KCE
ThermoFluidProperties

Property Library for Combustion Gas Mixtures calculated from VDI-Guideline 4670

FluidEXL *Graphics* Stud with LibldGas_Stud for Excel®

Student Version

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Software for the Calculation of the Properties of Combustion Gas Mixtures calculated from VDI-Guideline 4670

Including DLL and Add-In for Excel®

FluidEXL*Graphics*Stud
LibIdGas_Stud

Contents

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0 Package Contents

0.1 Zip file for 64-bit Office®

The following zip file is delivered for your computer running a 64 bit Office® version
"CD_FluidEXL_Graphics_Eng_LibIF97_x64.zip"
including the following files and folders:

setup.exe	- Self-extracting and self-installing program for FluidEXLGraphics
FluidEXL_Graphics_Eng_64_Setup.msi	- Self-extracting and self-installing program
FluidEXL_Graphics_Eng_LibIF97_Docu.pdf	- User's Guide

0.2 Zip file for 32-bit Office®

The following zip file is delivered for your computer running a 32 bit Office® version
"CD_FluidEXL_Graphics_Eng_LibIF97.zip"
including the following files:

setup.exe	- Self-extracting and self-installing program for FluidEXL*Graphics*
FluidEXL_Graphics_Eng_Setup.msi	- Self-extracting and self-installing program
FluidEXL_Graphics_Eng_LibIF97_Docu.pdf	- User's Guide

1. Property Functions

1.1 Range of Validity and Structure of the Program Library

The thermodynamic properties of combustion gas mixtures in the ideal gas state are calculated corresponding to the

VDI Guideline 4670 [21].

The transport properties are calculated corresponding to

Brandt [15] and VDI-Wärmeatlas [19].

Important property constants were taken from the compendium from *Blanke* [20].

The mixture can contain the following components:

Number	Component	
1	Argon	Ar
2	Neon	Ne
3	Nitrogen	N_2
4	Oxygen	O_2
5	Carbon monoxide	CO
6	Carbon dioxide	CO_2
7	Steam	H_2O
8	Sulfur dioxide	SO_2
9	Air (dry)	
10	Air nitrogen	

Range of validity:

Temperature *t*: from -30 °C to 1500 °C

Mixture pressure *p*: from >0 bar to 10 bar

For temperatures above 1000 °C and mole fractions of oxygen of more than 1 % ($\psi_{O_2} \geq 0.01$) the dissociation based on the VDI 4670 for the gases nitrogen, oxygen, carbon dioxide, steam, and sulfur dioxide are considered. For programming reasons, the calculation of the correction for the dissociation is already carried out from 500 °C.

1.2 Property Functions for Ideal Gas Mixtures

Functional Dependence	Function Name	Property or Function	Unit of the Result	Reference	Page
$c_p = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	cp_pt_id_stud	Specific isobaric heat capacity	kJ/(kg · K)	[18]	3/2
$\eta = f(t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	Eta_t_id_stud	Dynamic viscosity	Pa·s = kg/(m·s)	[15], [18]	3/4
$h = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	h_pt_id_stud	Specific enthalpy	kJ/kg	[18]	3/5
$\kappa = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	Kappa_pt_id_stud	Isentropic exponent		[18]	3/6
$\lambda = f(t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	Lambda_t_id_stud	Thermal conductivity	W/(m · K)	[15]	3/7
$M = f(\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	M_id_stud	Molar mass of the mixture	kg/kmol	[17]	3/8
$\psi_i = f(i,\xi_1 \ldots \xi_{10})$	Psi_igas_Xsi_id_stud	Mole fraction of the mixture gas i from the mass fractions of all mixture gases	kmol/kmol	Mixture calculation	3/13
$R = f(\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	R_id_stud	Specific gas constant	kJ/(kg · K)	[17]	3/14
$s = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	s_pt_id_stud	Specific entropy of the mixture	kJ/(kg · K)	[18]	3/16
$t = f(p,h,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	t_ph_id_stud	Backward Function: Temperature from pressure and enthalpy of the mixture	°C	[18]	3/17
$t = f(p,s,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	t_ps_id_stud	Backward Function: Temperature from pressure and entropy of the mixture	°C	[18]	3/18
$v = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	v_pt_id_stud	Specific volume	m^3/kg	Ideal gas equation	3/21
$\xi_i = f(i,\psi_1 \ldots \psi_{10})$	Xsi_igas_Psi_id_stud	Mass fraction of the mixture gas i from the mole fractions of all mixture gases	kg/kg	Mixture calculation	3/23
$v = f(p,t,\xi_1 \ldots \xi_{10}$ or $\psi_1 \ldots \psi_{10})$	v_pt_id_stud	Specific volume	m^3/kg	Ideal gas equation	3/21
$\xi_i = f(i,\psi_1 \ldots \psi_{10})$	Xsi_igas_Psi_id_stud	Mass fraction of the mixture gas i from the mole fractions of all mixture gases	kg/kg	Mixture calculation	3/23

Units:

Symbol	Name	Unit
t	Temperature	°C
p	Mixture pressure	bar
ξ_1 ... ξ_{10}	Mass fractions of the components	kg/kg
ψ_1... ψ_{10}	Mole fractions, volume fractions of the components	kmol/kmol
type	Input: type = 1 for mass fractions ξ_1, ... ξ_{10} type = 0 for mole fractions ψ_1, ... ψ_{10}	
comp(1:10) for type =1	Mass fractions ξ_1, ... ξ_{10}	kg/kg
comp(1:10) for type =0	Mole fractions ψ_1, ... ψ_{10}	kmol/kmol

Mixture Gases:

Gas	Mixture gas	
1	Argon	Ar
2	Neon	Ne
3	Nitrogen	N_2
4	Oxygen	O_2
5	Carbon monoxide	CO
6	Carbon dioxide	CO_2
7	Steam	H_2O
8	Sulfur dioxide	SO_2
9	Air (dry) from VDI4670 [21]	Composition in mole fractions: 78.1109 % N_2 20.9548 % O_2 0.9343 % Ar Composition in mass fractions: 75.5577 % N_2 23.1535 % O_2, 1.2888 % Ar
10	Air nitrogen from *Brandt* [15]	Composition in mole fractions: 98.8180 % N_2 1.1820 % Ar Composition in mass fractions: 98.3229 % N_2 1.6771 % Ar

Range of Validity:

Temperature:	t = -73.15 °C ... 3026.85 °C
Pressure:	p = 0.01 mbar ... 50 bar

Reference States:

Property	Gases (except steam)	Steam
Pressure	1.01325 bar	0.006112127 bar
Temperature	0.0 °C	0 °C
Enthalpy	0 kJ/kg	0 kJ/kg
Entropy	0 kJ/kg K	0 kJ/(kg K)

Variable Types for Function Call:

All functions:	Double
Variable p, t, v, h, s :	Double
Variable to [1..10] :	Array of Double
Variable type, i :	Integer

Note:

If the input values are located outside the range of validity or if they do not fit together, the chosen function to be calculated results in -1.

2. Application of FluidEXL*Graphics*Stud in Excel®

The FluidEXL*Graphics*Stud Add-In has been developed to calculate thermodynamic properties in Excel® more conveniently. Within Excel®, it enables the direct call of functions from the LibIdGas_Stud property library.

2.1 Installing FluidEXL*Graphics*Stud

Complete the following steps for initial installation of FluidEXL*Graphics*Stud.
The installation routine for 32 bit and 64 bit versions of Excel is similar.
The following instructions are valid for both versions.

