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Property Library for Iso-Butane

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

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Software for the Calculation of the Properties of Iso-Butane

LibButane_iso FluidEXL*Graphics*

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0. Package Contents

0.1 Zip files for 32-bit Windows®

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

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

FluidEXL_Graphics_Eng_Setup.exe	- English installation program for the Add-In FluidEXL <i>Graphics</i> for use in Excel®.
FluidEXL_Graphics_Eng.xla	- English Add-In for FluidEXL <i>Graphics</i>
LibButan_iso.dll	- Dynamic Link Library for use in Windows programs
LibButan_iso.hlp	- Help file for the LibButane_iso property library
FluidEXL_Graphics_LibButan_iso_Docu_Eng.pdf	- User's Guide

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

FluidEXL_Graphics_Setup.exe	- German installation program for the Add-In FluidEXL <i>Graphics</i> for application in Excel®.
FluidEXL_Graphics.xla	- German Add-In for FluidEXL <i>Graphics</i>
LibButan_iso.dll	- Dynamic Link Library for use in Windows programs
LibButan_iso.hlp	- Help file for the LibButane_iso property library
FluidEXL_Graphics_LibButan_iso_Docu_Eng.pdf	- User's Guide

0.2 Zip files for 64-bit Windows®

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

English zip file "CD_FluidEXL_Graphics_LibButan_iso_x64_Eng.zip" including the following files and folders:

Files:

FluidEXL_Graphics_LibButan_iso_Docu_Eng.pdf	- User's Guide
FluidEXL_Graphics_Eng.xla	- English FluidEXL <i>Graphics</i> Add-In
FluidEXL_Graphics_Eng_64_Setup.msi	- Self-extracting and self-installing program

LibButan_iso.dll	- Dynamic link library for use in Windows [®] programs
LibButan_iso.hlp	- Help file for the LibButane_iso property 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_LibButan_iso_x64.zip" including the following files and folders:

Files:

FluidEXL_Graphics_LibButan_iso_Docu_Eng.pdf	- User's Guide
FluidEXL_Graphics.xla	- German FluidEXL <i>Graphics</i> Add-In
FluidEXL_Graphics_64_Setup.msi	- Self-extracting and self-installing program
LibButan_iso.dll	- Dynamic link library for use in Windows [®] programs
LibButan_iso.hlp	- Help file for the LibButane_iso property 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

Functional Dependence	Function Name	Call from Fortran program	Call in DLL LibButan_iso as parameter	Property or Function	Unit of the result
$a = f(p, t, x)$	a_ptx_BUTl	APTxBUTI(P,T,X)	C_APTxBUTI(A,P,T,X)	Thermal diffusivity	m ² /s
$c_p = f(p, t, x)$	cp_ptx_BUTl	CPPTxBUTI(P,T,X)	C_CPPTxBUTI(CP,P,T,X)	Specific isobaric heat capacity	kJ/(kg K)
$\eta = f(p, t, x)$	eta_ptx_BUTl	ETAPTxBUTI(P,T,X)	C_ETAPTxBUTI(ETA,P,T,X)	Dynamic viscosity	Pa s
$h = f(p, t, x)$	h_ptx_BUTl	HPTxBUTI(P,T,X)	C_HPTxBUTI(H,P,T,X)	Specific enthalpy	kJ/kg
$\kappa = f(p, t, x)$	kappa_ptx_BUTl	KAPTxBUTI(P,T,X)	C_KAPTxBUTI(KAP,P,T,X)	Isentropic exponent	-
$\lambda = f(p, t, x)$	lambda_ptx_BUTl	LAMPTxBUTI(P,T,X)	C_LAMPTxBUTI(LAM,P,T,X)	Thermal conductivity	W/(m K)
$\nu = f(p, t, x)$	ny_ptx_BUTl	NYPTxBUTI(P,T,X)	C_NYPTxBUTI(NY,P,T,X)	Kinematic viscosity	m ² /s
$p_{\text{mel}} = f(t)$	pmel_t_BUTl	PMELBUTI(T)	C_PMELBUTI(PMEL,T)	Melting pressure from temperature	bar
$p_s = f(t)$	ps_t_BUTl	PSTBUTI(T)	C_PSTBUTI(PS,T)	Vapor pressure from temperature	bar
$Pr = f(p, t, x)$	Pr_ptx_BUTl	PRPTxBUTI(P,T,X)	C_PRPTxBUTI(PR,P,T,X)	Prandtl-Number	-
$\rho = f(p, t, x)$	rho_ptx_BUTl	ROPTxBUTI(P,T,X)	C_ROPTxBUTI(RHO,P,T,X)	Density	kg/m ³
$s = f(p, t, x)$	s_ptx_BUTl	SPTxBUTI(P,T,X)	C_SPTxBUTI(S,P,T,X)	Specific entropy	kJ/(kg K)
$t = f(p, h)$	t_ph_BUTl	TPHBUTI(P,H)	C_TPHBUTI(T,P,H)	Backward function: Temperature from pressure and enthalpy	°C
$t = f(p, s)$	t_ps_BUTl	TPSBUTI(P,S)	C_TPSBUTI(T,P,S)	Backward function: Temperature from pressure and entropy	°C
$t_{\text{mel}} = f(p)$	tmel_p_BUTl	TMELBUTI(P)	C_TMELBUTI(TMEL,P)	Melting temperature from pressure	°C
$t_s = f(p)$	ts_p_BUTl	TSPBUTI(P)	C_TSPBUTI(TS,P)	Saturation temperature from pressure	°C
$u = f(p, t, x)$	u_ptx_BUTl	UPTxBUTI(P,T,X)	C_UPTxBUTI(U,P,T,X)	Specific internal energy	kJ/kg
$v = f(p, t, x)$	v_ptx_BUTl	VPTxBUTI(P,T,X)	C_VPTxBUTI(V,P,T,X)	Specific volume	m ³ /kg

Functional Dependence	Function Name	Call from Fortran program	Call in DLL LibButan_iso as parameter	Property or Function	Unit of the result
$w = f(p, t, x)$	w_ptx_BUTl	WPTXBUTl(P,T,X)	C_WPTXBUTl(W,P,T,X)	Isentropic speed of sound	m/s
$x = f(p, h)$	x_ph_BUTl	XPHBUTl(P,H)	C_XPHBUTl(X,P,H)	Backward function: Vapor fraction from pressure and enthalpy	kg/kg
$x = f(p, s)$	x_ps_BUTl	XPSBUTl(P,S)	C_XPSBUTl(X,P,S)	Backward function: Vapor fraction from pressure and entropy	kg/kg

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

Range of validity:

Temperature t : from $t_{\text{mel}}(p)$ to 301.85 °C
 Pressure p : from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Reference state

$h = 200$ kJ/kg and $s = 1$ kJ/(kg K) at $t = 0$ °C on the boiling curve ($x = 0$)

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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

Wet steam region: Temperature from $t_t = -159.42$ °C to $t_c = 134.66$ °C

Pressure from $p_t = 2.19 \times 10^{-7}$ bar to 36.29 bar

Note!

If the input values are located outside the range of validity, the result for the calculated function will always be -1000 . You can find more exact details on every function and its corresponding range of validity in the enclosed program documentation in chapter 3.

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 iso butane from the LibButane_Iso property library.

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 June 2010, please complete the initial installation procedure described below.

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

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

In this section, the installation of FluidEXL^{Graphics} for a 32-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_LibButan_iso_Eng.zip" (for English version of Windows)

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

you will see the folder

CD_FluidEXL_Graphics_LibButan_iso_Eng (for English version of Windows)

CD_FluidEXL_Graphics_LibButan_iso (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)

FluidEXL_Graphics_LibButan_iso_Docu_Eng.pdf

LibButan_iso.dll

LibButan_iso.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 "Next >" button.

In the following dialog box, "Choose Destination Location", 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).

By clicking the "Browse..." button, you can change the installation directory before installation (see Figure 2.1).



Figure 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.

Close the "Control Panel" window. 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	

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

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

In the next step, the following files

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

from the extracted folder

CD_FluidEXL_Graphics_LibButan_iso_Eng	(for English version of Windows)
CD_FluidEXL_Graphics_LibButan_iso	(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 close any Windows[®] applications, since Windows[®] may need to be rebooted during the installation process.

After you have downloaded and extracted the zip-file

"CD_FluidEXL_Graphics_LibButan_iso_x64_Eng.zip"	(for English version of Windows)
"CD_FluidEXL_Graphics_LibButan_iso_x64.zip,"	(for German version of Windows)

you will see the folder

"CD_FluidEXL_Graphics_LibButan_iso_Eng"	(for English version of Windows)
"CD_FluidEXL_Graphics_LibButan_iso"	(for German version of Windows)

in your Windows Explorer[®], Norton Commander[®], or any other similar program you may be using.

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

Within this folder you will see the following files

FluidEXL_Graphics_LibButan_iso_Docu_Eng	
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)
LibButan_iso.dll	
LibButan_iso.hlp	
Setup.exe	

and the folders

vcredist_x64
WindowsInstaller3_1.

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

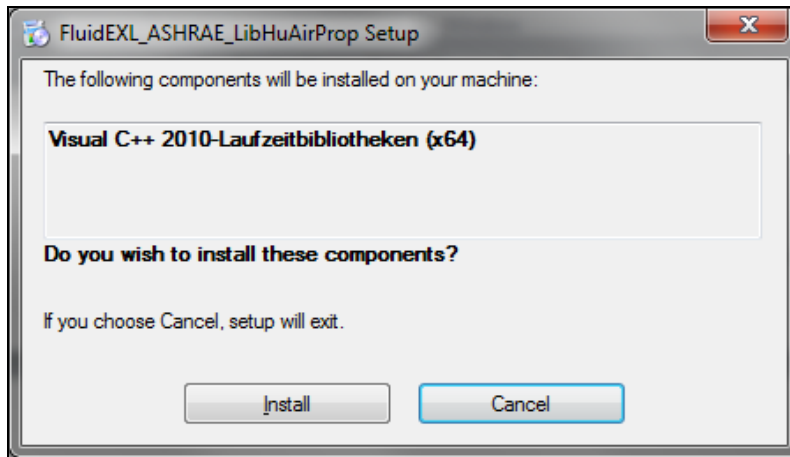


Figure 2.2: Installing the "Visual C++ 2010 runtime library (x64)"

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).

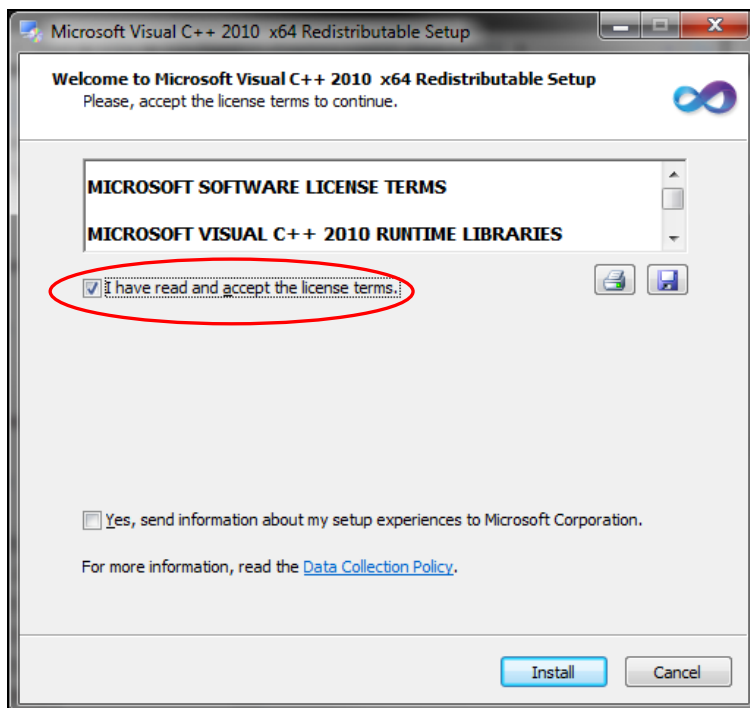


Figure 2.3: Accepting the license terms

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, "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).

By clicking the "Browse..." button, you can change the installation directory before installation (see Figure 2.4).

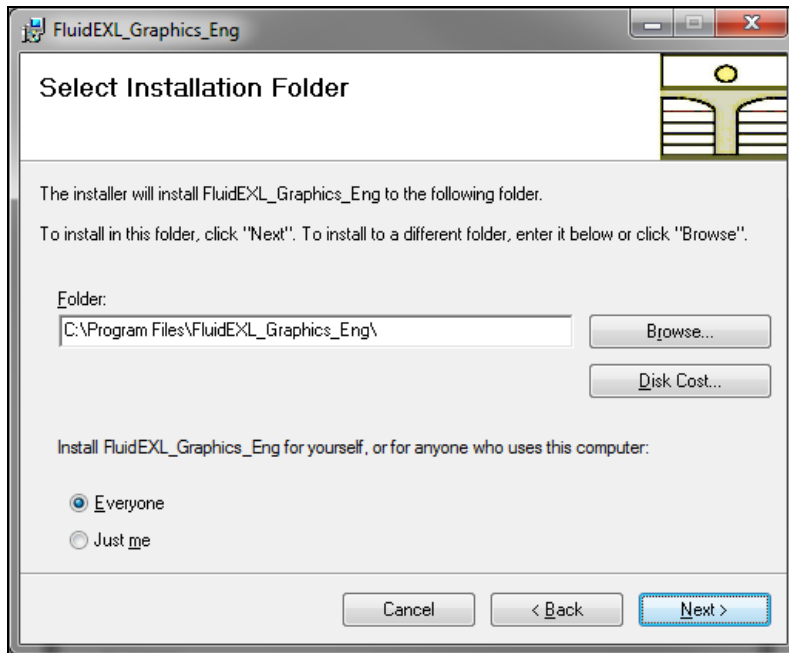


Figure 2.4: Choosing the installation folder

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_Eng has been successfully installed." Confirm this by clicking the "Close" button.

