])
CD_FluidEXL_Graphics_LibD4	(for German version of Windows)

into the folder you have chosen for the installation of FluidEXL^{Graphics} (the standard being

C:\Program Files\FuildEXL_Graphics_Eng	(for English version of Windows)
C:\Programme\FuildEXL_Graphics	(for German version of Windows)

using an appropriate program such as Explorer[®] or Norton Commander.

From within Excel you can now select the "Siloxanes_D4" DLL library property functions via this menu bar (cf. part 2.5).

2.3 The FluidEXL^{Graphics} Help System

As mentioned earlier, FluidEXL^{Graphics} also provides detailed online help functions. For general information in Excel[®]

- Click "Help" in the FluidEXL^{Graphics} menu bar.

Information on individual property functions may be accessed via the following steps:

- Click "Calculate" in the FluidEXL^{Graphics} menu bar.
- Select the "Siloxanes_D4" library under "Or select a category:" in the "Insert Function" window which will appear.
- Click the "Help on this function" button in the lower left-hand edge of the "Insert Function" window.
- If the "Office Assistant" is active, first double-click "Help on this feature" and in the next menu click "Help on selected function."

If the LibD4_Eng.hlp function help cannot be found, you will be asked whether you want to look for it yourself – answer with "Yes." Click on the LibD4_Eng.hlp file in the installation menu of FluidEXL^{Graphics} in the window which is opened, the standard being

C:\Program Files\FluidEXL_Graphics_Eng (for English version of Windows®)
 C:\Programme\FluidEXL_Graphics (for German version of Windows),
 and click "Yes" in order to complete the search.

Using the FluidEXL^{Graphics} Online Help in Windows Vista or Windows 7

If you are running Windows Vista or Windows 7 on your computer, you might not be able to open Help files. To view these files you have to install the Microsoft® Windows Help program which is provided by Microsoft®. Please carry out the following steps in order to download and install the Windows Help program.

Open Microsoft Internet Explorer® and go to the following address:

<http://support.microsoft.com/kb/917607/>

You will see the following web page:



Figure 2.12: Microsoft® Support web page

Scroll down until you see the headline "Resolution." Here you can see the bold hint:

"Download the appropriate version of Windows Help program (WinHlp32.exe), depending on the operating system that you are using."

The following description relates to Windows® 7. The procedure is analogous for Windows® Vista.

Click on the link "Windows Help program (WinHlp32.exe) for Windows 7" (see Figure 2.13).

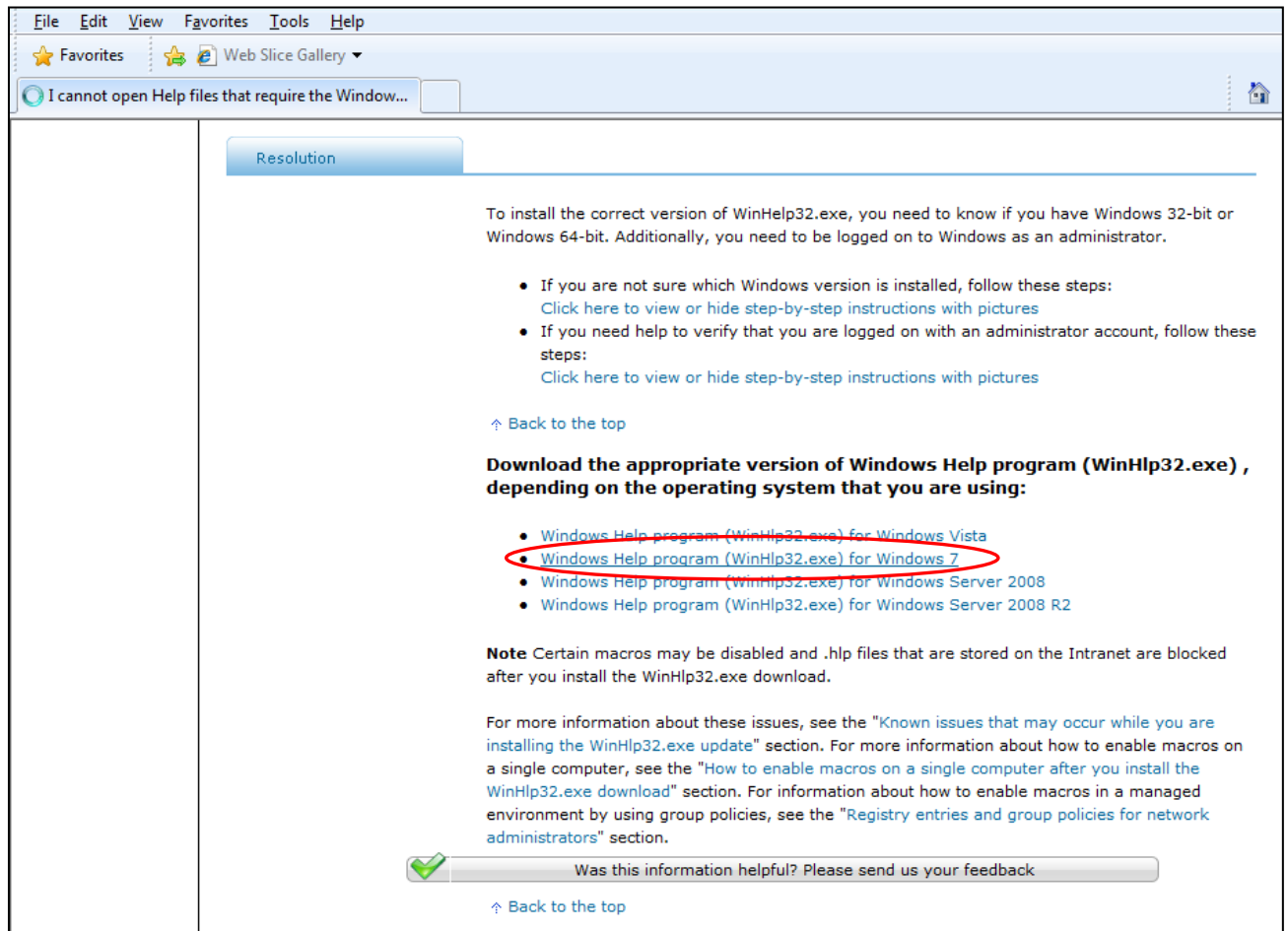


Figure 2.13: Selecting your Windows version

You will be forwarded to the Microsoft Download Center where you can download the Microsoft Windows Help program.

First, a validation of your Windows License is required.

To do this click on the "Continue" button (see Figure 2.14).

