Humid Air Properties

Psychrometrics

Excel® Add-In Library

DEMO VERSION

USER GUIDE

Windows® Operating System
SI and I-P Units
Version 2.0

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OVERVIEW

Psychrometrics (Demo Version) is an Excel Add-In Library that allows the calculation of thermodynamic and psychrometric properties of humid air, dry air, water, water vapor and ice based entirely on the mathematical formulation of the 2009 ASHRAE Handbook of Fundamentals.

This Demo Version includes limitations in the range of the input variables that are included.

REQUIREMENTS

The following are the requirements in order to install and utilize Psychrometrics (Demo Version). Please note that if your current operating system does not include the corresponding C++ Runtime Library it will be installed by the installation file.

	OPERATING SYSTEM
Windows OS	Windows 7 Windows 8 Windows 8.1 Windows 10

	MINIMUM VERSION	REQUIREMENT
Office Excel	Excel 2010	32-bit or 64-bit

	BITNESS	REQUIREMENT
C++ Runtime Library	32-bit	Microsoft Visual C++ 2012 Redistributable (32-bit) - 11.0.6.61030
	64-bit	Microsoft Visual C++ 2012 Redistributable (64-bit) - 11.0.6.61030

- Please note that the minimum supported Window OS is Windows 7, and the minimum supported Excel version is Office 2010.

Psychrometrics (Demo Version) is available as a 32-bit or 64-bit Excel Add-in in accordance with the installed Excel version. Please select the right installation file that matches your Office version.

Installation File	Excel Version
Psychrometrics_XLLDemo_x86_Setup	32-bit
Psychrometrics_XLLDemo_x64_Setup	64-bit

INSTALLATION

Unzip the file that corresponds to your Excel version. Double-click on the *_Setup.exe* file that is on the unzipped directory and follow the screen instructions.

Once installed, the next step is to register the following file as an Add-in in Excel (located in your installation directory):

PSYCHROMETRICSFLK_DEMO.xll

Now you are ready to evaluate Psychrometrics.

A sample excel file with all the functions available in this demo version can be found in the */EXAMPLE* directory of your installation.

Note : All files with extension *.dll* need to be located in the same directory of the add-in (file with extension *.xll*).

Please check *www.fluidika.com* for information on how to register an add-in in Excel.

You need to have **Administrator** privileges on your computer in order to install the software

USER DEFINED FUNCTIONS (UDF)

Psychrometrics (Evaluation Version) Excel Add-In Library is composed of User Defined Functions (UDF) that take parameters (string and/or double) and returns a double (number).

If incorrect or out of bounds input parameters are entered, the function will return the value of **-9999.**

Table 1 shows the functions defined as a combinations of input properties. Properties calculated based on these functions are described in Table 5.

Functions that return a single property are described in Tables 2 and 3; their properties and units are shown in Table 6.

SI UNITS	I-P UNITS	OUTPUT RESULT
HAFLK_SI_pTdbW_prop	**HAFLK_IP_pTdbW_prop**	**Depending on value of "prop", see Table 5** **PRESSURE FIXED AT 700000 Pa/101.5264 psi**
HAFLK_SI_pTdh_prop	**HAFLK_IP_pTdh_prop**	
HAFLK_SI_pWv_prop	**HAFLK_IP_pWv_prop**	
HAFLK_SI_pTdbTwb_prop	*HAFLK_IP_pTdbTwb_prop*	**NOT AVAILABLE IN DEMO VERSION**
HAFLK_SI_pTdbTd_prop	*HAFLK_IP_pTdbTd_prop*	
HAFLK_SI_pTdbPHI_prop	*HAFLK_IP_pTdbPHI_prop*	
HAFLK_SI_pTdbh_prop	*HAFLK_IP_pTdbh_prop*	
HAFLK_SI_pTdbv_prop	*HAFLK_IP_pTdbv_prop*	
HAFLK_SI_pTwbTd_prop	*HAFLK_IP_pTwbTd_prop*	
HAFLK_SI_pTwbPHI_prop	*HAFLK_IP_pTwbPHI_prop*	
HAFLK_SI_pTwbW_prop	*HAFLK_IP_pTwbW_prop*	
HAFLK_SI_pTdPHI_prop	*HAFLK_IP_pTdPHI_prop*	
HAFLK_SI_pTdv_prop	*HAFLK_IP_pTdv_prop*	
HAFLK_SI_pWPHI_prop	*HAFLK_IP_pWPHI_prop*	
HAFLK_SI_pWh_prop	*HAFLK_IP_pWh_prop*	
HAFLK_SI_pPHIh_prop	*HAFLK_IP_pPHIh_prop*	
HAFLK_SI_pPHIv_prop	*HAFLK_IP_pPHIv_prop*	