After you have downloaded and extracted the zip-file

for 64-bit version of Excel:

"CD_FluidEXL_Graphics_Stud_LibIdGas_64.zip"

for 32-bit version of Excel:

"CD_FluidEXL_Graphics_Stud_LibIdGas.zip"

you will see the folder

for 64-bit version of Excel:

\CD_FluidEXL_Graphics_Stud_LibIdGas_64\

for 32-bit version of Excel:

\CD_FluidEXL_Graphics_Stud_LibIdGas\

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 for 64 bit version of Excel

FluidEXL_Graphics_Stud_LibIdGas_Docu
FluidEXL_Graphics_Stud_Setup_64.msi
Setup_Stud_64.exe

or for 32-bit version of Excel

FluidEXL_Graphics_Stud_LibIdGas_Docu
FluidEXL_Graphics_Stud_Setup.msi
Setup_Stud.exe.

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

Setup_Stud_64.exe (for 64 bit version of Excel)

or

Setup_Stud.exe. (for 32 bit version of Excel).

If problems with Visual C++ runtime library appear then doubleclick the following

FluidEXL_Graphics_Stud_Setup_64.msi (for 64 bit version of Excel)
FluidEXL_Graphics_Stud_Setup.msi (for 32 bit version of Excel)

to install FluidEXL*Graphics*Stud.

The installation of FluidEXL*Graphics*Stud starts with a window telling you 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*Stud is

C:\Program Files\FluidEXL_Graphics_Stud (for 64 bit version of Excel)
C:\Program Files (x86)\FluidEXL_Graphics_Stud (for 32 bit version of Excel)

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

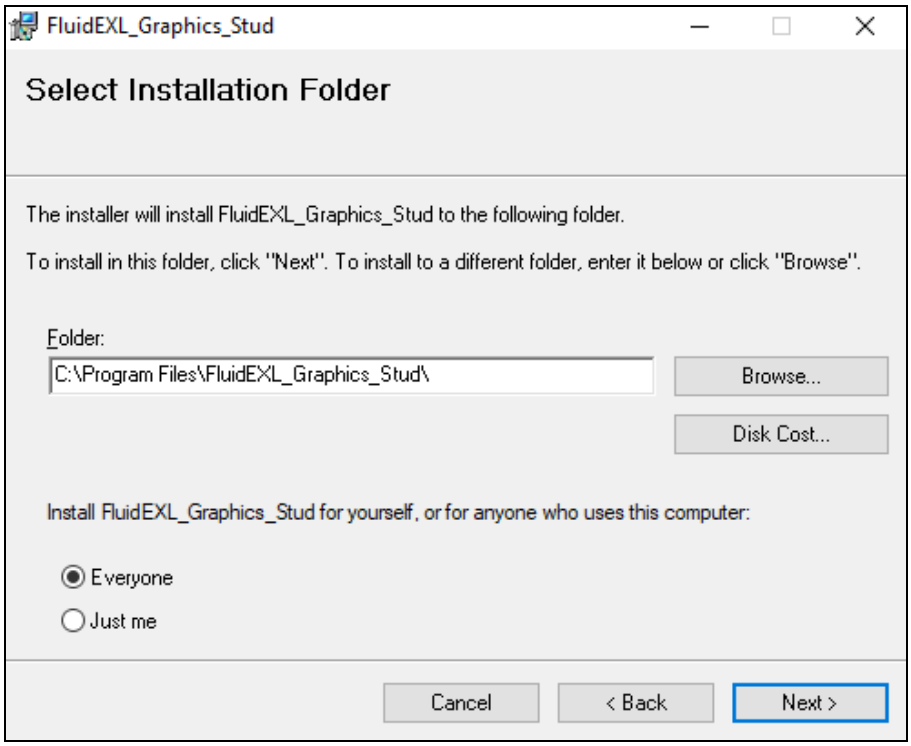

Figure 2.1: Choosing the Installation Folder of FluidEXL*Graphics*Stud

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*Stud.

After FluidEXL*Graphics*Stud has been installed, you will see the sentence "FluidEXL_Graphics_Stud has been successfully installed". Confirm this by clicking the "Close" button.

Note:

The standard file path for the 32 bit and the 64 bit versions of FluidEXL*Graphics*Stud is different. In the following sections the standard path file from the 64 bit version is used.

2.2 Registering FluidEXL*Graphics*Stud as Add-In in Excel®

After installation in Windows®, FluidEXL*Graphics*Stud must be registered in Excel® as an Add-In. To do this, start Excel® and carry out the following steps:

- Click the "File" button in the upper left hand corner of Excel® (see Figure 2.2)

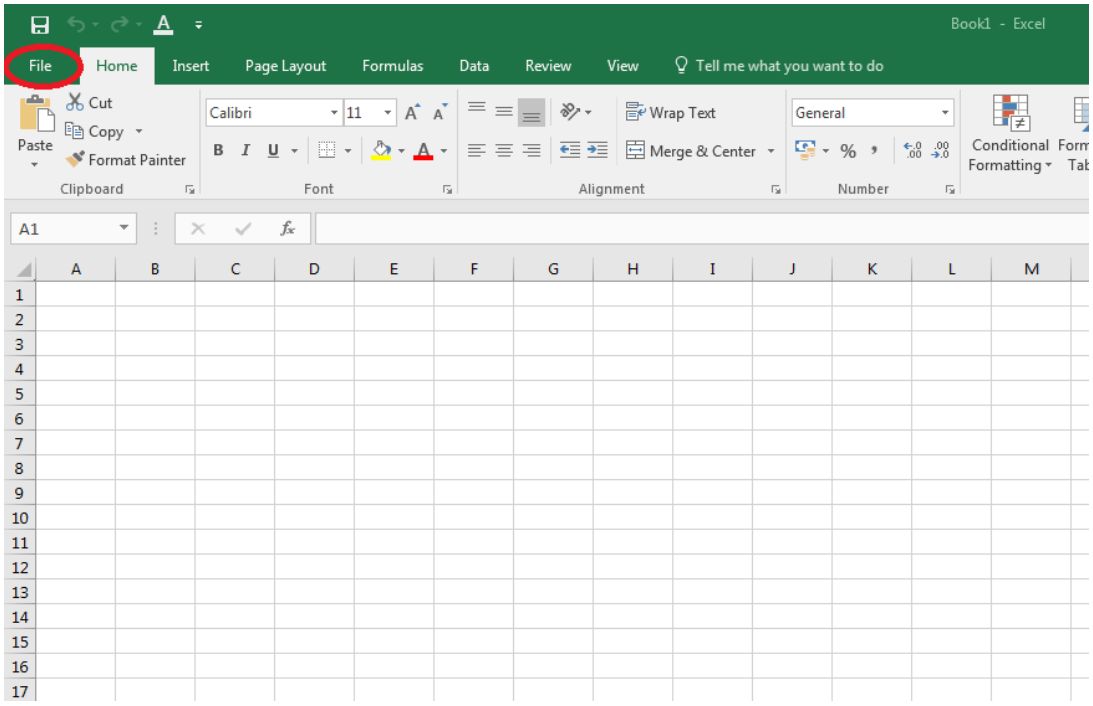

Figure 2.2: Registering FluidEXL*Graphics*Stud as Add-In in Excel®

- Click on the "Options" button in the menu which appears (see Figure 2.3)