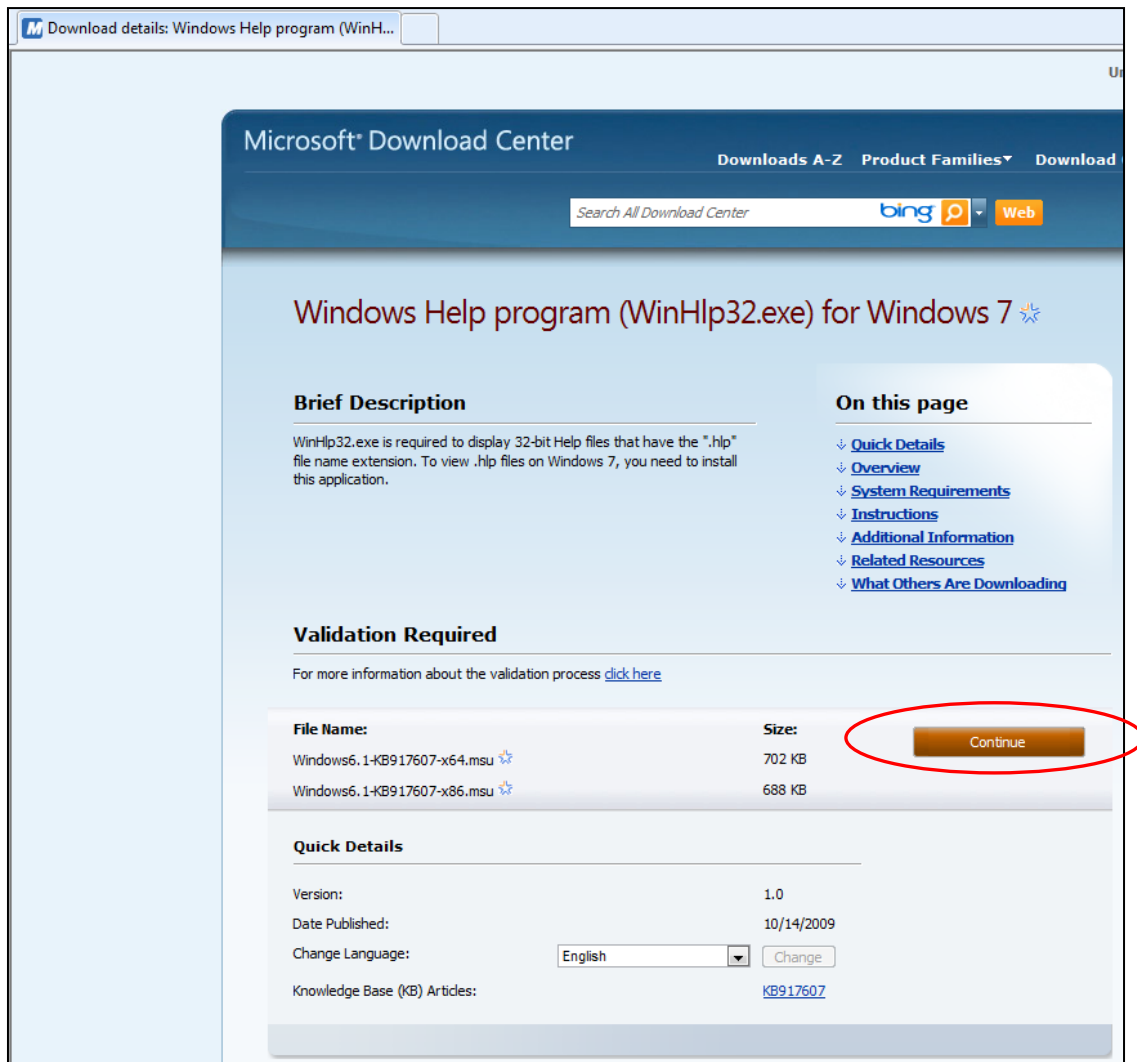


Figure 2.14: Microsoft® Download Center

You will be forwarded to a web page with instructions on how to install the Genuine Windows Validation Component.

At the top of your Windows Internet Explorer you will see a yellow information bar.

Right-click this bar and select "Install ActiveX Control" in the context menu (see Figure 2.15).

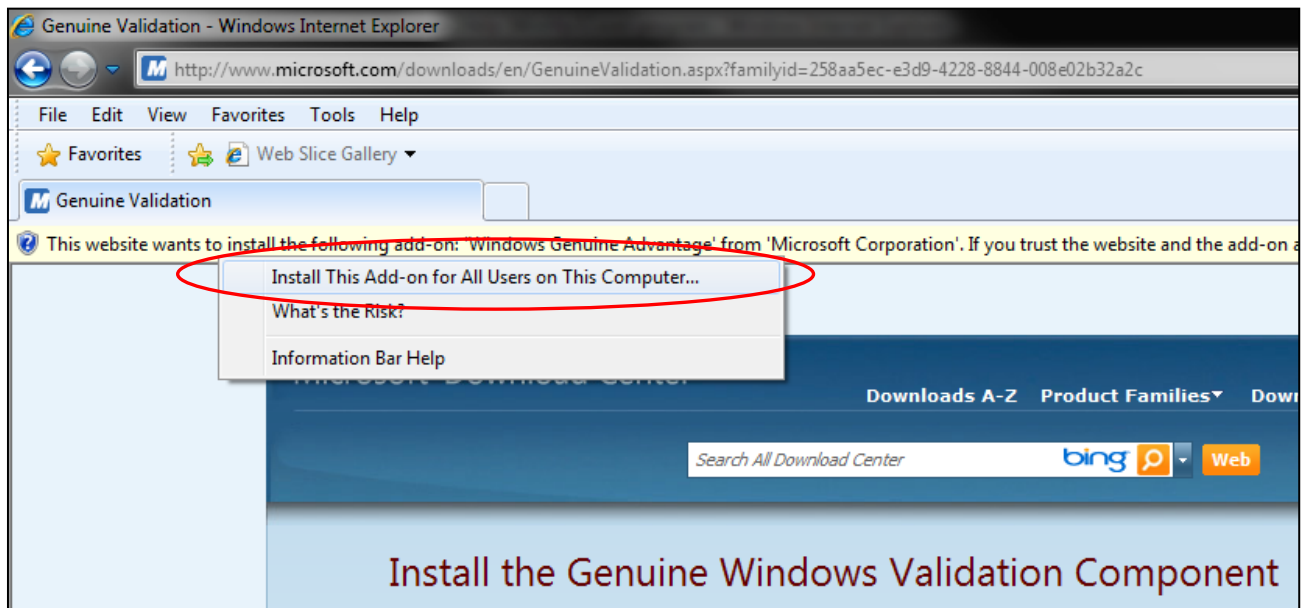


Figure 2.15: Installing the Genuine Windows Validation Component

A dialog window appears in which you will be asked if you want to install the software. Click the "Install" button to continue (see Figure 2.16).

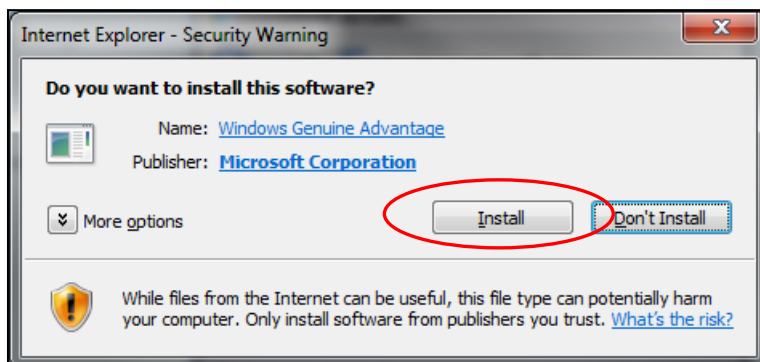


Figure 2.16: Internet Explorer – Security Warning

After the validation has been carried out you will be able to download the appropriate version of Windows Help program (see Figure 2.17).

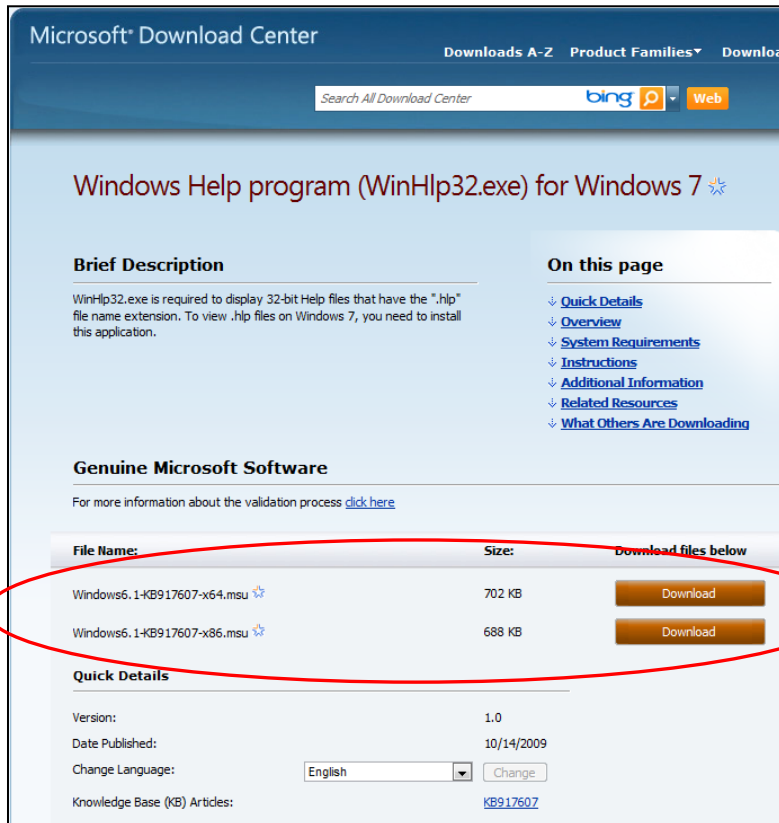


Figure 2.17: Downloading the Windows Help program

To download and install the correct file you need to know which Windows version (32 bit or 64 bit) you are running on your computer.

If you are running a 64 bit operating system, please download the file
Windows6.1-KB917607-x64.msu.

If you are running a 32 bit operating system, please download the file
Windows6.1-KB917607-x86.msu.

In order to run the installation of the Windows Help program double-click the file you have just downloaded on your computer:

Windows6.1-KB917607-x64.msu (for 64 bit operating system)

Windows6.1-KB917607-x86.msu. (for 32 bit operating system).

Installation starts with a window searching for updates on your computer. After the program has finished searching you may see the following window.

