KCE
ThermoFluidProperties

Property Library for Ammonia-Water Mixtures

FluidEXL *Graphics* with LibAmWa for Excel®

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Software for the Calculation of the Properties of Ammonia-Water Mixtures Including DLL and Add-In for Excel®

FluidEXL*Graphics*
LibAmWa

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0 Package Contents

0.1 Zip files for 64-bit Office®

The following zip file has been delivered for your computer running a 64-bit Office® version:

CD_FluidEXL_Graphics_Eng_LibAmWa_x64.zip

including the following folders an files:

\FLUFT\

\Formulation97\

FluidEXL_Graphics_LibAmWa_Docu_Eng

FluidEXL_Graphics_Eng.xla

LC.dll

LibAmWa.dll

LibAmWa.chm.

0.2 Zip files for 32-bit Office®

The following zip file has been delivered for your computer running a 32-bit Office® version:

CD_FluidEXL_Graphics_Eng_LibAmWa.zip

including the following folders and files:

\FLUFT\

\Formulation97\

FluidEXL_Graphics_LibAmWa_Docu_Eng

FluidEXL_Graphics_Eng.xla

LC.dll

LibAmWa.dll

LibAmWa.chm.

1 Property Functions

Functional Dependence	Function Name	Call in Fortran	Property or Function	Unit
$a = f(p,t,\xi)$	a_ptxi_AmWa	APTXIAMWA(P,T,XI)	Thermal diffusivity	m^2/s
$a' = f(p,t,\xi')$	al_ptxil_AmWa	ALPTXILAMWA(P,T,XIL)	Thermal diffusivity of saturated liquid	m^2/s
$a' = f(p,t,\xi'')$	al_ptxiv_AmWa	ALPTXIVAMWA(P,T,XIV)	Thermal diffusivity of saturated liquid	m^2/s
$a'' = f(p,t,\xi')$	av_ptxil_AmWa	AVPTXILAMWA(P,T,XIL)	Thermal diffusivity of saturated vapor	m^2/s
$a'' = f(p,t,\xi'')$	av_ptxiv_AmWa	AVPTXIVAMWA(P,T,XIV)	Thermal diffusivity of saturated vapor	m^2/s
$c_p = f(p,t,\xi)$	cp_ptxi_AmWa	CPPTXIAMWA(P,T,XI)	Specific isobaric heat capacity	kJ/(kg K)
$c_p' = f(p,t,\xi')$	cpl_ptxil_AmWa	CPLPTXILAMWA(P,T,XIL)	Specific isobaric heat capacity of saturated liquid	kJ/(kg K)
$c_p' = f(p,t,\xi'')$	cpl_ptxiv_AmWa	CPLPTXIVAMWA(P,T,XIV)	Specific isobaric heat capacity of saturated liquid	kJ/(kg K)
$c_p'' = f(p,t,\xi')$	cpv_ptxil_AmWa	CPVPTXILAMWA(P,T,XIL)	Specific isobaric heat capacity of saturated vapor	kJ/(kg K)
$c_p'' = f(p,t,\xi'')$	cpv_ptxiv_AmWa	CPVPTXIVAMWA(P,T,XIV)	Specific isobaric heat capacity of saturated vapor	kJ/(kg K)
$c_v = f(p,t,\xi)$	cv_ptxi_AmWa	CVPTXIAMWA(P,T,XI)	Specific isochoric heat capacity	kJ/(kg K)
$c_v' = f(p,t,\xi')$	cvl_ptxil_AmWa	CVLPTXILAMWA(P,T,XIL)	Specific isochoric heat capacity of saturated liquid	kJ/(kg K)
$c_v' = f(p,t,\xi'')$	cvl_ptxiv_AmWa	CVLPTXIVAMWA(P,T,XIV)	Specific isochoric heat capacity of saturated liquid	kJ/(kg K)
$c_v'' = f(p,t,\xi')$	cvv_ptxil_AmWa	CVVPTXILAMWA(P,T,XIL)	Specific isochoric heat capacity of saturated vapor	kJ/(kg K)
$c_v'' = f(p,t,\xi'')$	cvv_ptxiv_AmWa	CVVPTXIVAMWA(P,T,XIV)	Specific isochoric heat capacity of saturated vapor	kJ/(kg K)
$D_g = f(p,t,\xi_v)$	Dg_ptxiv_AmWa	DGPTXIVAMWA(P,T,XIV)	Diffusion coefficient vapor mixture	m^2/s
$D_l = f(t,\xi_l)$	Dl_txil_AmWa	DLTXILAMWA(P,XIL)	Diffusion coefficient in liquid mixture	m^2/s
$h = f(p,t,\xi)$	h_ptxi_AmWa	HPTXIAMWA(P,T,XI)	Specific enthalpy	kJ/kg
$h' = f(p,t,\xi')$	hl_ptxil_AmWa	HLPTXILAMWA(P,T,XIL)	Specific enthalpy of saturated liquid	kJ/kg

Functional Dependence	Function Name	Call in Fortran	Property or Function	Unit
$h' = f(p,t,\xi'')$	hl_ptxiv_AmWa	HLPTXIVAMWA(P,T,XIV)	Specific enthalpy of saturated liquid	kJ/kg
$h'' = f(p,t,\xi')$	hv_ptxil_AmWa	HVPTXILAMWA(P,T,XIL)	Specific enthalpy of saturated vapor	kJ/kg
$h'' = f(p,t,\xi'')$	hv_ptxiv_AmWa	HVPTXIVAMWA(P,T,XIV)	Specific enthalpy of saturated vapor	kJ/kg
$p = f(h,s,\xi)$	p_hsxi_AmWa	PHSXIAMWA(H,S,XI)	Backward function: Pressure from enthalpy, entropy, and NH_3 mass fraction	kg/kg
$p = f(t,\xi,x_\delta)$	p_txixd_AmWa	PTXIXDAMWA(T,XI,XD)	Pressure from temperature, NH_3 mass fraction, and vapor fraction	bar
$p_s = f(t,\xi')$	ps_txil_AmWa	PSTXILAMWA(T,XIL)	Vapor pressure	bar
$p_s = f(t,\xi'')$	ps_txiv_AmWa	PSTXIVAMWA(T,XIV)	Vapor pressure	bar
$Pr = f(p,t,\xi)$	Pr_ptxi_AmWa	PRPTXIAMWA(P,T,XI)	Prandtl-Number	-
$Pr' = f(p,t,\xi')$	Prl_ptxil_AmWa	PRLPTXILAMWA(P,T,XIL)	Prandtl-Number of saturated liquid	-
$Pr' = f(p,t,\xi'')$	Prl_ptxiv_AmWa	PRLPTXIVAMWA(P,T,XIV)	Prandtl-Number of saturated liquid	-
$Pr'' = f(p,t,\xi')$	Prv_ptxil_AmWa	PRVPTXILAMWA(P,T,XIL)	Prandtl-Number of saturated vapor	-
$Pr'' = f(p,t,\xi'')$	Prv_ptxiv_AmWa	PRVPTXIAMWA(P,T,XIV)	Prandtl-Number of saturated vapor	-
$region = f(p,h,\xi)$	region_phxi_AmWa	REGPHXIAMWA(P,H,XI)	Phase region from pressure, enthalpy, and NH_3 mass fraction	-
$region = f(p,s,\xi)$	region_psxi_AmWa	REGPSXIAMWA(P,S,XI)	Phase region from pressure, entropy, and NH_3 mass fraction	-
$region = f(p,t,\xi)$	region_ptxi_AmWa	REGPTXIAMWA(P,T,XI)	Phase region from pressure, temperature, and NH_3 mass fraction	-
$region = f(h,s,\xi)$	region_hsxi_AmWa	REGHSXIAMWA(H,S,XI)	Phase region from enthalpy, entropy, and NH_3 mass fraction	-
$s = f(p,t,\xi)$	s_ptxi_AmWa	SPTXIAMWA(P,T,XI)	Specific entropy	kJ/(kg K)
$s' = f(p,t,\xi')$	sl_ptxil_AmWa	SLPTXILAMWA(P,T,XIL)	Specific entropy of saturated liquid	kJ/(kg K)
$s' = f(p,t,\xi'')$	sl_ptxiv_AmWa	SLPTXIVAMWA(P,T,XIV)	Specific entropy of saturated liquid	kJ/(kg K)
$s'' = f(p,t,\xi')$	sv_ptxil_AmWa	SVPTXILAMWA(P,T,XIL)	Specific entropy of saturated vapor	kJ/(kg K)
$s'' = f(p,t,\xi'')$	sv_ptxiv_AmWa	SVPTXIVAMWA(P,T,XIV)	Specific entropy of saturated vapor	kJ/(kg K)
$\sigma_l = f(t,\xi')$	sigmal_txil_AmWa	SIGMALTXILAMWA(T,XIL)	Surface tension of saturated liquid	mN/m

Functional Dependence	Function Name	Call in Fortran	Property or Function	Unit
$t = \mathrm{f}(p,h,\xi)$	t_phxi_AmWa	TPHXIAMWA(P,H,XI)	Backward function: Temperature from pressure, enthalpy, and NH_3 mass fraction	°C
$t = \mathrm{f}(p,s,\xi)$	t_psxi_AmWa	TPSXIAMWA(P,S,XI)	Backward function: Temperature from pressure, entropy, and NH_3 mass fraction	°C
$t = \mathrm{f}(p,\xi,x_\delta)$	t_pxixd_AmWa	TPXIXDAMWA(P,XI,XD)	Temperature from pressure, NH_3 mass fraction, and vapor fraction	°C
$t_s = \mathrm{f}(p,\xi')$	ts_pxil_AmWa	TSPXILAMWA(P,XIL)	Saturation temperature	°C
$t_s = \mathrm{f}(p,\xi'')$	ts_pxiv_AmWa	TSPXIVAMWA(P,XIV)	Saturation temperature	°C
$v = \mathrm{f}(p,t,\xi)$	v_ptxi_AmWa	VPTXIAMWA(P,T,XI)	Specific volume	m^3/kg
$v' = \mathrm{f}(p,t,\xi')$	vl_ptxil_AmWa	VLPTXILAMWA(P,T,XIL)	Specific volume of saturated liquid	m^3/kg
$v' = \mathrm{f}(p,t,\xi'')$	vl_ptxiv_AmWa	VLPTXIVAMWA(P,T,XIV)	Specific volume of saturated liquid	m^3/kg
$v'' = \mathrm{f}(p,t,\xi')$	vv_ptxil_AmWa	VVPTXILAMWA(P,T,XIL)	Specific volume of saturated vapor	m^3/kg
$v'' = \mathrm{f}(p,t,\xi'')$	vv_ptxiv_AmWa	VVPTXIVAMWA(P,T,XIV)	Specific volume of saturated vapor	m^3/kg
$w = \mathrm{f}(p,t,\xi)$	w_ptxi_AmWa	WPTXIAMWA(P,T,XI)	Speed of sound	m/s
$w' = \mathrm{f}(p,t,\xi')$	wl_ptxil_AmWa	WLPTXILAMWA(P,T,XIL)	Speed of sound of saturated liquid	m/s
$w' = \mathrm{f}(p,t,\xi'')$	wl_ptxiv_AmWa	WLPTXIVAMWA(P,T,XIV)	Speed of sound of saturated liquid	m/s
$w'' = \mathrm{f}(p,t,\xi')$	wv_ptxil_AmWa	WVPTXILAMWA(P,T,XIL)	Speed of sound of saturated vapor	m/s
$w'' = \mathrm{f}(p,t,\xi'')$	wv_ptxiv_AmWa	WVPTXIVAMWA(P,T,XIV)	Speed of sound of saturated vapor	m/s
$\eta = \mathrm{f}(p,t,\xi)$	eta_ptxi_AmWa	ETAPTXIAMWA(P,T,XI)	Dynamic viscosity	Pa s
$\eta' = \mathrm{f}(p,t,\xi')$	etal_ptxil_AmWa	ETALPTXILAMWA(P,T,XIL)	Dynamic viscosity of saturated liquid	Pa s
$\eta' = \mathrm{f}(p,t,\xi'')$	etal_ptxiv_AmWa	ETALPTXIVAMWA(P,T,XIV)	Dynamic viscosity of saturated liquid	Pa s
$\eta'' = \mathrm{f}(p,t,\xi')$	etav_ptxil_AmWa	ETAVPTXILAMWA(P,T,XIL)	Dynamic viscosity of saturated vapor	Pa s
$\eta'' = \mathrm{f}(p,t,\xi'')$	etav_ptxiv_AmWa	ETAVPTXIVAMWA(P,T,XIV)	Dynamic viscosity of saturated vapor	Pa s
$\lambda = \mathrm{f}(p,t,\xi)$	lambda_ptxi_AmWa	LAMBDAPTXIAMWA(P,T,XI)	Therm. conductivity	W/(m K)

Functional Dependence	Function Name	Call in Fortran	Property or Function	Unit
$\lambda' = f(p,t,\xi')$	lambdal_ptxil_AmWa	LAMBDALPTXILAMWA(P,T,XIL)	Therm. conductivity of saturated liquid	W/(m K)
$\lambda' = f(p,t,\xi'')$	lambdal_ptxiv_AmWa	LAMBDALPTXIVAMWA(P,T,XIV)	Therm. conductivity of saturated liquid	W/(m K)
$\lambda'' = f(p,t,\xi')$	lambdav_ptxil_AmWa	LAMBDAVPTXILAMWA(P,T,XIL)	Therm. conductivity of saturated vapor	W/(m K)
$\lambda'' = f(p,t,\xi'')$	lambdav_ptxiv_AmWa	LAMBDAVPTXIVAMWA(P,T,XIV)	Therm. conductivity of saturated vapor	W/(m K)
$\nu = f(p,t,\xi)$	nue_ptxi_AmWa	NUEPTXIAMWA(P,T,XI)	Kinematic viscosity	m^2/s
$\nu' = f(p,t,\xi')$	nuel_ptxil_AmWa	NUELPTXILAMWA(P,T,XIL)	Kinematic viscosity of saturated liquid	m^2/s
$\nu' = f(p,t,\xi'')$	nuel_ptxiv_AmWa	NUELPTXIVAMWA(P,T,XIV)	Kinematic viscosity of saturated liquid	m^2/s
$\nu'' = f(p,t,\xi')$	nuev_ptxil_AmWa	NUEVPTXILAMWA(P,T,XIL)	Kinematic viscosity of saturated vapor	m^2/s
$\nu'' = f(p,t,\xi'')$	nuev_ptxiv_AmWa	NUEVPTXIVAMWA(P,T,XIV)	Kinematic viscosity of saturated vapor	m^2/s
$x_\delta = f(p,t,\xi)$	xd_ptxi_AmWa	XDPTXIAMWA(P,T,XI)	Vapor fraction from pressure, temperature and NH_3mass fraction	kg/kg
$x_\delta = f(h,s,\xi)$	xd_hsxi_AmWa	XDHSXIAMWA(H,S,XI)	Backward function: Vapor fraction from enthalpy, entropy, and NH_3 mass fraction	kg/kg
$\xi' = f(p,t,\xi'')$	xil_ptxiv_AmWa	XILPTXIVAMWA(P,T,XIV)	NH_3 mass fraction of saturated liquid	kg/kg
$\xi'' = f(p,t,\xi')$	xiv_ptxil_AmWa	XIVPTXILAMWA(P,T,XIL)	NH_3 mass fraction of saturated vapor	kg/kg

Units:

t	in °C
p	in bar
ξ	in (kg NH_3)/(kg mixture)

Details on the calculation of wet steam

The wet steam region is calculated automatically by the subprograms which are valid in the entire range of validity.

For the functions of saturated liquid (…^{I}) and saturated vapor (…^{II}) it is adequate to enter two parameters:

- either p and t ,
- or t and ξ' resp. t and ξ'' ,
- or p and ξ' resp. p and ξ'' .

Enter -1000 for the value which is not given. If p, t, and ξ' or p, t, and ξ'' are entered the program considers the parameters to match, i.e., to represent the p-t saturation curve. If this is not true the function value to be calculated results in -1000.