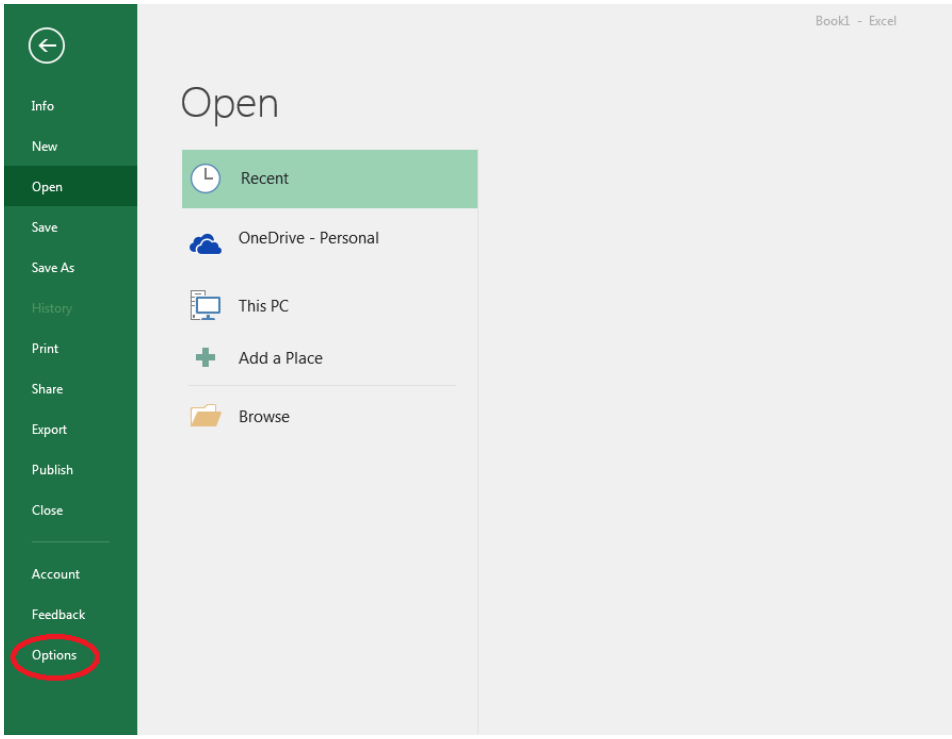

Figure 2.3: Registering FluidEXL*Graphics*Stud as Add-In in Excel®

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

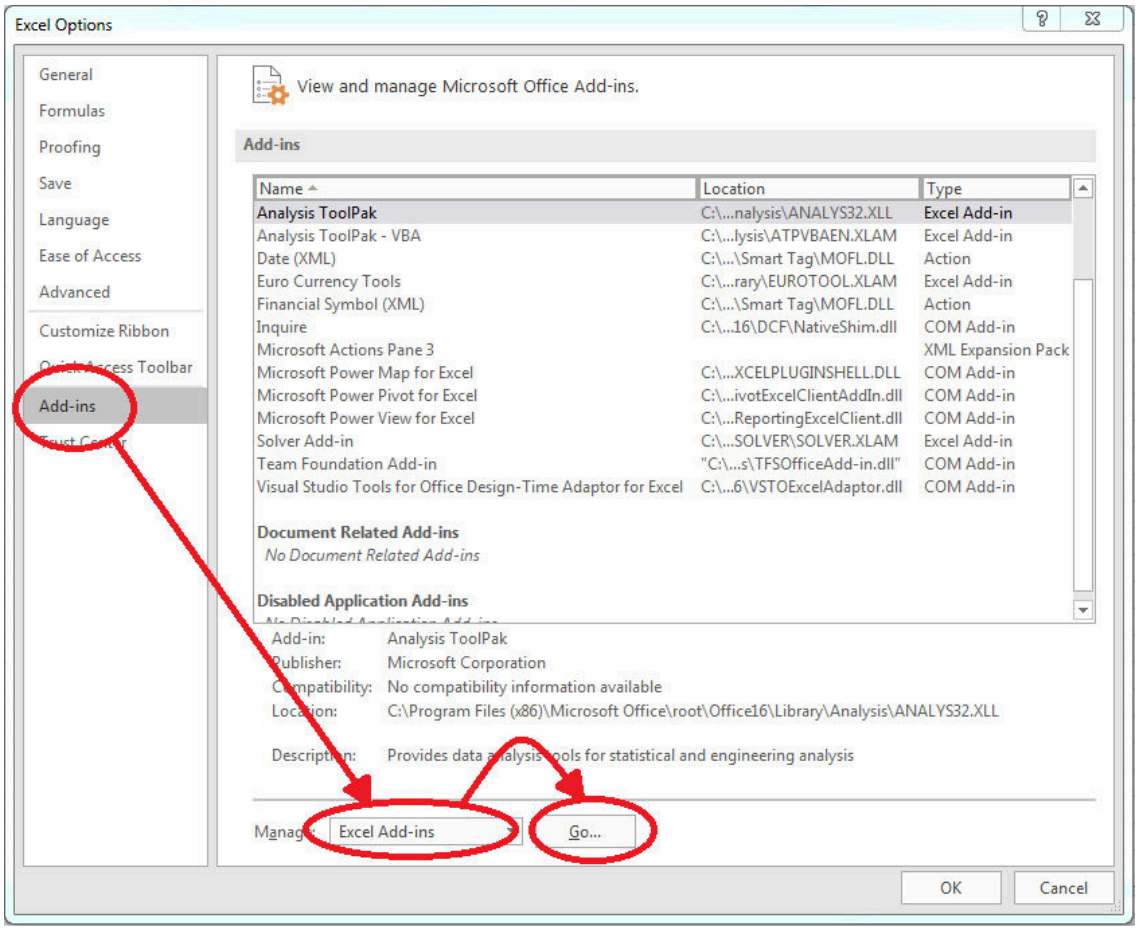

Figure 2.4: Dialog window "Excel Options"

- 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.
  The dialog box shown in Figure 2.5 appears.

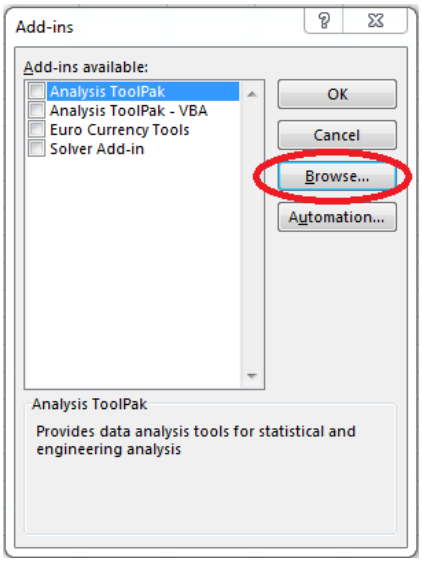

Figure 2.5: Dialog window "Add-Ins available"

Click "Browse" in this window and locate the destination folder, generally

C:\Program Files\FluidEXL_Graphics_Stud\ (for Excel 64 bit) or

C:\Program Files (x86)\FluidEXL_Graphics_Stud\ (for Excel 32 bit).

Now click on the file

"FluidEXL_Graphics_Stud.xla"

and then click "OK."

- Now, "FluidEXL Graphics Eng" will be shown in your list of Add-Ins; see Figure 2.6. (If a checkmark is in the box next to the name "FluidEXL Graphics Eng", this Add-In will automatically be loaded whenever Excel starts. This will continue to occur unless the checkmark is removed from the box by clicking on it.)
- In order to register the Add-In click the "OK" button in the "Add-Ins" window.

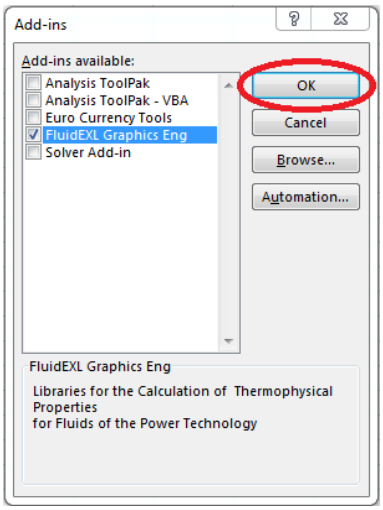

Figure 2.6: Dialog window "Add-Ins"

In order to use FluidEXL*Graphics*Stud in the following example, click on the menu item "Add-Ins" shown in Figure 2.7.