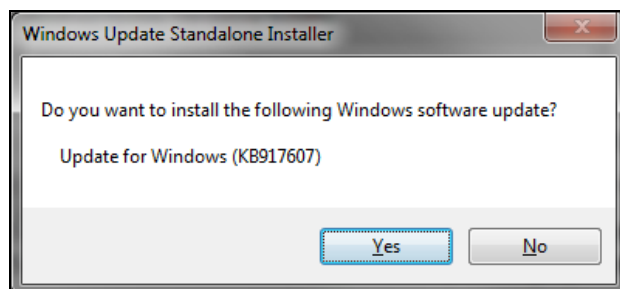


Figure 2.18: Windows Update Standalone Installer

In this case, the installation can be continued by clicking the "Yes" button.

(If you have already installed this update, you will see the message "Update for Windows (KB917607) is already installed on this computer.")

In the next window you have to accept the Microsoft license terms before installing the update by clicking on "I Accept" (see Figure 2.19)

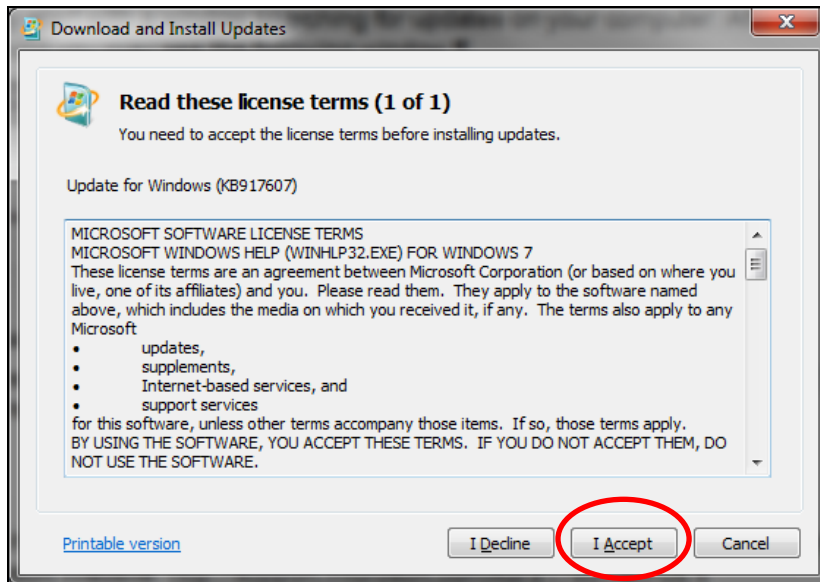


Figure 2.19: Windows License Terms

Installation starts once you have clicked the "I Accept" button (see Figure 2.20).

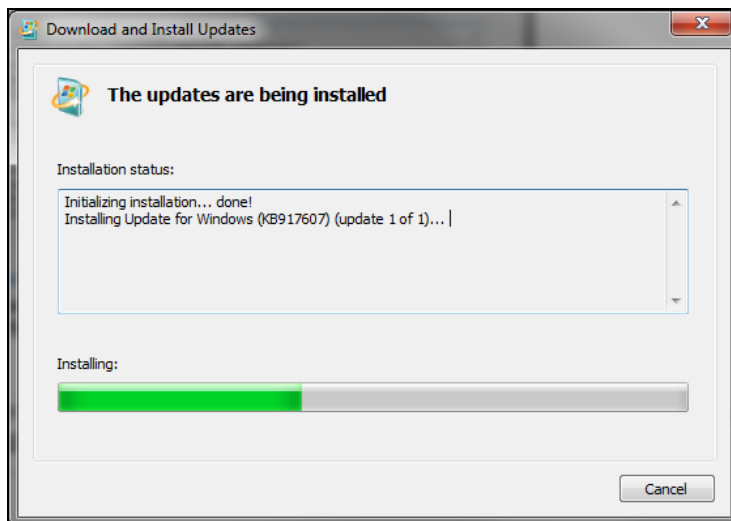


Figure 2.20: Installation process

After the Windows Help program has been installed, the notification "Installation complete" will appear. Confirm this by clicking the "Close" button.

The installation of the Windows Help program has been completed and you will now be able to open the Help files.

2.4 Licensing the LibD4 Property Library

The licensing procedure has to be carried out when Excel[®] starts up and a FluidEXL^{Graphics} prompt message appears. In this case, you will see the "License Information" window (see figure below).

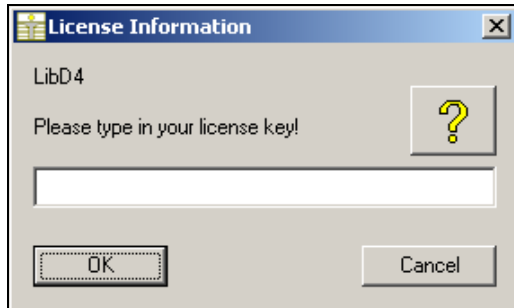


Figure 2.21: "License Information" window

Here you will have to type in the license key which you have obtained from the Zittau/Goerlitz University of Applied Sciences. You can find contact information on the "Content" page of this User's Guide or by clicking the yellow question mark in the "License Information" window. Then the following window will appear:

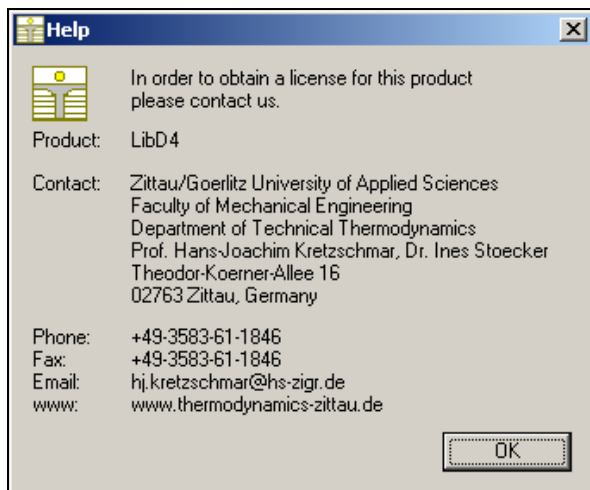


Figure 2.22: "Help" window

If you do not enter a valid license it is still possible to start Excel by clicking "Cancel". In this case, the LibD4 property library will display the result "-11111111" for every calculation you ask it to make.

The "License Information" window will appear every time you start Excel unless you uninstall FluidEXL^{Graphics} according to the description in section 2.6 of this User's Guide.

Should you not wish to license the LibD4 property library, you have to delete the files

LibD4.dll

LibD4_Eng.hlp

in the installation folder of FluidEXL^{Graphics} (the standard being

C:\Program Files\FluidEXL_Graphics_Eng (for English version of Windows)

C:\Programme\FluidEXL_Graphics (for German version of Windows))

using an appropriate program such as Explorer[®] or Norton Commander.

2.5 Example Calculation of $h = f(p, t, x)$

Now we will calculate, step by step, the specific enthalpy h as a function of pressure p , temperature t , and vapor fraction x , using FluidEXL *Graphics*. Please carry out the following steps:

- Start Excel[®]
- Enter a value for p in bar in a cell
(Range of validity: $p = 0.00001 \text{ bar}$ to 300 bar)

⇒ e. g.: Enter the value 10 into cell A2

- Enter a value for t in °C in a cell
(Range of validity: $t = 26.85^\circ\text{C}$ to 399.85°C)

⇒ e. g.: Enter the value 300 into cell B2

- Enter a value for x in kg saturated steam/kg wet steam into a cell

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:

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.

Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1.

When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1000 .

(D4 Saturation-pressure curve: $t = 26.85^\circ\text{C}$ to $t_c = 313.342^\circ\text{C}$

$p_s(26.85^\circ\text{C}) = 0.0014779 \text{ bar}$ to $p_c = 13.320 \text{ bar}$)

⇒ e.g.: Enter the value -1 into cell C2

- Click the cell in which the enthalpy h in kJ/kg is to be displayed.

⇒ e.g.: Click the D2 cell

- Click "Calculate" in the menu bar of FluidEXL *Graphics*.

Now the "Insert Function" window appears (see next figure).