Table 1. Functions based on combination of input variables

SI UNITS	I-P UNITS	OUTPUT RESULT
SWFLK_SI_pT_hlw	SWFLK_IP_pT_hlw	**Specific enthalpy of liquid water**
SWFLK_SI_T_hlws	SWFLK_IP_T_hlws	**Specific enthalpy of saturated liquid water**
SWFLK_SI_T_hwvs	SWFLK_IP_T_hwvs	**Specific enthalpy of saturated water vapor**
SWFLK_SI_pT_slw	SWFLK_IP_pT_slw	**Specific entropy of liquid water**
SWFLK_SI_T_slws	SWFLK_IP_T_slws	**Specific entropy of saturated liquid water**
SWFLK_SI_T_swvs	SWFLK_IP_T_swvs	**Specific entropy of saturated water vapor**
SWFLK_SI_pT_vlw	SWFLK_IP_pT_vlw	**Specific volume of liquid water**
SWFLK_SI_T_vlws	SWFLK_IP_T_vlws	**Specific volume of saturated liquid water**
SWFLK_SI_T_vwvs	SWFLK_IP_T_vwvs	**Specific volume of saturated water vapor**
SWFLK_SI_T_Pws	SWFLK_IP_T_Pws	**Saturation pressure of water**
SWFLK_SI_p_Tws	SWFLK_IP_p_Tws	**Saturation temperature of water**

Table 2. Functions for T ⩾ 273.15 K / 32 °F
DEMO - PRESSURE FIXED AT 700000 Pa/101.5264 psi
DEMO - TEMPERATURE RANGE : 273.15 - 275 K/32 - 35.33 °F

SI UNITS	I-P UNITS	OUTPUT RESULT
SWFLK_SI_T_hiws	SWFLK_IP_T_hiws	**Specific enthalpy of saturated ice**
SWFLK_SI_T_hwvs_sub	SWFLK_IP_T_hwvs_sub	**Specific enthalpy of saturated water vapor**
SWFLK_SI_T_siws	SWFLK_IP_T_siws	**Specific entropy of saturated ice**
SWFLK_SI_T_swvs_sub	SWFLK_IP_T_swvs_sub	**Specific entropy of saturated water vapor**
SWFLK_SI_T_viws	SWFLK_IP_T_viws	**Specific volume of saturated ice**
SWFLK_SI_T_vwvs_sub	SWFLK_IP_T_vwvs_sub	**Specific volume of saturated water vapor**
SWFLK_SI_T_Pmel	SWFLK_IP_T_Pmel	**Melting pressure of ice**
SWFLK_SI_T_Psub	SWFLK_IP_T_Psub	**Sublimation pressure of ice**
SWFLK_SI_p_Tmel	SWFLK_IP_p_Tmel	**Melting temperature of ice**
SWFLK_SI_p_Tsub	SWFLK_IP_p_Tsub	**Sublimation temperature of ice**

Table 3. Functions for T ⩽ 273.15 K / 32 °F
DEMO - PRESSURE FIXED AT 700000 Pa/101.5264 psi
DEMO - TEMPERATURE RANGE : 272 - 273.15 K/29.93 - 32 °F

SI UNITS	I-P UNITS	OUTPUT RESULT
SWFLK_SI_pT_Pwvs	*SWFLK_IP_pT_Pwvs*	**Partial saturation pressure of water vapor**
SWFLK_SI_pT_f	*SWFLK_IP_pT_f*	**Enhancement factor**
SWFLK_SI_pT_Ws	*SWFLK_IP_pT_Ws*	**Saturation humidity ratio**
SWFLK_SI_pW_Td	*SWFLK_IP_pW_Td*	**Dew/frost point temperture**
SWFLK_SI_W_PSIda	*SWFLK_IP_W_PSIda*	**Mole fraction of dry air**
SWFLK_SI_W_PSIwv	*SWFLK_IP_W_PSIwv*	**Mole fraction of water vapor**
SWFLK_SI_W_XIda	*SWFLK_IP_W_XIda*	**Mass fraction of dry air**
SWFLK_SI_W_XIwv	*SWFLK_IP_W_XIwv*	**Mass fraction of water vapor**
SWFLK_SI_Zele_p	*SWFLK_IP_Zele_p*	**Pressure of humid air**

Table 4. Functions NOT included in Psychrometrics (Demo Version)