The installation of FluidEXL *Graphics* has been completed.

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

In addition, the two subdirectories \FORMULATION97 and \FLuft were created in the destination folder.

In the next step, the files below

FluidEXL_Graphics_Eng.xla	(for English version of Windows)
FluidEXL_Graphics.xla	(for German version of Windows)
LibButan_iso.dll	
LibButan_iso.hlp,	

found in your CD folder, 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.

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 of Excel.
- Here, click on "Add-Ins..." in the menu.

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

- Click "Browse...".
- In the following dialog box, choose your 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))

here select

"FluidEXL_Graphics_Eng.xla" (for English version of Windows)
 "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 the Add-Ins list.

Note:

As long as the check box next to the file name

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

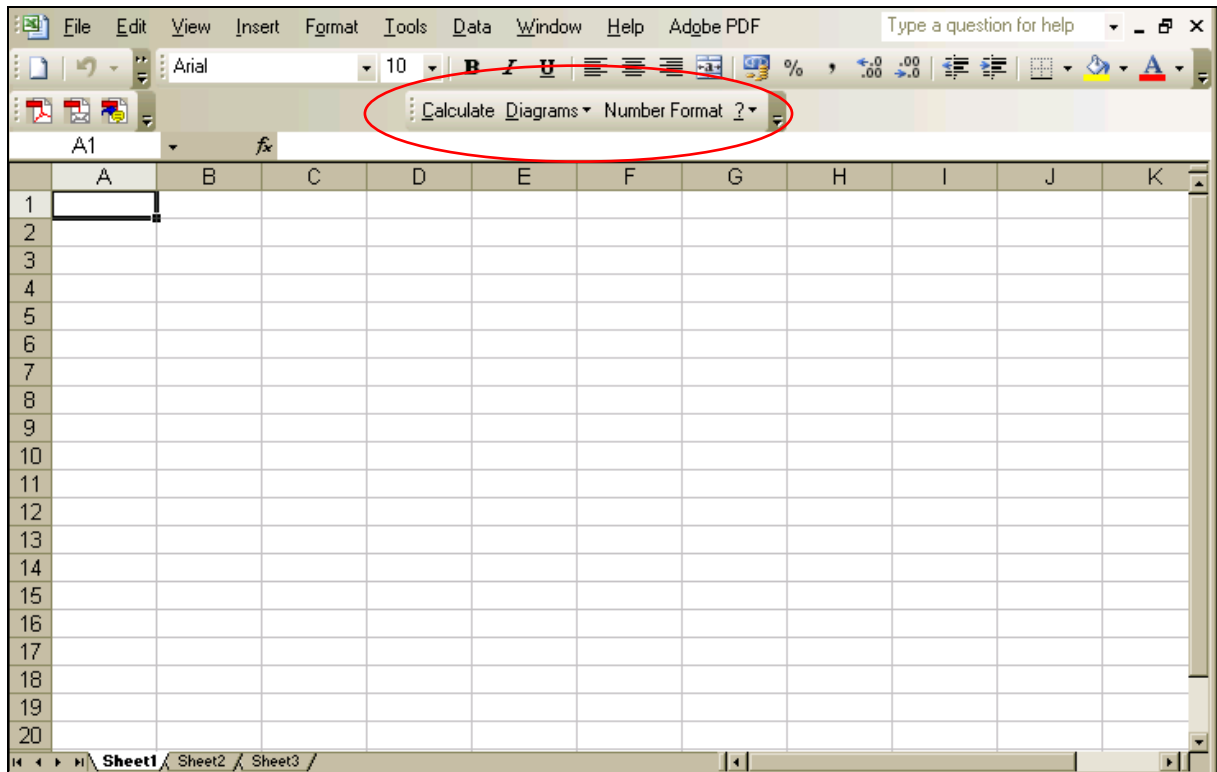


Figure 2.5: Menu bar of FluidEXLGraphics

From within Excel you can now select the "Iso_Butane LibButane_Iso" library property functions via this menu bar (see section 2.5 on page 2/19).

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

After installation in Windows®, FluidEXL *Graphics* must be registered in Excel® 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 appears (see figure below)

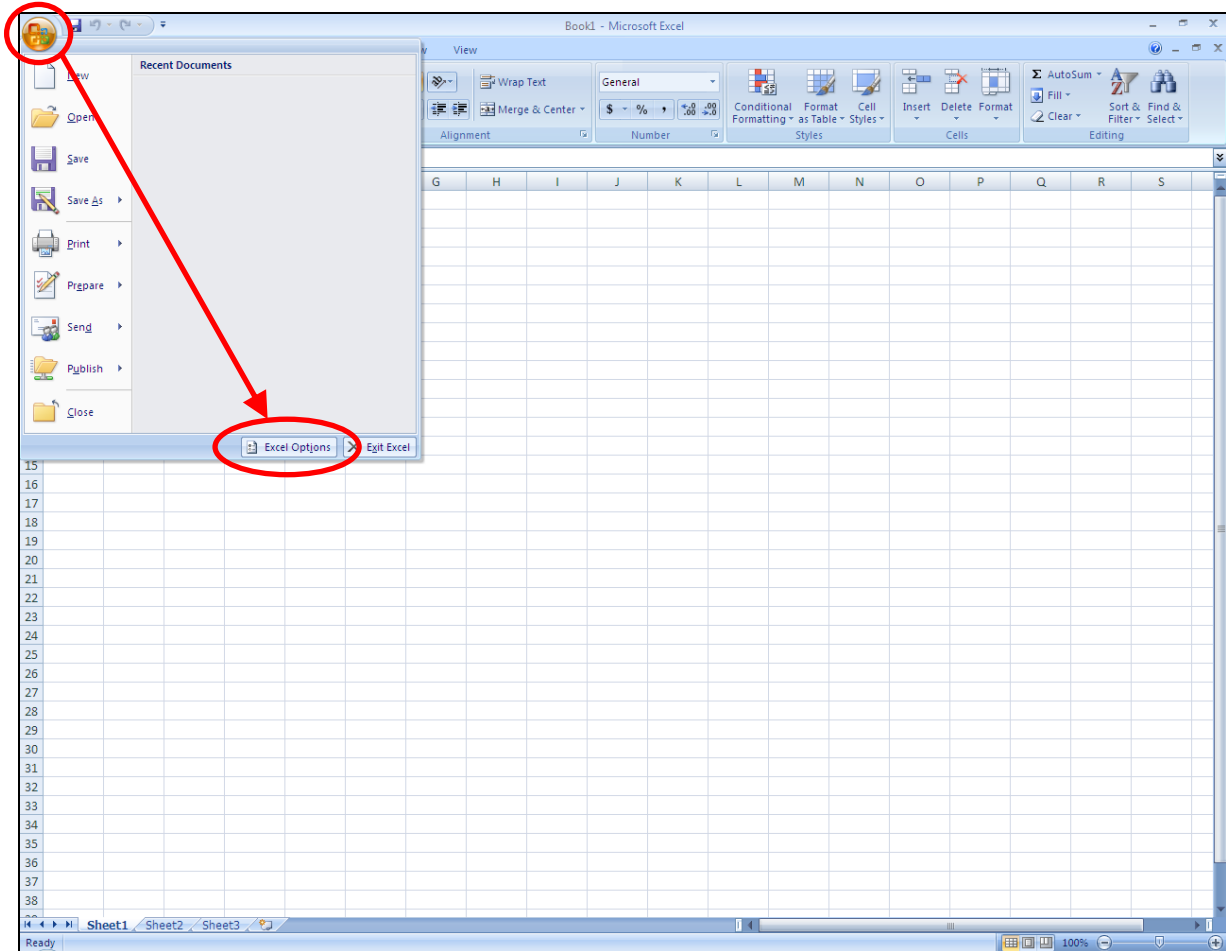


Figure 2.6: Registering FluidEXL *Graphics* as Add-In in Excel® 2007

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

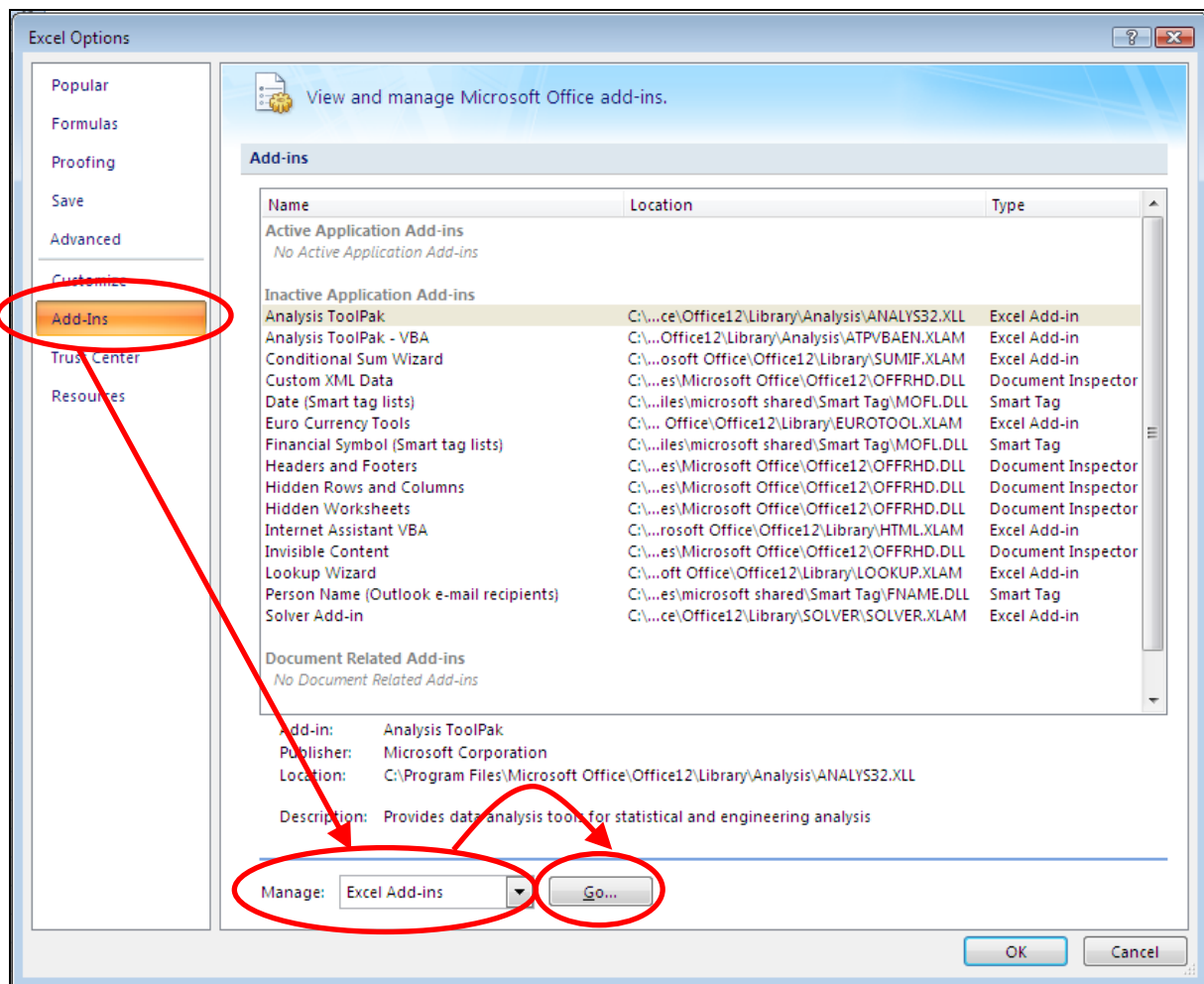


Figure 2.7: Dialog window "Add-Ins"

- 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."

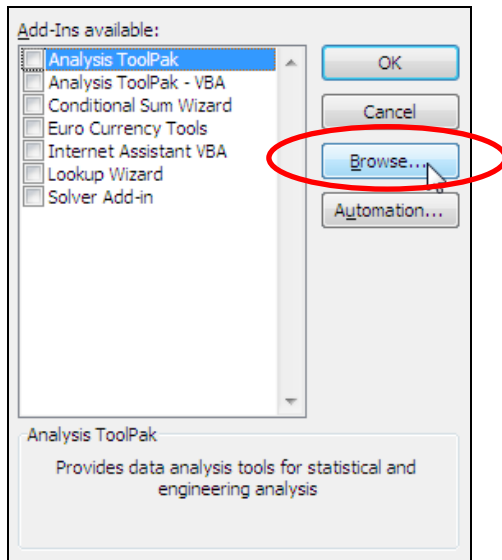


Figure 2.8: Dialog window "Add-Ins available"

- 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.)