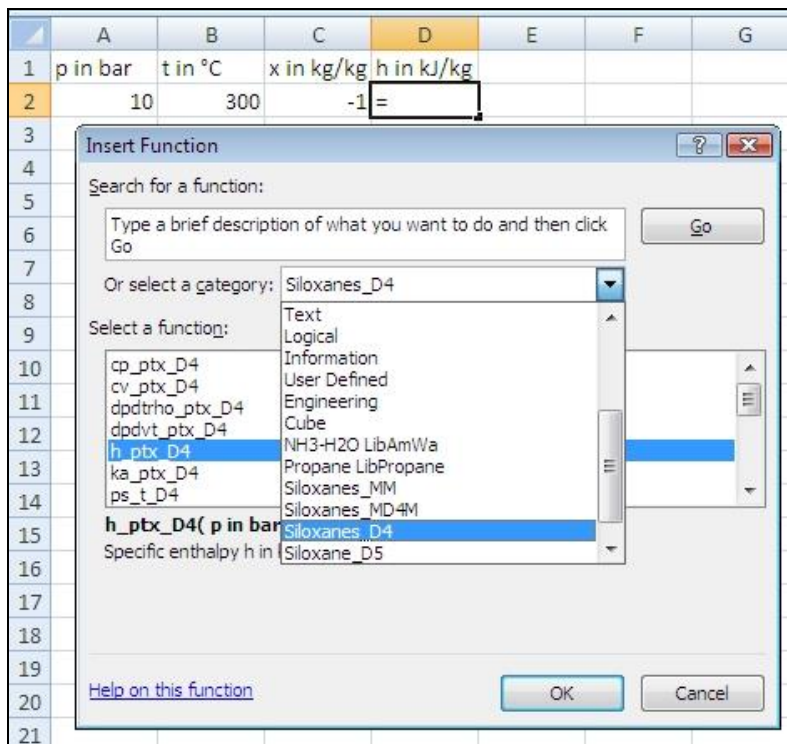


Image 2.23: Choice of library and function name

- Next to "Or select a category:" in the upper part of the window scroll down to select the "Siloxanes_D4" library.
- Then click on h_ptx_D4 under "Select a function:" directly below that.

Here it is possible to get more information on the range of validity, measuring units, error responses, etc. by clicking the "Help on this function" button.

- Click the "OK" button.

The window should now look as follows:

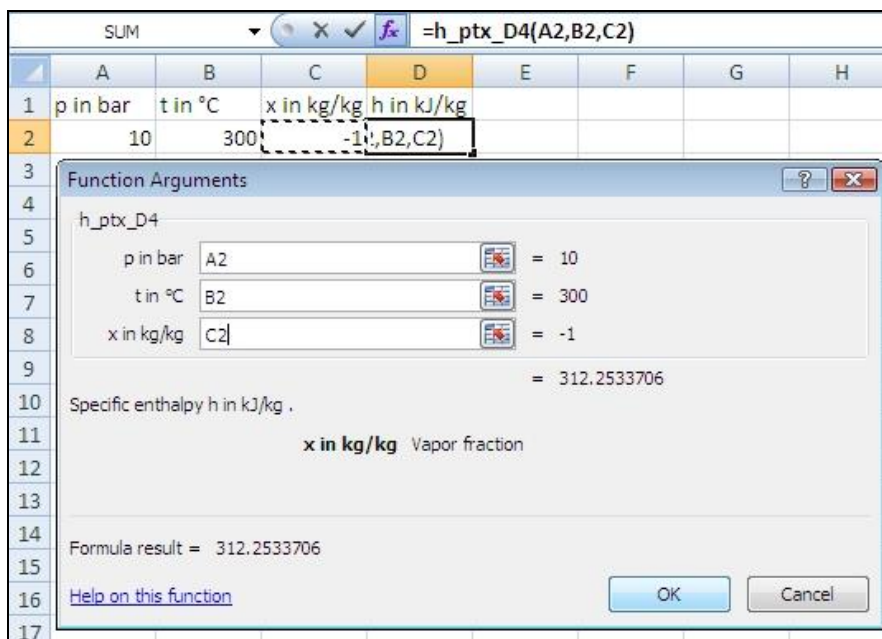


Image 2.24: Enter the given values for the property calculation

- The Cursor is now situated on the line next to "p in bar". You can now enter the value for p either by clicking the cell with the value for p , by entering the name of the cell with the value for p , or by entering the value for p directly.

⇒ e. g.: Click on the cell A2

- Situate the cursor next to "t in °C" and enter the value for t by clicking the cell with the value for t , by entering the name of the cell with the value for t , or by entering the value for t directly.

⇒ e. g.: Type B2 into the window next to "t in °C"

- Situate the cursor next to "x in kg/kg" and enter the value for x by clicking the cell with the value for x , by entering the name of the cell with the value for x , or by entering the value for x directly.

⇒ e. g.: Click on the cell C2

- Click the "OK" button.

The result for h in kJ/kg appears in the chosen cell.

⇒ The result of this example must be $h = 312.2533706$ kJ/kg

The calculation of $h = f(p, t, x)$ has been carried out. You can now arbitrarily change the values for p , t , or x in the appropriate cells. The specific enthalpy is recalculated and updated every time you change the data. This shows that the Excel[®] data flow and the DLL calculations are working together successfully.

Note.

If the calculation results in -1000 , this indicates that the values entered are located outside the range of validity of LibD4. More detailed information on each function and its range of validity is available in Chapter 3.

For further property functions calculable in FluidEXL^{Graphics}, see the function table in Chapter 1.

Number Formats

When using FluidEXL *Graphics* you have the option of choosing special number formats in advance.

Changes can be made as follows:

- Select the cell or cells you wish to format.
(In empty cells the new format will be applied once a value has been entered.)
- Click "Number Format" in the FluidEXL *Graphics* menu bar.
- Select the desired number format in the dialog box which appears:
 - "STD – Standard": Insignificant zeros behind the decimal point are not shown.
 - "FIX – Fixed Number of Digits": All set decimal places are shown, including insignificant zeros.
 - "SCI – Scientific Format": Numbers are always shown in the exponential form with the set number of decimal places.
- Set the "Number of decimal places" by entering the number into the appropriate window.
- Confirm this by clicking the "OK" button.

As an example, the table below shows the three formats for the number 1.230 adjusted for three decimal places:

STD	1.23
FIX	1.230
SCI	1.230E+00

This formatting can also be applied "after-the-fact" to cells which have already been calculated.

2.6 Removing FluidEXL *Graphics*

Should you wish to remove only the LibD6 library, delete the files

LibD6.dll

LibD6_Eng.hlp

in the directory selected for the installation of FluidEXL *Graphics* (the standard being

C:\Program Files\FuildEXL_Graphics_Eng (for English version of Windows®)

C:\Programme\FuildEXL_Graphics (for German version of Windows),

by using an appropriate program such as Explorer®, Windows, or Norton Commander.

Unregistering FluidEXL *Graphics* as Add-In in Excel®, versions 2003 or earlier

To remove FluidEXL *Graphics* completely, proceed as follows: First cancel the registration of

FluidEXL_Graphics_Eng.xla (for English version of Windows®) or

FluidEXL_Graphics.xla (for German version of Windows)

in Excel®.

In order to do that, click "Tools" in the upper menu bar of Excel and here "Add-Ins..." Unmark the box on the left-hand side of

"FluidEXL Graphics Eng" (for English version of Windows) or

"FluidEXL Graphics" (for German version of Windows)

in the window that appears and click the "OK" button. The additional menu bar of FluidEXL *Graphics* will disappear from the upper part of the Excel window. Afterwards, we recommend closing Excel.

If the FluidEXL *Graphics* menu bar does not disappear, take the following steps:

Click "View" in the upper menu bar of Excel, then "Toolbars" and then "Customize..." in the list box which appears.

"FluidEXL Graphics Eng" (for English version of Windows) or

"FluidEXL Graphics" (for German version of Windows),

situated at the bottom of the "Toolbars" entries, must be selected by clicking on it. Delete the entry manually by clicking "Delete". When asked whether you really want to delete the toolbar, click "OK."

As the next step delete the files

LibD6.dll

LibD6_Eng.hlp

in the directory selected for the installation of FluidEXL *Graphics* (the standard being

C:\Program Files\FuildEXL_Graphics_Eng (for English version of Windows)

C:\Programme\FuildEXL_Graphics (for German version of Windows),

using an appropriate program such as Explorer® or Norton Commander.

In order to remove FluidEXL *Graphics* from Windows and the hard disk, click "Start" in the Windows task bar, select "Settings" and click "Control Panel." Now double-click on "Add or Remove Programs."

In the list box of the "Add or Remove Programs" window that appears, select

"FluidEXL Graphics Eng" (for English version of Windows) or

"FluidEXL Graphics" (for German version of Windows)

by clicking on it and click the "Add/Remove..." button. In the following dialog box click "Automatic" and then "Next >." Click "Finish" in the "Perform Uninstall" window. Answer the question whether all shared components shall be removed with "Yes to All." Finally, close the "Add/Remove Programs" and "Control Panel" windows.

Now FluidEXL *Graphics* has been removed.