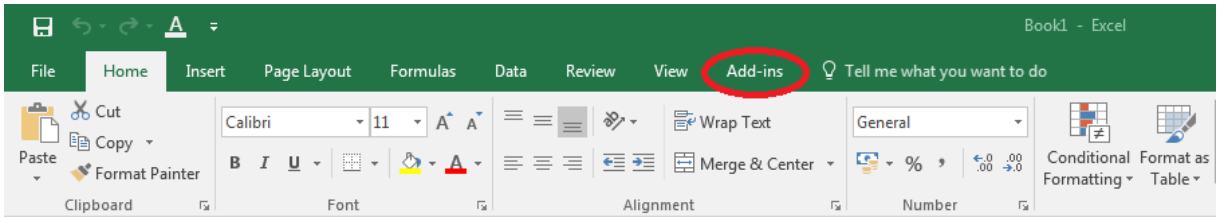

Figure 2.7: Menu item "Add-Ins"

In the upper menu region of Excel®, the FluidEXL*Graphics*Stud menu bar will appear as marked with the red circle in the next figure (Figure 2.8).

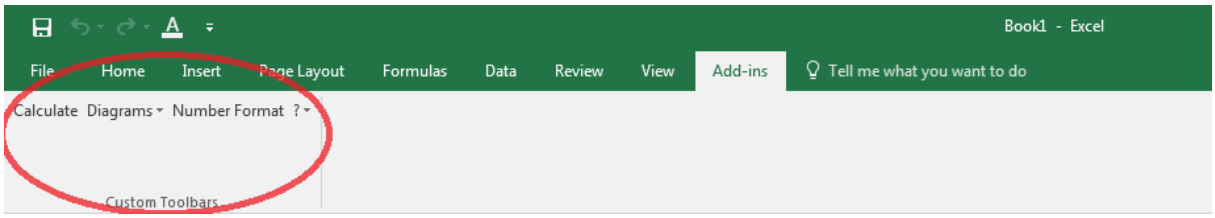

Figure 2.8: FluidEXL*Graphics*Stud menu bar

Installation of FluidEXL*Graphics*Stud in Excel® is now complete.

An example calculation of "LibIdGas_Stud" DLL library property functions can be found in chapter 2.3.

2.3 Example calculation

Now we will calculate, step by step, the specific enthalpy *h* as a function of mixture pressure p = 1 bar, temperature t = 100 °C for a given mixture composed of the following mass fractions using FluidEXL*Graphics*.

13 % Carbon dioxide, 11 % Steam, 76 % Air nitrogen.

From the gas classification in the program library (table: mixture gases) in chapter 1.2 follows:

Gas	Number	Mass fraction
Carbon dioxide	6	$\xi_6 = 13\,\%$
Steam	7	$\xi_7 = 11\,\%$
Air nitrogen	10	$\xi_{10} = 76\,\%$

Please carry out the following steps:

- Start Excel®
- Prepare an Excel book like the example book shown in Figure 2.14

	A	B	C	D	E	F	G	H
1	No.	Mixture Gas	Xsi in kg/kg	Psi in kmol/kmol	type	p in bar	t in °C	h in kJ/kg
2	1	Argon	0					
3	2	Neon	0					
4	3	Nitrogen	0					
5	4	Oxygen	0					
6	5	Carbon monoxide	0					
7	6	Carbon dioxide	0.13					
8	7	Steam	0.11					
9	8	Sulfur dioxide	0					
10	9	Air - dry	0					
11	10	Air - Nitrogen	0.76					

Figure 2.14: Example worksheet for the calculation

- Enter the value for *p* in bar into a cell
  (Range of validity: p = 0.01 mbar ... 50 bar)

  ⇒ e.g.: Enter the value 1 into cell F2

- Enter the value for *t* in °C into a cell
  (Range of validity: t = - 73.15 °C ... 3026.85 °C)

  ⇒ e.g.: Enter the value 100 into cell G2

- Enter the code "type" for the identification of mole fraction or mass fraction as input value into a cell:

  type = 1 for mass fraction as input value
  type = 0 for mole fraction as input value

  ⇒ e.g.: Enter the type 1 into cell E2

- Enter the value for the mass fractions ξ_1 ... ξ_{10} of the mixture gases into the cells:

ξ_1 for argon Ar ⇒ e. g.: Enter the value 0 into cell C2

ξ_2	for neon	Ne	⇒ e. g.: Enter the value 0	into cell C3
ξ_3	for nitrogen	N_2	⇒ e. g.: Enter the value 0	into cell C4
ξ_4	for oxygen	O_2	⇒ e. g.: Enter the value 0	into cell C5
ξ_5	for carbon monoxide	CO	⇒ e. g.: Enter the value 0	into cell C6
ξ_6	for carbon dioxide	CO_2	⇒ e. g.: Enter the value 0.13	into cell C7
ξ_7	for steam	H_2O	⇒ e. g.: Enter the value 0.11	into cell C8
ξ_8	for sulfur dioxide	SO_2	⇒ e. g.: Enter the value 0	into cell C9
ξ_9	for air nitrogen (dry)		⇒ e. g.: Enter the value 0	into cell C10
ξ_{10}	for air nitrogen		⇒ e. g.: Enter the value 0.76	into cell C11

- Make sure, the Excel book looks like the example book shown in Figure 2.15

	A	B	C	D	E	F	G	H
1	No.	Mixture Gas	Xsi in kg/kg	Psi in kmol/kmol	type	p in bar	t in °C	h in kJ/kg
2	1	Argon	0		1	1	100	
3	2	Neon	0					
4	3	Nitrogen	0					
5	4	Oxygen	0					
6	5	Carbon monoxide	0					
7	6	Carbon dioxide	0.13					
8	7	Steam	0.11					
9	8	Sulfur dioxide	0					
10	9	Air - dry	0					
11	10	Air - Nitrogen	0.76					
12								

Figure 2.15: Example book after input of given parameters

Note:

It is not necessary to enter the value 0 into the cells because Excel interprets them to be empty cells.

- Click the cell in which the enthalpy *h* in kJ/kg is to be displayed
  ⇒ e.g.: Click on the cell H2

- Click "Calculate" in the menu bar of FluidEXL*Graphics*
  Now, the "Insert Function" window appears (see Figure 2.16.)