Result Property	SI Units	I-P Units	prop
Dry-Bub Temperature	K	°F	**Tdb**
Wet-Bulb Temperature	K	°F	**Twb**
Dew Point Temperature	K	°F	**Td**
Partial Pressure of Water Vapor in Humid Air	Pa	psi	**Pwv**
Partial Pressure of Dry Air in Humid Air	Pa	psi	**Pda**
Partial Saturation Water Vapor Pressure	Pa	psi	**Pwvs**
Mole Fraction of Dry Air in Humid Air	[-]	[-]	**PSIda**
Mole Fraction of Water Vapor in Humid Air	[-]	[-]	**PSIwv**
Mass Fraction of Dry Air in Humid Air	[-]	[-]	**XIda**
Mass Fraction of Water Vapor in Humid Air	[-]	[-]	**XIwv**
Humidity Ratio	kg(w)/kg(da)	lb(w)/lb(da)	**W**
Saturation Humidity Ratio	kg(w)/kg(da)	lb(w)/lb(da)	**Ws**
Relative Humidity	(decimal ratio)	(decimal ratio)	**PHI**
Absolute Humidity	kg(w)/m^3	lb(w)/ft^3	**AH**
Parts per million by weight	ppmw	ppmw	**ppmw**
Parts per million by volume	ppmv	ppmv	**ppmv**
Enhancement Factor	[-]	[-]	**f**
Specific Volume of Humid Air	m^3/kg(da)	ft^3/lb(da)	**v**
Specific Volume of Dry Air	m^3/kg(da	ft^3/lb(da)	**vda**
Density of Humid Air	kg/m^3	lb/ ft^3	**RHO**
Density of Dry Air	kg/m^3	lb/ ft^3	**RHOda**
Specific Enthalpy of Humid Air	J/kg	Btu/lb	**h**
Specific Enthalpy of Dry Air	J/kg	Btu/lb	**hda**
Specific Entropy of Humid Air	J/(kg·K)	Btu/(lb °R)	**s**
Specific Entropy of Dry Air	J/(kg·K)	Btu/(lb °R)	**sda**
Specific Internal Energy of Humid Air	J/kg	Btu/lb	**u**
Specific Internal Energy of Dry Air	J/kg	Btu/lb	**uda**
Specific Isobaric Heat Capacity of Humid Air	J/(kg·K)	Btu/(lb °R)	**cp**
Compressibility of Humid Air	[-]	[-]	**Z**

Table 5. **Properties calculated for each combination of input thermodynamic variables**

Property	SI Units (output)	I-P Units (output)
Specific Enthalpy of Liquid Water	J/kg	Btu/lb
Specific Enthalpy of Saturated Liquid Water	J/kg	Btu/lb
Specific Enthalpy of Saturated Water Vapor	J/kg	Btu/lb
Specific Entropy of Liquid Water	J/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Liquid Water	J/(kg·K)	Btu/(lb·°R)
Specific Entropy of Saturated Water Vapor	J/(kg·K)	Btu/(lb·°R)
Specific Volume of Liquid Water	m^3/kg	ft^3/lb
Specific Volume of Saturated Liquid Water	m^3/kg	ft^3/lb
Specific Volume of Saturated Water Vapor	m^3/kg	ft^3/lb
Saturation Pressure of Water	Pa	psi
Saturation Temperature of Water	K	°F
Specific Enthalpy of Saturated Ice	J/kg	Btu/lb
Specific Entropy of Saturated Ice	J/(kg·K)	Btu/(lb·°R)
Specific Volume of Saturated Ice	m^3/kg	ft^3/lb
Melting Pressure of Ice	Pa	psi
Sublimation Pressure of Ice	Pa	psi
Melting Temperature of Ice	K	°F
Sublimation Temperature of Ice	K	°F

Table 6. Additional properties calculated

FUNCTION NAME: HAFLK_SI_pTdbW_prop

EXCEL function usage : HAFLK_SI_pTdbW_prop(p, Tdb, W, prop)

Input values :

p : Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

Tdb : Dry-bulb temperature in K.
Range: 130.0 ⩽ Tdb ⩽ 623.15 [K]

W : Humidity ratio kg(water)/kg(dry air).
Range: 0 ⩽ W ⩽ 10 [kg/kg]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific enthalpy of humid air ("h") as function of pressure, dry-bulb temperature and humidity ratio.
Cell E2 is interpreted as: =HAFLK_SI_pTdbW_prop(700000, 380, 0.01, "h").