Unregistering FluidEXL *Graphics* as Add-In in Excel® 2007 (or later versions)

In order to unregister the FluidEXL *Graphics* Add-In in Excel® 2007 start Excel and carry out the following commands:

- Click the Windows Office® button in the upper left hand corner of Excel
- Click on the "Excel Options" button in the menu which appears

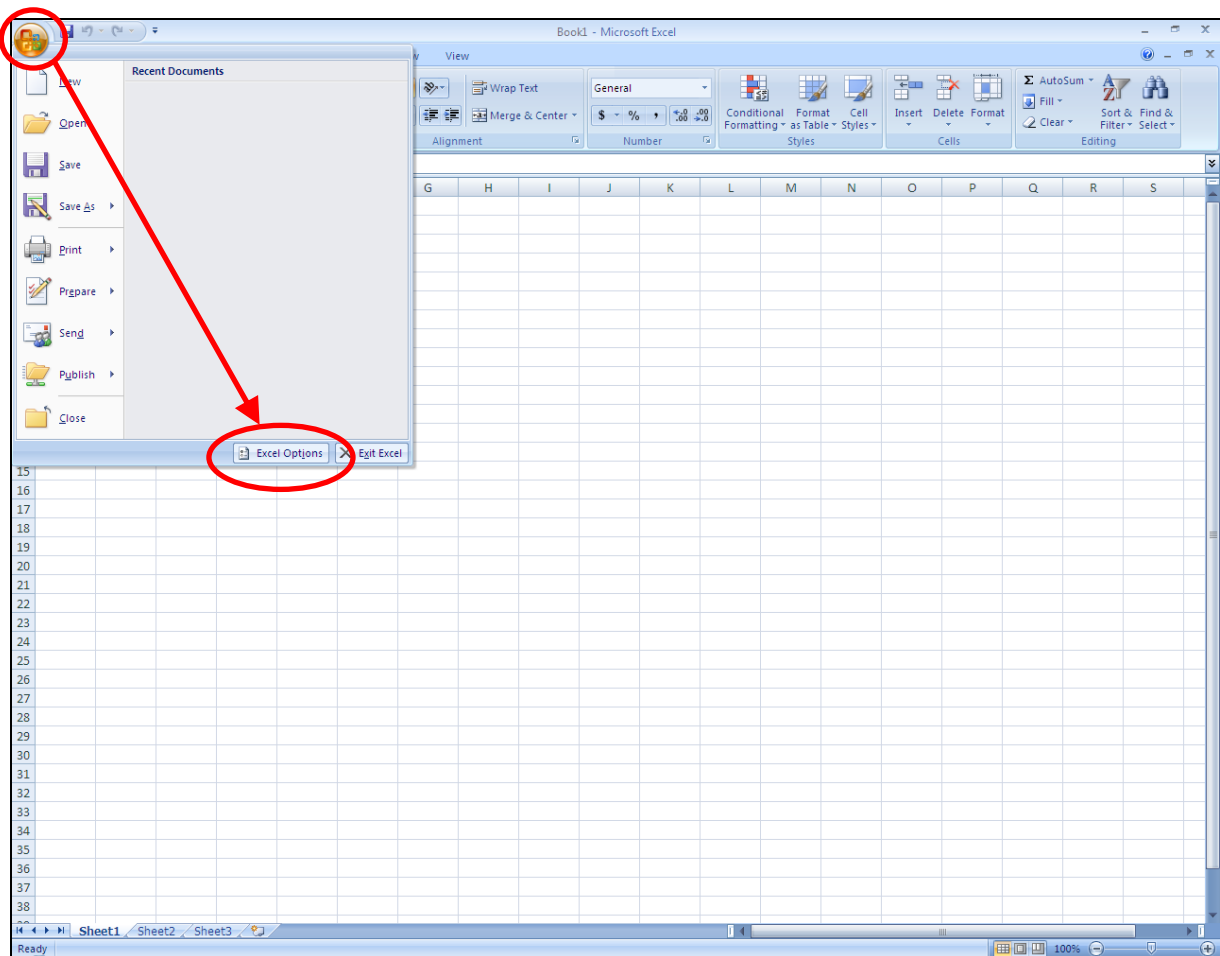


Figure 2.25: Unregistering FluidEXL *Graphics* as Add-In in Excel 2007

- Click on "Add-Ins" in the next menu

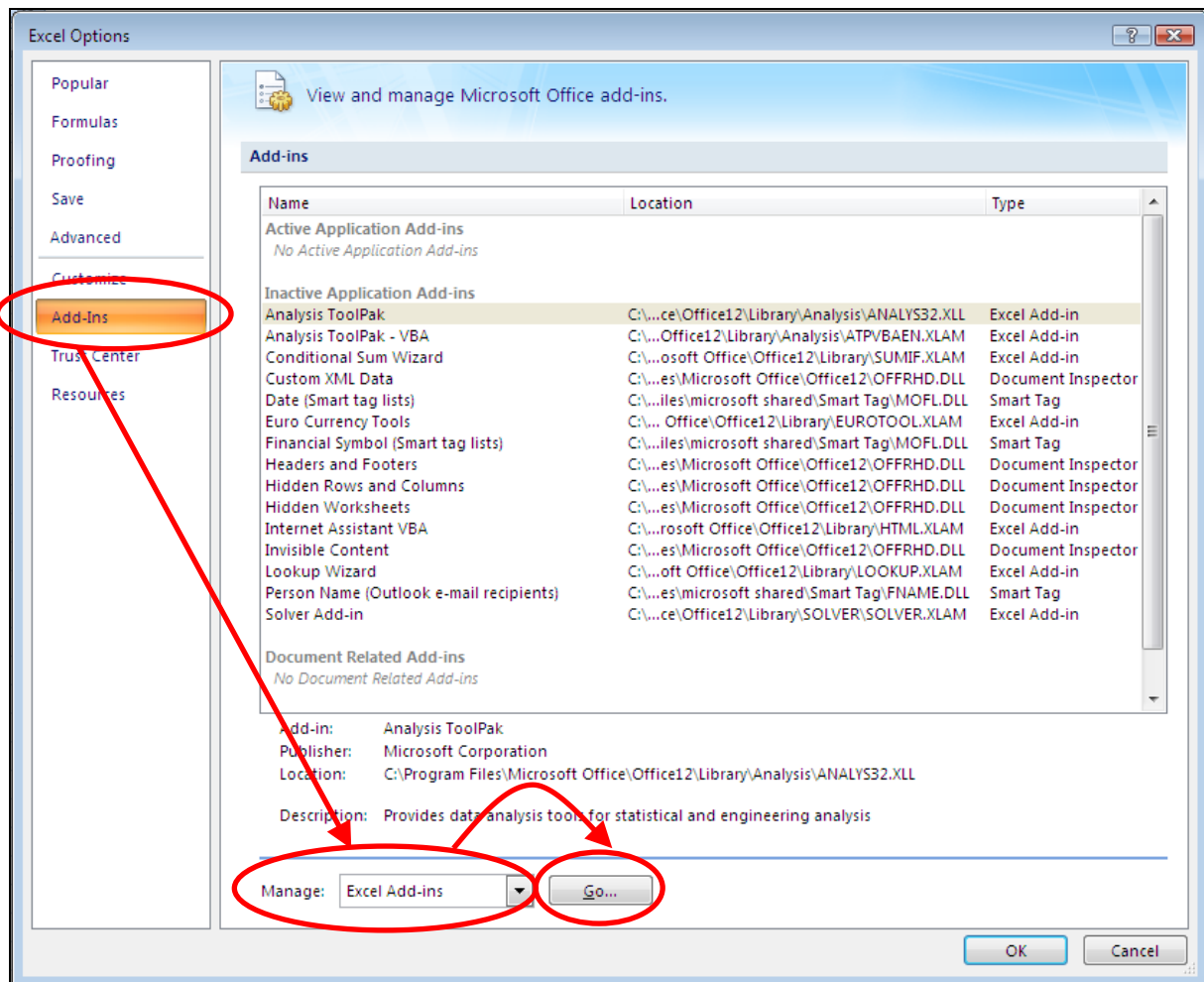


Figure 2.26: Dialog window "Excel Options"

- If it is not shown in the list automatically, select "Excel Add-ins" next to "Manage:" in the lower area of the menu
 - Then click the "Go..." button
 - Remove the checkmark in front of
 - "FluidEXL Graphics Eng" (for English version of Windows)
 - "FluidEXL Graphics" (for German version of Windows)
- in the window which now appears. Click the "OK" button to confirm your entry.