Range of validity

Temperature ranges	from $t_{tr}(\xi)$ up to $2 \cdot t_c\ (\xi)$,
	with: t_{tr,NH_3} = -77.655 °C, t_{tr,H_2O} = 0.01 °C
Pressure ranges	from 0.1 bar up to 400 bar
Composition ranges	from 0.0 up to 1.0 (kg NH_3)/(kg mixture)

Reference state

Water:	triple point for saturated liquid
	h_{H2O} = 0.000611783 kJ/kg and
	s_{H2O} = 0.0 kJ/(kg K)
	at p_{tr} = 0.00611657 bar and t_{tr} = 0.01 °C
Ammonia:	triple point for saturated liquid
	h_{NH3} = 2.333 kJ/kg and
	s_{NH3} = 0.0 kJ/(kg K)
	at p_{tr} = 0.060912 bar and t_{tr} = -77.655 °C

Note:

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

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 Water and Steam from the LibAmWa property program library.

2.1 Installing FluidEXL*Graphics*

Complete the following steps for initial installation of FluidEXL*Graphics*.
Before you begin, it is best to uninstall any older version of FluidEXL*Graphics*.

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:

CD_FluidEXL_Graphics_LibAmWa_x64_Eng.zip (for 64 bit version)

or

CD_FluidEXL_Graphics_LibAmWa_Eng.zip" (for 32 bit version).

you will see the folder

\CD_FluidEXL_Graphics_LibAmWa_x64_Eng\ (for 64 bit version)

or

\CD_FluidEXL_Graphics_LibAmWa_Eng\ (for 32 bit version)

in your Windows Explorer, Total Commander etc.

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

Within this folder you will see the following folders and files:

\FLUFT\
\Formulation97\
FluidEXL_Graphics_Eng.xla
FluidEXL_Graphics_LibAmWa_Docu_Eng
LC.dll
LibAmWa.dll
LibAmWa.chm
Reg_.reg

Now, please copy the following folders and files

\FLUFT\
\Formulation97\
FluidEXL_Graphics_Eng.xla
LibAmWa.dll
LibAmWa.chm
LC.dll

into the folder

C:\Users\[your name]\AppData\Roaming\Microsoft\AddIns\,

where [your name] is your name in the Windows system.

If this folder is not found, follow the next section anyway.

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

After installation in Windows®, FluidEXL*Graphics* 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 Fig. 2.1)

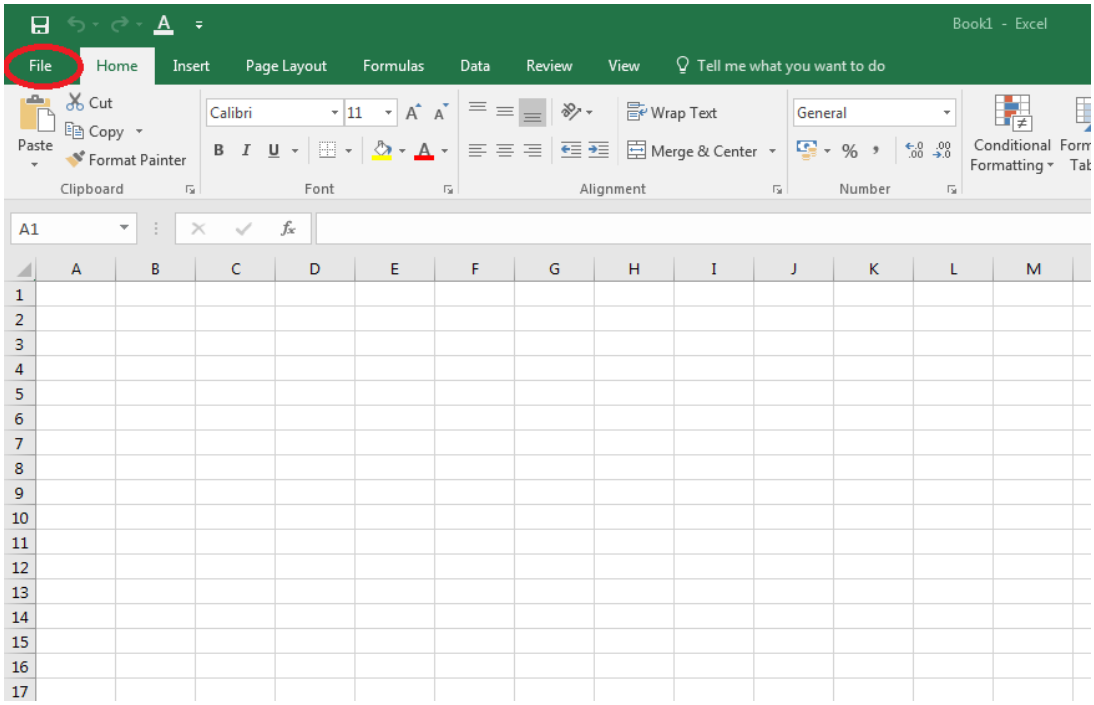


Figure 2.1: Registering FluidEXL*Graphics* as Add-In in Excel® 2016

- Click on the "Options" button in the menu which appears (see Fig. 2.2)

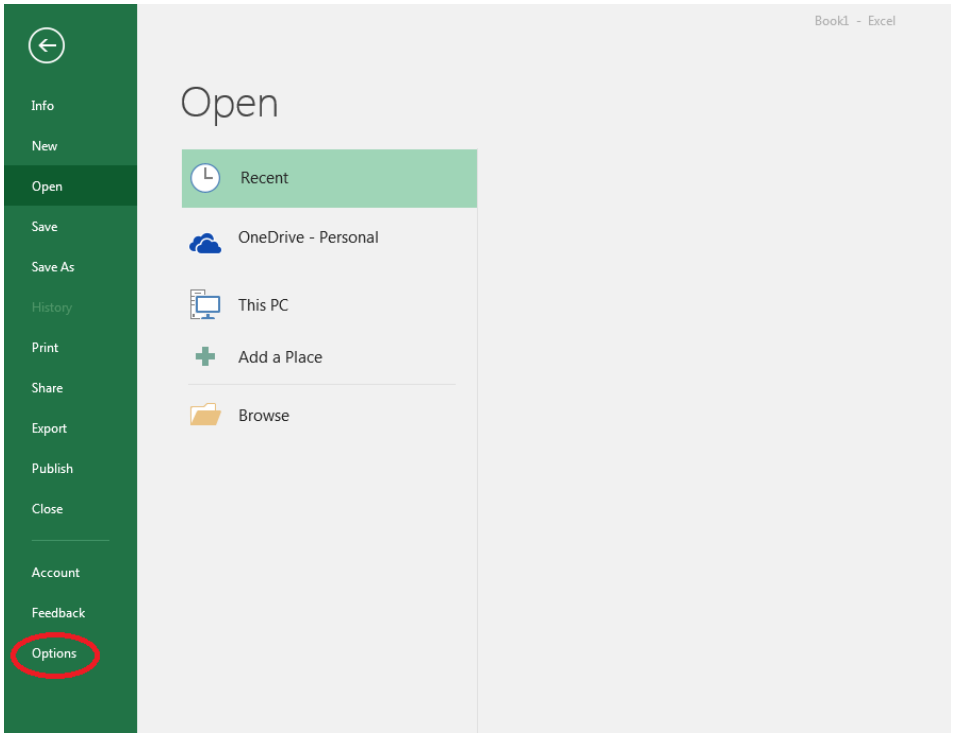


Figure 2.2: Registering FluidEXL*Graphics* as Add-In in Excel® 2016

- Click on "Add-Ins" in the next menu (Fig. 2.3)

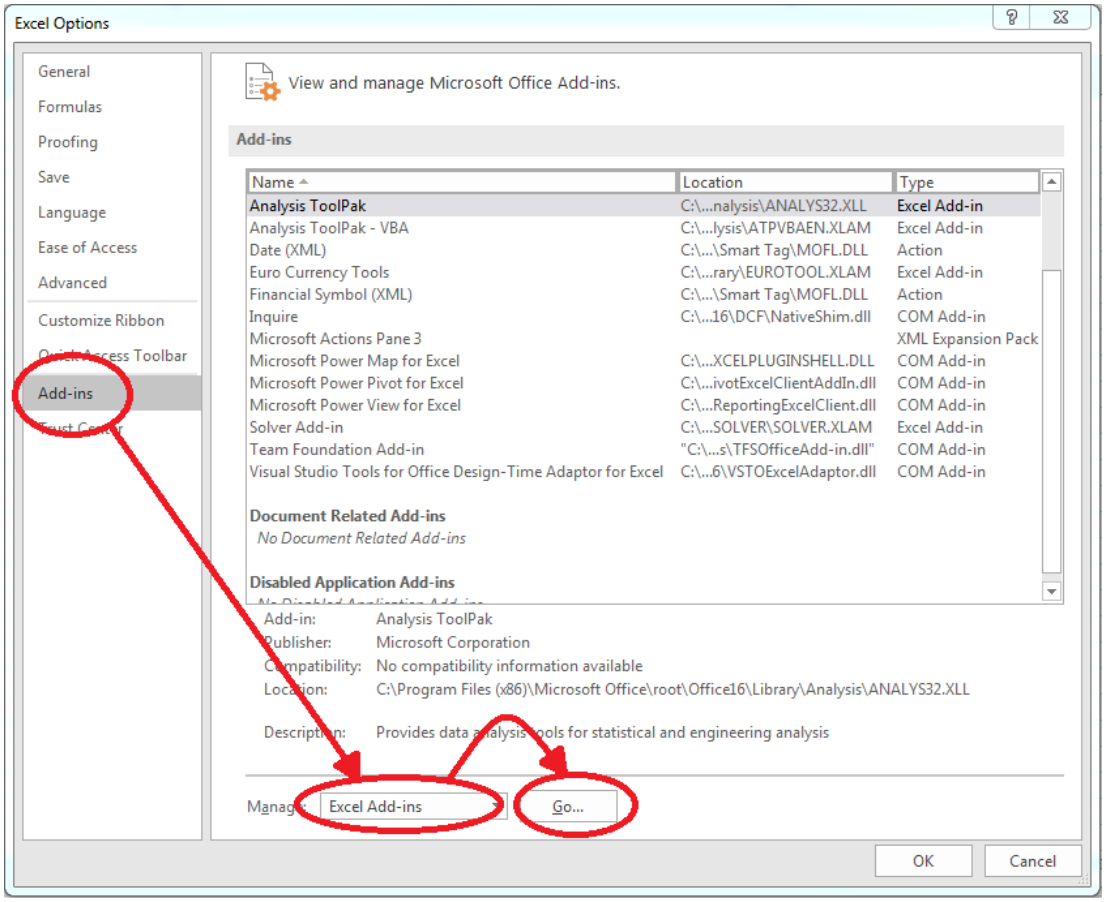


Figure 2.3: Dialog window "Excel Options"

- Select "Excel Add-ins" next to "Manage:" in the lower area of the menu
- Then click the "Go…" button
- Click "Browse" in the following window (Fig. 2.4)

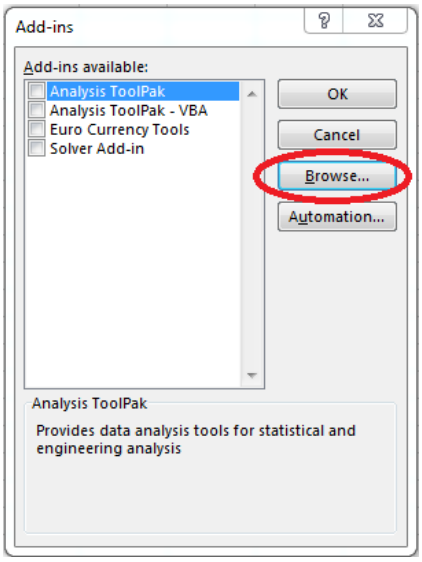


Figure 2.4: Dialog window "Add-ins"

- Excel opens the AddIns folder. This is usually
  C:\Users\[your name]\AppData\Roaming\Microsoft\AddIns\.
- If the FluidEXL files have already been copied to this directory in section 2.1, please skip the following indented section. If not, follow the indented instructions to successful paste the needed files for the FluidEXL Add-In:

  In the upper part of the "Browse" window the correct Add-In path is displayed (see Figure 2.5). Please note that not the entire path is displayed.

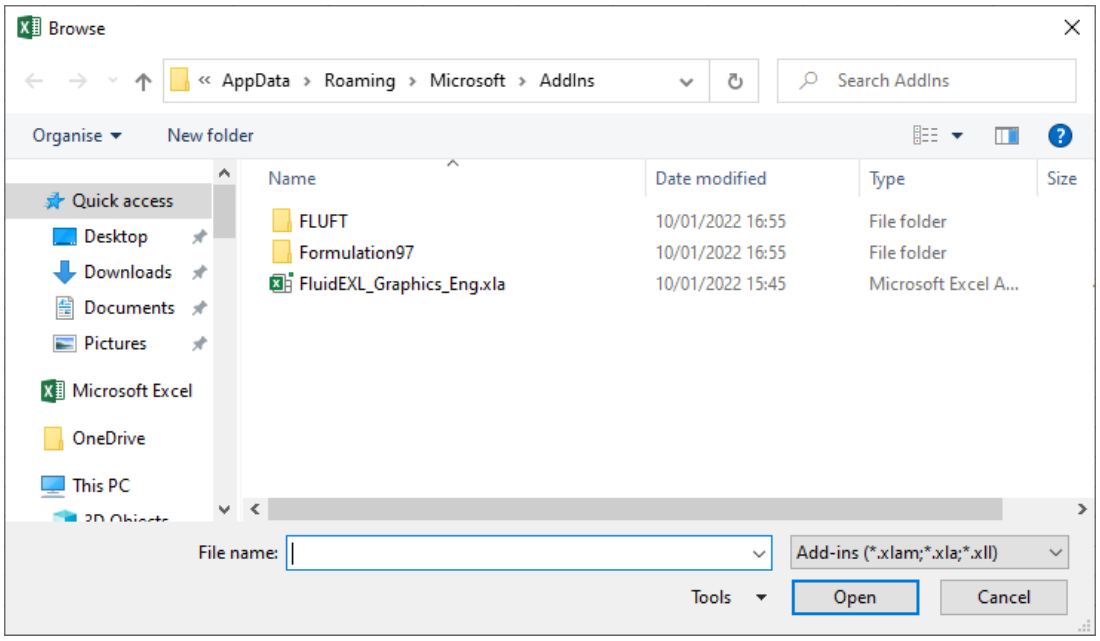


  Figure 2.5: "Browse"-Window

  Please copy this path and paste it into your file manager.
  Now, please copy the following directories and files:
  \FLUFT\
  \Formulation97\
  LC.dll
  FluidEXL_Graphics_Eng.xla
  LibAmWa.dll
  LibAmWa.chm
  from the delivered CD-folder into this folder.

- Click "FluidEXL_Graphics_Eng.xla" in this folder (see Fig. 2.5) and click "OK."
- Now, "FluidEXL Graphics Eng" will be shown in the list of Add-ins (see Fig. 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 (see Fig. 2.6).

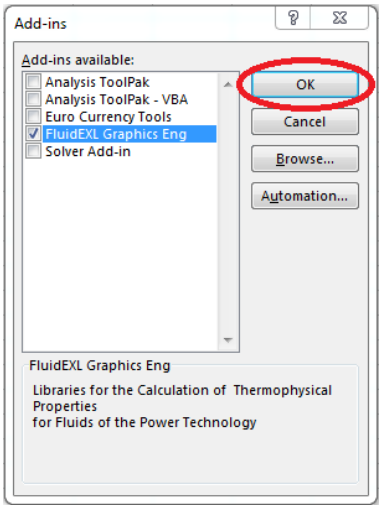


Figure 2.6: Dialog window "Add-Ins"

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

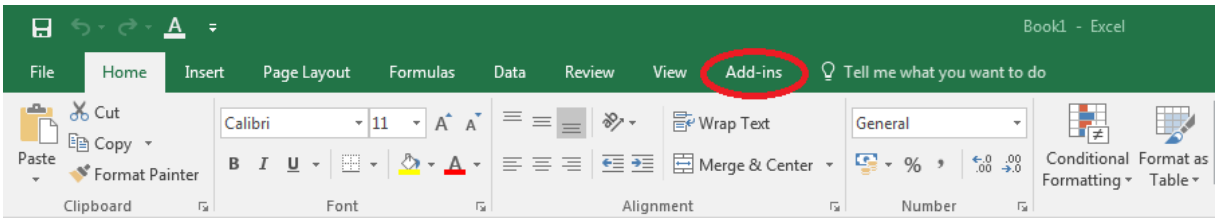


Figure 2.7: Menu item "Add-Ins"

In the upper menu region of Excel®, the FluidEXL*Graphics* menu bar will appear as marked with the red circle in Fig. 2.8.

