

Model Calculation Add-in for use in Excel
By T2E3, Inc.
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rhoL_T:	Density of saturated liquid water given temperature
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qual_Ps:	Quality of a water/steam mixture given pressure and entropy

Contact T2E3

Getting Started

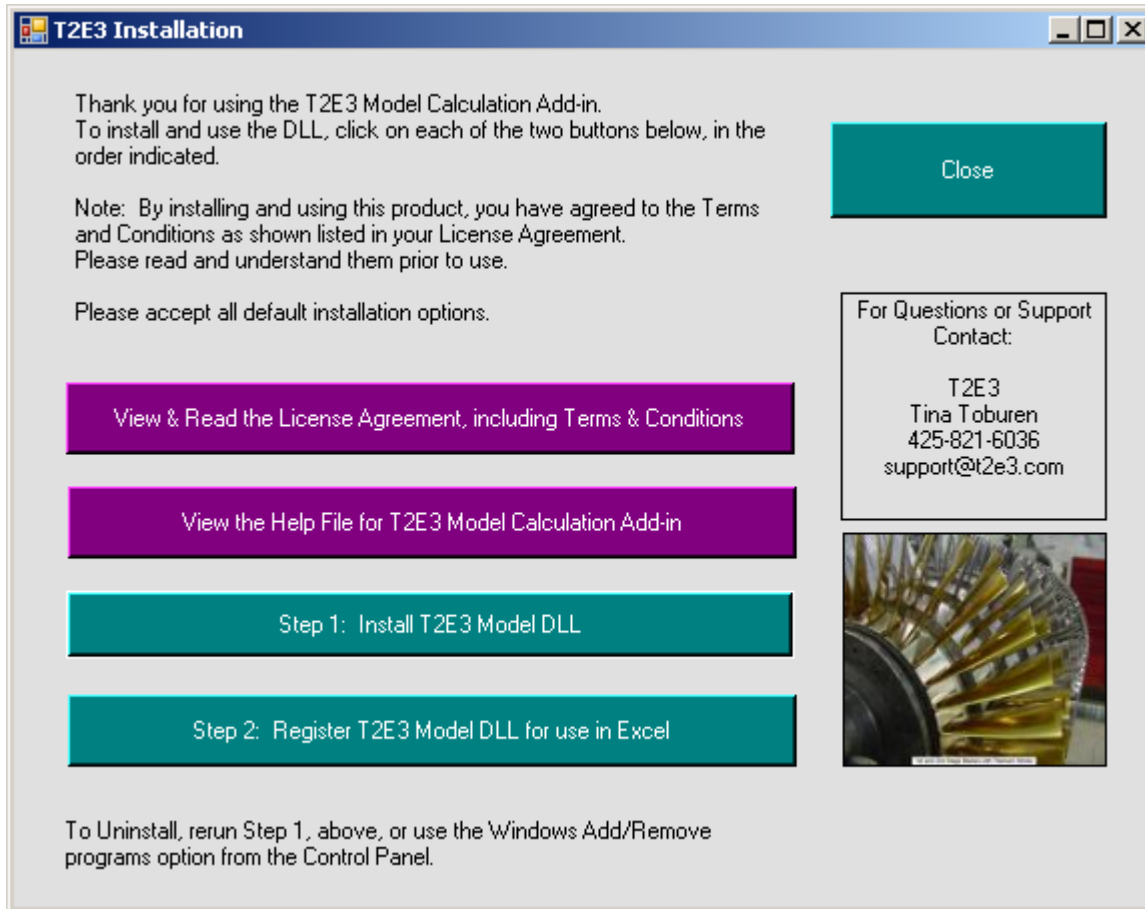
Congratulations! You now have in your possession a program which will help you analyze your plant and equipment using custom functions in Excel. We hope you are able to put these functions to use in analyzing and improving the performance, reliability and profitability of your operations.

Installation

To install the add-in, you have been provided with the following files on an installation CD or ZIP file:

- **T2E3 License.htm** – Please open and read this file, it contains the license agreement, including terms and conditions, that you agree to by installing and using the T2E3 Add-in.
- **T2E3setup.msi** – The Microsoft installation package for the Add-in.
- **T2E3setup.exe** – the executable setup file for the Add-in.
- **T2E3install.exe** – the executable installation program for the Add-in: this is the program you will run to step through the installation process.
- **T2E3regDLL.exe** – a program required for registering the Add-in with the operating system.