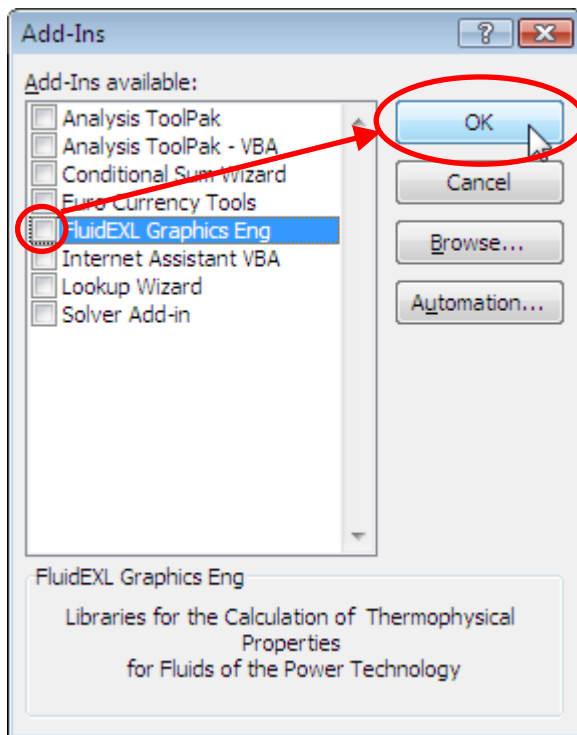


Figure 2.27: Dialog window "Add-Ins"

In order to remove FluidEXL *Graphics* from Windows® and from your hard drive, click "Start" in the lower task bar; then click "Settings" and "Control Panel." Now, double click "Add or Remove Programs," click on

"FluidEXL Graphics Eng" (for English version of Windows)

"FluidEXL Graphics" (for German version of Windows)

in the list box and then click the "Add/Remove..." button. Mark "Automatic" and click the "Next >" button. Now click the "Finish" button in the "Perform Uninstall" window. Click "Yes to All" in the "Remove Shared Component" window. Finally, the windows "Add or Remove Programs" and "Control Panel" should be closed.

Now FluidEXL *Graphics* has been removed.

3 Program Documentation

Thermal Diffusivity $a = f(p, t, x)$

Function Name: **a_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION APTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_APTXD4(A,P,T,X)**
REAL*8 A,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

APTXD4, A or a_ptx_D4 - Thermal diffusivity $a = \frac{\lambda}{\rho \cdot c_p} = \frac{\lambda \cdot v}{c_p}$ in Pa s

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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.
 Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **APTXD4 = -1000, A = -1000 or a_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: Internal calculation from ρ or v and c_p [1] and λ [2], [3], [4]

Specific Isobaric Heat Capacity $c_p = f(p, t, x)$

Function Name: **cp_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION CPPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_CPPTXD4(CP,P,T,X)**
REAL*8 CP,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

CPPTXD4, CP or cp_ptx_D4 - specific isobaric heat capacity c_p in kJ/(kg K)

Range of validity

Temperature range: from $t = 26.85\text{ °C}$ to 399.85 °C
 Pressure range: from $p = 0.00001\text{ bar}$ to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85\text{ °C}$ to $t_c = 313.342\text{ °C}$
 Pressure ranges from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Results for wrong input values

Result **CPPTXD4 = -1000, CP = -1000 or cp_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300\text{ bar}$ or $p < 0.00001\text{ bar}$ or
 ($x = -1$) $t > 399.85\text{ °C}$ or $t < 26.85\text{ °C}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 313.342\text{ °C}$ or $t < 26.85\text{ °C}$
 at $t = -1000$ and $p > p_c = 13.32\text{ bar}$
 or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ or
 at $p > p_c = 13.32\text{ bar}$ or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ and
 $t > t_c = 313.342\text{ °C}$ or $t < 26.85\text{ °C}$

References: [1]

Specific Isochoric Heat Capacity $c_v = f(p, t, x)$

Function Name: **cv_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION CVPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_CVPTXD4(CV,P,T,X)**
REAL*8 CV,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

CVPTXD4, CV or **cv_ptx_D4** - specific isochoric heat capacity c_v in kJ/(kg K)

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **CVPTXD4 = -1000, CV = -1000** or **cv_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Boiling or dew curve: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Derivative of Pressure with Respect to Temperature (at Constant Specific Volume) $\left(\frac{\partial p}{\partial T}\right)_v = f(p, t, x)$

Function Name: **dpdtv_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION DPDTVPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_DPDTVPTXD4(DPDTV,P,T,X)**
REAL*8 DPDTV,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

DPDTVPTXD4, dpdtv or dpdtv_ptx_D4 - Derivative of pressure with respect to temperature (at constant specific volume) dpdtv in kPa/K

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1 .

Boiling and dew curve: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **DPDTVPTXD4 = -1000, DPDTV = -1000 or dpdtv_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Boiling or dew curve: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Derivative of Pressure with Respect to Specific Volume (at Constant Temperature) $\left(\frac{\partial p}{\partial v}\right)_T = f(p, t, x)$

Function Name: **dpdvt_ptx_D4**
 Subroutine with function value: **REAL*8 FUNCTION DPDVTPTXD4(P,T,X)**
 for call from Fortran **REAL*8 P,T,X**
 Subroutine with parameter: **INTEGER*4 FUNCTION C_DPDVTPTXD4(DPDVT,P,T,X)**
 for call from DLL **REAL*8 DPDVT,P,T,X**

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

DPDVTPTXD4, dpdvt or dpdvt_ptx_D4 - Derivative of pressure with respect to temperature (at constant specific volume) dpdvt in kPa/K

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **DPDVTPTXD4 = -1000, DPDVT = -1000 or dpdvt_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Boiling or dew curve: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Dynamic Viscosity $\eta = f(p, t, x)$

Function Name: **eta_ptx_D4**
 Subroutine with function value: **REAL*8 FUNCTION ETAPTXD4(P,T,X)**
 for call from Fortran **REAL*8 P,T,X**
 Subroutine with parameter: **INTEGER*4 FUNCTION C_ETAPTXD4(ETA,P,T,X)**
 for call from DLL **REAL*8 ETA,P,T,X**

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

ETAPTXD4, ETA or eta_ptx_D4 – Dynamic viscosity η in Pa·s

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **ETAPTXD4 = -1000, ETA = -1000 or eta_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [2],[3], internal calculation from ρ or v [1]

Specific Enthalpy $h = f(p, t, x)$

Function Name: **h_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION HPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_HPTXD4(H,P,T,X)**
REAL*8 H,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

HPTXD4, H or h_ptx_D4 - Specific enthalpy h in kJ/kg

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **HPTXD4 = -1000, H = -1000 or h_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Isentropic Exponent $\kappa = f(p, t, x)$

Function Name: **kappa_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION KAPPAPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_KAPPATXD4(KAPPA,P,T,X)**
REAL*8 KAPPA,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

KAPPAPTXD4, KAPPA or kappa_ptx_D4 - Isentropic exponent $\kappa = \frac{w^2}{p \cdot v}$

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1 .

Boiling and dew curve: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **KAPPAPTXD4, KAPPA = -1000 or kappa_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 $(x = -1)$ $t > 399.85$ °C or $t < 26.85$ °C

Boiling or dew curve: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Thermal Conductivity $\lambda = f(p, t, x)$

Function Name: **lambda_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION LAMPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_LAMPTXD4(LAM,P,T,X)**
REAL*8 LAM,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

LAMPTXD4, LAM or **lambda_ptx_D4** – Thermal conductivity λ in W/(m·K)

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **LAMPTXD4 = -1000, LAM = -1000** or **lambda_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [2], [3], [4], internal calculation from ρ or v [1]

Kinematic Viscosity $\nu = f(p, t, x)$

Function Name: **nu_ptx_D4**

Subroutine with function value: **REAL*8 FUNCTION NUPTXD4(P,T,X)**
for call from Fortran **REAL*8 P,T,X**

Subroutine with parameter: **INTEGER*4 FUNCTION C_NUPTXD4(NU,P,T,X)**
for call from DLL **REAL*8 NU,P,T,X**

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

NUPTXD4, NU or nu_ptx_D4 - Kinematic viscosity $\nu = \frac{\eta}{\rho} = \eta \cdot \nu$ in m²/s

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **NUPTXD4 = -1000, NU = -1000 or nu_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: Internal calculation from ρ or ν [1] and η [2], [3]

Prandtl-Number $Pr = f(p, t, x)$

Function Name: **Pr_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION PRPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_PRPTXD4(PR,P,T,X)**
REAL*8 PR,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

PRPTXD4, PR or Pr_ptx_D4 - Prandtl number $Pr = \frac{\nu}{a} = \frac{\eta \cdot c_p}{\lambda}$

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **PRPTXD4 = -1000, PR = -1000 or Pr_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85^\circ\text{C}$

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85^\circ\text{C}$

References: Internal calculation from ρ or v [1], c_p [1] and η [2], [3]

Vapor Pressure $p_s = f(t)$

Function Name:	ps_t_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION PSTD4(T) REAL*8 T
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_PSTD4(PS,T) REAL*8 PS,T

Input Values

T - Temperature t in °C

Result

PSTD4, PS or **ps_t_D4** - Vapor pressure p_s in bar

Range of validity

Temperature range: from $t = 26.85$ °C to $t_c = 313.342$ °C

Results for wrong input values

Result **PSTD4 = -1000, PS = -1000** or **ps_t_D4 = -1000** for Input Values

$t = 26.85$ °C to $t_c = 313.342$ °C

References: [1]