	A	B	C	D	E
1	p	Tdb	W	prop	
2	700000	380	0.01	h	=HAFLK_SI_pTdbW_prop(A2, B2, C2, D2)

FUNCTION NAME: HAFLK_SI_pTdh_prop

EXCEL function usage : HAFLK_SI_pTdh_prop(p, Td, h, prop)

Input values :

p : Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

Td : Dew point temperature in K.
Range: 130.0 ⩽ Td ⩽ 623.15 [K]

h: Specific enthalpy of humid air in J/kg.
Range: -311357 ⩽ h ⩽ 32135848 [J/kg]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific entropy of humid air ("s") as function of pressure, dew point temperature and specifc enthalpy of humid air.
Cell E2 is interpreted as: =HAFLK_SI_pTdh_prop(700000, 320.5785744, 133892.2056, "s").

	A	B	C	D	E
1	p	Td	h	prop	
2	700000	320.5785744	133892.2056	s	=HAFLK_SI_pTdh_prop(A2, B2, C2, D2)

FUNCTION NAME: HAFLK_SI_pWv_prop

EXCEL function usage : HAFLK_SI_pWv_prop(p, W, v, prop)

Input values :

p : Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

W : Humidity ratio kg(water)/kg(dry air).
Range: 0 ⩽ W ⩽ 10 [kg/kg]

v : Specific volume of humid air in m^3/kg(dry air).
Range: 1.469E-3 ⩽ v ⩽ 3.055E5 [m^3/kg]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific enthalpy of humid air ("h") as function of pressure, humidity ratio and specific volume of humid air.
Cell E2 is interpreted as: =HAFLK_SI_pWv_prop(700000, 0.01, 0.158457326, "h").

	A	B	C	D	E
1	p	W	v	prop	
2	700000	0.01	0.158457326	h	=HAFLK_SI_pWv_prop(A2, B2, C2, D2)

FUNCTION NAME: SWFLK_SI_pT_hlw

Specific enthalpy of liquid water

EXCEL function usage : SWFLK_SI_pT_hlw(p, T)

Input values :

p : Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

T : Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific enthalpy of liquid water in J/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific enthalpy of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_SI_pT_hlw(700000, 275).

	A	B	C
1	p	T	
2	700000	275	=SWFLK_SI_pT_hlw(A2, B2)

FUNCTION NAME: **SWFLK_SI_T_hlws**

Specific enthalpy of saturated liquid water

EXCEL function usage : SWFLK_SI_T_hlws(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific enthalpy of saturated liquid water in J/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_hlws(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_hlws(A2)

FUNCTION NAME: **SWFLK_SI_T_hwvs**

Specific enthalpy of saturated water vapor

EXCEL function usage : SWFLK_SI_T_hwvs(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific enthalpy of saturated water vapor in J/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_hwvs(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_hwvs(A2)

FUNCTION NAME: **SWFLK_SI_pT_slw**

Specific entropy of liquid water

EXCEL function usage : SWFLK_SI_pT_slw(p, T)

Input values : **p :** Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

T : Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific entropy of liquid water in J/(kg·K).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific entropy of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_SI_pT_slw(700000, 275).

	A	B	C
1	p	T	
2	700000	275	=SWFLK_SI_pT_slw(A2, B2)

FUNCTION NAME: **SWFLK_SI_T_slws**

Specific entropy of saturated liquid water

EXCEL function usage : SWFLK_SI_T_slws(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific entropy of saturated liquid water in J/(kg·K).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_slws(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_slws(A2)

FUNCTION NAME: **SWFLK_SI_T_swvs**

Specific entropy of saturated water vapor

EXCEL function usage : SWFLK_SI_T_swvs(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific entropy of saturated water vapor in J/(kg·K).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_swvs(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_swvs(A2)

FUNCTION NAME: **SWFLK_SI_pT_vlw**

Specific volume of liquid water

EXCEL function usage : SWFLK_SI_pT_vlw(p, T)

Input values : **p :** Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

T : Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific volume of liquid water in m^3/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific volume of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_SI_pT_vlw(700000, 275).

	A	B	C
1	p	T	
2	700000	275	=SWFLK_SI_pT_vlw(A2, B2)

FUNCTION NAME: **SWFLK_SI_T_vlws**

Specific volume of saturated liquid water

EXCEL function usage : SWFLK_SI_T_vlws(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific volume of saturated liquid water in m^3/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_vlws(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_vlws(A2)

FUNCTION NAME: **SWFLK_SI_T_vwvs**

Specific volume of saturated water vapor

EXCEL function usage : SWFLK_SI_T_vwvs(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Specific volume of saturated water vapor in m^3/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_vwvs(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_vwvs(A2)

FUNCTION NAME: **SWFLK_SI_T_Pws**

Saturation pressure of water

EXCEL function usage : SWFLK_SI_T_Pws(T)

Input values : **T :** Temperature in K.
Range: 273.15 ⩽ T ⩽ 275.0 [K]

Output Result : **Saturation pressure of water in Pa.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of saturation pressure of water as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_Pws(275).