To install the program, run the program named “**T2E3install.exe**”.
The following window will open:



Follow the instructions on the screen to install the Add-in.

Step 1 is to install the files from the setup package to your local hard drive. Please agree to all default program locations. The default program location for the add-in files is:

C:\program files\T2E3\XLL

Step 2 is to register the Add-in with your operating system, which will make the functions within the Add-in visible to Excel. If you receive a message, stating that there was an “Error registering the DLL”, verify that there is a file named “T2E3_Model.DLL” in the directly listed above. If the files were installed correctly, [contact T2E3](#) for additional support on registering the DLL for use in Excel.

Also available from this screen is access to the License Agreement, and this Help File.

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Making the Add-in available in Excel

Once the Add-in has been successfully registered with the operating system, you must add the Add-in to the Excel list of available Add-ins.

Office 2007

From within Excel, select “**Excel Options**” from the main button menu (top left of the application window). Select “**Add-ins**” from the menu list on the left of the window that opens. At the bottom of that window, select “**Excel Add-ins**” in the drop-down box next to “**Manage**” and then click on “**Go...**”

... continued below

Office 2003

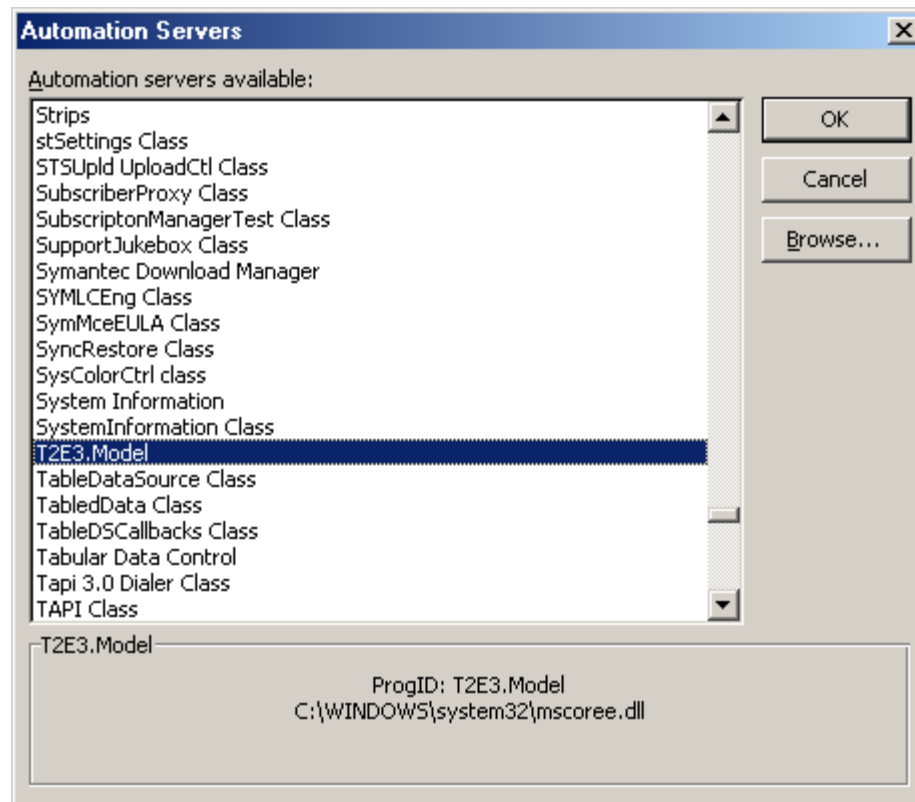
From within Excel (with any workbook open), select “**Add-ins...**” from the “**Tools**” menu.