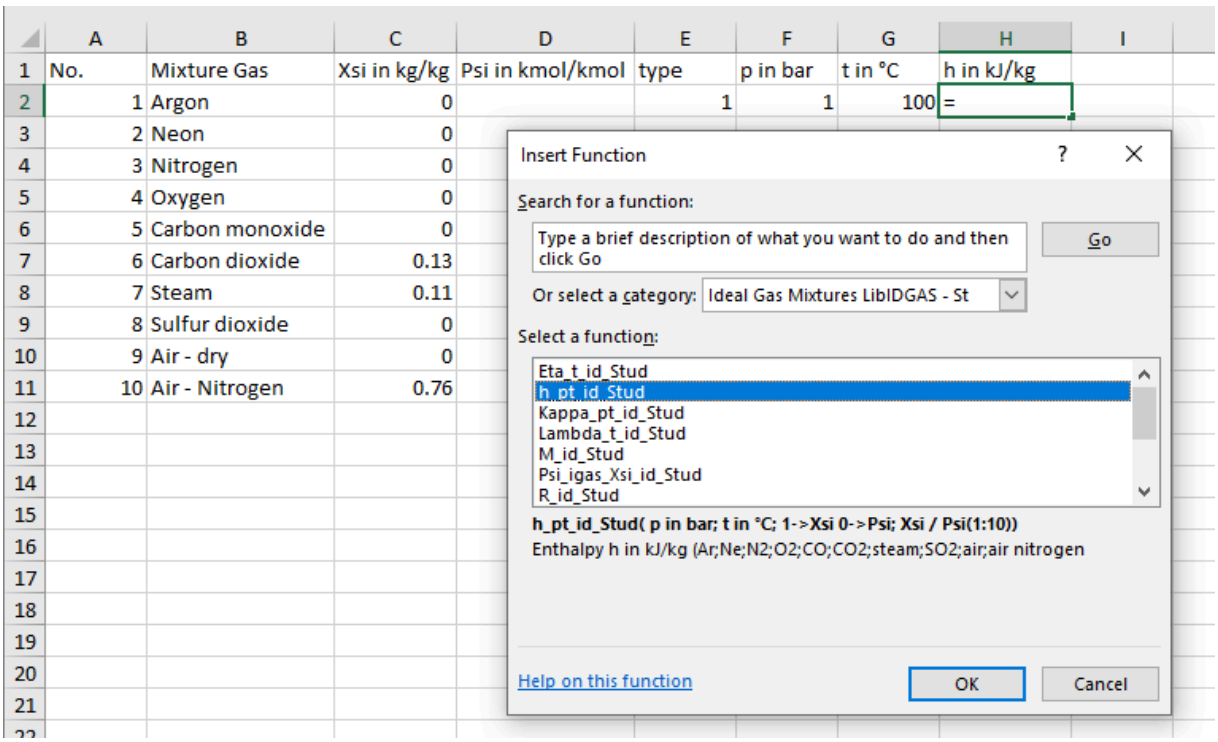

Figure 2.16: Choice of library and function name

- Search and click the "Ideal Gas Mixtures LibIdGas_Stud" library under "Or select a category:" in the upper part of the window.
- Search and click the "h_pt_id" function under "Select a function:" right below.

  Here it is possible to get more information on the range of validity, measuring units, error responses, etc. by clicking on the "Help on this function" link below.
- Click the "OK" button
  The window shown in the next figure will now appear.

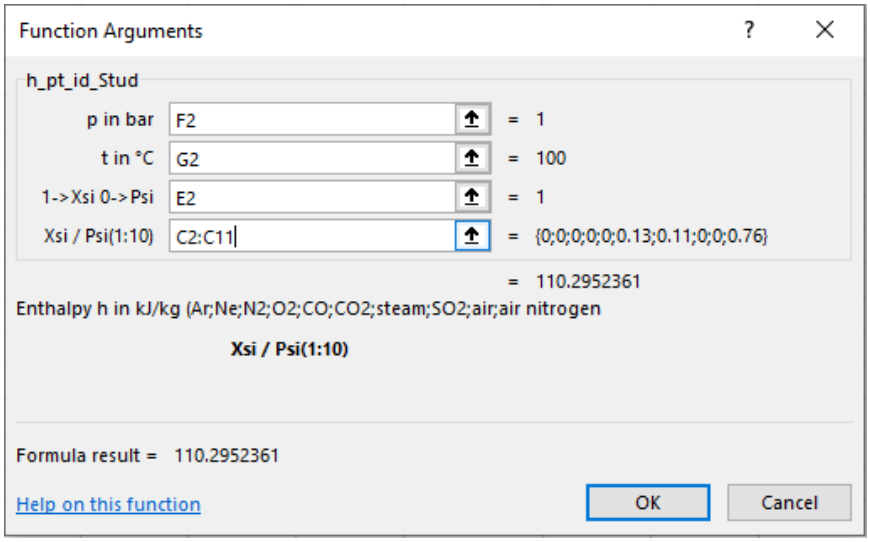

Figure 2.17: Input menu for the function

- The cursor is situated on the line next to "p in bar". You can now enter the value for the mixture pressure *p* either by clicking the cell with the value for *p*, by entering the name of the cell with the value for *p*, or by entering the value for *p* directly.
  ⇒ e. g.: Click on the cell F2

- Situate the cursor next to "t in °C" and enter the value for *t* by clicking the cell with the value for *t*, by entering the name of the cell with the value for *t*, or by entering the value for *t* directly.
  ⇒ e. g.: Type G2 into the window next to "t in °C"

- Situate the cursor next to "1->Xsi 0->Psi" and enter the value for the type by clicking the cell with the value for the type, by entering the name of the cell with the value for the type or by entering the value for the type directly

  type = 1 for composition in mass fractions $\xi_1 \ldots \xi_{10}$
  = 0 for composition in mole fractions $\psi_1 \ldots \psi_{10}$

  ⇒ e. g.: Click on the cell E2

- Situate the cursor next to "Xsi / Psi(1:10)". Click on the cell with the mass or mole fraction of argon. Now the cursor changes to a cross. Mark the other cells with the fractions ξ_2 to ξ_{10} for neon/ nitrogen/ oxygen/ carbon monoxide/ carbon dioxide/ steam/ sulfur dioxide/ air(dry)/ air nitrogen. The marked sector appears on the line next to "Xsi / Psi(1:10)". This step can also be finished by typing the sector of the fractions directly on the line next to "Xsi / Psi(1:10)".

  ⇒ e. g.: Click on the cell C2 and mark the cells C3 to C11 with pushed mouse button
  "C2:C11" appears on the line next to "Xsi / Psi(1:10)"

- Click "OK"
  The result for *h* in kJ/kg appears in the cell selected above.
  ⇒ The result in our sample calculation here is: h = 110.2952361.

The calculation of $h = f(p,t,\xi_1 \ldots \xi_{10})$ has thus been completed.

You can now arbitrarily change the values for *p*, *t* or $\xi_1 \ldots \xi_{10}$ 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:

The mass or mole fractions of the ten gas mixtures can be arranged in a column or a row but they have to be in the correct order and there should not be empty cells in it.

If the input values are located outside the range of validity of the LibIdGas_Stud or they do not fit together, the result of the calculated function will always be -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.

2.4 Removing FluidEXL*Graphics*Stud

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

- Click the “File” button in the upper left corner of Excel®
- Click on the "Options" button in the menu which appears