	A	B
1	T	
2	275	=SWFLK_SI_T_Pws(A2)

FUNCTION NAME: **SWFLK_SI_p_Tws**

Saturation temperature of water

EXCEL function usage : SWFLK_SI_p_Tws(p)

Input values : **p :** Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

Output Result : **Saturation temperature of water in K.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of saturation temperature of water as function of pressure.
Cell B2 is interpreted as: =SWFLK_SI_p_Tws(700000).

	A	B
1	p	
2	700000	=SWFLK_SI_p_Tws(A2)

FUNCTION NAME: **SWFLK_SI_T_hiws**

Specific enthalpy of saturated ice

EXCEL function usage : SWFLK_SI_T_hiws(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific enthalpy of saturated ice in J/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_hiws(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_hiws(A2)

FUNCTION NAME: **SWFLK_SI_T_hwvs_sub**

Specific enthalpy of saturated water vapor

EXCEL function usage : SWFLK_SI_T_hwvs_sub(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific enthalpy of saturated water vapor in J/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_hwvs_sub(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_hwvs_sub(A2)

FUNCTION NAME: **SWFLK_SI_T_siws**

Specific entropy of saturated ice

EXCEL function usage : SWFLK_SI_T_siws(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific entropy of saturated ice in J/(kg·K).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_siws(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_siws(A2)

FUNCTION NAME: **SWFLK_SI_T_swvs_sub**

Specific entropy of saturated water vapor

EXCEL function usage : SWFLK_SI_T_swvs_sub(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific entropy of saturated water vapor in J/(kg·K).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_swvs_sub(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_swvs_sub(A2)

FUNCTION NAME: **SWFLK_SI_T_viws**

Specific volume of saturated ice

EXCEL function usage : SWFLK_SI_T_viws(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific volume of saturated ice in m^3/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_viws(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_viws(A2)

FUNCTION NAME: **SWFLK_SI_T_vwvs_sub**

Specific volume of saturated water vapor

EXCEL function usage : SWFLK_SI_T_vwvs_sub(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Specific volume of saturated water vapor in m^3/kg.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_vwvs_sub(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_vwvs_sub(A2)

FUNCTION NAME: **SWFLK_SI_T_Pmel**

Melting pressure of ice

EXCEL function usage : SWFLK_SI_T_Pmel(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Melting pressure of ice in Pa.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of melting pressure of ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_Pmel(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_Pmel(A2)

FUNCTION NAME: **SWFLK_SI_T_Psub**

Sublimation pressure of ice

EXCEL function usage : SWFLK_SI_T_Psub(T)

Input values : **T :** Temperature in K.
Range: 272.0 ⩽ T ⩽ 273.15 [K]

Output Result : **Sublimation pressure of ice in Pa.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of sublimation pressure of ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_SI_T_Psub(273.15).

	A	B
1	T	
2	273.15	=SWFLK_SI_T_Psub(A2)

FUNCTION NAME:	**SWFLK_SI_p_Tmel** **Melting temperature of ice**

EXCEL function usage : SWFLK_SI_p_Tmel(p)

Input values : **p :** Pressure in Pa.
FIXED PRESSURE AT : 700000 Pa

Output Result : **Melting temperature of ice in K.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of melting temperature of ice as function of pressure.
Cell B2 is interpreted as: =SWFLK_SI_p_Tmel(700000).

	A	B
1	p	
2	700000	=SWFLK_SI_p_Tmel(A2)

FUNCTION NAME:	**SWFLK_SI_p_Tsub** **Sublimation temperature of ice**

EXCEL function usage : SWFLK_SI_p_Tsub(p)

Input values : **p :** Pressure in Pa.
Range: $600 \leqslant p \leqslant 610$ [Pa]

Output Result : **Sublimation temperature of ice in K.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of sublimation temperature of ice as function of pressure.
Cell B2 is interpreted as: =SWFLK_SI_p_Tsub(610).

	A	B
1	p	
2	610	=SWFLK_SI_p_Tsub(A2)

FUNCTION NAME: HAFLK_IP_pTdbW_prop

EXCEL function usage : HAFLK_IP_pTdbW_prop(p, Tdb, W, prop)

Input values :

p : Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

Tdb : Dry-bulb temperature in °F.
Range: -225.67 ⩽ Tdb ⩽ 662 [°F]

W : Humidity ratio lb(water)/lb(dry air).
Range: 0 ⩽ W ⩽ 10 [lb/lb]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific enthalpy of humid air ("h") as function of pressure, dry-bulb temperature and humidity ratio.
Cell E2 is interpreted as: =HAFLK_IP_pTdbW_prop(101.5264, 224.3304286, 0.01, "h").