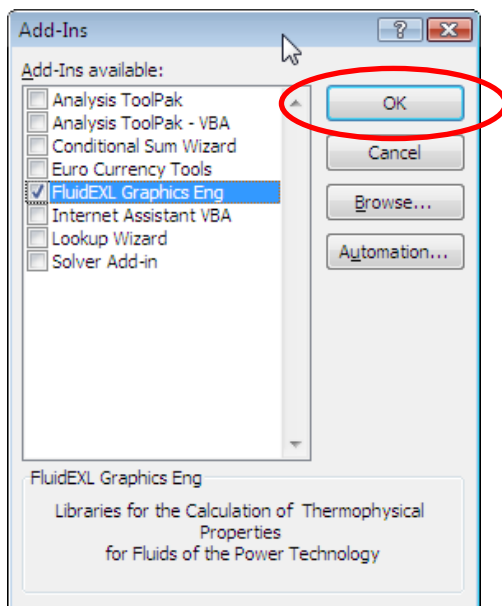


Figure 2.9: Dialog window "Add-Ins"

- 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 figure.

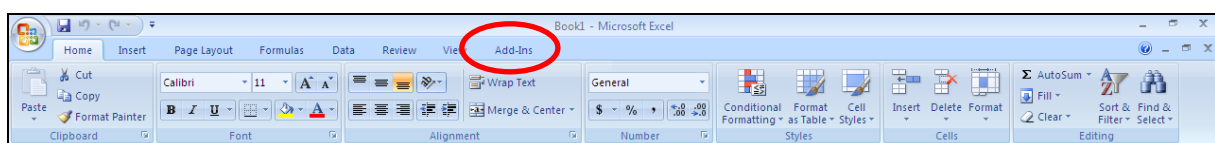


Figure 2.10: Menu item "Add-Ins"

In the upper menu region of Excel®, the FluidEXL^{Graphics} menu bar will appear as marked with the red circle in the next figure.

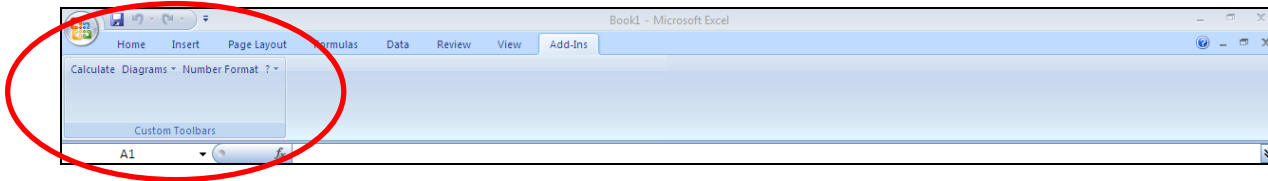


Figure 2.11: FluidEXL^{Graphics} menu bar

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 library LibButane_iso

If FluidEXL^{Graphics} has already been installed in the June 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)
LibButan_iso.dll	
LibButan_iso.hlp	

provided in the extracted folder

CD_FluidEXL_Graphics_LibButan_iso_Eng	(for English version of Windows)
CD_FluidEXL_Graphics_LibButan_iso	(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 "Iso_Butane LibButane_Iso" library property functions via this menu bar (see section 2.5 on page 2/19).

2.3 The FluidEXL^{Graphics} Help System

As mentioned earlier, FluidEXL^{Graphics} also provides detailed online help functions. If you are running Windows Vista or Windows 7, please note the paragraph

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

For general information in Excel[®]:

- Click on "?" and then "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 "Iso_Butane LibButane_Iso" library under "Or select a category:" in the "Insert Function" window which will appear.
- Click the "Help on this function" link 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 "LibButan_iso.hlp" cannot be found, you will be asked whether you want to look for it yourself – answer with "Yes." Click on the "LibButan_iso.hlp" file in the installation menu of FluidEXL^{Graphics} in the window which is opened, the standard being

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

and click "OK" 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).

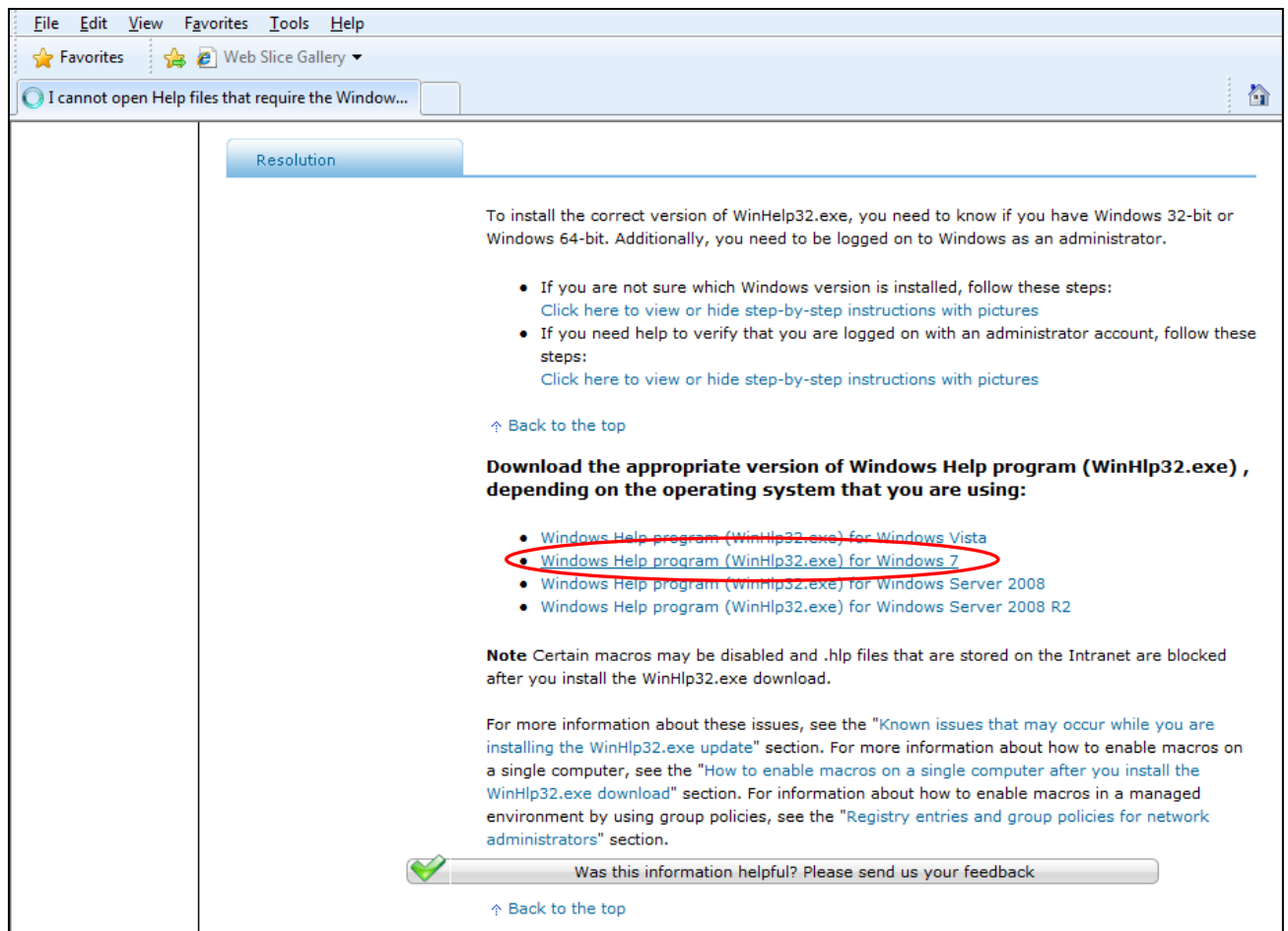


Figure 2.13: Selecting your Windows version

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).

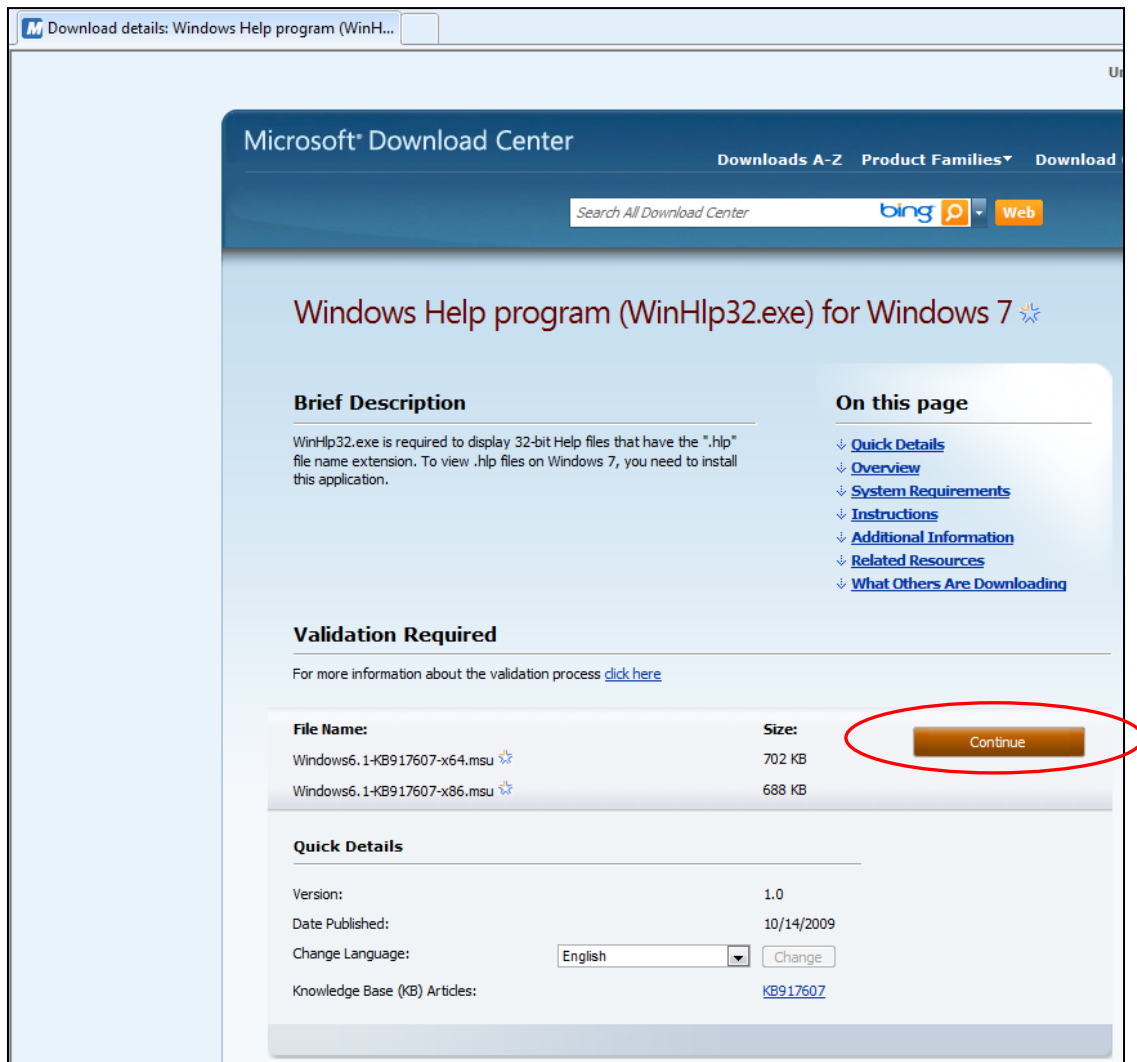


Figure 2.14: Microsoft® Download Center

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).

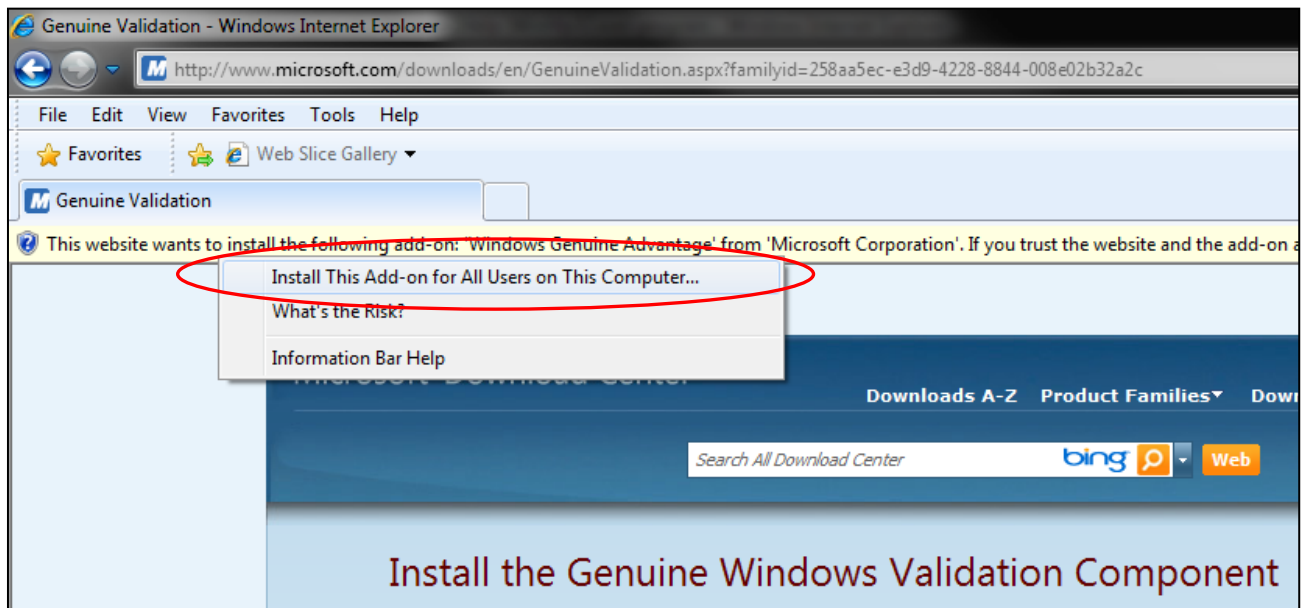


Figure 2.15: Installing the Genuine Windows Validation Component

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).