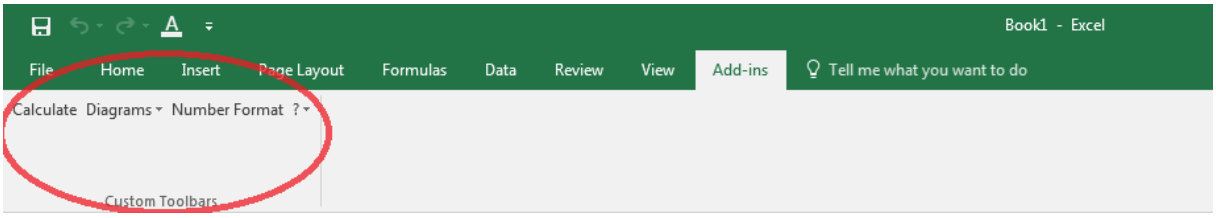


Figure 2.8: FluidEXL*Graphics* menu bar

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

An example calculation of "LibAmWa" DLL library property functions can be found in chapter 2.4.

2.3 Licensing the LibAmWa Property LibAmWarary

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).

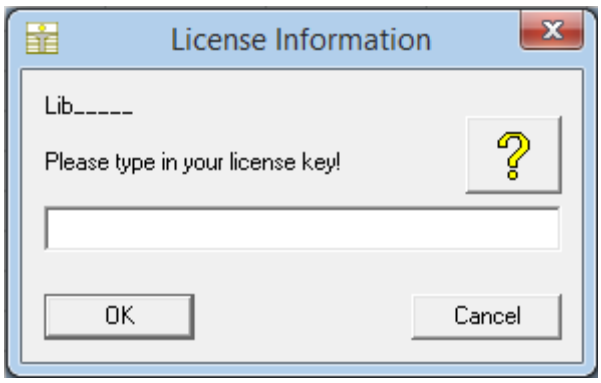


Figure 2.12: "License Information" window

Here you will have to type in the license key. 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:

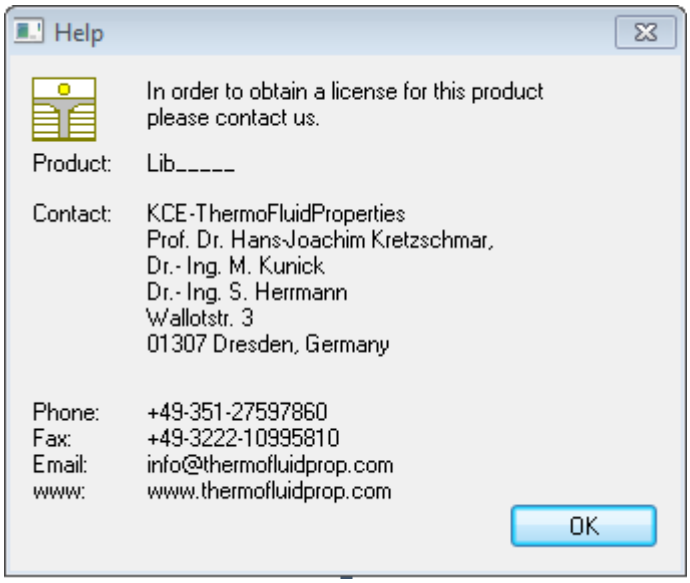


Figure 2.13: "Help" window

If you do not enter a valid license it is still possible to start Excel® by clicking "Cancel" twice. In this case, the LibAmWa 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 LibAmWa property library, you have to delete the files

LibAmWa.dll
LibAmWa.chm

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

C:\Program Files\FluidEXL_Graphics_Eng

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

Note:

The product name "LibAmWa_ _ _ _ _ in Figure 2.12 and 2.13 stands for the LibAmWarary you are installing. In this case it is the LibAmWa library.

2.4 Example Calculations

Example: Calculation of h = f(p,t,xi)

Now we will calculate, step by step, the specific enthalpy *h* as a function of pressure *p*, temperature *t*, and water mass fraction ξ, using FluidEXL*Graphics*.

- Start Excel®
- Enter a value for *p* in bar into a cell.
  (Range of validity: p = 0.1 bar ... 400 bar)
  ⇒ e.g.: Enter 10 into the cell A2.
- Enter a value for *t* in °C into a cell.
  (Range of validity: $t = t_{tr}(\xi)$ ... $2 \cdot t_c(\xi)$)
  ⇒ e.g.: Enter 130 into the cell B2.
- Enter a value for ξ in kg ammonia / kg mixture into a cell.
  (Range of validity: ξ = 0.0 kg NH_3/kg ... 1.0 kg NH_3/kg)
  ⇒ e.g.: Enter 0.5 into the cell C2.
- Click the cell in which the enthalpy *h* in kJ/kg is to be displayed.
  ⇒ e.g.: Click the cell D2.
- Click "Calculate" in the menu bar of FluidEXL*Graphics*.

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

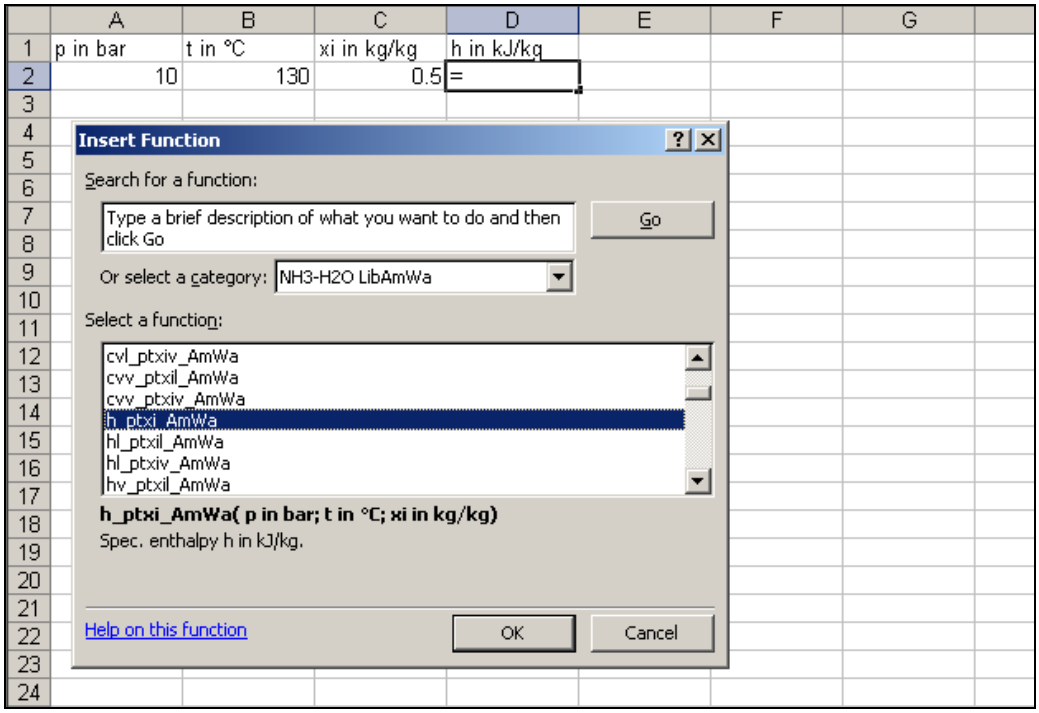


Figure 2.14: Selecting the library and the function

- Search and click the "NH3-H2O LibAmWa" library in the upper list box next to "Or select a category:".
- Search and click the "h_ptxi_AmWa" function in the lower list box under "Select a function:".

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

- Click "OK".
  The window shown in the next figure will now appear.

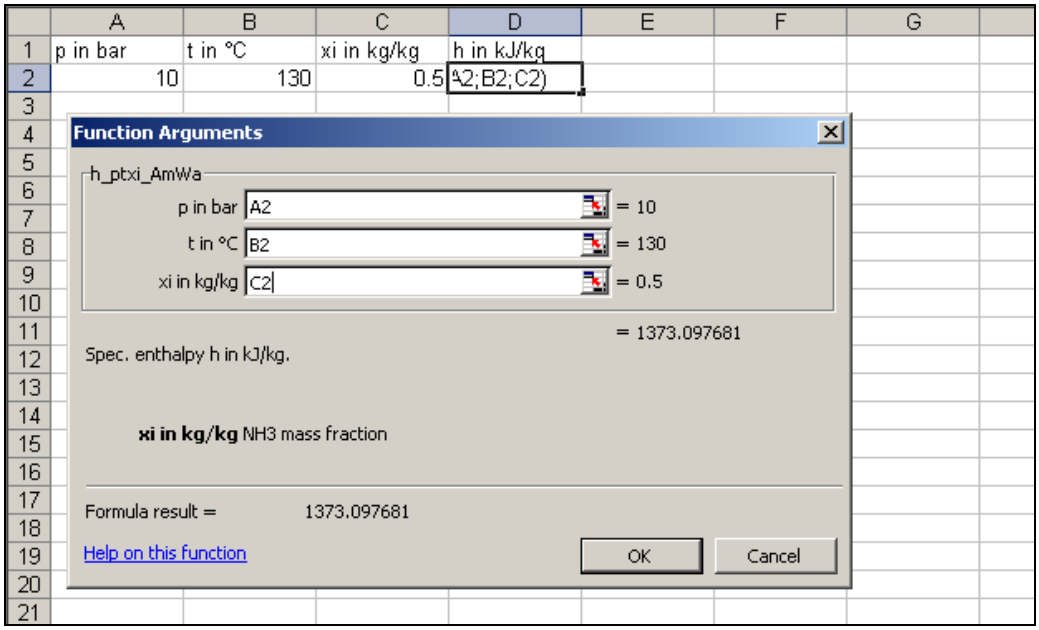


Figure 2.15: Entering the values given for the property calculation

- 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 on the line next to "*xi* in kg NH3/kg" and enter the value of ξ by clicking the cell with the value for ξ, o by entering the name of the cell with the value for ξ, or by entering the value for ξ 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 = 1373.097681 kJ/kg.

The calculation of $h = f(p,t,\xi)$ has thus been completed. You can now arbitrarily change the values for *p*, *t*, or ξ 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 LibAmWa. 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.

Example: Calculation of hl = f(p,t,□ l)

We will now calculate the specific enthalpy for the boiling liquid h^l as a function of pressure p, and the water mass fraction in boiling liquid ξ^l, using FluidEXL*Graphics*. Please carry out the following steps:

- Enter a value for p in bar into a cell:
  (Range of validity: p = 0.1 bar ... 400 bar)
  ⇒ e.g.: Enter 10 into the cell A2.

- Enter a value for t in °C into a cell.
  (Range of validity: $t = t_{tr}(\xi)$ ... $2 \cdot t_c(\xi)$)

  For the calculation of the specific enthalpy for the boiling liquid h^l it is adequate to determine only two parameters, i.e., either t and ξ^l, or p and ξ^l, or p and t. Enter the value -1000 for the missing parameter. If p, t, and ξ^l are entered, the program considers all parameters to be appropriate, i.e., to meet the vapor-pressure curve. If this is not true the property calculated with the selected function results in -1000.

  The following input varieties are possible:

  $h^l = f(-1000, t, \xi^l)$
  $h^l = f(p, -1000, \xi^l)$
  $h^l = f(p, t, -1000)$
  $h^l = f(p, t, \xi^l)$

  ⇒ In our example here the input variety $h^l = f(p, -1000, \xi^l)$ has been chosen. The value -1000 has to be entered into the cell B2.

- Enter a value for ξ^l in kg ammonia/kg mixture into a cell.
  (Range of validity: ξ^l = 0.0 kg NH_3/kg ... 1.0 kg NH_3/kg)
  ⇒ e.g.: Enter 0.5 into the cell C2.

- Click the cell in which the enthalpy calculated for the boiling liquid h^l in kJ/kg is to be displayed.
  ⇒ e.g.: Click the cell D2.

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

The "Insert Function" window appears (see Figure 2.16).

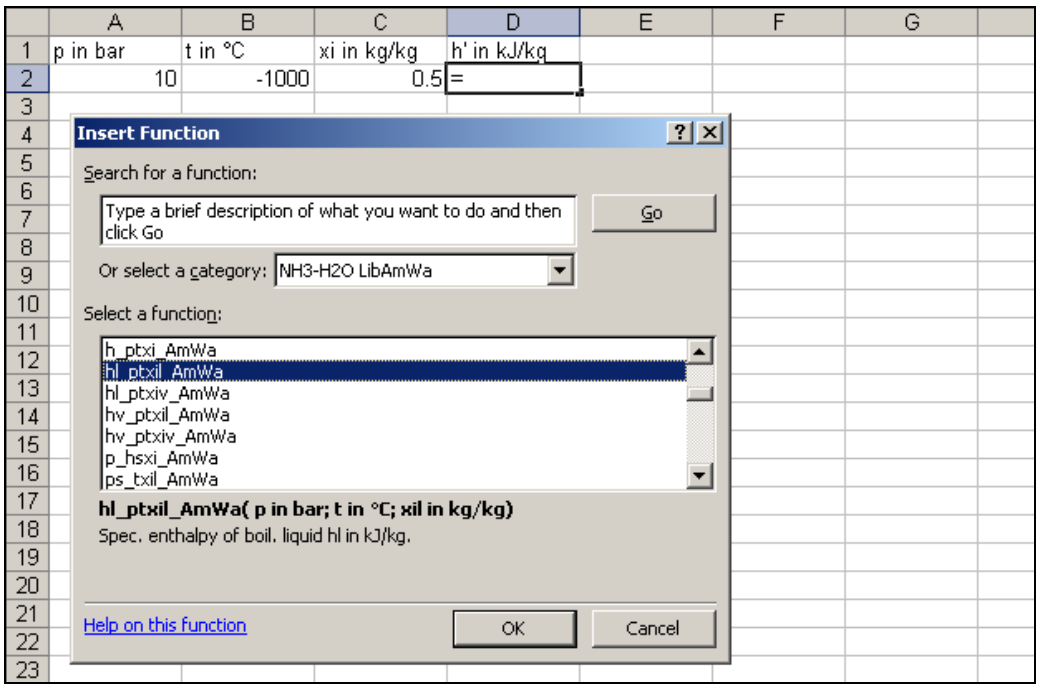


Figure 2.16: Selecting the library and the function

- Search and click the "NH3-H2O LibAmWa" library in the upper list box next to "Or select a category:".
- Search and click the "hl_ptxil_AmWa" function in the lower list box under "Select a function:".

  Here it is possible to get more information on scope, measuring units, error responses, etc. by clicking the "Help on this function" button.
- Click "OK".
  The "Function Arguments" window is displayed (see Figure 2.17).

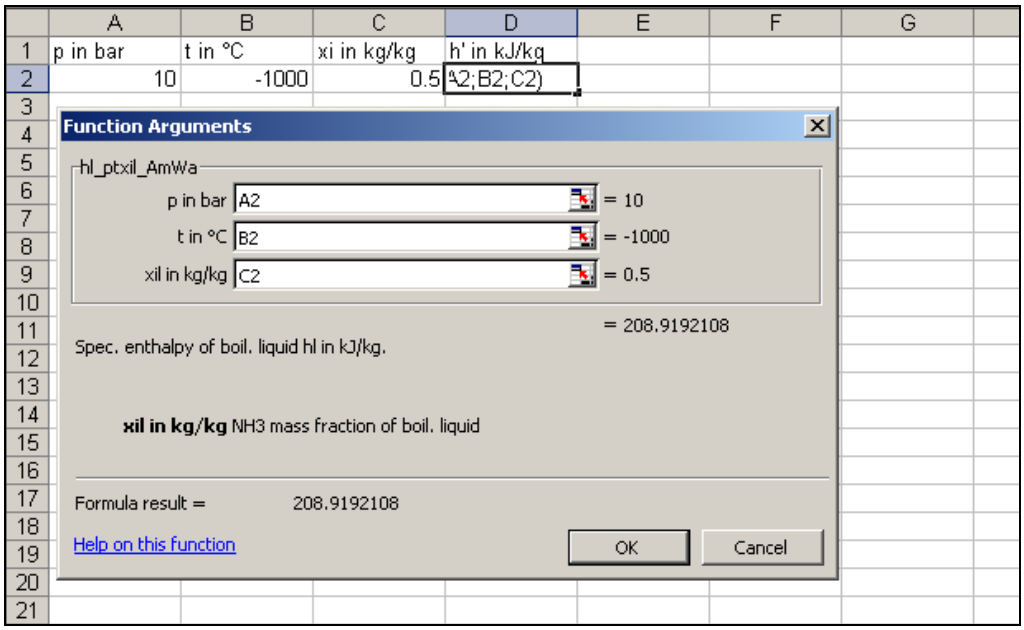


Figure 2.17: Entering the given values for the property calculation

- 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 on the line next to "xil in kg NH3/kg" and enter the value for ξ', by clicking the cell with the value for ξ', by entering the name of the cell with the value for ξ', or by entering the value for ξ' 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: $h' = 208.9192108$ kJ/kg.