	A	B	C	D	E
1	p	Tdb	W	prop	
2	101.5264	224.3304286	0.01	h	=HAFLK_IP_pTdbW_prop(A2, B2, C2, D2)

FUNCTION NAME: HAFLK_IP_pTdh_prop

EXCEL function usage : HAFLK_IP_pTdh_prop(p, Td, h, prop)

Input values :

p : Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

Td : Dew point temperature in °F.
Range: -225.67 ⩽ Td ⩽ 662 [°F]

h: Specific enthalpy of humid air in Btu/lb.
Range: -126.174 ⩽ h ⩽ 13823.61 [Btu/lb]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific entropy of humid air ("s") as function of pressure, dew point temperature and specifc enthalpy of humid air.
Cell E2 is interpreted as: =HAFLK_IP_pTdh_prop(101.5264, 117.3714339, 62.24904485, "s").

	A	B	C	D	E
1	p	Td	h	prop	
2	101.5264	117.3714339	62.24904485	s	=HAFLK_IP_pTdh_prop(A2, B2, C2, D2)

FUNCTION NAME: HAFLK_IP_pWv_prop

EXCEL function usage : HAFLK_IP_pWv_prop(p, W, v, prop)

Input values :

p : Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

W : Humidity ratio lb(water)/lb(dry air).
Range: 0 ⩽ W ⩽ 10 [lb/lb]

v : Specific volume of humid air in ft^3/lb(dry air).
Range: 2.353E-2 ⩽ v ⩽ 4.893E6 [ft^3/lb]

prop: Output Property. String (See Table 5)

Output Result : See Table 5.

Invalid Output Result : **-9999** For input values outside the valid range , an incorrect string **prop**, or invalid calculation result.

Example : Cell E2 returns the value of specific enthalpy of humid air ("h") as function of pressure, humidity ratio and specific volume of humid air.
Cell E2 is interpreted as: =HAFLK_IP_pWv_prop(101.5264, 0.01, 2.538242875, "h").

	A	B	C	D	E
1	p	W	v	prop	
2	101.5264	0.01	2.538242875	h	=HAFLK_IP_pWv_prop(A2, B2, C2, D2)

FUNCTION NAME: SWFLK_IP_pT_hlw

Specific enthalpy of liquid water

EXCEL function usage : SWFLK_IP_pT_hlw(p, T)

Input values :

p : Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

T : Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific enthalpy of liquid water in Btu/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific enthalpy of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_IP_pT_hlw(14.7, 35.33).

	A	B	C
1	p	T	
2	101.5264	35.33	=SWFLK_IP_pT_hlw(A2, B2)

FUNCTION NAME: **SWFLK_IP_T_hlws**

Specific enthalpy of saturated liquid water

EXCEL function usage : SWFLK_IP_T_hlws(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific enthalpy of saturated liquid water in Btu/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_hlws(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_hlws(A2)

FUNCTION NAME: **SWFLK_IP_T_hwvs**

Specific enthalpy of saturated water vapor

EXCEL function usage : SWFLK_IP_T_hwvs(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific enthalpy of saturated water vapor in Btu/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_hwvs(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_hwvs(A2)

FUNCTION NAME: **SWFLK_IP_pT_slw**

Specific entropy of liquid water

EXCEL function usage : SWFLK_IP_pT_slw(p, T)

Input values : **p :** Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

T : Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific entropy of liquid water in Btu/(lb·°R).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific entropy of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_IP_pT_slw(101.5264, 35.33).

	A	B	C
1	p	T	
2	101.5264	35.33	=SWFLK_IP_pT_slw(A2, B2)

FUNCTION NAME: **SWFLK_IP_T_slws**

Specific entropy of saturated liquid water

EXCEL function usage : SWFLK_IP_T_slws(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific entropy of saturated liquid water in Btu/(lb·°R).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_slws(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_slws(A2)

FUNCTION NAME:	SWFLK_IP_T_swvs Specific entropy of saturated water vapor

EXCEL function usage : SWFLK_IP_T_swvs(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific entropy of saturated water vapor in Btu/(lb·°R).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_swvs(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_swvs(A2)

FUNCTION NAME:	SWFLK_IP_pT_vlw Specific volume of liquid water

EXCEL function usage : SWFLK_IP_pT_vlw(p, T)

Input values : **p :** Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

T : Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific volume of liquid water in ft^3/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell C2 returns the value of specific volume of liquid water as function of pressure and temperature.
Cell C2 is interpreted as: =SWFLK_IP_pT_vlw(101.5264, 35.33).