... continued below

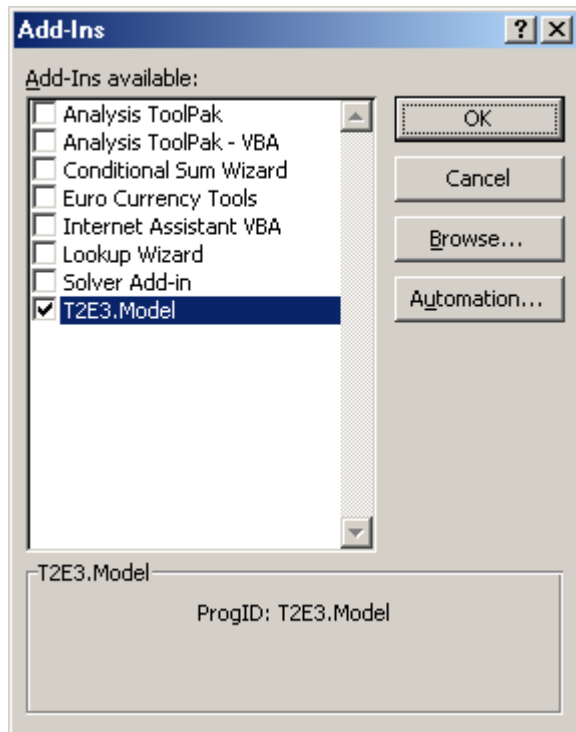
Office 2003 / 2007

If you do not see “**T2E3.Model**” on the available Add-ins list, you will need to click on the “**Automation...**” button and find “**T2E3.Model**” in the list. To find it faster within the list, type a “T”, which will bring you down to the items beginning with the letter “T” in the list.

T2E3.Model should be one of the first “T”’s shown.



Click on “**T2E3.Model**” and select OK to place the Add-in in the available add-in list. The list should now look similar to the following:



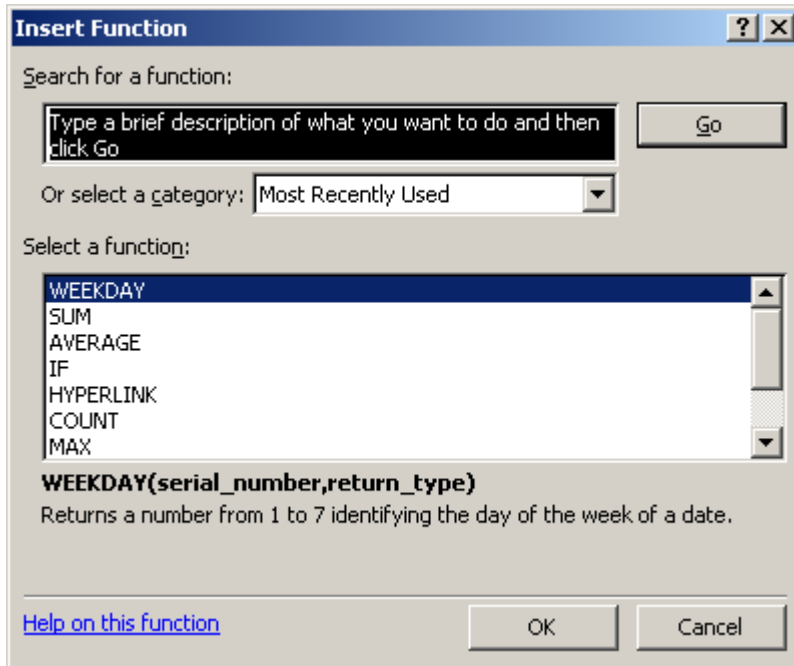
Then click “OK” to close out of the Add-in dialog box.

If you do not see T2E3.Model in the list of available Automation Add-ins, the DLL has not been successfully registered with the operating system. Rerun Step 2 from the T2E3install.exe program, above. If that does not correct the problem, [contact T2E3](#) for additional support.