The calculation of $h' = f(p, t, \xi')$ has thus been completed. You can now arbitrarily change the values for *p*, *t,* or ξ' 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 LibAmWa. 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.

2.5 The FluidEXL*Graphics* Help System

As mentioned earlier, FluidEXL*Graphics* also provides detailed help functions.

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

- Click "Calculate" in the FluidEXL*Graphics* menu bar.
- Click on the “LibAmWa” library under "Or select a category:" in the "Insert Function" window which will appear.
- Click the "Help on this function" button in the lower left-hand edge of the "Insert Function" window.

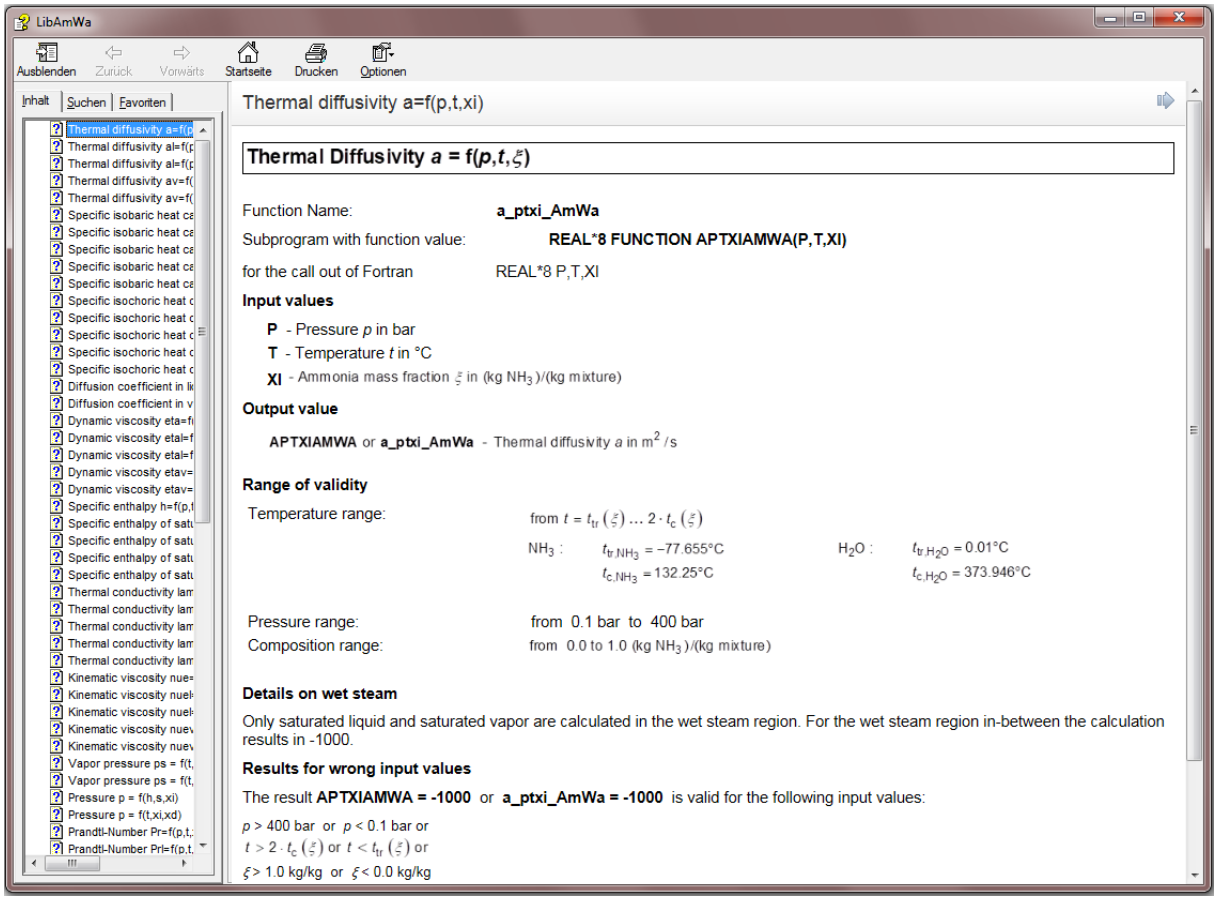


Figure 2.18: Help Window

If the LibAmWa.chm function help cannot be found, you will be redirected to a Microsoft® help website by your standard browser. In this case, the LibAmWa.chm file has to be copied into the folder of FluidEXL*Graphics*, in the standard case

C:\Program Files\FluidEXL_Graphics_Eng

to use the help system.

2.6 Removing FluidEXLGraphics

2.6.1 Removing LibAmWa Library

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

LibAmWa.dll
LibAmWa.chm

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

C:\Program Files\FluidEXL_Graphics_Eng

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

2.6.2 Unregistering and uninstalling FluidEXL*Graphics* as Add-In in versions of Excel® from 2007 onwards (for earlier versions see 2.6.3)

In order to unregister the FluidEXL*Graphics* Add-In in versions of Excel® from 2007 onwards start Excel® and 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

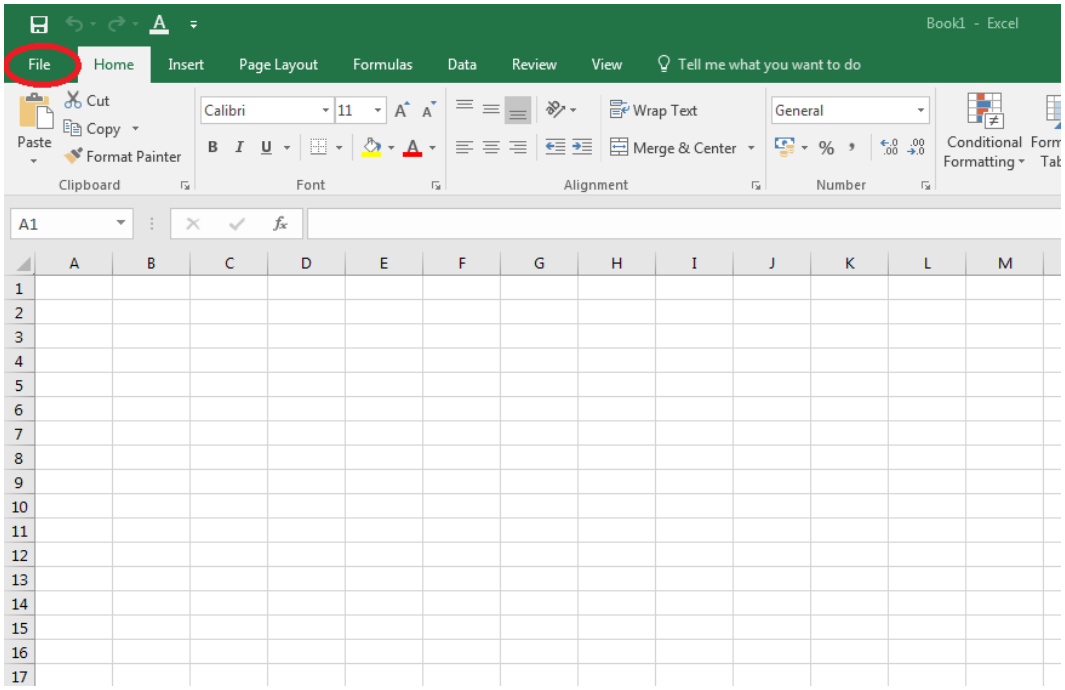


Figure 2.19: Unregistering FluidEXL*Graphics* as Add-In in Excel® 2016

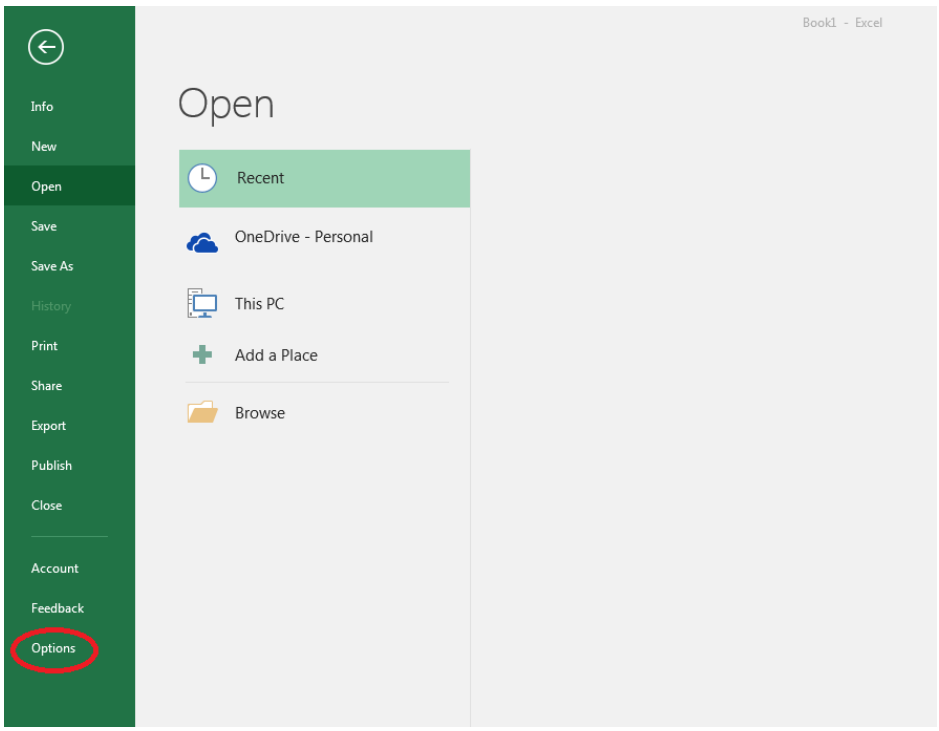


Figure 2.20 Unregistering FluidEXL*Graphics* as Add-In in Excel® 2016

- Click on "Add-Ins" in the next menu (Figure 2.21)

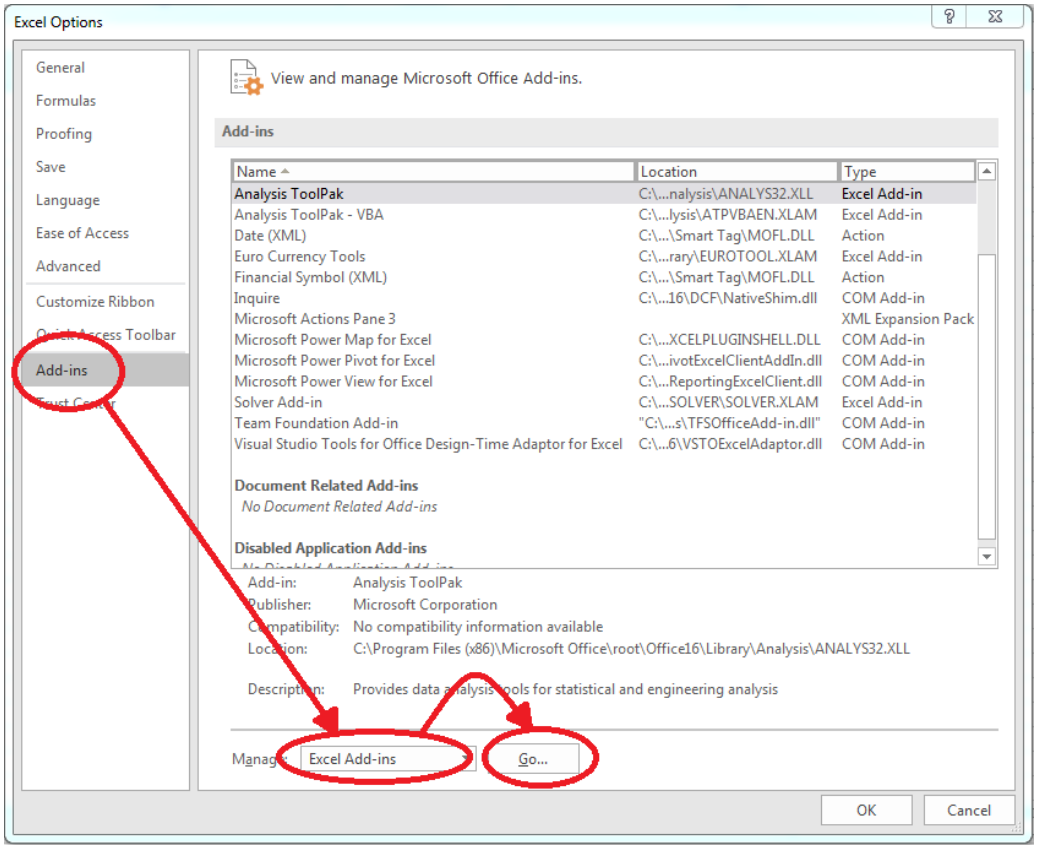


Figure 2.21: Dialog window "Add-Ins"

- 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"

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

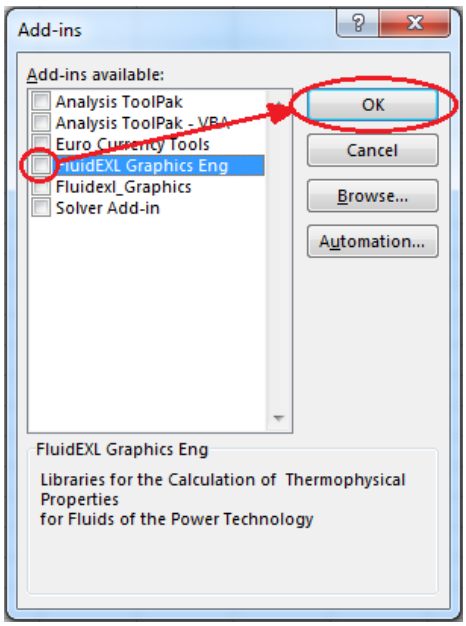


Figure 2.22: Dialog window "Add-Ins"

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"

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.

2.6.3 Unregistering and uninstalling 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

has to be cancelled in Excel®.

In order to do this, 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"

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"

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

LibAmWa.dll

LibAmWa.chm

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

C:\Program Files\FluidEXL_Graphics_Eng

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

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/Remove Programs" window that appears select

"FluidEXL Graphics Eng"

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

Now FluidEXL*Graphics* has been removed.

3. Program Documentation

Thermal Diffusivity $a = f(p,t,\xi)$

Function Name: **a_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION APTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

APTXIAMWA or **a_ptxi_AmWa** - Thermal diffusivity a in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **APTXIAMWA = -1000** or **a_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Thermal Diffusivity $a' = f(p,t,\xi')$

Function Name: **al_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ALPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

ALPTXILAMWA or **al_ptxil_AmWa** - Thermal diffusivity of saturated liquid a' in m^2 / s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ALPTXILAMWA = -1000** or **al_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

ξ' > 1.0 kg/kg or ξ' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Thermal Diffusivity $a' = f(p,t,\xi'')$

Function Name: **al_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ALPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

ALPTXIVAMWA or **al_ptxiv_AmWa** - Thermal diffusivity of saturated liquid a' in m^2 / s

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ALPTXIVAMWA = -1000** or **al_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

ξ" > 1.0 kg/kg or ξ" < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Thermal Diffusivity $a'' = f(p,t,\xi')$

Function Name: **av_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION AVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

AVPTXILAMWA or **av_ptxil_AmWa** - Thermal diffusivity of saturated vapor a'' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **AVPTXILAMWA = -1000** or **av_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

ξ' > 1.0 kg/kg or ξ' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Thermal Diffusivity $a'' = f(p,t,\xi'')$

Function Name: **av_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION AVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

AVPTXIVAMWA or **av_ptxiv_AmWa** - Thermal diffusivity of saturated vapor a'' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3: $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O: $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **AVPTXIVAMWA = -1000** or **av_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

ξ'' > 1.0 kg/kg or ξ'' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

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

Function Name: **cp_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CPPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

CPPTXIAMWA or **cp_ptxi_AmWa** - Specific isobaric heat capacity c_p in kJ/(kg K)

Range of validity

Temperature range: $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **CPPTXIAMWA = -1000** or **cp_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

State points in the wet steam region are located between saturated liquid and saturated vapor.