Density $\rho = f(p, t, x)$

Function Name: **rho_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION RHOPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_RHOPTXD4(RHO,P,T,X)**
REAL*8 RHO,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

RHO_PTX_D4, RHO or **rho_ptx_D4** - Density ρ in kg/m³

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **RHOPTXD4 = -1000, RHO = -1000** or **rho_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Specific Entropy $s = f(p, t, x)$

Function Name: **s_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION SPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_SPTXD4(S,P,T,X)**
REAL*8 S,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

SPTXD4, S or s_ptx_D4 - Specific entropy s in kJ/kg K

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **SPTXD4 = -1000, S = -1000 or s_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Backward Function: Temperature $t = f(p, h)$

Function Name:	t_ph_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION TPHD4(P,H) REAL*8 P,H
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_TPHD4(T,P,H) REAL*8 T,P,H

Input Values

P - Pressure p in bar
H - Specific enthalpy h in kJ/kg

Result

TPHD4, T or **t_ph_D4** - Temperature t in °C

Range of validity

Temperature range:	from $t = 26.85\text{ °C}$ to 399.85 °C
Pressure range:	from $p = 0.00001\text{ bar}$ to 300 bar

Details on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms. That means the given values of p and h are taken as a basis and the subprogram will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. Afterwards the calculation of the appropriate state region will be carried out.

Wet steam region: Pressure ranges from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Results for wrong input values

Result **T_PH_D4, T = -1000** or **t_ph_D4 = -1000** for Input Values

Single phase region: ($x = -1$)	$p > 300\text{ bar}$ or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ or at result $t > 399.85\text{ °C}$, $t < 26.85\text{ °C}$
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Boiling or dew curve:	at $p > p_c = 13.32\text{ bar}$ or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ at result $t > t_c = 313.342\text{ °C}$ or $t < 26.85\text{ °C}$
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References: [1]

Backward function: Temperature $t = f(p,s)$

Function Name: **t_ps_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION TPSD4(P,S)**
REAL*8 P,S

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_TPSD4(T,P,S)**
REAL*8 T,P,S

Input Values

P - Pressure p in bar
S - Specific entropy s in kJ/(kg K)

Result

TPSD4, T or t_ps_D4 - Temperature t in °C

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 bar

Details on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms. That means the given values of p and s are taken as a basis and the subprogram will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. Afterwards the calculation of the appropriate state region will be carried out.

Wet steam region: Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **T_PS_D4, T = -1000** or **t_ps_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 (x = -1) at result $t > 399.85$ °C, $t < 26.85$ °C

Boiling or dew curve: at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar
 at result $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Saturation Temperature $t_s = f(p)$

Function Name:	ts_p_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION TSPD4(P) REAL*8 P
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_TSPD4(TS,P) REAL*8 TS,P

Input Values

P - Pressure p in bar

Result

TSPD4, TS or ts_p_D4 - Saturation temperature t_s in °C

Range of validity

Pressure range: from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **TSPD4 = -1000, TS = -1000 or ts_p_D4 = -1000** for Input Values

$p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or $p > p_c = 13.32$ bar

References: [1]

Specific Internal Energy $u = f(p, t, x)$

Function Name: **u_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION UPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_UPTXD4(U,P,T,X)**
REAL*8 U,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

UPTXD4, U or **u_ptx_D4** - Specific internal energy u in kJ/kg

Range of validity

Temperature range: from $t = 26.85\text{ °C}$ to 399.85 °C
 Pressure range: from $p = 0.00001\text{ bar}$ to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85\text{ °C}$ to $t_c = 313.342\text{ °C}$
 Pressure ranges from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Results for wrong input values

Result **UPTXD4 = -1000, U = -1000** or **u_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300\text{ bar}$ or $p < 0.00001\text{ bar}$ or
 ($x = -1$) $t > 399.85\text{ °C}$ or $t < 26.85\text{ °C}$

Wet steam region: at $p = -1000$ and $t > t_c = 313.342\text{ °C}$ or $t < 26.85\text{ °C}$
 at $t = -1000$ and $p > p_c = 13.32\text{ bar}$
 or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ or
 at $p > p_c = 13.32\text{ bar}$ or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ and
 $t > t_c = 313.342\text{ °C}$ or $t < 26.85\text{ °C}$

References: [1]

Specific Volume $v = f(p, t, x)$

Function Name:	v_ptx_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION VPTXD4(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_VPTXD4(V,P,T,X) REAL*8 V,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

VPTXD4, V or v_ptx_D4 - Specific volume v in m³/kg

Range of validity

Temperature range:	from $t = 26.85$ °C to 399.85 °C
Pressure range:	from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-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: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **VPTXD4 = -1000, V = -1000 or v_ptx_D4 = -1000** for Input Values

Single phase region: $p > 300$ bar or $p < 0.00001$ bar or
 ($x = -1$) $t > 399.85$ °C or $t < 26.85$ °C

Wet steam region: at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Isentropic Speed of Sound $w = f(p, t, x)$

Function Name: **w_ptx_D4**

Subroutine with function value:
for call from Fortran **REAL*8 FUNCTION WPTXD4(P,T,X)**
REAL*8 P,T,X

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_WPTXD4(W,P,T,X)**
REAL*8 W,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

WPTXD4, W or **w_ptx_D4** - Speed of sound w in m/s

Range of validity

Temperature range: from $t = 26.85$ °C to 399.85 °C
 Pressure range: from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1 .

Boiling and dew curve: Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
 Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **WPTXD4 = -1000** , **W = -1000** or **w_ptx_D4 = -1000** for Input Values

Single phase region:
($x = -1$) $p > 300$ bar or $p < 0.00001$ bar or
 $t > 399.85$ °C or $t < 26.85$ °C

Boiling or dew curve:
 at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
 at $t = -1000$ and $p > p_c = 13.32$ bar
 or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
 at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and
 $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]

Backward Function: Vapor Fraction $x = f(p, h)$

Function Name:	x_ph_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION XPHD4(P,H) REAL*8 P,H
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_XPHD4(X,P,H) REAL*8 X,P,H

Input Values

P - Pressure p in bar
H - Specific enthalpy h in kJ/kg

Result

XPHD4, X or x_ph_D4 - Vapor fraction x in (kg saturated steam/kg wet steam)

Range of validity

Temperature range: from $t = 26.85\text{ °C}$ to $t_c = 313.342\text{ °C}$
 Pressure range: from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Details on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms. That means the given values of p and h are taken as a basis and the subprogram will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. In case of wet steam, x will be calculated, otherwise the result is set to $x = -1$.

Wet steam region: Pressure ranges from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Results for wrong input values

Result **X_PH_D4 = -1, X = -1 or x_ph_D4 = -1** for Input Values

If the state point is located in the single phase region:
 $p > p_c = 13.32\text{ bar}$ or $p < 0.0014779\text{ bar}$

References: [1]

Backward Function: Vapor Fraction $x = f(p,s)$

Function Name:	x_ps_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION XPSD4(P,S) REAL*8 P,S
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_XPSD4(X,P,S) REAL*8 X,P,S

Input Values

P - Pressure p in bar
S - Specific entropy s in kJ/(kg K)

Result

XPSD4, X or x_ps_D4 - Vapor fraction x in (kg saturated steam/kg wet steam)

Range of validity

Temperature range:	from $t = 26.85\text{ °C}$ to $t_c = 313.342\text{ °C}$
Pressure range:	from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Details on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms. That means the given values of p and s are taken as a basis and the subprogram will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. In case of wet steam, x will be calculated, otherwise the result is set to $x = -1$.

Wet steam region: Pressure ranges from $p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$ to $p_c = 13.32\text{ bar}$

Results for wrong input values

Result **X_PS_D4 = -1, X = -1 or x_ps_D4 = -1** for Input Values

If the state point is located in the single phase region:
 $p > p_c = 13.32\text{ bar}$ or $p < p_s(26.85\text{ °C}) = 0.0014779\text{ bar}$

References: [1]

Compression Factor $Z = f(p, t, x)$

Function Name:	Z_ptx_D4
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION ZPTXD4(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_ZPTXD4(Z,P,T,X) REAL*8 Z,P,T,X

Input Values

P - Pressure p in bar
T - Temperature t in °C
X - Vapor fraction x (kg of saturated steam)/(kg wet steam)

Result

ZPTXD4, Z or Z_ptx_D4 - Compression factor Z

Range of validity

Temperature range:	from $t = 26.85$ °C to 399.85 °C
Pressure range:	from $p = 0.00001$ bar to 300 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. Here the backward functions will also result in $x = -1$.