	A	B	C
1	p	T	
2	101.5264	35.33	=SWFLK_IP_pT_vlw(A2, B2)

FUNCTION NAME: **SWFLK_IP_T_vlws**

Specific volume of saturated liquid water

EXCEL function usage : SWFLK_IP_T_vlws(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific volume of saturated liquid water in ft³/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated liquid water as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_vlws(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_vlws(A2)

FUNCTION NAME: **SWFLK_IP_T_vwvs**

Specific volume of saturated water vapor

EXCEL function usage : SWFLK_IP_T_vwvs(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Specific volume of saturated water vapor in ft³/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_vwvs(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_vwvs(A2)

FUNCTION NAME: **SWFLK_IP_T_Pws**

Saturation pressure of water

EXCEL function usage : SWFLK_IP_T_Pws(T)

Input values : **T :** Temperature in °F.
Range: 32 ⩽ T ⩽ 35.33 [°F]

Output Result : **Saturation pressure of water in psi.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of saturation pressure of water as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_Pws(35.33).

	A	B
1	T	
2	35.33	=SWFLK_IP_T_Pws(A2)

FUNCTION NAME: **SWFLK_IP_p_Tws**

Saturation temperature of water

EXCEL function usage : SWFLK_IP_p_Tws(p)

Input values : **p :** Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

Output Result : **Saturation temperature of water in °F.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of saturation temperature of water as function of pressure.
Cell B2 is interpreted as: =SWFLK_IP_p_Tws(101.5264).

	A	B
1	p	
2	101.5264	=SWFLK_IP_p_Tws(A2)

FUNCTION NAME: **SWFLK_IP_T_hiws**

Specific enthalpy of saturated ice

EXCEL function usage : SWFLK_IP_T_hiws(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific enthalpy of saturated ice in Btu/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_hiws(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_hiws(A2)

FUNCTION NAME: **SWFLK_IP_T_hwvs_sub**

Specific enthalpy of saturated water vapor

EXCEL function usage : SWFLK_IP_T_hwvs_sub(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific enthalpy of saturated water vapor in Btu/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific enthalpy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_hwvs_sub(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_hwvs_sub(A2)

FUNCTION NAME:	SWFLK_IP_T_siws Specific entropy of saturated ice

EXCEL function usage : SWFLK_IP_T_siws(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific entropy of saturated ice in Btu/(lb·°R).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_siws(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_siws(A2)

FUNCTION NAME:	SWFLK_IP_T_swvs_sub Specific entropy of saturated water vapor

EXCEL function usage : SWFLK_IP_T_swvs_sub(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific entropy of saturated water vapor in Btu/(lb·°R).**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific entropy of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_swvs_sub(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_swvs_sub(A2)

FUNCTION NAME: **SWFLK_IP_T_viws**

Specific volume of saturated ice

EXCEL function usage : SWFLK_IP_T_viws(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific volume of saturated ice in ft^3/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_viws(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_viws(A2)

FUNCTION NAME: **SWFLK_IP_T_vwvs_sub**

Specific volume of saturated water vapor

EXCEL function usage : SWFLK_IP_T_vwvs_sub(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Specific volume of saturated water vapor in ft^3/lb.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of specific volume of saturated water vapor as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_vwvs_sub(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_vwvs_sub(A2)

FUNCTION NAME: **SWFLK_IP_T_Pmel**

Melting pressure of ice

EXCEL function usage : SWFLK_IP_T_Pmel(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Melting pressure of ice in psi.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of melting pressure of ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_Pmel(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_Pmel(A2)

FUNCTION NAME: **SWFLK_IP_T_Psub**

Sublimation pressure of ice

EXCEL function usage : SWFLK_IP_T_Psub(T)

Input values : **T :** Temperature in °F.
Range: 29.93 ⩽ T ⩽ 32 [°F]

Output Result : **Sublimation pressure of ice in psi.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of sublimation pressure of ice as function of temperature.
Cell B2 is interpreted as: =SWFLK_IP_T_Psub(32).

	A	B
1	T	
2	32	=SWFLK_IP_T_Psub(A2)

FUNCTION NAME: **SWFLK_IP_p_Tmel**

Melting temperature of ice

EXCEL function usage : SWFLK_IP_p_Tmel(p)

Input values : **p :** Pressure in psi.
FIXED PRESSURE AT : 101.5264 psi

Output Result : **Melting temperature of ice in °F.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of melting temperature of ice as function of pressure.
Cell B2 is interpreted as: =SWFLK_IP_p_Tmel(101.5264).