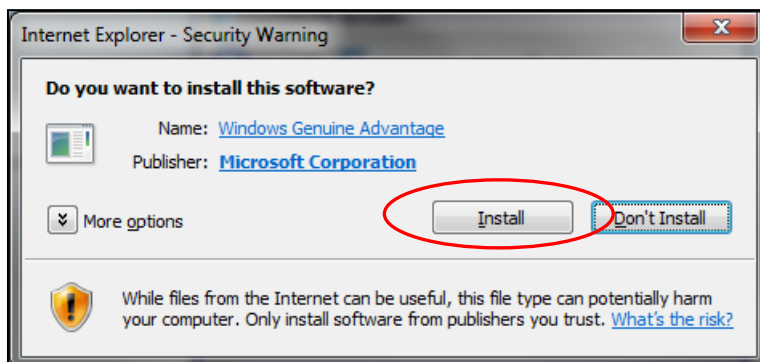


Figure 2.16: Internet Explorer – Security Warning

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

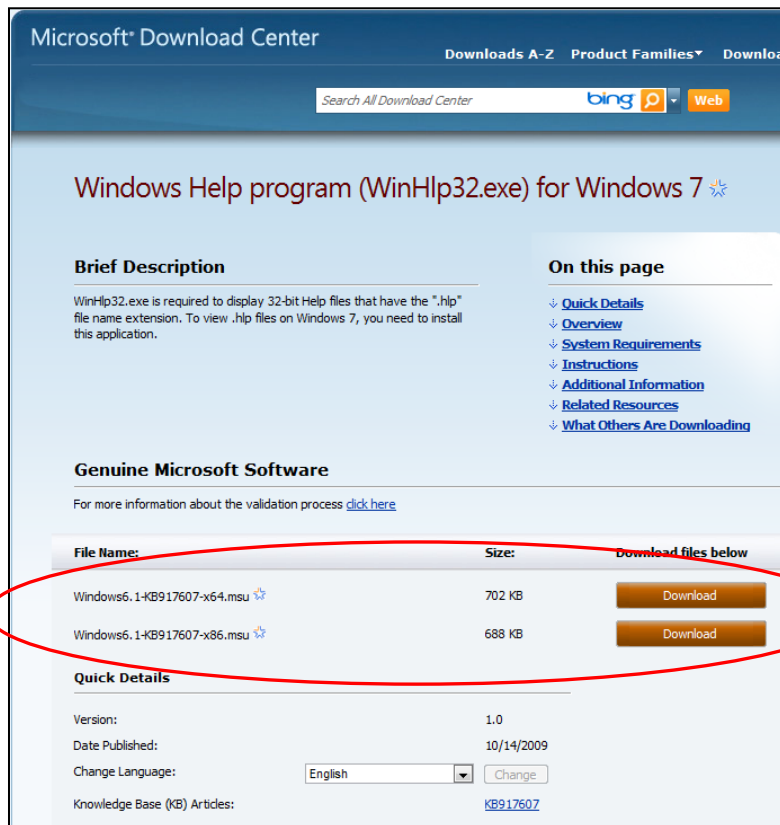


Figure 2.17: Downloading the Windows Help program

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.

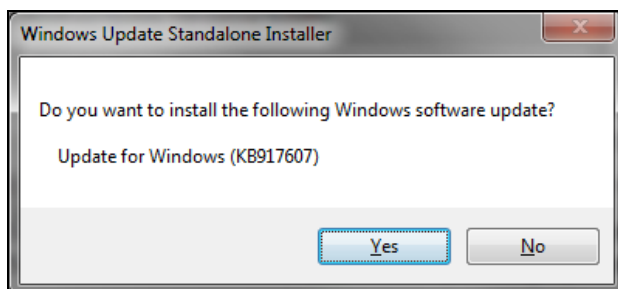


Figure 2.18: Windows Update Standalone Installer

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)

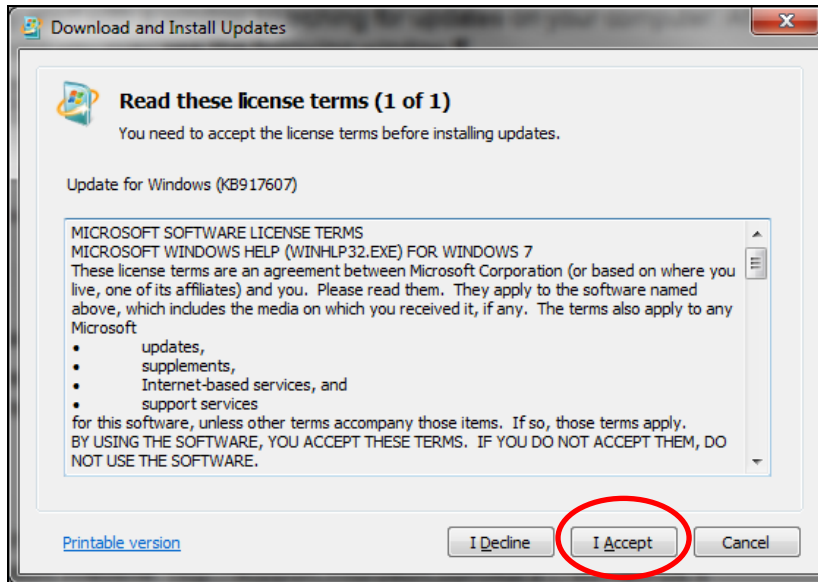


Figure 2.19: Windows License Terms

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

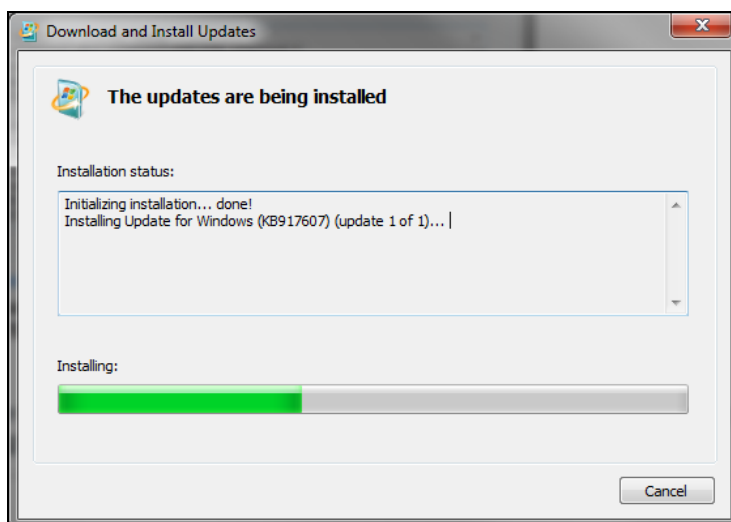


Figure 2.20: Installation process

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 LibButane_Iso 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).

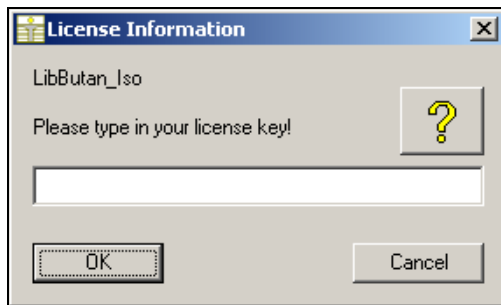


Figure 2.21: "License Information" window

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:

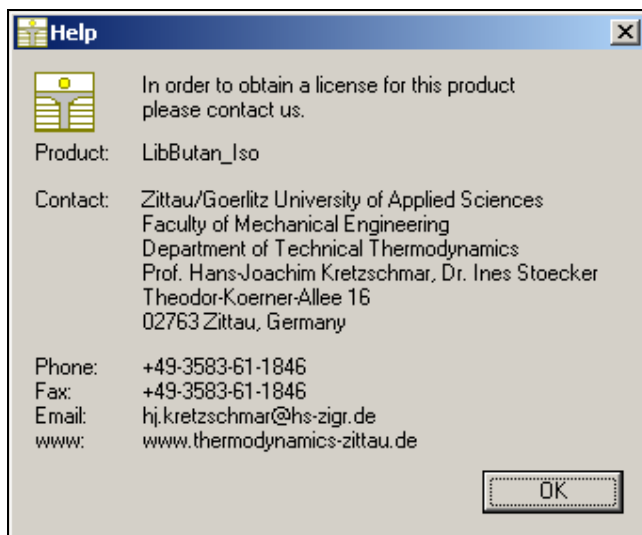


Figure 2.22: "Help" window

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

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 LibButane_iso property library, you have to delete the files

LibButan_iso.dll
LibButan_iso.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:

The following steps have to be completed:

- Enter the value for p in bar in a cell
(Range of validity: $p_t = 2.19 \times 10^{-7} \text{ bar} \dots 350 \text{ bar}$)

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

- Enter the value for t in °C in a cell
(Range of validity: $t = t_{\text{mel}}(p) \dots 301.85 \text{ °C}$)

⇒ e. g.: Enter the value 25 into cell B2

- Enter the 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 boiling 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 .

(Saturation line of Iso-Butane: $t_t = -159.42 \text{ °C} \dots t_c = 134.66 \text{ °C}$
 $p_t = 2.19 \times 10^{-7} \text{ bar} \dots p_c = 36.29 \text{ bar}$)

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

- Click the cell into which the calculated enthalpy h in kJ/kg should be entered

⇒ e.g.: Click cell D2

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

Now, the "Insert Function" window appears (see Figure 2.23).

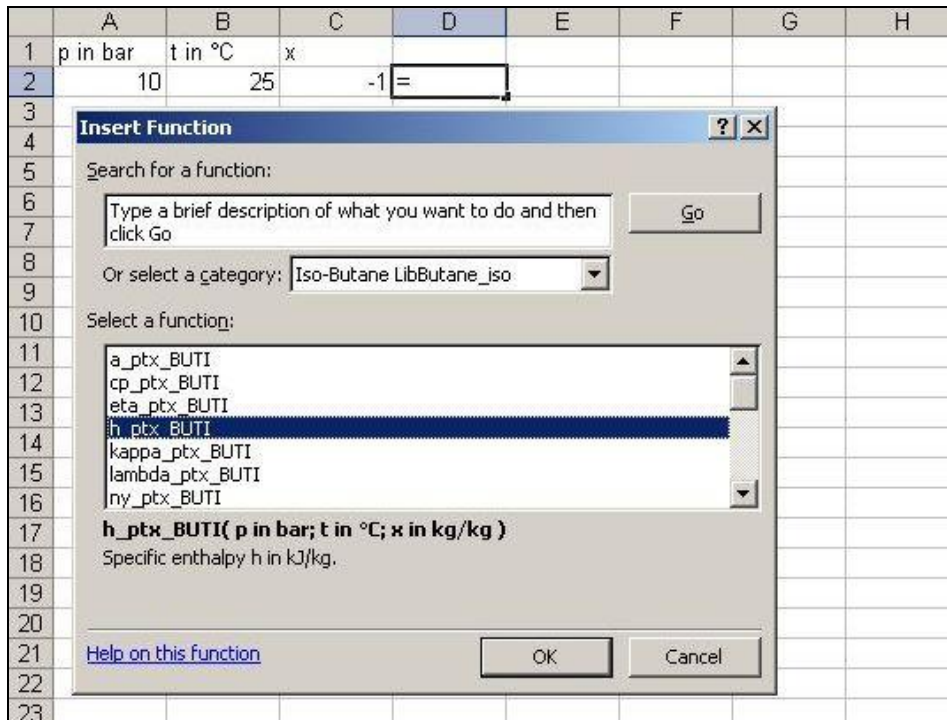


Figure 2.23: Selecting library and function

- Search and click the "Iso-Butane LibButane_iso" library in the upper list box next to "Or select a category:"
- Search and click the "h_ptx_BUTI" function in the lower list box under "Select a function:". Here it is possible to get more information on range of validity, measuring units, error responses, etc. by clicking the "Help on this function" button.
- Click "OK".
The window shown in Figure 2.24 appears.

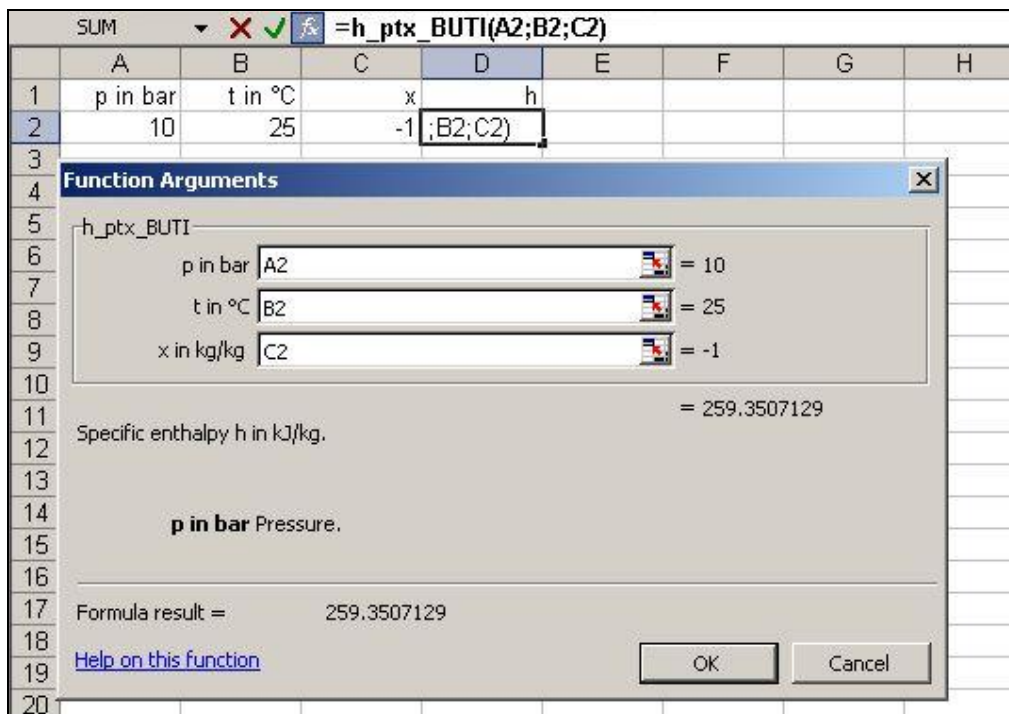


Figure 2.24: Entering the given values for the property calculation

- The cursor is 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.
- 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.
- 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.
- Click the "OK" button.