Wet-steam region

When calculating wet steam, a value 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 . It is adequate to enter either the given value for t and $p = -1$, or the given value for p and $t = -1$, plus the value for x between 0 and 1. When p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the saturation-pressure curve. If it is not the case the calculation for the property of the chosen function to be calculated results in -1 .

Boiling and dew curve:	Temperature ranges from $t = 26.85$ °C to $t_c = 313.342$ °C
	Pressure ranges from $p_s(26.85^\circ\text{C}) = 0.0014779$ bar to $p_c = 13.32$ bar

Results for wrong input values

Result **ZPTXD4 = -1000, Z = -1000 or Z_ptx_D4 = -1000** for Input Values

Single phase region: ($x = -1$)	$p > 300$ bar or $p < 0.00001$ bar or $t > 399.85$ °C or $t < 26.85$ °C
--------------------------------------	--

Boiling or dew curve:	at $p = -1000$ and $t > t_c = 313.342$ °C or $t < 26.85$ °C
	at $t = -1000$ and $p > p_c = 13.32$ bar
	or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar or
	at $p > p_c = 13.32$ bar or $p < p_s(26.85^\circ\text{C}) = 0.0014779$ bar and $t > t_c = 313.342$ °C or $t < 26.85$ °C

References: [1]



4. 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
 - IAPWS-IF97-S03rev
 - IAPWS-IF97-S04
 - IAPWS-IF97-S05
- IAPWS Revised Advisory Note No. 3 on Thermodynamic Derivatives (2008)

Humid Combustion Gas Mixtures

Library LibHuGas

- Model: Ideal mixture of the real fluids:
- CO₂ - Span and Wagner O₂ - Schmidt and Wagner
H₂O - IAPWS-95 Ar - Tegeler et al.
N₂ - Span et al.
- and of the ideal gases:
- SO₂, CO, Ne (Scientific Formulation of Bückner et al.)
- Consideration of:
- Dissociation from VDI 4670 and 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 the VDI 4670
 - Poynting effect from ASHRAE RP-1485

Carbon Dioxide including Dry Ice

Library LibCO2

Formulation of Span and Wagner (1994)

Seawater

Library LibSeaWa

IAPWS Formulation 2008 of Feistel and IAPWS-IF97

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 ₂ O | F ₂ | Propane |
| N ₂ | SO ₂ | NH ₃ | Iso-Butane |
| O ₂ | H ₂ | Methane | n-Butane |
| CO | H ₂ S | 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

Dry Air including Liquid Air

Library LibRealAir

Formulation of Lemmon et al. (2000)

Nitrogen

Library LibN2

Formulation of Span et al. (2000)

Hydrogen

Library LibH2

Formulation of Leachman et al. (2007)

Refrigerants

Ammonia

Library LibNH3

Formulation of Tillner-Roth (1995)

R134a

Library LibR134a

Formulation of Tillner-Roth and Baehr (1994)

Iso-Butane

Library LibButane_Iso

Formulation of Bückner et al. (2003)

n-Butane

Library LibButane_n

Formulation of Bückner et al. (2003)

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 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 ₂ H ₆ O ₂	Ethylene glycol
C ₃ H ₈ O ₂	Propylene glycol
C ₂ H ₅ OH	Ethyl alcohol
CH ₃ OH	Methyl alcohol
C ₃ H ₈ O ₃	Glycerol
K ₂ CO ₃	Potassium carbonate
CaCl ₂	Calcium chloride
MgCl ₂	Magnesium chloride
NaCl	Sodium chloride
C ₂ H ₃ KO ₂	Potassium acetate

Formulation of the International Institute of Refrigeration (1997)

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 $C_{14}H_{42}O_6Si_6$ **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)

Propane

Library LibPropane

Formulation of Lemmon et al. (2007)

Methanol

Library LibCH3OH

Formulation of de Reuck and Craven (1993)

Ethanol

Library LibC2H5OH

Formulation of Schroeder et al. (2012)

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 LibC5H14**

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 **H₂S** **Library LibH2S**

Dinitrogen monoxide **N₂O** **Library LibN2O**

Sulfur dioxide **SO₂** **Library LibSO2**

Acetone **C₃H₆O** **Library LibC3H6O**

Formulation of Lemmon and Span (2006)

For more information please contact:

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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

Backward Functions

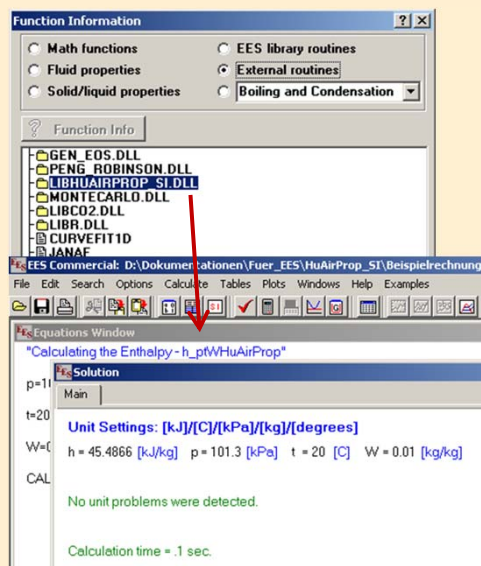
- $T, v, s(p, h)$
- $T, v, h(p, s)$
- $p, T, v(h, s)$
- $p, T(v, h)$
- $p, T(v, u)$

Thermodynamic Derivatives

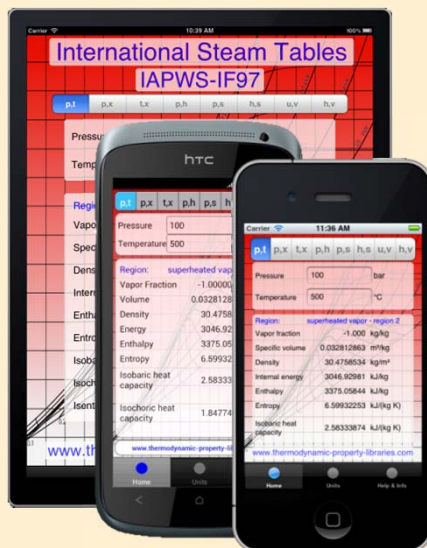
- Partial derivatives can be calculated.

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

Add-In FluidEES for Engineering Equation Solver®



App International Steam Tables for iPhone, iPad, iPod touch, Android smart phones and tablets



Online Property Calculator at www.thermodynamics-zittau.de

Zittau's Fluid Property Calculator

Fluid:

Function:

Unit System:

Enter given values: [Range of validity](#)

Pressure p: bar

Temperature t: °C

Vapor fraction x: kg/kg

Calculate / Recalculate

Result:

Specific enthalpy h = kJ/kg

For further information on property libraries available for EXCEL®, MATLAB®, Mathcad®, Engineering Equation Solver®, DYMOLA® (Modelica), SimulationX®, and LabView® click [here](#)

An App for calculating steam properties on iPhone, iPad, and iPod touch can be found [here](#)

PDF with the [description](#)

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www.thermodynamic-property-libraries.com
www.international-steam-tables.com
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Property Software for Pocket Calculators

FluidCasio



fx 9750 G II CFX 9850 fx-GG20 CFX 9860 G Graph 85 ALGEBRA FX 2.0

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TI 83 TI Voyage 200 TI 92

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The following thermodynamic and transport properties^a can be calculated in Excel®, MATLAB®, Mathcad®, Engineering Equation Solver® EES, DYMOLA® (Modelica), SimulationX®, and LabVIEW®:

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

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 can be calculated.

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

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6. Satisfied Customers

Date: 10/2011

The following companies and institutions use the property libraries

- FluidEXL^{Graphics} for Excel[®]
- FluidLAB for MATLAB[®]
- FluidMAT for Mathcad[®]
- FluidEES for Engineering Equation Solver[®] EES
- FluidDYM for Dymola[®] (Modelica)
- FluidVIEW for LabVIEW[®]:

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G.U.N.T. Geraetebau, Barsbuettel (general license for training test benches)	11/2000
Steinhaus Informationssysteme, Datteln (general license for process data software)	12/2000

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Bayernwerk, Munich	01/1999
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KEMA IEV, Dresden	03/1999
Regensburg University of Applied Sciences	04/1999
Fichtner Consulting & IT, Stuttgart (company licenses and distribution)	07/1999
Technical University of Cottbus, Chair in Power Plant Engineering	07/1999
Technical University of Graz, Department of Thermal Engineering, Austria	11/1999
Ostendorf Engineering, Gummersbach	12/1999

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Technical University of Cottbus, Chair in Power Plant Engineering	05/1998
Fichtner Consulting & IT (CADIS information systems) Stuttgart (general KPRO program license)	05/1998
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