	A	B
1	p	
2	101.5264	=SWFLK_IP_p_Tmel(A2)

FUNCTION NAME: **SWFLK_IP_p_Tsub**

Sublimation temperature of ice

EXCEL function usage : SWFLK_IP_p_Tsub(p)

Input values : **p :** Pressure in psi.
Range: 0.088 ⩽ p ⩽ 0.0884 [psi]

Output Result : **Sublimation temperature of ice in °F.**

Invalid Output Result : **-9999** For input values outside the valid range or invalid calculation result.

Example : Cell B2 returns the value of sublimation temperature of ice as function of pressure.
Cell B2 is interpreted as: =SWFLK_IP_p_Tsub(0.0884).

	A	B
1	p	
2	0.0884	=SWFLK_IP_p_Tsub(A2)

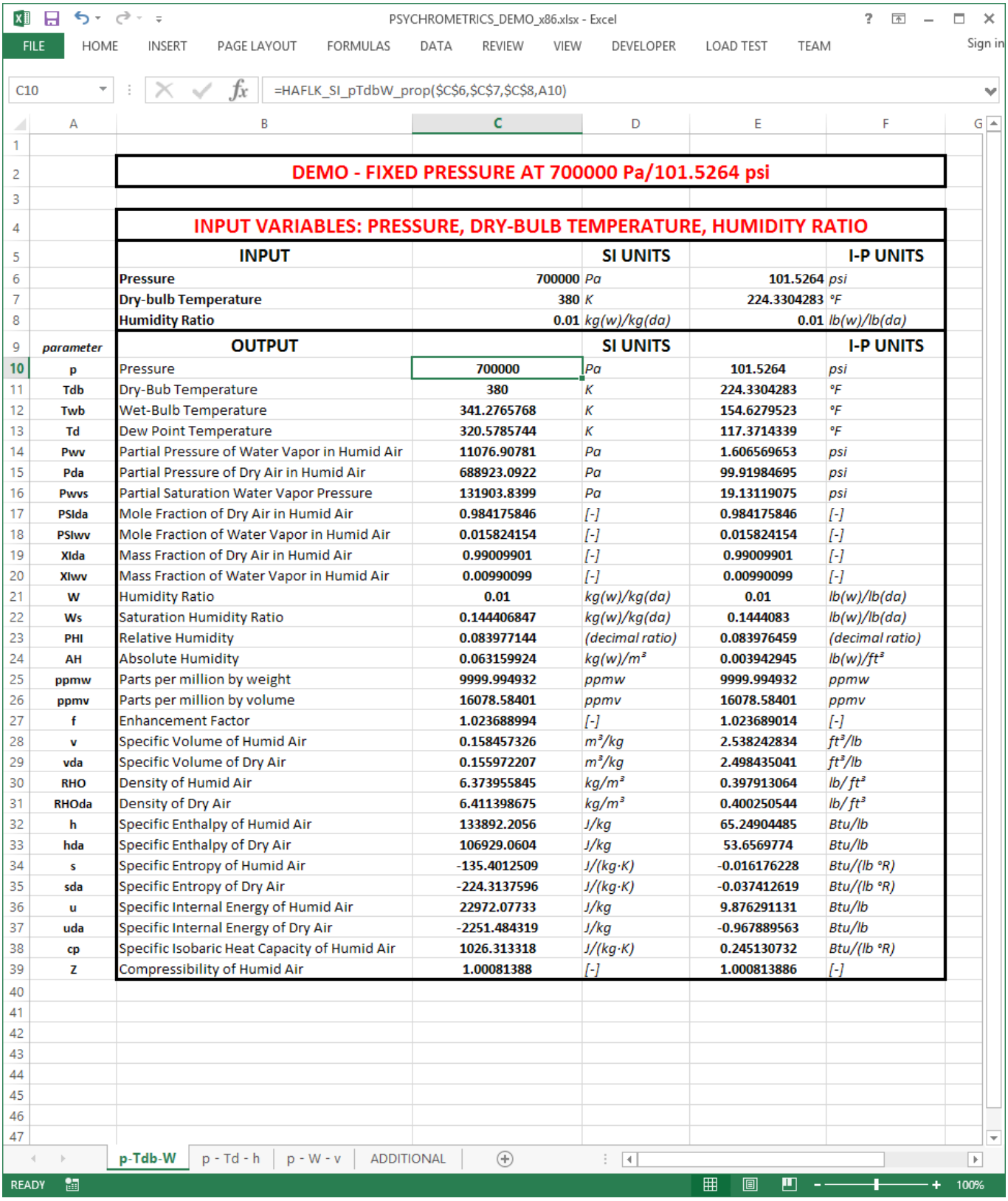

Figure 1. **Screenshot of Excel sheet with results from the pressure, dry-bulb temperature and humidity ratio combination of variables.**

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