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

⇒ The result in our sample calculation here is: $h = 259.350712913596$ kJ/kg.

The calculation of $h = f(p, t, x)$ has thus been carried out. You can now arbitrarily change the values for p , t , or x in the appropriate cells. The 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 LibButane_iso. More detailed information on each function and its range of validity is available in Chapter 3.

For further property functions calculable in FluidEXL^{Graphics}, please 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:

- Click the cell or select and click on the 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 to cells which have already been calculated.

2.6 Removing FluidEXL *Graphics*

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

LibButan_iso.dll

LibButan_iso.hlp

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

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.

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

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

FluidEXL_Graphics_Eng.xla (for English version of Windows)

FluidEXL_Graphics.xla (for German version of Windows)

has to be cancelled in Excel[®].

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

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

"FluidEXL Graphics" (for German version of Windows)

in the window that appears and click the "OK" button. The additional menu bar of FluidEXL *Graphics* disappears 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)

"FluidEXL Graphics" (for German version of Windows)

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

Within the next step delete the files

LibButan_iso.dll

LibButan_iso.hlp

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

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 drive, 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/Remove Programs" window that appears select

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

"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 thereafter "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 corner of Excel
- Click on the "Excel Options" button in the menu which appears

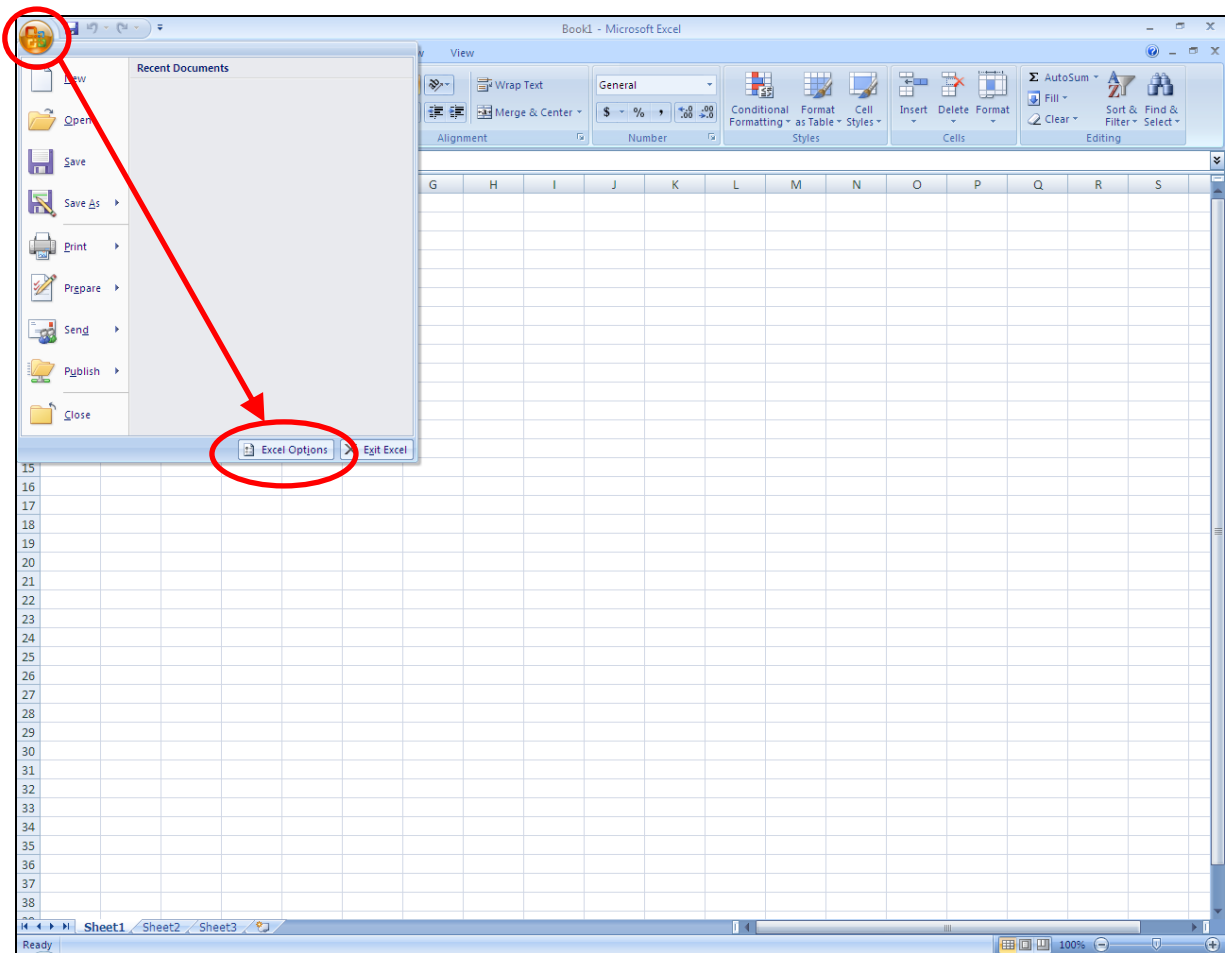


Figure 2.25: Unregistering FluidEXL *Graphics* as Add-In in Excel® 2007

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

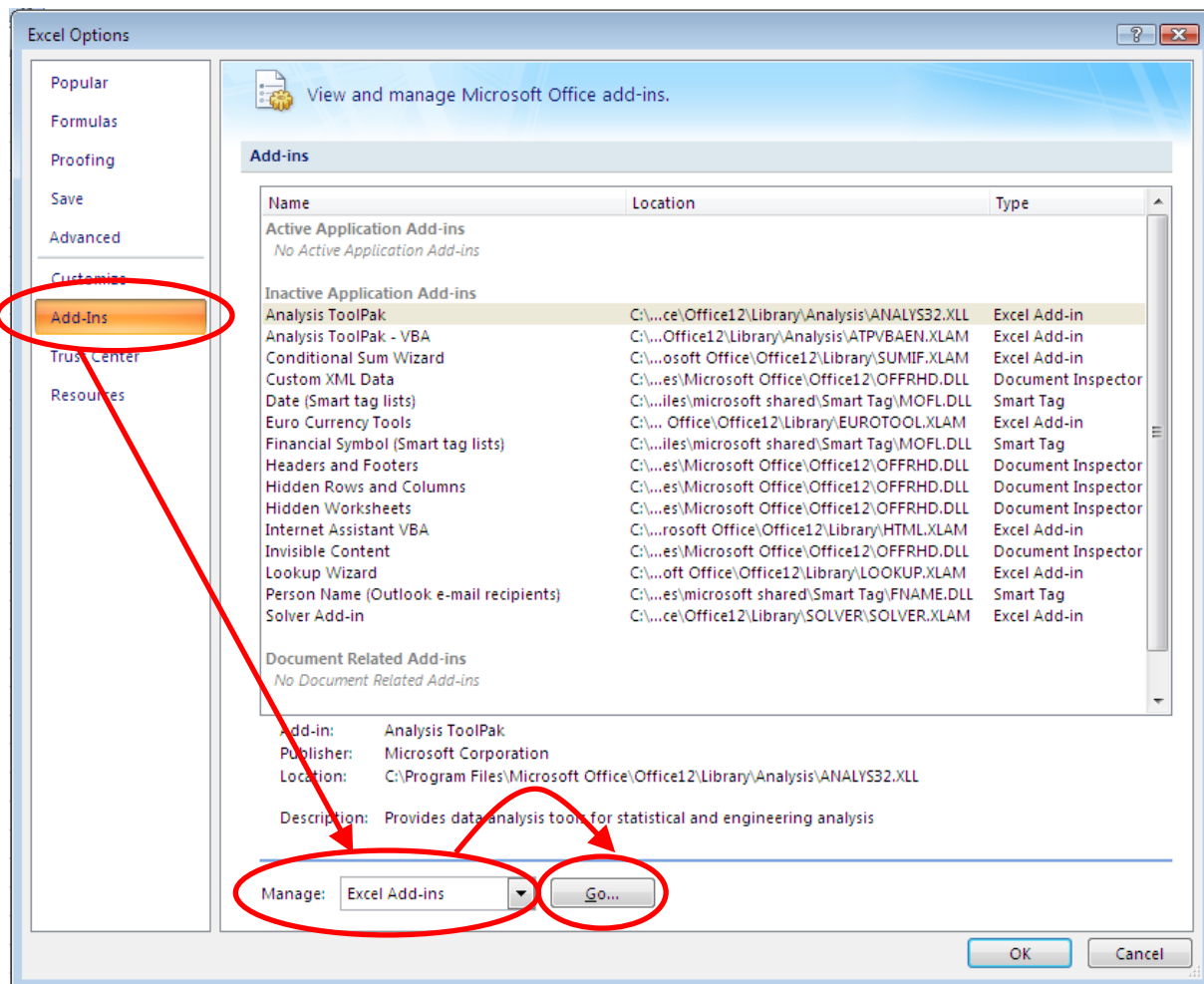


Figure 2.26: Dialog window "Add-Ins"

- If it is not shown in the list automatically, chose and click "Excel Add-ins" next to "Manage:" in the lower area of the menu
- Afterwards 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.

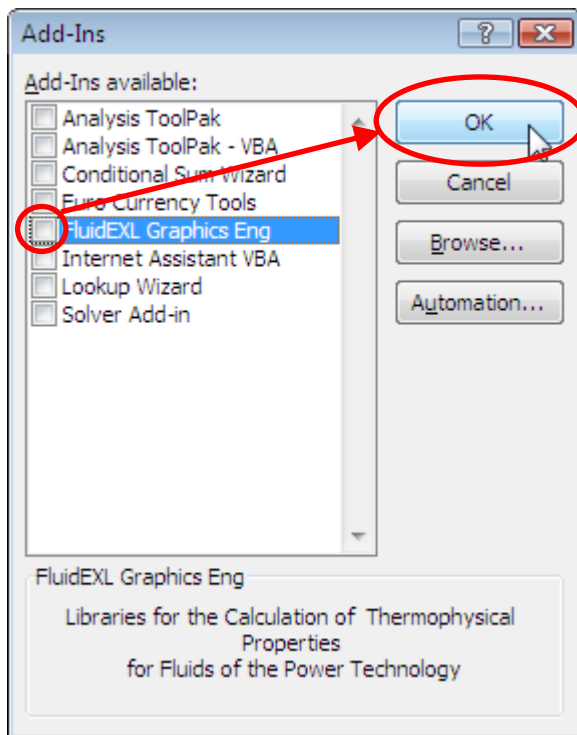


Figure 2.27: Dialog window "Add-Ins"

In order to remove FluidEXL *Graphics* from Windows and the hard drive, 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)

"FluidEXL Graphics" (for German version of Windows)

by clicking on it and then clicking the "Add/Remove..." button.

Click "Automatic" in the following dialog box and then the "Next >" button.

Click "Finish" in the "Perform Uninstall" window.

Answer the question of whether all shared components should be removed with "Yes to All."

Finally, close the "Add or Remove Programs" and "Control Panel" windows.

Now FluidEXL *Graphics* has been completely removed from your computer.

3. Program Documentation

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

Function Name: **a_ptx_BUTI**
 Subroutine with function value: **REAL*8 FUNCTION APTXBUTI(P,T,X)**
 for call from Fortran **REAL*8 P,T,X**
 Subroutine with parameter: **INTEGER*4 FUNCTION C_APTXBUTI(A,P,T,X)**
 for call from DLL **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

APTXBUTI, A or a_ptx_BUTI – Thermal diffusivity $a = \frac{\lambda \cdot v}{c_p}$ in m^2 / s

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.

The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **APTXBUTI = -1000, A = -1000 or a_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25], [27]

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

Function Name: **cp_ptx_BUTI**
 Subroutine with function value: **REAL*8 FUNCTION CPPTXBUTI(P,T,X)**
 for call from Fortran **REAL*8 P,T,X**
 Subroutine with parameter: **INTEGER*4 FUNCTION C_CPPTXBUTI(CP,P,T,X)**
 for call from DLL **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

CPTXBUTI, CP or **cp_ptx_BUTI** – Specific isobaric heat capacity c_p in kJ / (kg K)

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.
 The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42$ °C to $t_c = 134.66$ °C
 Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **CPPTXBUTI = -1000, CP = -1000** or **cp_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85$ °C or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C

References: [22], [25]

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

Function Name: **eta_ptx_BUTI**
 Subroutine with function value: **REAL*8 FUNCTION ETAPTXBUTI(P,T,X)**
 for call from Fortran **REAL*8 P,T,X**
 Subroutine with parameter: **INTEGER*4 FUNCTION C_ETAPTXBUTI(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

ETAPTXBUTI, ETA or **eta_ptx_BUTI** – Dynamic viscosity η in Pa s

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.