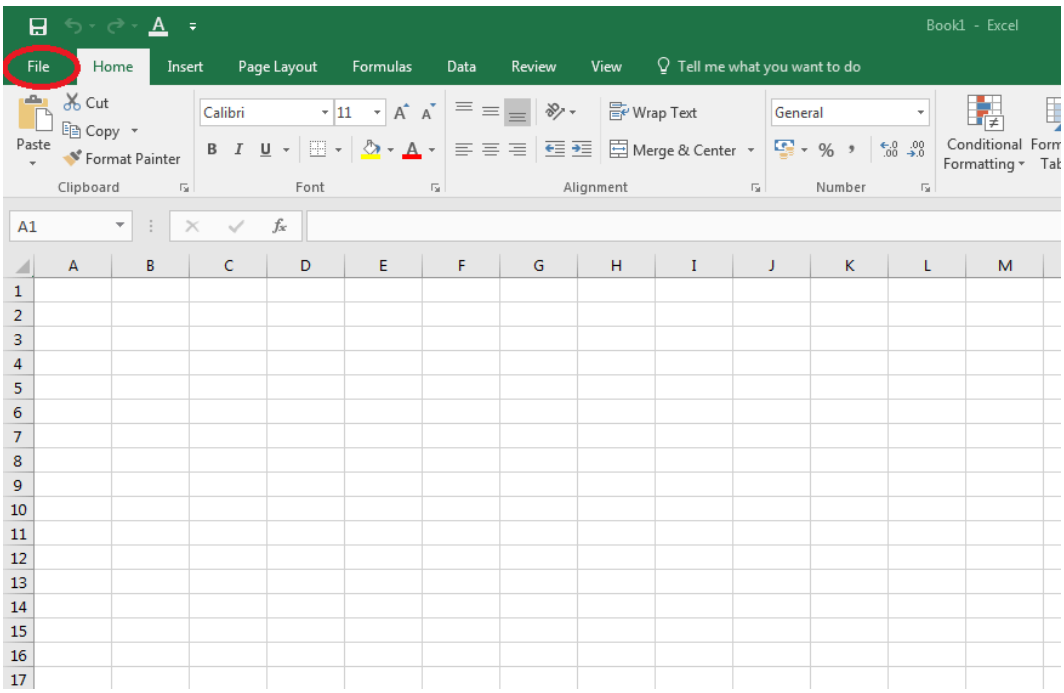

Figure 2.18: Unregistering FluidEXL*Graphics*Stud as Add-In in Excel®

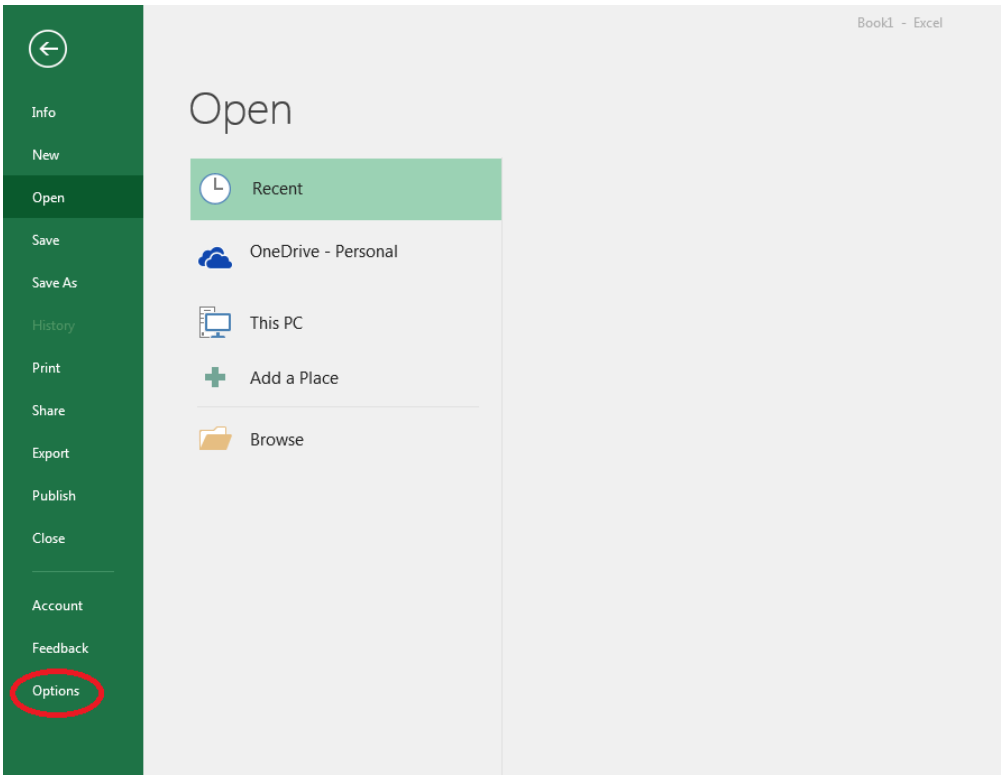

Figure 2.19 Unregistering FluidEXL*Graphics*Stud as Add-In in Excel®

- Click on "Add-Ins" in the next menu (Figure 2.19)

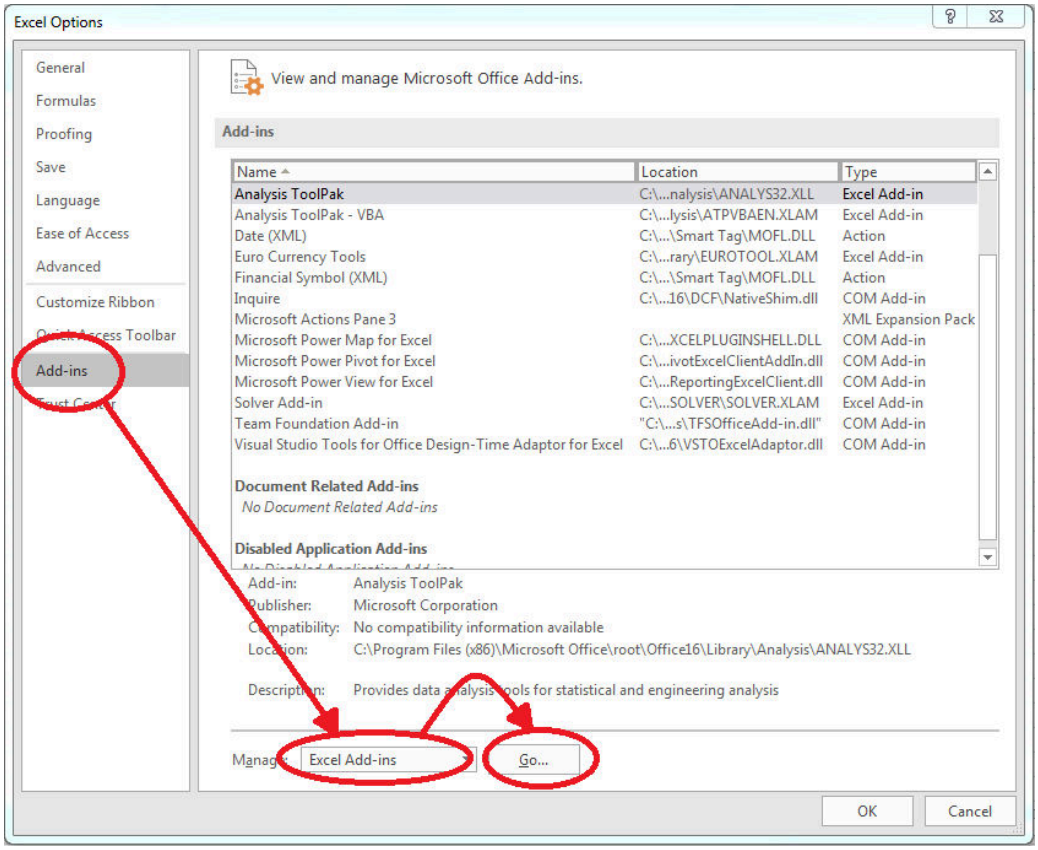

Figure 2.20: Dialog window "Add-Ins"

- 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 Stud"

  in the window which now appears. Click the "OK" button to confirm your entry.

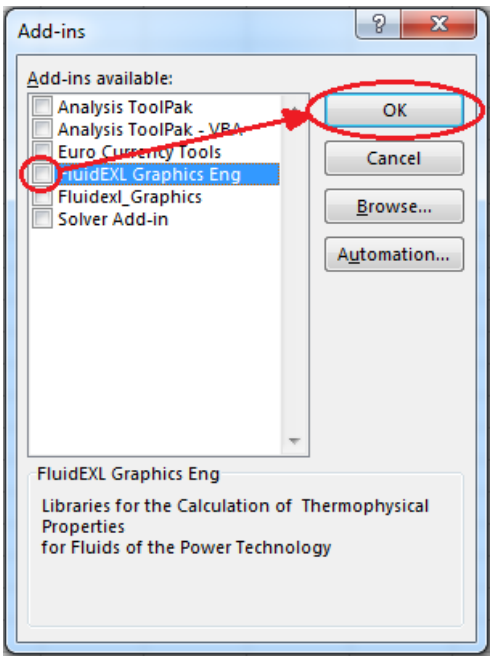

Figure 2.20: Dialog window "Add-Ins"

In order to remove FluidEXL*Graphics*Stud 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 Stud"

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*Stud has been completely removed from your computer.

KCE ThermoFluidProperties

KCE-ThermoFluidProperties
www.thermofluidprop.com

Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

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

Water and Steam

Library LibIF97

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

Library LibIF97_META

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

Humid Combustion Gas Mixtures

Library LibHuGas

Model: Ideal mixture of the real fluids:

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

and of the ideal gases:
SO_2, CO, Ne
(Scientific Formulation of Bücker et al.)