References: [1], [2], [3], [4]

Specific Isobaric Heat Capacity of Saturated Liquid $c'_p = f(p,t,\xi')$

Function Name: **cpl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CPLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3) / (kg mixture)

Output value

CPLPTXILAMWA or **cpl_ptxil_AmWa** - Specific isobaric heat capacity of saturated liquid c'_p in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isobaric heat capacity of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:

$c'_p = f(-1000,t,\xi')$

$c'_p = f(p,-1000,\xi')$

$c'_p = f(p,t,-1000)$

$c'_p = f(p,t,\xi')$

Results for wrong input values

The result **CPLPTXILAMWA = -1000** or **cpl_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isobaric Heat Capacity of Saturated Liquid $c'_p = f(p,t,\xi'')$

Function Name: **cpl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CPLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

CPLPTXIVAMWA or **cpl_ptxiv_AmWa** - Specific isobaric heat capacity of saturated liquid c'_p in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isobaric heat capacity of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:

$c'_p = f(-1000,t,\xi'')$

$c'_p = f(p,-1000,\xi'')$

$c'_p = f(p,t,-1000)$

$c'_p = f(p,t,\xi'')$

Results for wrong input values

The result **CPLPTXIVAMWA = -1000** or **cpl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or

$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isobaric Heat Capacity of Saturated Vapor c''_p = f(p,t,ξ')

Function Name: **cpv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CPVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3) / (kg mixture)

Output value

CPVPTXILAMWA or **cpv_ptxil_AmWa** - Specific isobaric heat capacity of saturated vapor c''_p in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isobaric heat capacity of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:

$c''_p = f(-1000, t, \xi')$

$c''_p = f(p, -1000, \xi')$

$c''_p = f(p, t, -1000)$

$c''_p = f(p, t, \xi')$

Results for wrong input values

The result **CPVPTXILAMWA = -1000** or **cpv_ptxil_AmWa = -1000** is valid for values which range from:

p > 400 bar or p < 0.1 bar or

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isobaric Heat Capacity of Saturated Vapor c''_p = f(p,t,ξ'')

Function Name: **cpv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CPVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated liquid ξ'' in (kg NH_3) / (kg mixture)

Output value

CPVPTXIVAMWA or **cpv_ptxiv_AmWa** - Specific isobaric heat capacity of saturated vapor c''_p in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isobaric heat capacity of saturated vapor it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:

$c''_p = f(-1000,t,\xi'')$

$c''_p = f(p,-1000,\xi'')$

$c''_p = f(p,t,-1000)$

$c''_p = f(p,t,\xi'')$

Results for wrong input values

The result **CPVPTXIVAMWA = -1000** or **cpv_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or

$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isobaric Heat Capacity c_v = f(p,t,ξ)

Function Name: **cv_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CVPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

CVPTXIAMWA or **cv_ptxi_AmWa** - Specific isochoric heat capacity c_v in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3: $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O: $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **CVPTXIAMWA = -1000** or **cv_ptxi_AmWa = -1000** for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

State points in the wet steam region are located between saturated liquid and saturated vapor.

References: [1], [2], [3], [4]

Specific Isochoric Heat Capacity of Saturated Liquid c'_v = f(p,t,ξ')

Function Name: **cvl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CVLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3) / (kg mixture)

Output value

CVLPTXILAMWA or **cvl_ptxil_AmWa** - Specific isochoric heat capacity of saturated liquid c'_v in kJ / (kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3) / (kg mixture)

Details on input types

For the calculation of the specific isochoric heat capacity of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:

$c'_v = f(-1000, t, \xi')$

$c'_v = f(p, -1000, \xi')$

$c'_v = f(p, t, -1000)$

$c'_v = f(p, t, \xi')$

Results for wrong input values

The result **CVLPTXILAMWA = -1000** or **cvl_ptxil_AmWa = -1000** is valid for values which range from:

p > 400 bar or p < 0.1 bar or

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isochoric Heat Capacity of Saturated Liquid $c'_v = f(p,t,\xi'')$

Function Name: **cvl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CVLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

CVLPTXIVAMWA or **cvl_ptxiv_AmWa** - Specific isochoric heat capacity of saturated liquid c'_v in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3: $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O: $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isochoric heat capacity of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$c'_v = f(-1000,t,\xi'')$
$c'_v = f(p,-1000,\xi'')$
$c'_v = f(p,t,-1000)$
$c'_v = f(p,t,\xi'')$

Results for wrong input values

The result **CVLPTXIVAMWA = -1000** or **cvl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isochoric Heat Capacity of Saturated Vapor $c''_v = f(p,t,\xi')$

Function Name: **cvv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CVVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3) / (kg mixture)

Output value

CVVPTXILAMWA or **cvv_ptxil_AmWa** - Specific isochoric heat capacity of saturated vapor c''_v in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isochoric heat capacity of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$c''_v = f(-1000,t,\xi')$
$c''_v = f(p,-1000,\xi')$
$c''_v = f(p,t,-1000)$
$c''_v = f(p,t,\xi')$

Results for wrong input values

The result **CVVPTXILAMWA = -1000** or **cvv_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Isochoric Heat Capacity of Saturated Vapor $c''_v = f(p,t,\xi'')$

Function Name: **cvv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION CVVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

CVVPTXIVAMWA or **cvv_ptxiv_AmWa** - Specific isochoric heat capacity of saturated vapor c''_v in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3: $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O: $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific isochoric heat capacity of saturated vapor it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$c''_v = f(-1000,t,\xi'')$
$c''_v = f(p,-1000,\xi'')$
$c''_v = f(p,t,-1000)$
$c''_v = f(p,t,\xi'')$

Results for wrong input values

The result **CVVPTXIVAMWA = -1000** or **cvv_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Diffusion Coefficient in Liquid Mixture $D_l = f(t, \xi_l)$

Function Name: **Dl_txil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION DLTXILAMWA(T,XIL)**
for the call out of Fortran REAL*8 T,XIL

Input values

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated steam ξ_l in (kg NH_3)/(kg mixture)

Output value

DLTXILAMWA or **Dl_txil_AmWa** - Diffusion coefficient in liquid mixture D_l in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi_l) \ldots t_c(\xi_l)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **DLTXILAMWA= -1000** or **Dl_txil_AmWa = -1000** is valid for values which range from:

$t < t_{tr}(\xi_l)$ or $t > t_c(\xi_l)$

$\xi_l > 1.0$ kg/kg *or* $\xi_l < 0.0$ kg/kg

References: [1], [2], [3], [4], [11]

Diffusion Coefficient in Gaseous Mixture $D_g = f(p,t,\xi_v)$

Function Name: **Dg_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION DGPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated steam ξ_v in (kg NH_3)/(kg mixture)

Output value

DGPTXIVAMWA or **Dg_ptxiv_AmWa** - Diffusion coefficient in gaseous mixture D_g in m^2 / s

Range of validity

Temperature range: from $t = t_{tr}(\xi_v) \ldots t_c(\xi_v)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **DGPTXIVAMWA = -1000** or **Dg_ptxiv_AmWa = -1000** is valid for values which range from:

p > 400 bar or p < 0.1 bar or

$t < t_{tr}(\xi_v)$ or $t > t_c(\xi_v)$

ξ_v > 1.0 kg/kg or ξ_v < 0.0 kg/kg

References: [1], [2], [3], [4], [12]

Dynamic Viscosity η = f(p,t,ξ)

Function Name: **eta_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ETAPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

ETAPTXIAMWA or **eta_ptxi_AmWa** - Dynamic viscosity η in Pa s

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ETAPTXIAMWA = -1000** or **eta_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Dynamic Viscosity $\eta' = f(p,t,\xi')$

Function Name: **etal_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ETALPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3) / (kg mixture)

Output value

ETALPTXILAMWA or **etal_ptxil_AmWa** - Dynamic viscosity of saturated liquid η' in Pa s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ETALPTXILAMWA = -1000** or **etal_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

ξ' > 1.0 kg/kg or ξ' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Dynamic Viscosity $\eta' = f(p,t,\xi'')$

Function Name: **etal_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ETALPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

ETALPTXIVAMWA or **etal_ptxiv_AmWa** - Dynamic viscosity of saturated liquid η' in Pa s

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ETALPTXIVAMWA = -1000** or **etal_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

ξ" > 1.0 kg/kg or ξ" < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Dynamic Viscosity $\eta'' = f(p,t,\xi')$

Function Name: **etav_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ETAVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

ETAVPTXILAMWA or **etav_ptxil_AmWa** - Dynamic viscosity of saturated vapor η'' in Pa s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ETAVPTXILAMWA = -1000** or **etav_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

ξ' > 1.0 kg/kg or ξ' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Dynamic Viscosity η'' = f(p,t,ξ'')

Function Name: **etav_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION ETAVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

ETAVPTXIVAMWA or **etav_ptxiv_AmWa** - Dynamic viscosity of saturated vapor η'' in Pa s

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **ETAVPTXIVAMWA = -1000** or **etav_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

ξ'' > 1.0 kg/kg or ξ'' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Specific Enthalpy $h = f(p,t,\xi)$

Function Name: **h_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION HPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

HPTXIAMWA or **h_ptxi_AmWa -** Specific enthalpy h in kJ/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **HPTXIAMWA = -1000** or **h_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Specific Enthalpy of Saturated Liquid $h' = f(p,t,\xi')$

Function Name: **hl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION HLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

HLPTXILAMWA or **hl_ptxil_AmWa -** Specific enthalpy of saturated liquid h' in kJ/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific enthalpy of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Possible input types:
$h' = f(-1000, t, \xi')$
$h' = f(p, -1000, \xi')$
$h' = f(p, t, -1000)$
$h' = f(p, t, \xi')$

Results for wrong input values

The result **HLPTXILAMWA = -1000** or **hl_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Enthalpy of Saturated Liquid $h' = f(p,t,\xi'')$

Function Name: **hl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION HLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

HLPTXIVAMWA or **hl_ptxiv_AmWa -** Specific enthalpy of saturated liquid h' in kJ/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific enthalpy of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Possible input types:
$h' = f(-1000,t,\xi'')$
$h' = f(p,-1000,\xi'')$
$h' = f(p,t,-1000)$
$h' = f(p,t,\xi'')$

Results for wrong input values

The result **HLPTXIVAMWA = -1000** or **hl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Enthalpy of Saturated Vapor $h'' = f(p,t,\xi')$

Function Name: **hv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION HVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

HVPTXILAMWA or **hv_ptxil_AmWa -** Specific enthalpy of saturated vapor h'' in kJ/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3: $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O: $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific enthalpy of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Possible input types:
$h'' = f(-1000,t,\xi')$
$h'' = f(p,-1000,\xi')$
$h'' = f(p,t,-1000)$
$h'' = f(p,t,\xi')$

Results for wrong input values

The result **HVPTXILAMWA = -1000** or **hv_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Enthalpy of Saturated Vapor $h'' = f(p,t,\xi'')$

Function Name: **hv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION HVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure *p* in bar

T - Temperature *t* in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

HVPTXIVAMWA or **hv_ptxiv_AmWa -** Specific enthalpy of saturated vapor *h*'' in kJ/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific enthalpy of saturated vapor it is adequate to enter two parameters (either *t* and ξ'', or *p* and ξ'', or *p* and *t*). Enter -1000 for the missing value. If *p*, *t*, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Possible input types:
$h'' = f(-1000, t, \xi'')$
$h'' = f(p, -1000, \xi'')$
$h'' = f(p, t, -1000)$
$h'' = f(p, t, \xi'')$

Results for wrong input values

The result **HVPTXIVAMWA = -1000** or **hv_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Thermal Conductivity λ = f(p,t,ξ)

Function Name: **lambda_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION LAMBDAPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

LAMBDAPTXIAMWA or **lambda_ptxi_AmWa** - Thermal conductivity λ in W/(m K)

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **LAMBDAPTXIAMWA = -1000** or **lambda_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Thermal Conductivity $\lambda' = f(p,t,\xi')$

Function Name: **lambdal_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION LAMBDALPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

LAMBDALPTXILAMWA or **lambdal_ptxil_AmWa** - Thermal conductivity of saturated liquid λ' in W/(m K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **LAMBDALPTXILAMWA = -1000** or **lambdal_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

ξ' > 1.0 kg/kg or ξ' < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Thermal Conductivity $\lambda' = f(p,t,\xi'')$

Function Name: **lambdal_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION LAMBDALPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

LAMBDALPTXIVAMWA or **lambdal_ptxiv_AmWa** - Thermal conductivity of saturated liquid λ' in W/(m K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **LAMBDALPTXIVAMWA = -1000** or **lambdal_ptxiv_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Thermal Conductivity $\lambda'' = f(p,t,\xi')$

Function Name: **lambdav_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION LAMBDAVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure *p* in bar

T - Temperature *t* in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

LAMBDAVPTXILAMWA or **lambdav_ptxil_AmWa** - Thermal conductivity of saturated vapor λ'' in W/(m K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **LAMBDAVPTXILAMWA = -1000** or **lambdav_ptxil_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Thermal Conductivity $\lambda'' = f(p,t,\xi'')$

Function Name: **lambdav_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION LAMBDAVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

LAMBDAVPTXIVAMWA or **lambdav_ptxiv_AmWa** - Thermal conductivity of saturated vapor λ'' in W/(m K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **LAMBDAVPTXIVAMWA = -1000** or **lambdav_ptxiv_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9]

Kinematic Viscosity ν = f(p,t,ξ)

Function Name: **nue_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION NUEPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

NUEPTXIAMWA or **nue_ptxi_AmWa** - Kinematic viscosity ν in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **NUEPTXIAMWA = -1000** or **nue_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Kinematic Viscosity $\nu' = f(p,t,\xi')$

Function Name: **nuel_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION NUELPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

NUELPTXILAMWA or **nuel_ptxil_AmWa** - Kinematic viscosity of saturated liquid ν' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **NUELPTXILAMWA = -1000** or **nuel_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Kinematic Viscosity $\nu' = f(p,t,\xi'')$

Function Name: **nuel_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION NUELPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated steam ξ'' in (kg NH_3)/(kg mixture)

Output value

NUELPTXIVAMWA or **nuel_ptxiv_AmWa** - Kinematic viscosity of saturated liquid ν' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **NUELPTXIVAMWA = -1000** or **nuel_ptxiv_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Kinematic Viscosity $\nu'' = f(p,t,\xi')$

Function Name: **nuev_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION NUEVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

NUEVPTXILAMWA or **nuev_ptxil_AmWa** - Kinematic viscosity of saturated vapor ν'' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **NUEVPTXILAMWA = -1000** or **nuev_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Kinematic Viscosity $\nu'' = f(p,t,\xi'')$

Function Name: **nuev_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION NUEVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated steam ξ'' in (kg NH_3)/(kg mixture)

Output value

NUELPTXIVAMWA or **nuel_ptxiv_AmWa** - Kinematic viscosity of saturated vapor ν'' in m^2/s

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **NUEVPTXIVAMWA = -1000** or **nuev_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Vapor Pressure p_s = f(t, ξ')

Function Name: **ps_txil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PS_TXIL_AMWA(T,XIL)**
for the call out of Fortran REAL*8 T,XIL

Input values

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

PS_TXIL_AMWA or **ps_txil_AmWa** - Vapor pressure p_s in bar

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **PS_TXIL_AMWA = -1000** or **ps_txil_AmWa = -1000** is valid for values which range from:

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Vapor Pressure p_s = f(t, ξ'')

Function Name: **ps_txiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PS_TXIV_AMWA(T,XIV)**
for the call out of Fortran REAL*8 T,XIV

Input values

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated steam ξ' in (kg NH_3)/(kg mixture)

Output value

PS_TXIV_AMWA or **ps_txiv_AmWa** - Vapor pressure p_s in bar

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **PS_TXIV_AMWA = -1000** or **ps_txiv_AmWa = -1000** is valid for values which range from:

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Backward Function: Pressure p = f(h,s,ξ)

Function Name: **p_hsxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PHSXIAMWA(H,S,XI)**
for the call out of Fortran REAL*8 H,S,XI

Input values

H - Enthalpy h in kJ/kg

S - Entropy s in kJ/(kg K)

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

PHSXIAMWA or **p_hsxi_AmWa -** Pressure p in bar

Range of validity

For the range of enthalpy and entropy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **PHSXIAMWA = -1000** or **p_hsxi_AmWa = -1000** is valid for the following input values:

The value of the enthalpy, entropy or composition entered is located outside the range of validity:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Backward Function: Pressure $p = f(t,\xi,x_\delta)$

Function Name: **p_txixd_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PTXIXDAMWA(T,XI,XD)**
for the call out of Fortran REAL*8 T,XI,XD

Input values

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

XD- Vapor fraction x_δ in kg/kg

Output value

PTXIXDAMWA or **p_txixd_AmWa -** Pressure p in bar

Range of validity

Pressure range: $p_{tr}(\xi) \le p \le p_c(\xi)$

Temperature range: $t = t_{tr}(\xi) \le t \le t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C H_2O : $t_{tr,H_2O} = 0.01$°C

$t_{c,NH_3} = 132.25$°C $t_{c,H_2O} = 373.946$°C

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Vapor fraction range: $0.0 \le x_\delta \le 1.0$ kg/kg

Details on wet steam

In the single-phase region the calculation results in -1.