The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42$ °C to $t_c = 134.66$ °C

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **ETAPTXBUTI = -1000**, **ETA = -1000** or **eta_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85$ °C or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C

References: [22], [25], [26]

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

Function Name:	h_ptx_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION HPTXBUTI(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_HPTXBUTI(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

HPTXBUTI, H or h_ptx_BUTI - Specific enthalpy h in kJ/kg

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

(Boiling and dew curve: Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **HPTXBUTI = -1000, H = -1000 or h_ptx_BUTI = -1000** for input values

Single phase region: $p > 350\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 at $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

Function Name: **kappa_ptx_BUTI**

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

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

KAPPTXBUTI, KAP or **kappa_ptx_BUTI** – Isentropic exponent $\kappa = \frac{w^2}{p \cdot v}$

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.
 The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42$ °C to $t_c = 134.66$ °C
 Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **KAPTXBUTI, KAP = -1000** or **kappa_ptx_BUTI = -1000** for input values

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85$ °C or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C

References: [22], [25]

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

Function Name:	lambda_ptx_BUTi
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION LAMPTXBUTi(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_LAMPTXBUTi(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

LAMPTXBUTi, LAM or **lambda_ptx_BUTi** – Thermal conductivity λ in W / m K

Range of validity

Temperature range: from t_{mel} to 301.85°C
 Pressure range: from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.
 The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from	$t_t = -159.42 \text{ °C}$ to $t_c = 134.66 \text{ °C}$
Pressure ranges from	$p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **LAMPTXBUTi = -1000, LAM = -1000** or **lambda_ptx_BUTi = -1000** for input values

Single phase region: $p > 350 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ or
 ($x = -1$) $t > 301.85 \text{ °C}$ or $t < t_{\text{mel}}$
 Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66 \text{ °C}$ or $t < t_t = -159.42 \text{ °C}$
 at $t = -1000$ and $p > p_c = 36.29 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ or
 at $p > p_c = 36.29 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ and
 $t > t_c = 134.66 \text{ °C}$ or $t < t_t = -159.42 \text{ °C}$

References: [22], [25], [27]

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

Function Name: **ny_ptx_BUTl**

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

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

NYPTXBUTl, NY or **ny_ptx_BUTl** – Kinematic viscosity $\nu = \eta \cdot \nu$ in m^2 / s

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.
 The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$
 Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **NYPTXBUTl = -1000, NY = -1000** or **ny_ptx_BUTl = -1000** for input values

Single phase region: $p > 350\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 at $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25], [26]

Melting Pressure $p_{\text{mel}} = f(t)$

Function Name:	pmel_t_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION PMELBUTI(T) REAL*8 T
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_PMELBUTI(PMEL,T) REAL*8 PMEL,P,T,X

Input Values

T - Temperature t in °C

Result

PMELTBUTI, PMEL or **pmel_t_BUTI** – Melting pressure p_{mel} in bar

Range of validity

Temperature range : from $t_t = -159.42^\circ\text{C}$ to -147.751°C

Results for wrong input values

Result **PMELBUTI = -1000**, **PMEL = -1000** or **pmel_t_BUTI = -1000** for input values

$t < t_t = -159.42^\circ\text{C}$ or $t > -147.751^\circ\text{C}$

References: [22], [25]

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

Function Name:	Pr_ptx_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION PRPTXBUTI(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_PRPTXBUTI(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

PRPTXBUTI, PR or Pr_ptx_BUTI – Prandtl – Number $Pr = \frac{\eta^* c_p}{\lambda}$

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.

The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t and x are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from $t_t = -159.42$ °C to $t_c = 134.66$ °C

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **PRPTXBUTI = -1000, PR = -1000 or Pr_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85$ °C or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66$ °C or $t < t_t = -159.42$ °C

References: [22], [25], [26], [27]

Vapor Pressure $p_s = f(t)$

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

Input Values

T - Temperature t in °C

Result

PSTBUTl, PS or **ps_t_BUTl** – Vapor pressure p_s in bar

Range of validity

Temperature range : from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Results for wrong input values

Result **PSTBUTl = -1000**, **PS = -1000** or **ps_t_BUTl = -1000** for input values

$t < t_t = -159.42^\circ\text{C}$ or $t > t_c = 134.66^\circ\text{C}$

References: [22], [25]

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

Function Name: **rho_ptx_BUTI**

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

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_ROPTXBUTI(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

RHOPTXBUTI, RHO or **rho_ptx_BUTI** – Density ρ in kg / m³

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

(Boiling and dew curve: Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **ROPTXBUTI = -1000, RHO = -1000** or **rho_ptx_BUTI = -1000** for input values

Single phase region: $p > 350\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ or
 at $p > p_c = 36.29\text{bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{bar}$ and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

Function Name:	s_ptx_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION SPTXBUTI(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_SPTXBUTI(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

SPTXBUTI, S or **s_ptx_BUTI** - Specific entropy s in kJ/kg K

Range of validity

Temperature range: from t_{mel} to 301.85°C
 Pressure range: from $p_t = 2.19 \times 10^{-7}$ bar to 350 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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

(Boiling and dew curve: Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **SPTXBUTI = -1000, S = -1000** or **s_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

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

Input Values

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

Result

TPHBUTI, T or **t_ph_BUTI** – Temperature t in °C

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the calculation of wet steam

The wet steam region is calculated automatically. This means that from the given values of p and h the function 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 t in the appropriate region will be carried out.

Wet steam region: Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar

Results for wrong input values

Result **T_PH_BUTI, T = -1000** or **t_ph_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) at result $t > 301.85^\circ\text{C}$, $t < t_t = -159.42^\circ\text{C}$ or $t < t_{\text{mel}}(p)$
 Boiling or dew curve: at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at result $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

Function Name: **t_ps_BUTI**

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

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

Input Values

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

Result

TPSBUTI, T or **t_ps_BUTI** – Temperature t in °C

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the calculation of wet steam

The wet steam region is calculated automatically. This means that from the given values of p and s the function 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 t in the appropriate region will be carried out.

Wet steam region: Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar

Results for wrong input values

Result **T_PS_BUTI, T = -1000** or **t_ps_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) at result $t > 301.85^\circ\text{C}$, $t < t_t = -159.42^\circ\text{C}$ or $t < t_{\text{mel}}(p)$
 Boiling or dew curve: at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at result $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

Saturation Temperature $t_s = f(p)$

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

Input Values

P – Pressure p in bar

Result

TSPBUTI, TS or ts_p_BUTI - Saturation temperature t_s in °C

Range of validity

Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar

Results for wrong input values

Result **TSPBUTI = -1000, TS = -1000 or ts_p_BUTI = -1000** for input values

$p < p_t = 2.19 \times 10^{-7}$ bar or $p > p_c = 36.29$ bar

References: [22], [25]

Melting Temperature $t_{\text{mel}} = f(p)$

Function Name:	tmel_p_BUTl
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION TMELBUTI(P) REAL*8 P
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_TMELBUTI(TMEL,P) REAL*8 TMEL,P

Input Values

P – Pressure p in bar

Result

TMELPBUTl, **TMEL** or **tmel_p_BUTl** - Melting temperature t_{mel} in °C

Range of validity

Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Results for wrong input values

Result **TMELBUTl** = **–1000**, **TMEL** = **–1000** or **tmel_p_BUTl** = **–1000** for input values

$p < p_t = 2.19 \times 10^{-7}$ bar or $p > p_c = 36.29$ bar

References: [22], [25]

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

Function Name: **u_ptx_BUTI**

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

Subroutine with parameter:
for call from DLL **INTEGER*4 FUNCTION C_UPTXBUTI(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

UPTXBUTI, H or u_ptx_BUTI - Specific internal energy u in kJ/kg

Range of validity

Temperature range: from t_{mel} to 301.85°C
 Pressure range: from $p_t = 2.19 \times 10^{-7}$ bar to 350 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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

(Boiling and dew curve: Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **UPTXBUTI = -1000, H = -1000 or u_ptx_BUTI = -1000** for input values

Single phase region: $p > 350$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar or
 at $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

Function Name:	v_ptx_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION VPTXBUTI(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_VPTXBUTI(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

VPTXBUTI, V or **v_ptx_BUTI** - Specific volume v in m^3/kg

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350 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:

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.

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

When calculating wet steam either the given value for t and $p = -1000$ or the given value for p and $t = -1000$ and in both cases the value for x between 0 and 1 must be entered.

If p and t and x are entered as given values, the program considers p and t to be appropriate to represent the vapor pressure curve.

(Boiling and dew curve: Temperature ranges from $t_t = -159.42^\circ\text{C}$ to $t_c = 134.66^\circ\text{C}$

Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **VPTXBUTI = -1000, H = -1000** or **v_ptx_BUTI = -1000** for input values

Single phase region: $p > 350\text{ bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{ bar}$ or
 ($x = -1$) $t > 301.85^\circ\text{C}$ or $t < t_{\text{mel}}$

Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$
 at $t = -1000$ and $p > p_c = 36.29\text{ bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{ bar}$ or
 at $p > p_c = 36.29\text{ bar}$ or $p < p_t = 2.19 \times 10^{-7}\text{ bar}$ and
 $t > t_c = 134.66^\circ\text{C}$ or $t < t_t = -159.42^\circ\text{C}$

References: [22], [25]

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

Function Name:	w_ptx_BUTl
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION WPTXBUTl(P,T,X) REAL*8 P,T,X
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_WPTXBUTl(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

WPTXBUTl, W or **w_ptx_BUTl** – Speed of sound w in m/s

Range of validity

Temperature range: from t_{mel} to 301.85°C
 Pressure range: from $p_t = 2.19 \times 10^{-7}$ bar to 350 bar

Details on the vapor fraction x and on the calculation of saturated liquid and saturated 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:

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.

If the state point to be calculated is located on the saturated liquid line, $x = 0$ must be entered. When calculating saturated steam (saturated vapor line) $x = 1$ must be entered.
 The calculation for x -values between 0 and 1 is not possible.

When calculating saturated liquid or saturated steam, 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 ($x = 0$ or $x = 1$). If p and t are entered as given values, the program will consider p and t to be appropriate to represent the vapor pressure curve.

(Saturated liquid and saturated vapor line:

Temperature ranges from	$t_t = -159.42 \text{ °C}$ to $t_c = 134.66 \text{ °C}$
Pressure ranges from	$p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar)

Results for wrong input values

Result **WPTXBUTl = -1000** or **w_ptx_BUTl = -1000** for input values

Single phase region: $p > 350 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ or
 ($x = -1$) $t > 301.85 \text{ °C}$ or $t < t_{\text{mel}}$
 Boiling or dew curve: at $p = -1000$ and $t > t_c = 134.66 \text{ °C}$ or $t < t_t = -159.42 \text{ °C}$
 at $t = -1000$ and $p > p_c = 36.29 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ or
 at $p > p_c = 36.29 \text{ bar}$ or $p < p_t = 2.19 \times 10^{-7} \text{ bar}$ and
 $t > t_c = 134.66 \text{ °C}$ or $t < t_t = -159.42 \text{ °C}$

References: [22], [25]

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

Function Name:	x_ph_BUTI
Subroutine with function value: for call from Fortran	REAL*8 FUNCTION XPHBUTI(P,H) REAL*8 P,H
Subroutine with parameter: for call from DLL	INTEGER*4 FUNCTION C_XPHBUTI(T,P,H) REAL*8 X,P,H

Input Values

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

Result

XPHBUTI, X or **x_ph_BUTI** – Vapor fraction x in (kg saturated steam/kg wet steam)

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the calculation of wet steam

The wet steam region is calculated automatically. This means that from the given values of p and h the function will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. When calculating wet steam the value for x between 0 and 1 is calculated (0 for saturated liquid, 1 for saturated steam). If the state point to be calculated is located in the single-phase region the result $x = -1$ will be returned.

Wet steam region: Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar

Results for wrong input values

Result **X_PH_BUTI, X** = -1 or **x_ph_BUTI** = -1 for input values

In case the point of state is located in the single phase region
 $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar

References: [22], [25]

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

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

Input Values

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

Result

XPSBUTI, X or **x_ps_BUTI** – Vapor fraction x in (kg saturated steam/kg wet steam)

Range of validity

Temperature range : from t_{mel} to 301.85°C
 Pressure range : from $p_t = 2.19 \times 10^{-7}$ bar to 350bar

Details on the calculation of wet steam

The wet steam region is calculated automatically. This means that from the given values of v and h the function will determine whether the state point to be calculated is located within the single-phase region (liquid or steam) or the wet steam region. When calculating wet steam the value for x between 0 and 1 is calculated (0 for saturated liquid, 1 for saturated steam). If the state point to be calculated is located in the single-phase region the result $x = -1$ will be returned.