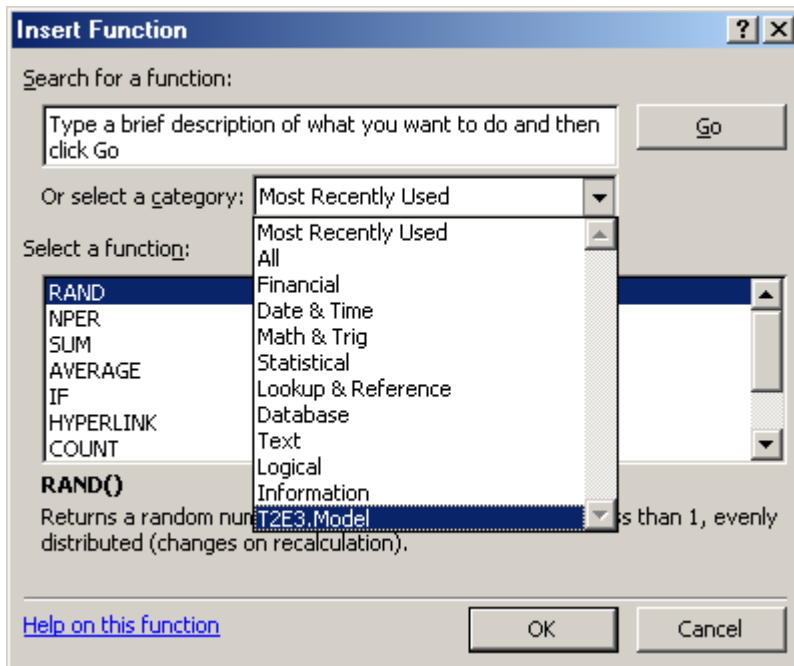
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Using Functions

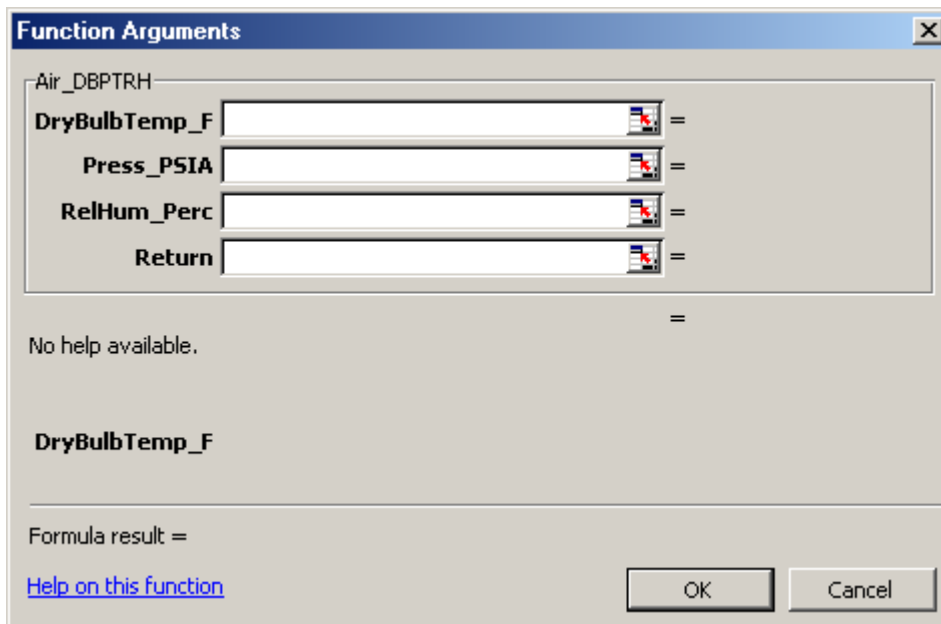
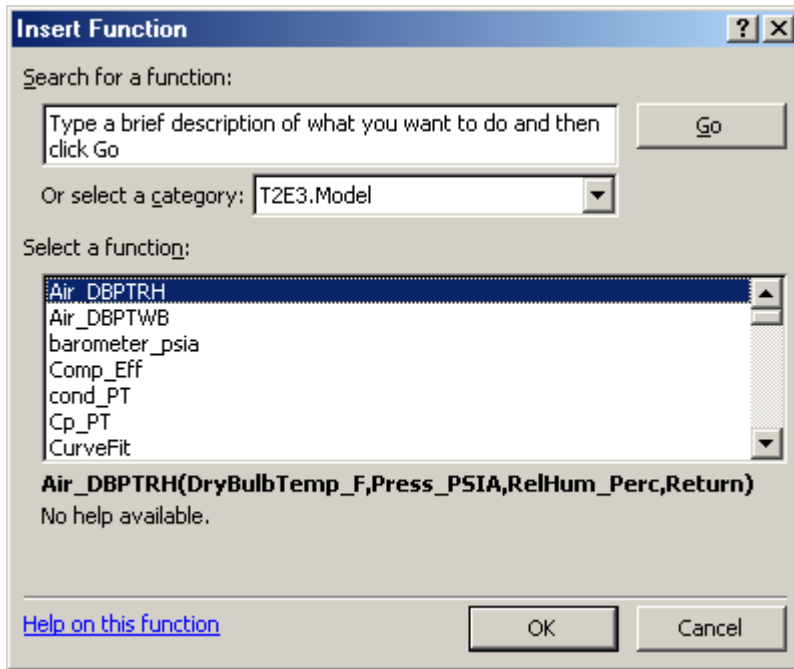
When using a function for the first time, it is recommended that you access the function from the “Function” item on the “Insert” menu within Excel. This will bring up the following dialog box:



To find the functions available within the T2E3 Add-in, scroll down in the Category list and select “T2E3.Model”.



The functions available will now be shown in the box under “Select a function”. Select the desired function and click on OK. This will bring up a dialog box which will guide you through the required inputs for the function. For the example below, the function “Air_DBPTRH” was selected, which is a function which returns selected properties of moist air. ([See below](#) for a list of the specific functions available.)



At this time, the only location for help on the functions is within this help file.

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Units on Function Inputs

Each function accepts inputs in a single set of units. Currently, this is based on the English set of units:

Pressure: PSIA (pounds per square inch – absolute. *Not gauge pressure*)

Temperature: Deg F

Differential Pressure: inH₂O (inches of Water column)

Enthalpy: Btu/lb

Entropy: Btu/lb-F

Pipe and Orifice diameters: inches

Note: if you only measure pressures in gauge pressure, and do not have a measured value for station barometric pressure, add the design station barometric pressure to convert from gauge to absolute. If you do not have a design barometric pressure value to use, a base reference value of 14.7 psia can be used for reference barometric pressure.

$$\text{Value (PSIA)} = \text{Value (PSIG)} + \text{Design Barometric Pressure (PSIA)}$$

For example, if you measured 50 PSIG on a water system, and your design station barometric pressure value is 14.55 PSIA, the value for pressure you would enter into the steam property functions would be 64.55 PSIA:

$$64.55 \text{ PSIA} = 50 \text{ PSIG} + 14.55 \text{ PSIA}$$

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Errors and Bad Values

If the inputs are such that the function cannot complete a calculation, due to divide by zero, out of range input, or other error, the function will return a large negative integer value, such as “-999” to the user. Note that any large negative value may result, due to unit conversions within the function and/or your spreadsheet.

If you are getting a “-999” return when you do not think you should be, [contact T2E3](#) for additional support.

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Available Functions

The following functions are currently available in the Add-in. If you are looking for a function which is not listed, contact T2E3 support (support@t2e3.com) and request that the function be added. Functions are added on an as needed basis, based on the perceived value and number of requests received.

The following performance functions are included in this version of T2E3.Model:

- [gas PTC22](#) – natural gas properties, calculated based on information and methods found in PTC-22

- [gas AGA8](#) – natural gas properties based on American Gas Association (AGA) Report No. 8
- [gas Flow Orifice](#) – natural gas flow calculations for orifice meters, calculated based on information and methods found in PTC-19.5
- [gasEnthalpy](#) – enthalpy of gas turbine exhaust gases at either inlet or exhaust temperature
- [Air DBPTRH](#) – air properties, given Dry Bulb temperature, Pressure and Relative Humidity, based on ASHRAE standard 41.6 (RA 2006)
- [Air DBPTWB](#) – air properties, given Dry Bulb temperature, Pressure and Wet Bulb temperature, based on ASHRAE standard 41.6 (RA 2006)
- [Relhumidity](#) – air relative humidity, given Dry Bulb temperature and Dew Point temperature
- [Barometer psia](#) – station barometric pressure, given station elevation
- [Elevation ft](#) – station elevation, given station barometric pressure
- [StationPressure psia](#) – station barometric pressure, given corresponding sea-level pressure (as reported at most airports)
- [SealevelPressure psia](#) – sea-level pressure (as reported at most airports), given station barometric pressure
- [CurveFit](#) – returns the y-value for a polynomial curve given the x-value and curve coefficients
- [Interpolate](#) – returns the y-value for a corresponding x-value, give a set of up to 5 pairs of values
- [EvapEff](#) – returns the evaporative cooler effectiveness, given dry bulb temperature, wet bulb temperature and compressor inlet temperature
- [expectedCIT](#) – returns the expected compressor inlet temperature, give dry bulb temperature, wet bulb temperature and evaporative cooler effectiveness
- [Comp Eff](#) – returns the compressor efficiency (either isentropic process, adiabatic work or polytropic work) given the compressor inlet and discharge pressures and temperatures