Consideration of:

- Dissociation from VDI 4670
- Poynting effect

Humid Air

Library LibHuAir

Model: Ideal mixture of the real fluids:

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

Consideration of:

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

Extremely Fast Property Calculations

Spline-Based Table Look-up Method (SBTL)

Library LibSBTL_IF97
Library LibSBTL_95
Library LibSBTL_HuAir

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

Carbon Dioxide Including Dry Ice

Library LibCO2

Formulation of Span and Wagner (1996)

Seawater

Library LibSeaWa

IAPWS Industrial Formulation 2013

Ice

Library LibICE

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

Ideal Gas Mixtures

Library LibIdGasMix

Model: Ideal mixture of the ideal gases:

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

Consideration of:

- Dissociation from the VDI Guideline 4670

Library LibIDGAS

Model: Ideal gas mixture from VDI Guideline 4670

Consideration of:

- Dissociation from the VDI Guideline 4670

Humid Air

Library ASHRAE LibHuAirProp

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

Consideration of:

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

www.ashrae.org/bookstore

Dry Air Including Liquid Air

Library LibRealAir

Formulation of Lemmon et al. (2000)

Refrigerants

Ammonia

Library LibNH3

Formulation of Tillner-Roth et al. (1993)

R134a

Library LibR134a

Formulation of Tillner-Roth and Baehr (1994)

Iso-Butane

Library LibButane_Iso

Formulation of Bücker and Wagner (2006)

n-Butane

Library LibButane_n

Formulation of Bücker and Wagner (2006)

Mixtures for Absorption Processes

Ammonia/Water Mixtures

Library LibAmWa

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

Helmholtz energy equation for the mixing term

(also useable for calculating the Kalina Cycle)

Water/Lithium Bromide Mixtures

Library LibWaLi

Formulation of Kim and Infante Ferreira (2004)

Gibbs energy equation for the mixing term

Liquid Coolants

Liquid Secondary Refrigerants

Library LibSecRef

Liquid solutions of water with

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

Formulation of the International Institute of Refrigeration (IIR 2010)

Ethanol

Library LibC2H5OH

Formulation of
Schroeder et al. (2014)

Methanol

Library LibCH3OH

Formulation of
de Reuck and Craven (1993)

Propane

Library LibPropane

Formulation of
Lemmon et al. (2009)

Siloxanes as ORC Working Fluids

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

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

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

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

Formulation of Colonna et al. (2006)

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

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

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

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

Formulation of Colonna et al. (2008)

Nitrogen and Oxygen

Libraries LibN2 and LibO2

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

Hydrogen

Library LibH2

Formulation of
Leachman et al. (2009)

Helium

Library LibHe

Formulation of
Arp et al. (1998)

Hydrocarbons

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

Isopentane C_5H_{12} **Library LibC5H12_Iso**

Neopentane C_5H_{12} **Library LibC5H12_Neo**

Isohexane C_6H_{14} **Library LibC6H14**

Toluene C_7H_8 **Library LibC7H8**

Formulation of Lemmon and Span (2006)

Further Fluids

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

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

Hydrogen sulfide H_2S **Library LibH2S**

Nitrous oxide N_2O **Library LibN2O**

Sulfur dioxide SO_2 **Library LibSO2**

Acetone C_3H_6O **Library LibC3H6O**

Formulation of Lemmon and Span (2006)

KCE ThermoFluidProperties

For more information please contact:

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01307 Dresden, Germany

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

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

Thermodynamic Properties

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

Transport Properties

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

Backward Functions

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

Thermodynamic Derivatives

- Partial derivatives used in process modeling can be calculated.

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

www.thermofluidprop.com

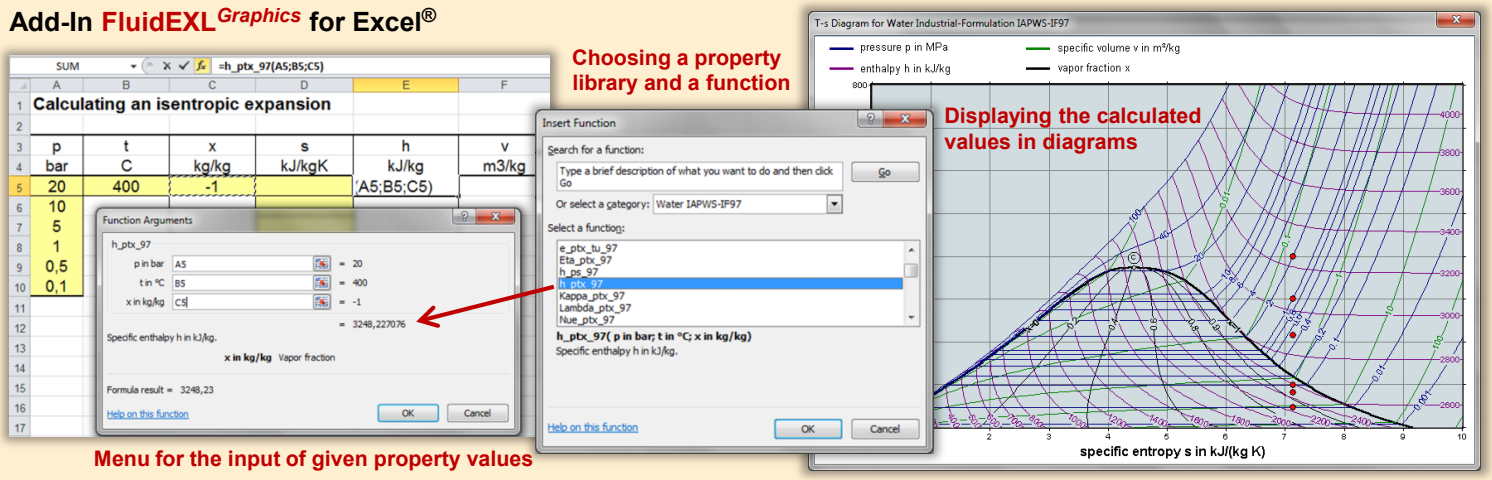
KCE-ThermoFluidProperties
www.thermofluidprop.com

KCE ThermoFluidProperties

Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

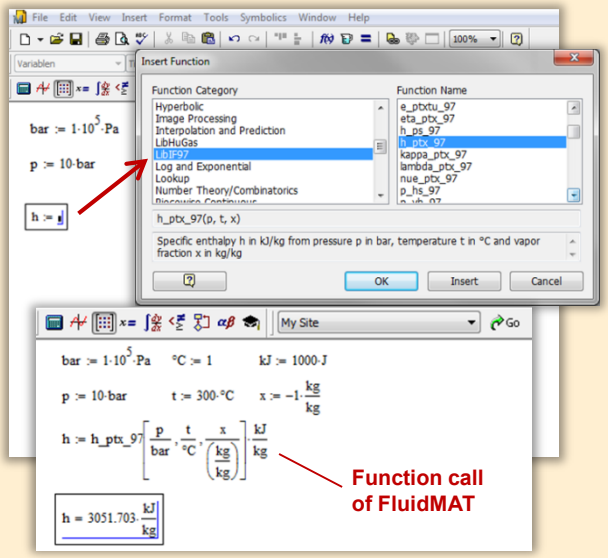
Property Software for Calculating Heat Cycles, Boilers, Turbines and Refrigerators