Wet steam region: Pressure ranges from $p_t = 2.19 \times 10^{-7}$ bar to $p_c = 36.29$ bar

Results for wrong input values

Result **X_PS_BUTI, X** = -1 or **x_ps_BUTI** = -1 for input values

In case the point of state is located in the single phase region
 $p > p_c = 36.29$ bar or $p < p_t = 2.19 \times 10^{-7}$ bar

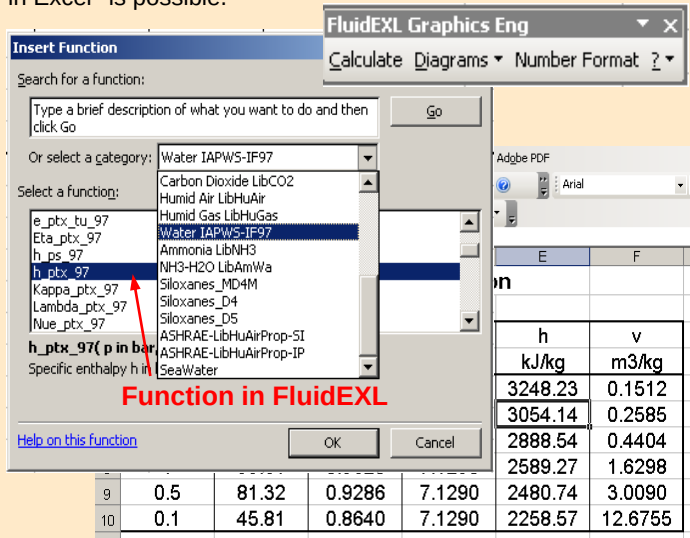
References: [22], [25]

Water and Steam	Humid Combustion Gas Mixtures	Humid Air
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)	Library LibHuGas 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 equations of Bückner et al.) Consideration of Dissociation from VDI 4670 and Poynting effect Library LibIDGAS Ideal gas mixture calculated from the VDI-Guideline 4670	Library LibHuAir Ideal mixture of the real fluids: - Dry air from Lemmon et al. - Steam and water from IAPWS-IF97 Consideration of - Dissociation from VDI-Guideline 4670 - Poynting effect Library LibIdAir Ideal gas mixture calculated from VDI-Guideline 4670

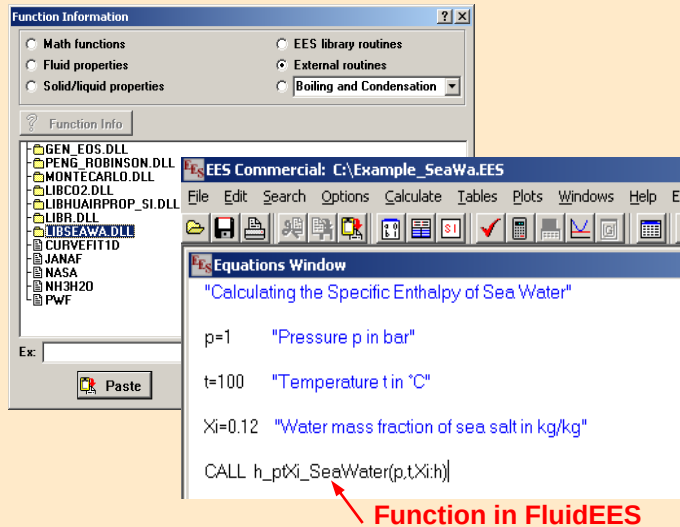
Carbon Dioxide	Ideal Gas Mixtures	Seawater
Library LibCO2 Formulation of Span and Wagner (1994)	Library LibIdGasMix Ideal mixture of the ideal gases: Ar SO₂ Methane Ne H₂ Ethane N₂ H₂S Ethylene O₂ OH Propylene CO He Propane CO₂ F₂ Iso-Butane Air NH₃ n-Butane NO Benzene H₂O Methanol Consideration of - Dissociation from VDI-Guideline 4670	Library LibSeaWa IAPWS Formulation (2008) and IAPWS-IF97
Hydrogen		Refrigerant R134a
Library LibH2 Formulation of Leachman et al. (2007)		Library LibR134a Formulation of Tillner-Roth and Baehr (1994)
Helium		Refrigerant NH3
Library LibHe Formulation of McCarty and Arp (1990)		Library LibNH3 Formulation of Tillner-Roth (1995)
Methanol		
Library LibCH3OH Formulation of de Reuck and Craven (1993)		

ORC Working Fluids	Mixtures for Absorption Processes	Refrigerants
Library LibMM Siloxane C₆H₁₈OSi₂ (MM) Formulation of Colonna et al. (2006) Library LibD4 Siloxane C₈H₂₄O₄Si₄ (D4) Formulation of Colonna et al. (2006) Library LibD5 Siloxane C₁₀H₃₀O₅Si₅ (D5) Formulation of Colonna et al. (2006) Library LibMD4M Siloxane C₁₄H₄₂O₅Si₆ (MD4M) Formulation of Colonna et al. (2006)	Library LibAmWa Ammonia/Water Mixtures IAPWS Guideline 2005 of Tillner-Roth and Friend (1998) Helmholtz energy formulation for the mixing term Library LibWaLi Water/Lithium Bromide Mixtures Formulation of Kim and Infante Ferreira (2004) Gibbs energy equation for the mixing term	Library LibPropan Refrigerant Propane Formulation of Lemmon et al. (2008) Library LibButan_Iso Refrigerant Iso-Butane Formulation of Bückner et al. (2003) Library LibButan_n Refrigerant n-Butane Formulation of Bückner et al. (2003)

Using the Add-In FluidEXL a direct call of the property functions in Excel® is possible.

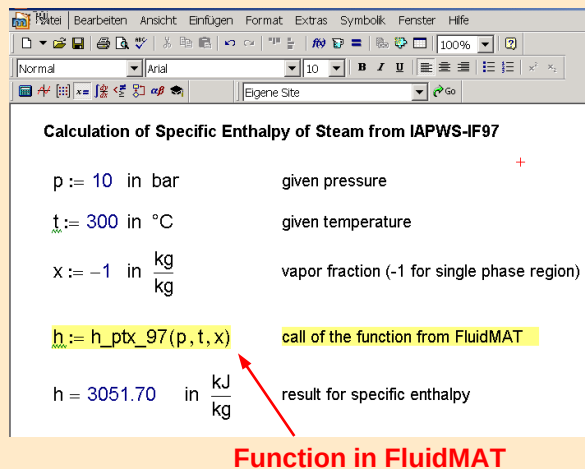


The Add-In FluidEES allows to call the functions of the property libraries within the Engineering Equation Solver EES®.



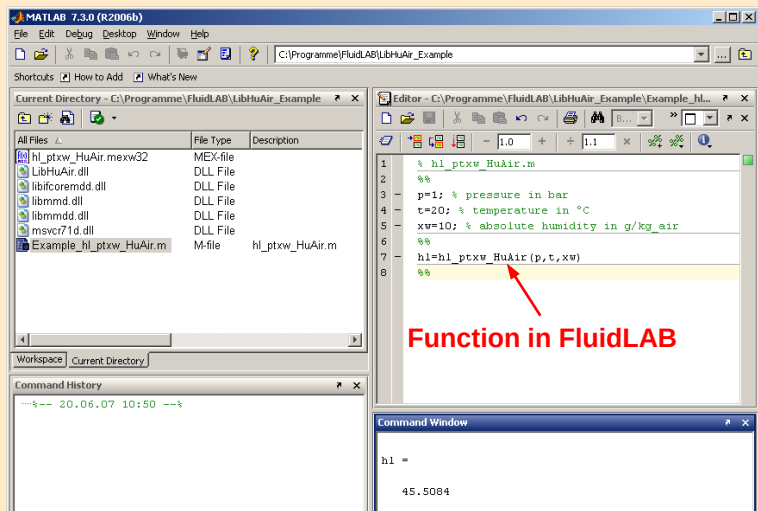
Add-In FluidMAT for Mathcad®

Using the Add-on FluidMAT, the functions of the property libraries can be used in Mathcad®.



Add-In FluidLAB for MATLAB®

The property functions can be called in MATLAB®.



The following thermodynamic and transport properties can be calculated¹:

Thermodynamic Properties

- Saturation 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

Thermodynamic Derivatives

- Partial derivatives can be calculated

Transport Properties

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

Backward Functions

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

For information please contact:

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Fax.: +49-3583-61-1846

¹ Not all of these property functions are available in all property libraries listed before.

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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[®]:

2011

Lopez, Munguia, Spain	10/2011
University of KwaZulu-Natal, Westville, South Africa	10/2011
Voith, Heidenheim	09/2011
SpgBe Montreal, Canada	09/2011
SPG TECH, Montreuil Cedex, France	09/2011
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MTU Aero Engines, Munich	08/2011
MIBRAG, Zeitz	08/2011
RWE, Essen	07/2011
Fels, Elingerode	07/2011
Weihenstephan University of Applied Sciences	07/2011, 09/2011, 10/2011
Forschungszentrum Juelich	07/2011
RWTH Aachen University	07/2011, 08/2011
Voith, Zschopau	07/2011
INNEO Solutions, Ellwangen	06/2011
Caliqua, Basel, Switzerland	06/2011
Technical University of Freiberg	06/2011
Fichtner IT Consulting, Stuttgart	05/2011, 06/2011, 08/2011
Salzgitter Flachstahl, Salzgitter	05/2011
Helbling Beratung & Bauplanung, Zurich, Switzerland	05/2011
INEOS, Cologne	04/2011
Enseleit Consulting Engineers, Siebigerode	04/2011

Witt Consulting Engineers, Stade	03/2011
Helbling, Zurich, Switzerland	03/2011
MAN Diesel, Copenhagen, Denmark	03/2011
AGO, Kulmbach	03/2011
University of Duisburg	03/2011, 06/2011
CCP, Marburg	03/2011
BASF, Ludwigshafen	02/2011
ALSTOM Power, Baden, Switzerland	02/2011
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Calorifer, Elgg, Switzerland	01/2011
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2010

Umweltinstitut Neumarkt	12/2010
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MCI Innsbruck, Austria	12/2010
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Siemens Energy, Goerlitz	01/2010, 12/2010
Technical University of Freiberg	01/2010
ILK, Dresden	01/2010, 12/2010
Fischer-Uhrig Consulting Engineers, Berlin	01/2010

2009

ALSTOM Power, Baden, Schweiz	01/2009, 03/2009, 05/2009
Nordostschweizerische Kraftwerke AG, Doettingen, Switzerland	02/2009
RWE, Neurath	02/2009
Brandenburg University of Technology, Cottbus	02/2009
Hamburg University of Applied Sciences	02/2009
Kehrein, Moers	03/2009
EPP Software, Marburg	03/2009
Bernd Münstermann, Telgte	03/2009
Suedzucker, Zeitz	03/2009
CPP, Marburg	03/2009
Gelsenkirchen University of Applied Sciences	04/2009
Regensburg University of Applied Sciences	05/2009
Gatley & Associates, Atlanta, USA	05/2009
BOSCH, Stuttgart	06/2009, 07/2009
Dr. Nickolay, Consulting Engineers, Gommersheim	06/2009
Ferrostal Power, Saarlouis	06/2009
BHR Bilfinger, Essen	06/2009
Intraserv, Wiesbaden	06/2009
Lausitz University of Applied Sciences, Senftenberg	06/2009
Nuernberg University of Applied Sciences	06/2009
Technical University of Berlin	06/2009
Fraunhofer Institut UMSICHT, Oberhausen	07/2009
Bischoff, Aurich	07/2009
Fichtner IT Consulting, Stuttgart	07/2009
Techsoft, Linz, Austria	08/2009

DLR, Stuttgart	08/2009
Wienstrom, Vienna, Austria	08/2009
RWTH Aachen University	09/2009
Vattenfall, Hamburg	10/2009
AIC, Chemnitz	10/2009
Midiplan, Bietigheim-Bissingen	11/2009
Institute of Air Handling and Refrigeration ILK, Dresden	11/2009
FZD, Rossendorf	11/2009
Techgroup, Ratingen	11/2009
Robert Sack, Heidelberg	11/2009
EC, Heidelberg	11/2009
MCI, Innsbruck, Austria	12/2009
Saacke, Bremen	12/2009
ENERKO, Aldenhoven	12/2009

2008

Pink, Langenwang	01/2008
Fischer-Uhrig, Berlin	01/2008
University of Karlsruhe	01/2008
MAAG, Kuesnacht, Switzerland	02/2008
M&M Turbine Technology, Bielefeld	02/2008
Lentjes, Ratingen	03/2008
Siemens Power Generation, Goerlitz	04/2008
Evonik, Zwingenberg (general EBSILON program license)	04/2008
WEBASTO, Neubrandenburg	04/2008
CFC Solutions, Munich	04/2008
RWE IT, Essen	04/2008
Rerum Cognitio, Zwickau	04/2008, 05/2008
ARUP, Berlin	05/2008
Research Center, Karlsruhe	07/2008
AWECO, Neukirch	07/2008
Technical University of Dresden, Professorship of Building Services	07/2008
Technical University of Cottbus, Chair in Power Plant Engineering	07/2008, 10/2008
Ingersoll-Rand, Unicov, Czech Republic	08/2008
Technip Benelux BV, Zoetermeer, Netherlands	08/2008

Fennovoima Oy, Helsinki, Finland	08/2008
Fichtner Consulting & IT, Stuttgart	09/2008
PEU, Espenhain	09/2008
Poyry, Dresden	09/2008
WINGAS, Kassel	09/2008
TUEV Sued, Dresden	10/2008
Technical University of Dresden, Professorship of Thermic Energy Machines and Plants	10/2008, 11/2008
AWTEC, Zurich, Switzerland	11/2008
Siemens Power Generation, Erlangen	12/2008