Results for wrong input values

The result **PTXIXDAMWA = -1000** or **p_txixd_AmWa = -1000** is valid for the following input values:

$p > p_{tr}(\xi)$ *or* $p < p_c(\xi)$ *or*

$t > t(p, \xi'' = \xi)$ or $t < t(p, \xi' = \xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

PRANDTL-Number $Pr = f(p,t,\xi)$

Function Name: **Pr_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PRPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

PRPTXIAMWA or **Pr_ptxi_AmWa -** Prandtl-Number Pr

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **PRPTXIAMWA = -1000** or **Pr_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

PRANDTL-Number $Pr' = f(p,t,\xi')$

Function Name: **Prl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PRLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure *p* in bar

T - Temperature *t* in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

PRLPTXILAMWA or **Prl_ptxil_AmWa** – Prandtl – Number *Pr''* of saturated liquid

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **PRLPTXILAMWA = -1000** or **Prl_ptxil_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

PRANDTL-Number $Pr' = f(p,t,\xi'')$

Function Name: **Prl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PRLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

PRLPTXIVAMWA or **Prl_ptxiv_AmWa** – Prandtl – Number Pr' of saturated liquid

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **PRLPTXIVAMWA = -1000** or **Prl_ptxiv_AmWa = -1000** is valid for the following input values:

$p > 400$ bar or $p < 0.1$ bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

PRANDTL-Number *Pr″* = f(*p*,*t*,ξ')

Function Name: **Prv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PRVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure *p* in bar

T - Temperature *t* in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

PRVPTXILAMWA or **Prv_ptxil_AmWa** – Prandtl – Number *Pr″* of saturated vapor

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **PRVPTXILAMWA = -1000** or **Prv_ptxil_AmWa = -1000** is valid for the following input values:

p > 400 bar or *p* < 0.1 bar or

$t > t_c(\xi')$ or $t < t_{tr}(\xi')$ or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

PRANDTL-Number $Pr'' = f(p,t,\xi'')$

Function Name: **Prv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION PRVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

PRVPTXIVAMWA or **Prv_ptxiv_AmWa** – Prandtl – Number Pr'' of saturated vapor

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000.

Results for wrong input values

The result **PRVPTXIVAMWA = -1000** or **Prv_ptxiv_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > t_c(\xi'')$ or $t < t_{tr}(\xi'')$ or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]

Phase Region Region = f(p,t,ξ)

Function Name: **region_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION REGPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

REGPTXIAMWA or **region_ptxi_AmWa -** Phase region

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the function

This function determines the phase region at hand. The output values are defined as follows:

1 - supercooled liquid
2 - two-phase region
3 - gas phase

If the value for the state point is located outside the range of validity the output value is -1000.

Results for wrong input values

The result **REGPTXIAMWA = -1000** or **region_ptxi_AmWa = -1000** is valid fort he following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Phase Region Region = f(*p*,*h*,ξ)

Function Name: **region_phxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION REGPHXIAMWA(P,H,XI)**
for the call out of Fortran REAL*8 P,H,XI

Input values

P - Pressure *p* in bar

H - Enthalpy *h* in kJ/kg

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

REGPHXIAMWA or **region_phxi_AmWa -** Phase region

Range of validity

For the range of the enthalpy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the function

This function determines the phase region at hand. The output values are defined as follows:

1 - supercooled liquid
2 - two-phase region
3 - gas phase

If the value for the state point is located outside the range of validity the output value is -1000.

Results for wrong input values

The result **REGPHXIAMWA = -1000** or **region_phxi_AmWa = -1000** is valid for the following input values:

The enthalpy is located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Phase Region Region = f(p,s,ξ)

Function Name: **region_psxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION REGPSXIAMWA(P,S,XI)**
for the call out of Fortran REAL*8 P,S,XI

Input values

P - Pressure p in bar

S - Entropy s in kJ/(kg K)

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

REGPSXIAMWA or **region_psxi_AmWa -** Phase region

Range of validity

For the range of the entropy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the function

This function determines the phase region at hand. The output values are defined as follows:

1 - supercooled liquid
2 - two-phase region
3 - gas phase

If the value for the state point is located outside the range of validity the output value is -1000.

Results for wrong input values

The result **REGPSXIAMWA = -1000** or **region_psxi_AmWa = -1000** is valid for the following input values:

The entropy is located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Phase Region Region = f(*h*,*s*,ξ)

Function Name: **region_hsxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION REGHSXIAMWA(H,S,XI)**
for the call out of Fortran REAL*8 H,S,XI

Input values

H - Enthalpy *h* in kJ/kg

S - Entropy *s* in kJ/(kg K)

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

REGHSXIAMWA or **region_hsxi_AmWa -** Phase region

Range of validity

For the range of enthalpy and entropy, see the ranges of validity of temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the function

This function determines the phase region at hand. The output values are defined as follows:

1 - supercooled liquid
2 - two-phase region
3 - gas phase

If the value for the state point is located outside the range of validity the output value is -1000.

Results for wrong input values

The result **REGHSXIAMWA = -1000** or **region_hsxi_AmWa = -1000** is valid for the following input values:

Enthalpy, entropy, or composition are located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Specific Entropy $s = f(p,t,\xi)$

Function Name: **s_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

SPTXIAMWA or **s_ptxi_AmWa -** Specific entropy s in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **SPTXIAMWA = -1000** or **s_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Specific Entropy of Saturated Liquid $s' = f(p,t,\xi')$

Function Name: **sl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

SLPTXILAMWA or **sl_ptxil_AmWa -** Specific entropy of saturated liquid s‘ in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific entropy of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible: $s' = f(-1000,t,\xi')$
$s' = f(p,-1000,\xi')$
$s' = f(p,t,-1000)$
$s' = f(p,t,\xi')$

Results for wrong input values

The result **SLPTXILAMWA = -1000** or **sl_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Entropy of Saturated Liquid $s' = f(p,t,\xi'')$

Function Name: **sl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

SLPTXIVAMWA or **sl_ptxiv_AmWa -** Specific entropy of saturated liquid s‘ in kJ/(kg K)

Range of validity

Temperature range: von $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific entropy of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible: $s' = f(-1000,t,\xi'')$
$s' = f(p,-1000,\xi'')$
$s' = f(p,t,-1000)$
$s' = f(p,t,\xi'')$

Results for wrong input values

The result **SLPTXIVAMWA = -1000** or **sl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Entropy of Saturated Vapor $s'' = f(p,t,\xi')$

Function Name: **sv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of boiling liquid ξ' in (kg NH_3)/(kg mixture)

Output value

SVPTXILAMWA or **sv_ptxil_AmWa -** Specific entropy of saturated vapor s'' in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific entropy of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$s'' = f(-1000,t,\xi')$
$s'' = f(p,-1000,\xi')$
$s'' = f(p,t,-1000)$
$s'' = f(p,t,\xi')$

Results for wrong input values

The result **SVPTXILAMWA = -1000** or **sv_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Entropy of Saturated Vapor $s'' = f(p,t,\xi'')$

Function Name: **sv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

SVPTXIVAMWA or **sv_ptxiv_AmWa -** Specific entropy of saturated vapor s'' in kJ/(kg K)

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific entropy of saturated vapor it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$s'' = f(-1000,t,\xi'')$
$s'' = f(p,-1000,\xi'')$
$s'' = f(p,t,-1000)$
$s'' = f(p,t,\xi'')$

Results for wrong input values

The result **SVPTXIVAMWA = -1000** or **sv_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Surface Tension of Saturated Liquid σ_l = f(t,ξ')

Function Name: **sigmal_txil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION SIGMALTXILAMWA(T,XIL)**
for the call out of Fortran REAL*8 T,XIL

Input values

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

SIGMALTXILAMWA or **sigmal_ptxil_AmWa** - Surface tension of sat. liquid σ_l in mN/m

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **SIGMALTXILAMWA= -1000** or **sigmal_txil_AmWa = -1000** is valid for values which range from:

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg *or* $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4], [5]

Saturation Temperature t_s = f(p, ξ')

Function Name: **ts_pxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION TS_PXIL_AMWA(P,XIL)**
for the call out of Fortran REAL*8 P,XIL

Input values

P - Pressure p in bar

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

TS_PXIL_AMWA or **ts_pxil_AmWa** - Saturation temperature t_s in °C

Range of validity

Pressure range: from 0.1 bar to $p_C(\xi')$

NH_3 : $p_{c,NH_3} = 113.33$bar H_2O : $p_{c,H_2O} = 220.64$ bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **TS_PXIL_AMWA = -1000** or **ts_pxil_AmWa = -1000** is valid for values which range from:

$p > p_c(\xi')$ or $p < 0.1$ bar or

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Saturation Temperature $t_s = f(p, \xi'')$

Function Name: **ts_pxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION TS_PXIV_AMWA(P,XIV)**
for the call out of Fortran REAL*8 P,XIV

Input values

P - Pressure p in bar

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

TS_PXIV_AMWA or **ts_pxiv_AmWa** - Saturation temperature t_S in °C

Range of validity

Pressure range: from 0.1 bar to $p_c(\xi'')$

NH_3 : $p_{c,NH_3} = 113.33$bar H_2O : $p_{c,H_2O} = 220.64$ bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Results for wrong input values

The result **TS_PXIV_AMWA = -1000** or **ts_pxiv_AmWa = -1000** is valid for values which range from:

$p > p_c(\xi'')$ or $p < 0.1$ bar or

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

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

Function Name: **t_phxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION TPHXIAMWA(P,H,XI)**
for the call out of Fortran REAL*8 P,H,XI

Input values

P - Pressure p in bar

H - Enthalpy h in kJ/kg

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

TPHXIAMWA or **t_phxi_AmWa -** Temperature t in °C

Range of validity

For the range of the enthalpy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **TPHXIAMWA = -1000** or **t_phxi_AmWa = -1000** is valid for the following input values:

The enthalpy is located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Backward Function: Temperature t = f(p,s,ξ)

Function Name: **t_psxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION TPSXIAMWA(P,S,XI)**
for the call out of Fortran REAL*8 P,S,XI

Input values

P - Pressure p in bar

S - Entropy s in kJ/(kg K)

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

TPSXIAMWA or **t_psxi_AmWa -** Temperature t in °C

Range of validity

For the range of the entropy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **TPSXIAMWA = -1000** or **t_psxi_AmWa = -1000** is valid for the following input values:

The entropy is located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Backward Function: Temperature $t = f(p,\xi,x_\delta)$

Function Name: **t_pxixd_AmWa**

Subprogram with function value: **REAL*8 FUNCTION TPXIXDAMWA(P,XI,XD)**
for the call out of Fortran REAL*8 P,XI,XD

Input values

P - Pressure p in bar

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

XD - Vapor fraction x_δ in kg/kg

Output value

TPXIXDAMWA or **t_pxixd_AmWa -** Temperature t in °C

Range of validity

Temperature range: $t = t_{tr}(\xi) \le t \le t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C H_2O : $t_{tr,H_2O} = 0.01$°C

$t_{c,NH_3} = 132.25$°C $t_{c,H_2O} = 373.946$°C

Pressure range: $p_{tr}(\xi) \le p \le p_c(\xi)$

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Vapor fraction range: $0.0 \le x_\delta \le 1.0$ kg/kg

Details on wet steam

In the single-phase region the calculation results in -1.

Results for wrong input values

The result **TPXIXDAMWA = -1000** or **t_pxixd_AmWa = -1000** is valid for the following input values:

$p > p_{tr}(\xi)$ *or* $p < p_c(\xi)$ *or*

$t > t(p, \xi'' = \xi)$ or $t < t(p, \xi' = \xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Specific Volume $v = f(p,t,\xi)$

Function Name: **v_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION VPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

VPTXIAMWA or **v_ptxi_AmWa** - Specific volume v in m^3/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

The wet steam region is calculated automatically by the sub-programs.

Results for wrong input values

The result **VPTXIAMWA = -1000** or **v_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Specific Volume of Saturated Liquid $v' = f(p,t,\xi')$

Function Name: **vl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION VLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

VLPTXILAMWA or **vl_ptxil_AmWa** - Specific volume of saturated liquid v' in m^3/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific volume of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible: $v' = f(-1000,t,\xi')$
$v' = f(p,-1000,\xi')$
$v' = f(p,t,-1000)$
$v' = f(p,t,\xi')$

Results for wrong input values

The result **VLPTXILAMWA = -1000** or **vl_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Volume of Saturated Liquid $v' = f(p,t,\xi'')$

Function Name: **vl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION VLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

VLPTXIVAMWA or **vl_ptxiv_AmWa** - Specific volume of saturated liquid v' in m^3/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific volume of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible: $v' = f(-1000,t,\xi'')$
$v' = f(p,-1000,\xi'')$
$v' = f(p,t,-1000)$
$v' = f(p,t,\xi'')$

Results for wrong input values

The result **VLPTXIVAMWA = -1000** or **vl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Volume of Saturated Vapor $v'' = f(p,t,\xi')$

Function Name: **vv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION VVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

VVPTXILAMWA or **vv_ptxil_AmWa** - Specific volume of saturated vapor v'' in m^3/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3: $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O: $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific volume of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$v'' = f(-1000,t,\xi')$
$v'' = f(p,-1000,\xi')$
$v'' = f(p,t,-1000)$
$v'' = f(p,t,\xi')$

Results for wrong input values

The result **VVPTXILAMWA = -1000** or **vv_ptxil_AmWa = -1000** is valid for values which range from:

p > 400 bar or p < 0.1 bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Specific Volume of Saturated Vapor $v'' = f(p,t,\xi'')$

Function Name: **vv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION VVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

VVPTXIVAMWA or **vv_ptxiv_AmWa** - Specific volume of saturated vapor v'' in m^3/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the specific volume of saturated vapor it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$v'' = f(-1000,t,\xi'')$
$v'' = f(p,-1000,\xi'')$
$v'' = f(p,t,-1000)$
$v'' = f(p,t,\xi'')$

Results for wrong input values

The result **VVPTXIVAMWA = -1000** or **vv_ptxiv_AmWa = -1000** is valid for values which range from:

p > 400 bar or p < 0.1 bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Speed of Sound $w = f(p,t,\xi)$

Function Name: **w_ptxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION WPTXIAMWA(P,T,XI)**
for the call out of Fortran REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

WPTXIAMWA or **w_ptxi_AmWa -** Speed of sound w in m/s

Range of validity

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on wet steam

Only saturated liquid and saturated vapor are calculated in the wet steam region. For the wet steam region in-between the calculation results in -1000

Results for wrong input values

The result **WPTXIAMWA = -1000** or **w_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Speed of Sound of Saturated Liquid $w' = f(p,t,\xi')$

Function Name: **wl_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION WLPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction in saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