Add-In FluidEXL*Graphics* for Excel®



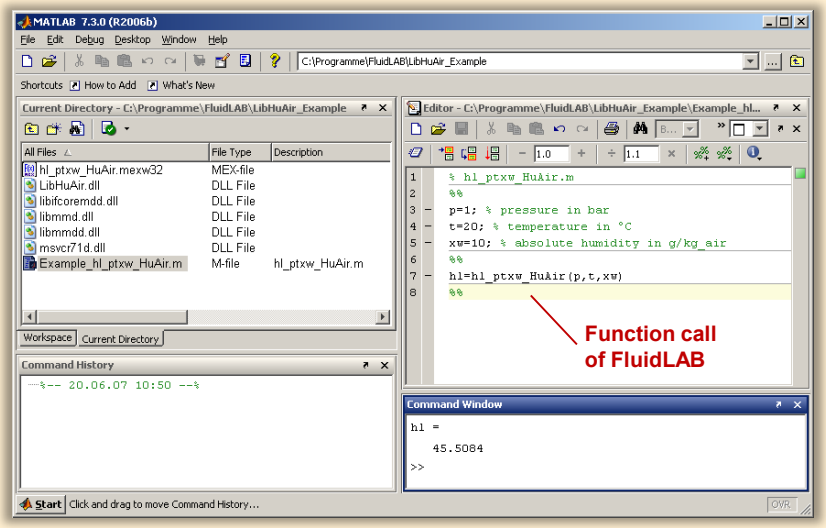
Add-On FluidMAT for Mathcad®
Add-On FluidPRIME for Mathcad Prime®

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



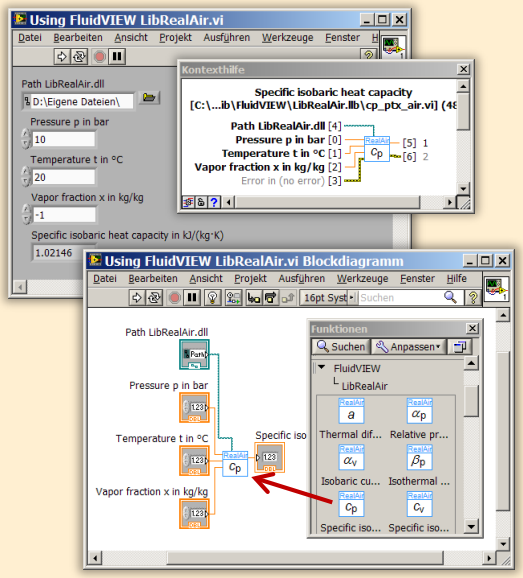
Add-On FluidLAB for MATLAB® and SIMULINK®

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



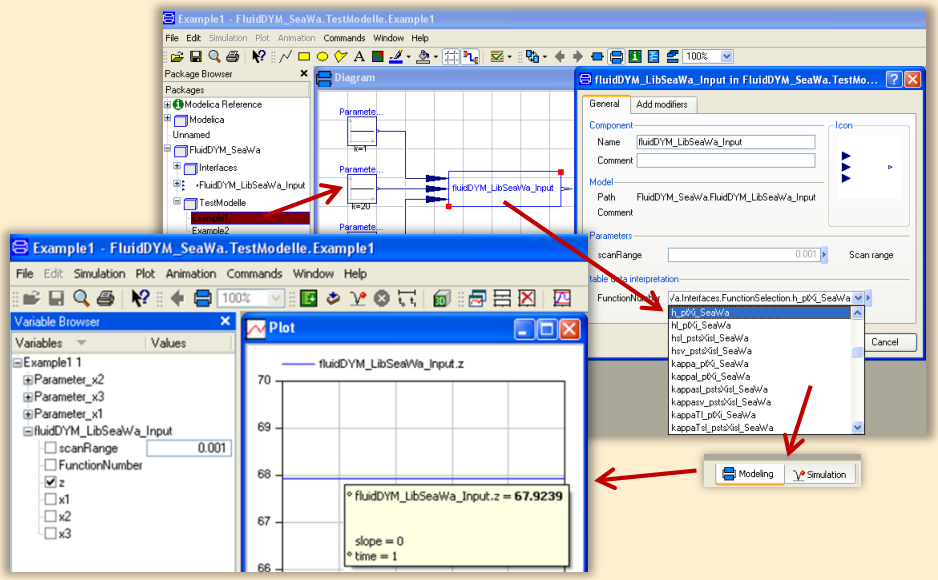
Add-On FluidVIEW for LabVIEW™

The property functions can be calculated in LabVIEW™.

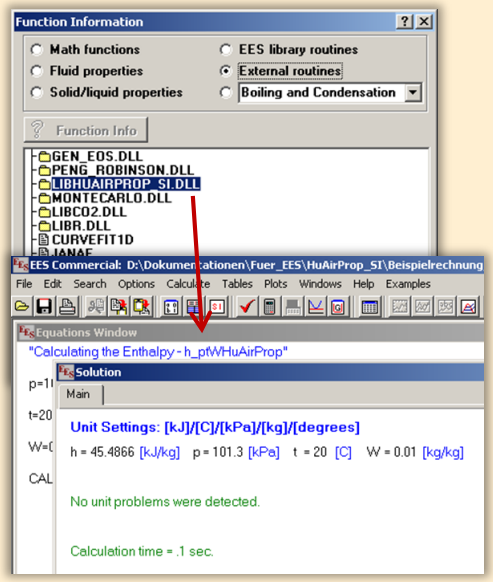


Add-On FluidDYM for DYMOLA® (Modelica) and SimulationX®

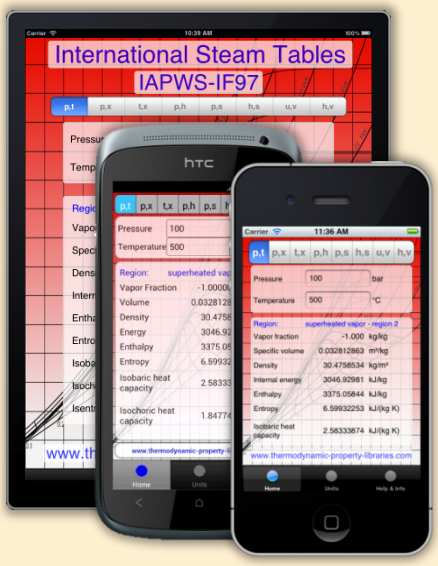
The property functions can be called in DYMOLA® and SimulationX®.



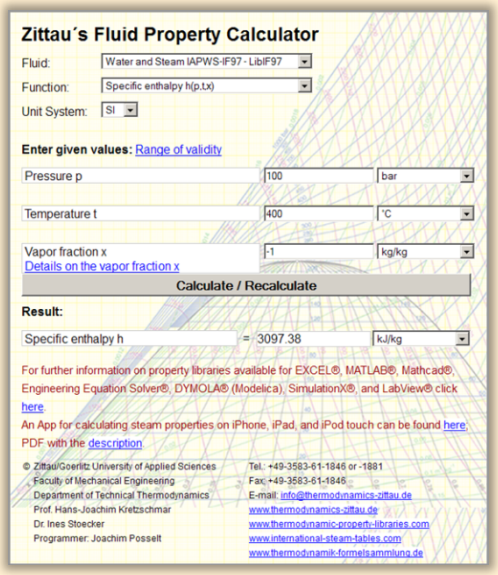
Add-On FluidEES for Engineering Equation Solver®



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



Online Property Calculator at www.thermofluidprop.com



Property Software for Pocket Calculators

FluidCasio

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

FluidHP

HP 48 | HP 49

FluidTI

TI Nspire CX CAS
TI Nspire CAS

TI 83
TI 84
TI 89

TI Voyage 200

TI 92

For more information please contact:

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Mobile: +49-172-7914607
Fax: +49-3222-1095810

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

Thermodynamic Properties

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

Transport Properties

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

Backward Functions

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

Thermodynamic Derivatives

- Partial derivatives used in process modeling can be calculated.

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

www.thermofluidprop.com

4. References

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Formulations for the Thermodynamic Properties of Saturated Phases of H_2O from 173.15 K to 473.15 K.
Report No. 2793 (RP-216), National Bureau of Standards, Washington, D.C. (1983)