2007

Audi, Ingolstadt	02/2007
ANO Abfallbehandlung Nord, Bremen	02/2007
TUEV NORD SysTec, Hamburg	02/2007
VER, Dresden	02/2007
Technical University of Dresden, Chair in Jet Propulsion Systems	02/2007
Redacom, Nidau, Switzerland	02/2007
Universität der Bundeswehr, Munich	02/2007
Maxxtec, Sinsheim	03/2007
University of Rostock, Chair in Technical Thermodynamics	03/2007
AGO, Kulmbach	03/2007
University of Stuttgart, Chair in Aviation Propulsions	03/2007
Siemens Power Generation, Duisburg	03/2007
ENTHAL Haustechnik, Rees	05/2007
AWECO, Neukirch	05/2007
ALSTOM, Rugby, Great Britain	06/2007
SAAS, Possendorf	06/2007
Grenzebach BSH, Bad Hersfeld	06/2007
Reichel Engineering, Haan	06/2007
Technical University of Cottbus, Chair in Power Plant Engineering	06/2007
Voith Paper Air Systems, Bayreuth	06/2007
Egger Holzwerkstoffe, Wismar	06/2007
Tissue Europe Technologie, Mannheim	06/2007
Dometic, Siegen	07/2007
RWTH Aachen University, Institute for Electrophysics	09/2007

National Energy Technology Laboratory, Pittsburg, USA	10/2007
Energieversorgung Halle	10/2007
AL-KO, Jettingen	10/2007
Grenzebach BSH, Bad Hersfeld	10/2007
Wiesbaden University of Applied Sciences, Department of Engineering Sciences	10/2007
Endress+Hauser Messtechnik, Hannover	11/2007
Munich University of Applied Sciences, Department of Mechanical Engineering	11/2007
Rerum Cognitio, Zwickau	12/2007
Siemens Power Generation, Erlangen	11/2007
University of Rostock, Chair in Technical Thermodynamics	11/2007, 12/2007

2006

STORA ENSO Sachsen, Eilenburg	01/2006
Technical University of Munich, Chair in Energy Systems	01/2006
NUTEC Engineering, Bisikon, Switzerland	01/2006, 04/2006
Conwel eco, Bochov, Czech Republic	01/2006
Offenburg University of Applied Sciences	01/2006
KOCH Transporttechnik, Wadgassen	01/2006
BEG Bremerhavener Entsorgungsgesellschaft	02/2006
Deggendorf University of Applied Sciences, Department of Mechanical Engineering and Mechatronics	02/2006
University of Stuttgart, Department of Thermal Fluid Flow Engines	02/2006
Technical University of Munich, Chair in Apparatus and Plant Engineering	02/2006
Energietechnik Leipzig (company license),	02/2006
Siemens Power Generation, Erlangen	02/2006, 03/2006
RWE Power, Essen	03/2006
WAETAS, Pobershau	04/2006
Siemens Power Generation, Goerlitz	04/2006
Technical University of Braunschweig, Department of Thermodynamics	04/2006
EnviCon & Plant Engineering, Nuremberg	04/2006
Brassel Engineering, Dresden	05/2006
University of Halle-Merseburg, Department of USET Merseburg incorporated society	05/2006

Technical University of Dresden, Professorship of Thermic Energy Machines and Plants	05/2006
Fichtner Consulting & IT Stuttgart (company licenses and distribution)	05/2006
Suedzucker, Ochsenfurt	06/2006
M&M Turbine Technology, Bielefeld	06/2006
Feistel Engineering, Volkach	07/2006
ThyssenKrupp Marine Systems, Kiel	07/2006
Caliqua, Basel, Switzerland (company license)	09/2006
Atlas-Stord, Rodovre, Denmark	09/2006
Konstanz University of Applied Sciences, Course of Studies Construction and Development	10/2006
Siemens Power Generation, Duisburg	10/2006
Hannover University of Applied Sciences, Department of Mechanical Engineering	10/2006
Siemens Power Generation, Berlin	11/2006
Zikesch Armaturentechnik, Essen	11/2006
Wismar University of Applied Sciences, Seafaring Department	11/2006
BASF, Schwarzheide	12/2006
Enertech Energie und Technik, Radebeul	12/2006

2005

TUEV Nord, Hannover	01/2005
J.H.K Plant Engineering and Service, Bremerhaven	01/2005
Electrowatt-EKONO, Zurich, Switzerland	01/2005
FCIT, Stuttgart	01/2005
Energietechnik Leipzig (company license)	02/2005, 04/2005, 07/2005
eta Energieberatung, Pfaffenhofen	02/2005
FZR Forschungszentrum, Rossendorf/Dresden	04/2005
University of Saarbruecken	04/2005
Technical University of Dresden Professorship of Thermic Energy Machines and Plants	04/2005
Grenzebach BSH, Bad Hersfeld	04/2005
TUEV Nord, Hamburg	04/2005
Technical University of Dresden, Waste Management	05/2005
Siemens Power Generation, Goerlitz	05/2005

Duesseldorf University of Applied Sciences, Department of Mechanical Engineering and Process Engineering	05/2005
Redacom, Nidau, Switzerland	06/2005
Dumas Verfahrenstechnik, Hofheim	06/2005
Alensys Engineering, Erkner	07/2005
Stadtwerke Leipzig	07/2005
SaarEnergie, Saarbruecken	07/2005
ALSTOM ITC, Rugby, Great Britain	08/2005
Technical University of Cottbus, Chair in Power Plant Engineering	08/2005
Vattenfall Europe, Berlin (group license)	08/2005
Technical University of Berlin	10/2005
Basel University of Applied Sciences, Department of Mechanical Engineering, Switzerland	10/2005
Midiplan, Bietigheim-Bissingen	11/2005
Technical University of Freiberg, Chair in Hydrogeology	11/2005
STORA ENSO Sachsen, Eilenburg	12/2005
Energieversorgung Halle (company license)	12/2005
KEMA IEV, Dresden	12/2005

2004

Vattenfall Europe (group license)	01/2004
TUEV Nord, Hamburg	01/2004
University of Stuttgart, Institute of Thermodynamics and Heat Engineering	02/2004
MAN B&W Diesel A/S, Copenhagen, Denmark	02/2004
Siemens AG Power Generation, Erlangen	02/2004
Ulm University of Applied Sciences	03/2004
Visteon, Kerpen	03/2004, 10/2004
Technical University of Dresden, Professorship of Thermic Energy Machines and Plants	04/2004
Rerum Cognitio, Zwickau	04/2004
University of Saarbruecken	04/2004
Grenzebach BSH, Bad Hersfeld	04/2004
SOFBID Zwingenberg (general EBSILON program license)	04/2004
EnBW Energy Solutions, Stuttgart	05/2004
HEW-Kraftwerk, Tiefstack	06/2004
h s energieanlagen, Freising	07/2004
FCIT, Stuttgart	08/2004

Physikalisch Technische Bundesanstalt (PTB), Braunschweig	08/2004
Mainova Frankfurt	08/2004
Rietschle Energieplaner, Winterthur, Switzerland	08/2004
MAN Turbo Machines, Oberhausen	09/2004
TUEV Sued, Dresden	10/2004
STEAG Kraftwerk, Herne	10/2004, 12/2004
University of Weimar	10/2004
energeticals (e-concept), Munich	11/2004
SorTech, Halle	11/2004
Enertech EUT, Radebeul (company license)	11/2004
Munich University of Applied Sciences	12/2004
STORA ENSO Sachsen, Eilenburg	12/2004
Technical University of Cottbus, Chair in Power Plant Engineering	12/2004
Freudenberg Service, Weinheim	12/2004

2003

Paper Factory, Utzenstorf, Switzerland	01/2003
MAB Plant Engineering, Vienna, Austria	01/2003
Wulff Energy Systems, Husum	01/2003
Technip Benelux BV, Zoetermeer, Netherlands	01/2003
ALSTOM Power, Baden, Switzerland	01/2003, 07/2003
VER, Dresden	02/2003
Rietschle Energieplaner, Winterthur, Switzerland	02/2003
DLR, Leupholdhausen	04/2003
Emden University of Applied Sciences, Department of Technology	05/2003
Petterssson+Ahrends, Ober-Moerlen	05/2003
SOFBID ,Zwingenberg (general EBSILON program license)	05/2003
Ingenieurbuero Ostendorf, Gummersbach	05/2003
TUEV Nord, Hamburg	06/2003
Muenstermann GmbH, Telgte-Westbevern	06/2003
University of Cali, Colombia	07/2003
Atlas-Stord, Rodovre, Denmark	08/2003
ENERKO, Aldenhoven	08/2003
STEAG RKB, Leuna	08/2003
eta Energieberatung, Pfaffenhofen	08/2003
exergie, Dresden	09/2003

AWTEC, Zurich, Switzerland	09/2003
Energie, Timelkam, Austria	09/2003
Electrowatt-EKONO, Zurich, Switzerland	09/2003
LG, Annaberg-Buchholz	10/2003
FZR Forschungszentrum, Rossendorf/Dresden	10/2003
EnviCon & Plant Engineering, Nuremberg	11/2003
Visteon, Kerpen	11/2003
VEO Vulkan Energiewirtschaft Oderbruecke, Eisenhuettenstadt	11/2003
Stadtwerke Hannover	11/2003
SaarEnergie, Saarbruecken	11/2003
Fraunhofer-Gesellschaft, Munich	12/2003
Erfurt University of Applied Sciences, Department of Supply Engineering	12/2003
SorTech, Freiburg	12/2003
Mainova, Frankfurt	12/2003
Energieversorgung Halle	12/2003

2002

Hamilton Medical AG, Rhaezuens, Switzerland	01/2002
Bochum University of Applied Sciences, Department of Thermo- and Fluid Dynamics	01/2002
SAAS, Possendorf/Dresden	02/2002
Siemens, Karlsruhe (general license for the WinIS information system)	02/2002
FZR Forschungszentrum, Rossendorf/Dresden	03/2002
CompAir, Simmern	03/2002
GKS Gemeinschaftskraftwerk, Schweinfurt	04/2002
ALSTOM Power Baden, Switzerland (group licenses)	05/2002
InfraServ, Gendorf	05/2002
SoftSolutions, Muehlhausen (company license)	05/2002
DREWAG, Dresden (company license)	05/2002
SOFBID, Zwingenberg (general EBSILON program license)	06/2002
Kleemann Engineering, Dresden	06/2002
Caliqua, Basel, Switzerland (company license)	07/2002
PCK Raffinerie, Schwedt (group license)	07/2002
Fischer-Uhrig Engineering, Berlin	08/2002

Fichtner Consulting & IT, Stuttgart (company licenses and distribution)	08/2002
Stadtwerke Duisburg	08/2002
Stadtwerke Hannover	09/2002
Siemens Power Generation, Goerlitz	10/2002
Energieversorgung Halle (company license)	10/2002
Bayer, Leverkusen	11/2002
Dillinger Huette, Dillingen	11/2002
G.U.N.T. Geraetebau, Barsbuettel (general license and training test benches)	12/2002
VEAG, Berlin (group license)	12/2002

2001

ALSTOM Power, Baden, Switzerland	01/2001, 06/2001, 12/2001
KW2 B. V., Amersfoot, Netherlands	01/2001, 11/2001
Eco Design, Saitamaken, Japan	01/2001
M&M Turbine Technology, Bielefeld	01/2001, 09/2001
MVV Energie, Mannheim	02/2001
Technical University of Dresden, Department of Power Machinery and Plants	02/2001
PREUSSAG NOELL, Wuerzburg	03/2001
Fichtner Consulting & IT Stuttgart (company licenses and distribution)	04/2001
Muenstermann GmbH, Telgte-Westbevern	05/2001
SaarEnergie, Saarbruecken	05/2001
Siemens, Karlsruhe (general license for the WinIS information system)	08/2001
Neusiedler AG, Ulmerfeld, Austria	09/2001
h s energieanlagen, Freising	09/2001
Electrowatt-EKONO, Zurich, Switzerland	09/2001
IPM Zittau/Goerlitz University of Applied Sciences (general license)	10/2001
eta Energieberatung, Pfaffenhofen	11/2001
ALSTOM Power Baden, Switzerland	12/2001
VEAG, Berlin (group license)	12/2001

2000

SOFBID, Zwingenberg (general EBSILON program license)	01/2000
AG KKK - PGW Turbo, Leipzig	01/2000

PREUSSAG NOELL, Wuerzburg	01/2000
M&M Turbine Technology, Bielefeld	01/2000
IBR Engineering Reis, Nittendorf-Undorf	02/2000
GK, Hannover	03/2000
KRUPP-UHDE, Dortmund (company license)	03/2000
UMAG W. UDE, Husum	03/2000
VEAG, Berlin (group license)	03/2000
Thinius Engineering, Erkrath	04/2000
SaarEnergie, Saarbruecken	05/2000, 08/2000
DVO Data Processing Service, Oberhausen	05/2000
RWTH Aachen University	06/2000
VAUP Process Automation, Landau	08/2000
Knuerr-Lommatec, Lommatzsch	09/2000
AVACON, Helmstedt	10/2000
Compania Electrica, Bogota, Colombia	10/2000
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

1999

Bayernwerk, Munich	01/1999
DREWAG, Dresden (company license)	02/1999
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

1998

Technical University of Cottbus, Chair in Power Plant Engineering	05/1998
Fichtner Consulting & IT (CADIS information systems) Stuttgart (general KPRO program license)	05/1998
M&M Turbine Technology Bielefeld	06/1998
B+H Software Engineering Stuttgart	08/1998
Alfa Engineering, Switzerland	09/1998

VEAG Berlin (group license)	09/1998
NUTEC Engineering, Bisikon, Switzerland	10/1998
SCA Hygiene Products, Munich	10/1998
RWE Energie, Neurath	10/1998
Wilhelmshaven University of Applied Sciences	10/1998
BASF, Ludwigshafen (group license)	11/1998
Energieversorgung, Offenbach	11/1998

1997

Gerb, Dresden	06/1997
Siemens Power Generation, Goerlitz	07/1997