WLPTXILAMWA or **wl_ptxil_AmWa -** Speed of sound of saturated liquid w' in m/s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the speed of sound of saturated liquid it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$w' = f(-1000,t,\xi')$
$w' = f(p,-1000,\xi')$
$w' = f(p,t,-1000)$
$w' = f(p,t,\xi')$

Results for wrong input values

The result **WLPTXILAMWA = -1000** or **wl_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Speed of Sound of Saturated Liquid $w' = f(p,t,\xi'')$

Function Name: **wl_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION WLPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

WLPTXIVAMWA or **wl_ptxiv_AmWa -** Speed of sound of saturated liquid w' in m/s

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the speed of sound of saturated liquid it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$w' = f(-1000,t,\xi'')$
$w' = f(p,-1000,\xi'')$
$w' = f(p,t,-1000)$
$w' = f(p,t,\xi'')$

Results for wrong input values

The result **WLPTXIVAMWA = -1000** or **wl_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Speed of Sound of Saturated Vapor $w'' = f(p,t,\xi')$

Function Name: **wv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION WVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

WVPTXILAMWA or **wv_ptxil_AmWa -** Speed of sound of saturated vapor w'' in m/s

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the speed of sound of saturated vapor it is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t). Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$w'' = f(-1000,t,\xi')$
$w'' = f(p,-1000,\xi')$
$w'' = f(p,t,-1000)$
$w'' = f(p,t,\xi')$

Results for wrong input values

The result **WVPTXILAMWA = -1000** or **wv_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi')$ or $t > t_c(\xi')$
$\xi' > 1.0$ kg/kg *or* $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Speed of Sound of Saturated Vapor $w'' = f(p,t,\xi'')$

Function Name: **wv_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION WVPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

WVPTXIVAMWA or **wv_ptxiv_AmWa -** Speed of sound of saturated vapor w'' in m/s

Range of validity

Temperature range: from $t = t_{tr}(\xi'')$ ... $t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

For the calculation of the speed of sound of saturated vapor it is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t). Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$w'' = f(-1000,t,\xi'')$
$w'' = f(p,-1000,\xi'')$
$w'' = f(p,t,-1000)$
$w'' = f(p,t,\xi'')$

Results for wrong input values

The result **WVPTXIVAMWA = -1000** or **wv_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Vapor Fraction x_δ = f(p,t,ξ)

Function Name:	**xd_ptxi_AmWa**
Subprogram with function value: for the call out of Fortran	**REAL*8 FUNCTION XDPTXIAMWA(P,T,XI)** REAL*8 P,T,XI

Input values

P - Pressure p in bar

T - Temperature t in °C

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

XDPTXIAMWA or **xd_ptxi_AmWa** - Vapor fraction x_δ in kg/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi)$ … $2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the single-phase region

In the single-phase region the calculation results in -1.

Results for wrong input values

The result **XDPTXIAMWA = -1000** or **xd_ptxi_AmWa = -1000** is valid for the following input values:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Backward Function: Vapor Fraction x_δ = f(h,s,ξ)

Function Name: **xd_hsxi_AmWa**

Subprogram with function value: **REAL*8 FUNCTION XDHSXIAMWA(H,S,XI)**
for the call out of Fortran REAL*8 H,S,XI

Input values

H - Enthalpy h in kJ/kg

S - Entropy s in kJ/(kg K)

XI - Ammonia mass fraction ξ in (kg NH_3)/(kg mixture)

Output value

XDHSXIAMWA or **xd_hsxi_AmWa** - Vapor fraction x_δ in kg/kg

Range of validity

For the range of the enthalpy and entropy, see ranges of validity for temperature, pressure, and composition:

Temperature range: from $t = t_{tr}(\xi) \ldots 2 \cdot t_c(\xi)$

NH_3 : $t_{tr,NH_3} = -77.655°C$ $t_{c,NH_3} = 132.25°C$

H_2O : $t_{tr,H_2O} = 0.01°C$ $t_{c,H_2O} = 373.946°C$

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on the single-phase region

In the single-phase region the calculation results in -1.

Results for wrong input values

The result **XDHSXIAMWA = -1000** or **xd_hsxi_AmWa = -1000** is valid for the following input values:

Values of the enthalpy, entropy or composition are located outside the range of validity if:

p > 400 bar or p < 0.1 bar or

$t > 2 \cdot t_c(\xi)$ or $t < t_{tr}(\xi)$ or

ξ > 1.0 kg/kg or ξ < 0.0 kg/kg

References: [1], [2], [3], [4]

Ammonia Mass Fraction ξ = f(p,t,x_δ)

Function Name: **xi_ptxd_AmWa**

Subprogram with function value: **REAL*8 FUNCTION XIPTXDAMWA(P,T,XD)**
for the call out of Fortran REAL*8 P,T,XD

Input values

P - Pressure p in bar

T - Temperature t in °C

XD - Vapor fraction x_δ in kg/kg

Output value

XIPTXDAMWA or **xi_ptxd_AmWa** - Ammonia mass fraction ξ in (kg NH_3)/kg

Range of validity

Pressure range: $p_{tr}(\xi) \le p \le p_c(\xi)$

Temperature range: $t = t_{tr}(\xi) \le t \le t_c(\xi)$

NH_3: $t_{tr,NH_3} = -77.655$°C H_2O: $t_{tr,H_2O} = 0.01$°C

$t_{c,NH_3} = 132.25$°C $t_{c,H_2O} = 373.946$°C

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Vapor fraction range: $0.0 \le x_\delta \le 1.0$ kg/kg

Details on input types

In the single-phase region the calculation results in -1.

Results for wrong input values

The result **XIPTXDAMWA = -1000** or **xi_ptxd_AmWa = -1000** is valid for values which range from:

$p > p_{tr}(\xi)$ *or* $p < p_c(\xi)$

$t > t(p, \xi'' = \xi)$ or $t < t(p, \xi' = \xi)$

$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Ammonia Mass Fraction of Saturated Liquid $\xi' = f(p,t,\xi'')$

Function Name: **xil_ptxiv_AmWa**

Subprogram with function value: **REAL*8 FUNCTION XILPTXIVAMWA(P,T,XIV)**
for the call out of Fortran REAL*8 P,T,XIV

Input values

P - Pressure p in bar

T - Temperature t in °C

XIV - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/(kg mixture)

Output value

XILPTXIVAMWA or **xil_ptxiv_AmWa** - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi'') \ldots t_c(\xi'')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

It is adequate to enter two parameters (either t and ξ'', or p and ξ'', or p and t) for the calculation of the ammonia mass fraction of saturated liquid. Enter -1000 for the missing value. If p, t, and ξ'' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$\xi' = f(-1000,t,\xi'')$
$\xi' = f(p,-1000,\xi'')$
$\xi' = f(p,t,-1000)$
$\xi' = f(p,t,\xi'')$

Results for wrong input values

The result **XILPTXIVAMWA = -1000** or **xil_ptxiv_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or
$t < t_{tr}(\xi'')$ or $t > t_c(\xi'')$
$\xi'' > 1.0$ kg/kg or $\xi'' < 0.0$ kg/kg

References: [1], [2], [3], [4]

Ammonia Mass Fraction of Saturated Vapor $\xi'' = f(p,t,\xi')$

Function Name: **xiv_ptxil_AmWa**

Subprogram with function value: **REAL*8 FUNCTION XIVPTXILAMWA(P,T,XIL)**
for the call out of Fortran REAL*8 P,T,XIL

Input values

P - Pressure p in bar

T - Temperature t in °C

XIL - Ammonia mass fraction of saturated liquid ξ' in (kg NH_3)/(kg mixture)

Output value

XIVPTXILAMWA or **xiv_ptxil_AmWa** - Ammonia mass fraction of saturated vapor ξ'' in (kg NH_3)/kg

Range of validity

Temperature range: from $t = t_{tr}(\xi') \ldots t_c(\xi')$

NH_3 : $t_{tr,NH_3} = -77.655$°C $t_{c,NH_3} = 132.25$°C

H_2O : $t_{tr,H_2O} = 0.01$°C $t_{c,H_2O} = 373.946$°C

Pressure range: from 0.1 bar to 400 bar

Composition range: from 0.0 to 1.0 (kg NH_3)/(kg mixture)

Details on input types

It is adequate to enter two parameters (either t and ξ', or p and ξ', or p and t) for the calculation of the ammonia mass fraction of saturated vapor. Enter -1000 for the missing value. If p, t, and ξ' are entered, the program considers all parameters to match, i.e., to represent the vapor-pressure curve. If this is not true, the property to be calculated of the selected function results in -1000.

Input types possible:
$\xi'' = f(-1000,t,\xi')$
$\xi'' = f(p,-1000,\xi')$
$\xi'' = f(p,t,-1000)$
$\xi'' = f(p,t,\xi')$

Results for wrong input values

The result **XIVPTXILAMWA = -1000** or **xiv_ptxil_AmWa = -1000** is valid for values which range from:

$p > 400$ bar or $p < 0.1$ bar or

$t < t_{tr}(\xi')$ or $t > t_c(\xi')$

$\xi' > 1.0$ kg/kg or $\xi' < 0.0$ kg/kg

References: [1], [2], [3], [4]

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:

KCE-ThermoFluidProperties UG & Co. KG
Prof. Dr. Hans-Joachim Kretzschmar
Wallotstr. 3
01307 Dresden, Germany

Internet: www.thermofluidprop.com
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

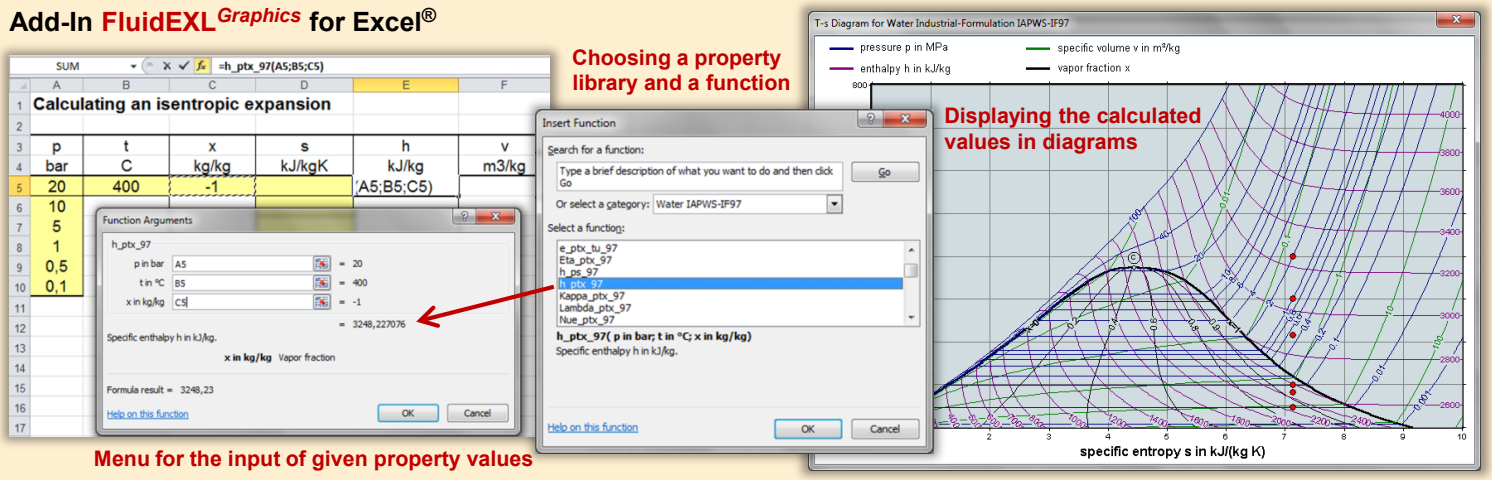
KCE-ThermoFluidProperties
www.thermofluidprop.com

KCE ThermoFluidProperties

Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

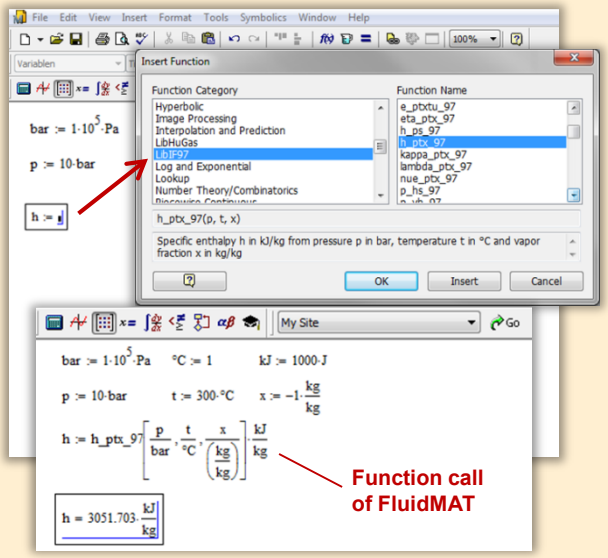
Property Software for Calculating Heat Cycles, Boilers, Turbines and Refrigerators

Add-In FluidEXL*Graphics* for Excel®



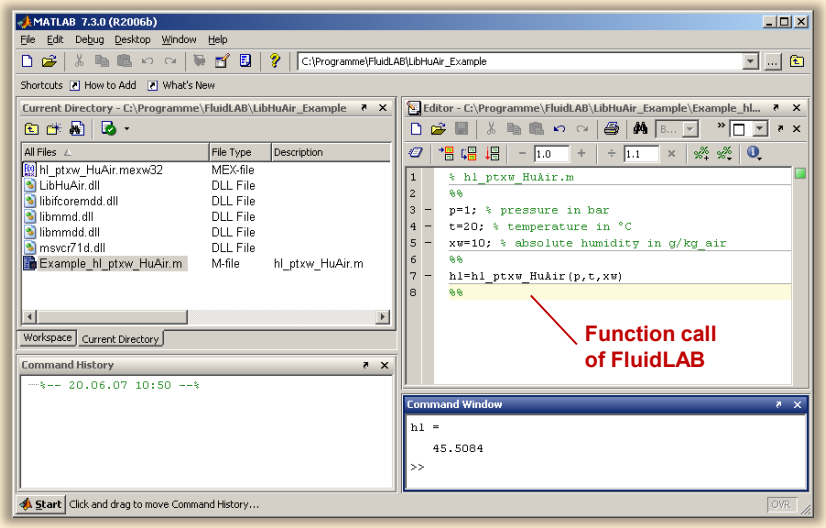
Add-On FluidMAT for Mathcad®
Add-On FluidPRIME for Mathcad Prime®

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



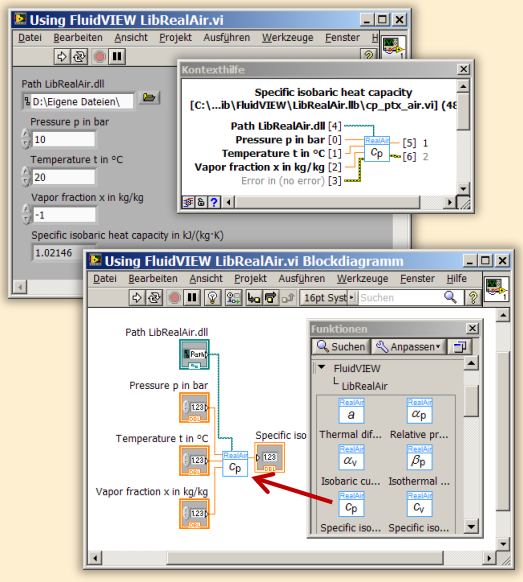
Add-On FluidLAB for MATLAB® and SIMULINK®

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



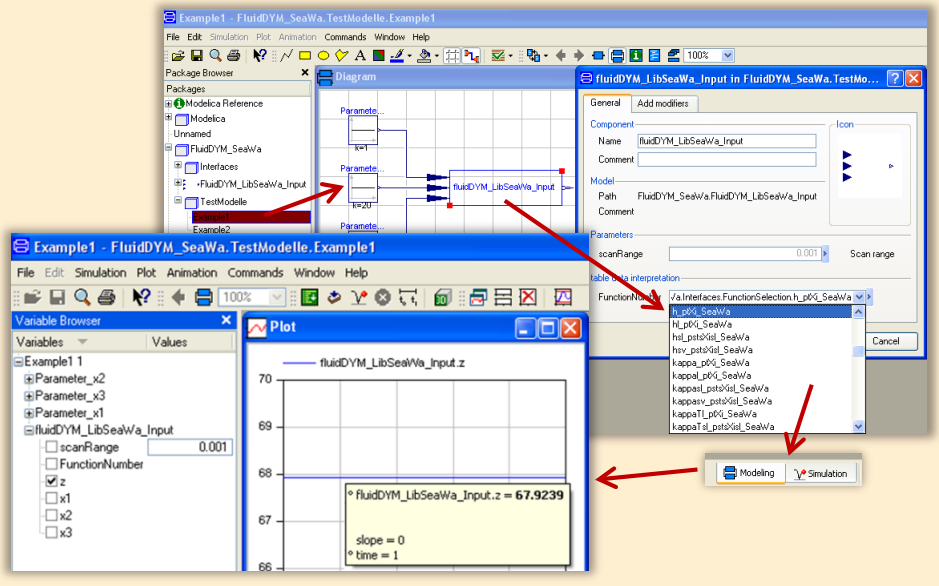
Add-On FluidVIEW for LabVIEW™

The property functions can be calculated in LabVIEW™.

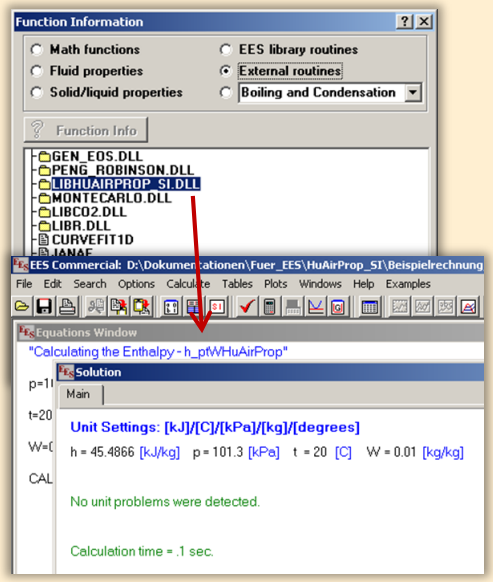


Add-On FluidDYM for DYMOLA® (Modelica) and SimulationX®

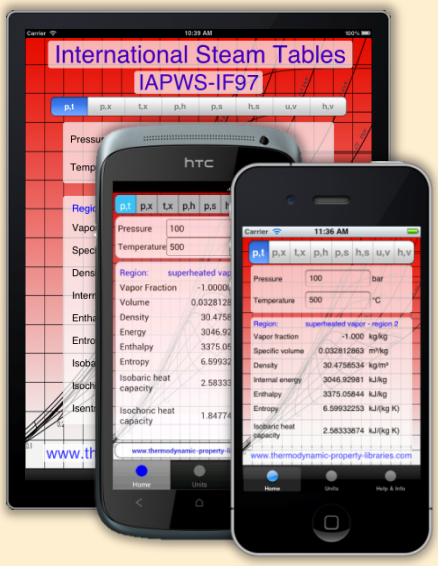
The property functions can be called in DYMOLA® and SimulationX®.



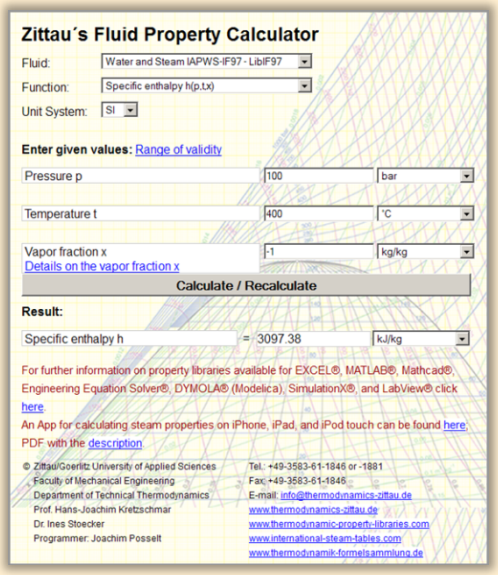
Add-On FluidEES for Engineering Equation Solver®



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:

KCE ThermoFluidProperties

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

Thermodynamic Properties

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

Transport Properties

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

5. References

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NH3 + H2O, and NH3 + CH3OH Liquid Mixtures.
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6. Satisfied Customers

Period from 2018 to 2022

The following companies and institutions use the property libraries:

- FluidEXL*Graphics* for Excel® incl. VBA
- FluidLAB for MATLAB® and Simulink
- FluidMAT for Mathcad®
- FluidPRIME for Mathcad Prime®
- FluidEES for Engineering Equation Solver® EES
- FluidDYM for Dymola® (Modelica) and SimulationX®
- FluidVIEW for LabVIEW™
- FluidPYT for Python
- FluidJAVA for Java
- DLLs for Windows Applications
- Shared Objects for Linux
- Shared Objects for macOS.

2022

ASTG, Graz, Austria	12/2022
Wandschneider + Gutjahr, Hamburg	
RWE Supply & Trading, Essen	11/2022
Stadtwerke Rosenheim	
CEA, Saclay, France	10/2022
RWE Supply & Trading, Essen	
SEEC Saudi Energy Efficiency Center, Riyadh, Saudi Arabia	
MAN, Copenhagen, Denmark	
Hermeler & Partner Consulting Engineers, Sassenberg	09/2022
Envi Con, Nürnberg	
Drill Cool Systems, Bakersfield CA, USA	
RWE Supply & Trading, Essen	
Maerz Ofenbau, Zürich, Switzerland	
Saale Energie, Schkopau	
ERGO, Dresden	
Mainova, Frankfurt/Main	
Bundeswehr, Koblenz	08/2022
RWE Supply & Trading, Essen	
Grenzebach Corporation, Newnan GE, USA	
AGRANA, Gmuend, Austria	07/2022
MIBRAG, Zeitz	
Hochschule Niederrhein, Krefeld	
ULT, Löbau	06/2022
LEAG, Cottbus	
VPC Group, Vetschau	

Wärme, Hamburg	
ILK, Dresden	
Stricker IB, Küssnacht a. Rigi, Switzerland	
LEAG, Cottbus	05/2022
RWE Supply & Trading, Essen	
IGT Tomalla, Kreuztal	
B+T Engineering, Dübendorf, Switzerland	
Stricker IB, Küssnacht a. Rigi, Switzerland	
Vogelsang & Benning, Bochum	04/2022
Frischli, Rehburg-Loccum	
BPS Consulting, Sprenge	03/2022
HS Hannover, Maschinenbau & BioVT	
M+M Turbinentechnik, Bad Salzuflen	
Uni. Strathclyde, Glasgow, UK	02/2022
Delta Energy Group, Jiaozhou City, Qingdao, China	
Wetzel IB, Guben	
Wijbenga, PC Geldermalsen, The Netherlands	
Voith Paper, Heidenheim	
HS Zittau/Görlitz, Maschinenwesen	01/2022
Thermische Abfallbehandlung, Lauta	
Webb Institute, Glen Cove NY, USA	
TU Berlin, Umweltverfahrenstechnik	
SachsenEnergie, Dresden	
Doosan, Chang-won-si, Gyeongsangnam-do, South Korea	
KW3, LH Veenendaal, The Netherlands	
Université du Luxembourg, Esch-sur-Alzette	
Enseleit IB, Mansfeld	
Caliqua/Equans, Zürich, Switzerland	
Rudnick & Enners, Alpenrod	

2021

Wenisch IB, Vetschau	12/2021
PPCHEM, Hinwil, Switzerland	
KW3, The Netherlands	
BASF Ludwigshafen	
Air-Consult, Jena	
Sjerp & Jongeneel, RB Zoetermeer, The Netherlands	11/2021
Maerz Ofenbau, Zürich, Switzerland	
RWE Supply & Trading, Essen	
Hahn IB, Dresden	10/2021
Therm, South Africa	
RWE Supply & Trading, Essen	
TH Nürnberg, Verfahrenstechnik	09/2021
RWE Supply & Trading, Essen	
Enseleit IB, Mansfeld	
SachsenEnergie, Dresden	
BSH Hausgeräte, Berlin	

Norsk Energi, Oslo, Norway	08/2021
AKM Industrieanlagen, Haltern	
Drill Cool Systems, Bakersfield CA, USA	
Siemens Energy Global, Erlangen	07/2021
Wulff & Umag, Husum	
Planungsbüro Waidhas, Chemnitz	
Burkhardt Energie Technik, Mühlhausen	
Lücke IB, Paderborn	06/2021
TU Dresden, Energieverfahrenstechnik	
Wärme, Hamburg	
AL-KO Therm, Kötz	
PCK Raffinerie, Schwedt	
Vogelsang & Benning, Bochum	05/2021
MTU, München	
VPC Group, Vetschau	
AVG, Köln	04/2021
TH Ulm, Institut für Fahrzeugtechnik	
Marty IB, Oberwil, Switzerland	
HypTec, Lebring, Austria	
Lopez IB, Getxo, Bizkaia, Spain	03/2021
GM Remediation Systems, Leoben, Austria	
Jager Kältetechnik, Osnabrück	
T&M Automation, GR Leidschendam, The Netherlands	
RWE Supply & Trading, Essen	
Stadtwerke Leipzig	
Beuth Hochschule für Technik, Berlin	
Beleth IB, Woeth	02/2021
ZTL, Thal, Austria	
ETABO Bochum	
RWE Supply & Trading, Essen	
Onyx Germany, Berlin	
TU Dresden, Kältetechnik	
GOHL-KTK, Durmersheim	
Therm Development, South Africa	
thermofin, Heinsdorfergrund	
RWE Supply & Trading, Essen	01/2021
STEAG, Essen	
ETA Energieberatung, Pfaffenhofen	
Enex Power, Kirchseeon	

2020

Drill Cool, Bakersfield CA, USA	12/2020
Manders, The Netherlands	
RWE Supply & Tranding, Essen	
NEOWAT Lodz, Poland	
University of Duisburg-Essen, Duisburg	11/2020
Stellenbosch University, South Africa	

University De France-COMTe, France	
RWE, Essen	
STEAG, Herne	
Isenmann Ingenierbüro	
University of Stuttgart, ITLR, Stuttgart	
Norsk Energi, Oslo, Norway	
TGM Kanis, Nürnberg	
Stadtwerke Neuburg	10/2020
Smurfit Kappa, Roermond, The Netherlands	
RWE, Essen	
Hochschule Zittau/Görlitz, Wirtschaftsingenieurwesen	
Stadtwerke, Neuburg	
ILK, Dresden	
ATESTEO, Alsdorf	
Hochschule Zittau/Görlitz, Maschinenwesen	
TH Nürnberg, Verfahrenstechnik	
Drill Cool, Bakersfield CA,USA	09/2020
RWE, Essen	
2Meyers Ingenieurbüro, Nürnberg	
FELUWA, Mürlenbach	
Stadtwerke Neuburg	
Caverion, Wien, Austria	
GMVA Niederrhein, Oberhausen	
INWAT Lodz, Poland	
Troche Ingenieurbüro, Hayingen	08/2020
CEA Saclay, France	
VPC, Vetschau	07/2020
FSK System-Kälte-Klima, Dortmund	
Exergie Etudes, Sarl, Switzerland	
AWG Wuppertal	
STEAG Energy Services, Zwingenberg	
Hochschule Braunschweig	06/2020
DBI, Leipzig	
GOHL-KTK, Dumersheim	
TU Dresden, Energieverfahrenstechnik	
BASF SE, ESI/EE, Ludwigshafen	
Wärme Hamburg	
Ruchti Ingenieurbüro, Uster, Switzerland	
IWB, Basel, Switzerland	
Midiplan, Bietingen-Bissingen	05/2020
Knieschke, Ingenieurbüro	
RWE, Essen	
Leser, Hamburg	
AGRANA, Gmünd, Austria	
EWT Wassertechnik, Celle	
Hochschule Darmstadt	04/2020
MTU München CCP	
HAW Hamburg	03/2020

Hanon, Novi Jicin, Czech Republic	
TU Dresden, Kältetechnik	
MAN, Copenhagen, Denmark	
EnerTech, Radebeul	02/2020
LEAG, Cottbus	
B+B Enginering Magdeburg	
Hochschule Offenburg	
WIB, Dennheritz	01/2020
Universität Duisburg-Essen, Strömungsmaschinen	
Kältetechnik Dresen-Bremen	
TH Ingolstadt	
Vattenfall AB, Jokkmokk, Sweden	
Fraunhofer UMSICHT	

2019

PEU Leipzig, Rötha	12/2019
MB-Holding, Vestenbergsgreuth	
RWE, Essen	
Georg-Büchner-Hochschule, Darmstadt	11/2019
EEB ENERKO, Aldenhoven	
Robert Benoufa Energietechnik, Wiesloch	
Kehrein & Kubanek Klimatechnik, Moers	10/2019
Hanon Systems Autopal Services, Hluk, Czech Republic	
CEA Saclay, Gif Sur Yvette cedex, France	
Saudi Energy Efficiency Center SEEC, Riyadh, Saudi Arabia	
VPC, Vetschau	09/2019
jGanser PM + Engineering, Forchheim	
Endress+Hauser Flowtec AG, Reinach, Switzerland	
Ruchti IB, Uster, Switzerland	
ZWILAG Zwischenlager Würenlingen, Switzerland	08/2019
Hochschule Zittau/Görlitz, Faculty Maschinenwesen	
Stadtwerke Neubrandenburg	
Physikalisch Technische Bundesanstalt PTB, Braunschweig	
GMVA Oberhausen	07/2019
Endress+Hauser Flowtec AG, Reinach, Switzerland	
WARNICA, Waterloo, Canada	
MIBRAG, Zeitz	06/2019
Pöyry, Zürich, Switzerland	
RWTH Aachen, Institut für Strahlantriebe und Turbomaschinen	
Midiplan, Bietigheim-Bissingen	
GKS Schweinfurt	
HS Zittau/Görlitz, Wirtschaftswissenschaften und Wirtschaftsingenieurwesen	
ILK Dresden	
HZDR Helmholtz Zentrum Dresden-Rossendorf	
TH Köln, Technische Gebäudeausrüstung	05/2019
IB Knittel, Braunschweig	
Norsk Energi, Oslo, Norway	

STEAG, Essen	
Stora Enso, Eilenburg	
IB Lücke, Paderborn	
Haarslev, Sonderso, Denmark	
MAN Augsburg	
Wieland Werke, Ulm	04/2019
Fels-Werke, Elbingerode	
Univ. Luxembourg, Luxembourg	
BTU Cottbus, Power Engineering	03/2009
Eins-Energie Sachsen, Schwarzenberg	
TU Dresden, Kälte- und Kryotechnik	
ITER, St. Paul Lez Durance Cedex, France	
Fraunhofer UMSICHT, Oberhausen	
Comparex Leipzig for Spedition Thiele HEMMERSBACH	
Rückert NaturGas, Lauf/Pegnitz	
BASF, Basel, Switzerland	02/2019
Stadtwerke Leipzig	
Maerz Ofenbau Zürich, Switzerland	
Hanon Systems Germany, Kerpen	
Thermofin, Heinsdorfergrund	01/2019
BSH Berlin	

2018

Jaguar Energy, Guatemala	12/2018
WEBASTO, Gilching	
Smurfit Kappa, Oosterhout, Netherlands	
Univ. BW München	
RAIV, Liberec for VALEO, Prague, Czech Republic	11/2018
VPC Group Vetschau	
SEITZ, Wetzikon, Switzerland	
MVV, Mannheim	10/2018
IB Troche	
KANIS Turbinen, Nürnberg	
TH Ingolstadt, Institut für neue Energiesysteme	
IB Kristl & Seibt, Graz, Austria	09/2018
INEOS, Köln	
IB Lücke, Paderborn	
Südzucker, Ochsenfurt	08/2018
K&K Turbinenservice, Bielefeld	07/2018
OTH Regensburg, Elektrotechnik	
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Münstermann, Telgte	05/2018
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HS Niederrhein, Krefeld	
Wilhelm-Büchner HS, Pfungstadt	03/2018

GRS, Köln	
WIB, Dennheritz	
RONAL AG, Härklingen, Schweiz	02/2018
Ingenieurbüro Leipert, Riegelsberg	
AIXPROCESS, Aachen	
KRONES, Neutraubling	
Doosan Lentjes, Ratingen	01/2018