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The following IAPWS IF-97 steam and water property functions are **included in this version of T2E3.Model**:

Note: The function names for steam and water properties follow the following convention: return value first, followed by indication of Vapor or Liquid (if required), next comes an underscore, ‘_’, followed by the required inputs to the function:

P for Pressure

T for Temperature

h for enthalpy

s for entropy

x for quality, or vapor fraction

- **Tsat P** – saturation Temperature of steam, given Pressure
- **Psat T** – saturation Pressure of steam, given Temperature
- **hV P** – enthalpy of saturated water vapor, given Pressure
- **hL P** – enthalpy of saturated liquid water, given Pressure
- **hV T** – enthalpy of saturated water vapor, given Temperature
- **hL T** – enthalpy of saturated liquid water, given Temperature
- **h PT** – enthalpy of water or steam, given Pressure and Temperature
- **h Ps** – enthalpy of water or steam, given Pressure and entropy
- **h Px** – enthalpy of water or steam, given Pressure and quality (vapor fraction)
- **h Tx** – enthalpy of water or steam, given Temperature and quality (vapor fraction)
- **vV P** – specific volume of saturated water vapor, given Pressure
- **vL P** – specific volume of saturated liquid water, given Pressure
- **vV T** – specific volume of saturated water vapor, given Temperature
- **vL T** – specific volume of saturated liquid water, given Temperature
- **v PT** – specific volume of water or steam, given Pressure and Temperature
- **rhoV P** – density of saturated water vapor, given Pressure
- **rhoL P** – density of saturated liquid water, given Pressure
- **rhoV T** – density of saturated water vapor, given Temperature
- **rhoL T** – density of saturated liquid water, given Temperature
- **rho PT** – density of water or steam, given Pressure and Temperature
- **sV P** – entropy of saturated water vapor, given Pressure
- **sL P** – entropy of saturated liquid water, given Pressure
- **sV T** – entropy of saturated water vapor, given Temperature
- **sL T** – entropy of saturated liquid water, given Temperature
- **s PT** – entropy of water or steam, given Pressure and Temperature
- **s Ph** – entropy of water or steam, given Pressure and enthalpy
- **Cp PT** – specific heat (at constant pressure) of water or steam, given Pressure and Temperature
- **Cv PT** – specific heat (at constant volume) of water or steam, given Pressure and Temperature
- **visc PT** – viscosity of water or steam, given Pressure and Temperature
- **cond PT** – conductivity of water or steam, given Pressure and Temperature
- **qual Ph** – quality (vapor fraction) of water & steam mixture, given Pressure and enthalpy
- **qual Ps** – quality (vapor fraction) of water & steam mixture, given Pressure and entropy

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Detailed Function Descriptions

gas_PTC22:
given in ASME PTC 22

Natural gas properties based on methods

Returns: The selected property for a natural gas mixture, based on the value of “Return”, as shown below.

Required Inputs:

xMethane – molar percent of methane (CH₄) in gas mixture

xNitrogen – molar percent of nitrogen (N₂) in gas mixture

xCO₂ – molar percent of carbon dioxide (CO₂) in gas mixture

xEthane – molar percent of ethane (C₂H₆) in gas mixture

xPropane – molar percent of propane (C₃H₈) in gas mixture

xWater – molar percent of water (H₂O) in gas mixture

xH₂S – molar percent of hydrogen sulfide (H₂S) in gas mixture

xHydrogen – molar percent of hydrogen (H₂) in gas mixture

xCO – molar percent of carbon monoxide (CO) in gas mixture

xOxygen – molar percent of oxygen (O₂) in gas mixture

xiButane – molar percent of isoButane (C₄H₁₀) in gas mixture

xnButane – molar percent of n-Butane (C₄H₁₀) in gas mixture

xiPentane – molar percent of isoPentane (C₅H₁₂) in gas mixture

xnPentane – molar percent of n-Pentane (C₅H₁₀) in gas mixture

xHexane – molar percent of hexane (C₆H₁₄) in gas mixture

xHeptane – molar percent of heptane (C₇H₁₆) in gas mixture

xOctane – molar percent of octane (C₈H₁₈) in gas mixture

xNonane – molar percent of nonane (C₉H₂₀) in gas mixture

xDecane – molar percent of decane (C₁₀H₂₂) in gas mixture

xHelium – molar percent of helium (He) in gas mixture

xArgon – molar percent of argon (Ar) in gas mixture

Return – desired return value from the function, selected from the following:

“**HHV**” - gas mixture higher heating value, Btu/lb

“**LHV**” - gas mixture lower heating value, Btu/lb

“**SD**” - gas mixture density at standard conditions (14.696 psia & 60.0 Deg F), lb/ft³

“**MW**” - molecular weight of gas mixture, lb/lbmol

“**VS**” – kinematic viscosity of gas mixture, lbm/ft-s

“**CP**” – specific heat at constant pressure of gas mixture, Btu/lbm-F

“**CHM**” - carbon-hydrogen ratio of gas mixture, by mol; molC/molH

“**CHW**” - carbon-hydrogen ratio of gas mixture, by weight; lbC/lbH

Limitations and Assumptions:

- Values are based on Table 4-4.5 of PTC-22 (2005). Referenced to 60.0F and 14.696 psia.

References: ASME PTC 22 (2005)

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gas_AGA8:
in AGA Report No. 8

Natural gas properties based on methods given

Returns: The selected property for a natural gas mixture, based on the value of “Return”, as shown below.

Required Inputs:

Pin – Pressure of gas mixture, PSIA

Tin – Temperature of gas mixture, Deg F

xMethane – molar percent of methane (CH₄) in gas mixture

xNitrogen – molar percent of nitrogen (N₂) in gas mixture

xCO₂ – molar percent of carbon dioxide (CO₂) in gas mixture

xEthane – molar percent of ethane (C₂H₆) in gas mixture

xPropane – molar percent of propane (C₃H₈) in gas mixture

xWater – molar percent of water (H₂O) in gas mixture

xH₂S – molar percent of hydrogen sulfide (H₂S) in gas mixture

xHydrogen – molar percent of hydrogen (H₂) in gas mixture

xCO – molar percent of carbon monoxide (CO) in gas mixture

xOxygen – molar percent of oxygen (O₂) in gas mixture

xiButane – molar percent of isoButane (C₄H₁₀) in gas mixture

xnButane – molar percent of n-Butane (C₄H₁₀) in gas mixture

xiPentane – molar percent of isoPentane (C₅H₁₂) in gas mixture

xnPentane – molar percent of n-Pentane (C₅H₁₀) in gas mixture

xHexane – molar percent of hexane (C₆H₁₄) in gas mixture

xHeptane – molar percent of heptane (C₇H₁₆) in gas mixture

xOctane – molar percent of octane (C₈H₁₈) in gas mixture

xNonane – molar percent of nonane (C₉H₂₀) in gas mixture

xDecane – molar percent of decane (C₁₀H₂₂) in gas mixture

xHelium – molar percent of helium (He) in gas mixture

xArgon – molar percent of argon (Ar) in gas mixture

Return – desired return value from the function, selected from the following:

“SCFDENSITY” - lb/scf at standard conditions

“ACFDENSITY” - lb/acf at flowing conditions

“Z” - Compressibility at flowing conditions

“FPV” - Ratio of compressibility at flowing versus standard conditions

Limitations and Assumptions:

- Values are based on AGA Report NO. 8. Referenced to 60.0F and 14.73 psia.

References: AGA Report No. 8, 1994

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*gas_Flow_Orifice:
calculations for an orifice meter*

Natural gas mass flow rate

Returns: The selected flow calculation result for a orifice meter with natural gas as the flowing fluid, based on the value of “Return”, as shown below.

Required Inputs:

Pflow – Flowing pressure (upstream), PSIA

Tflow – Flowing temperature (upstream), Deg F

DP - Differential Pressure across Orifice meter, in H2O

OrificeDiam - Diameter of the orifice bore, inches

PipeDiam - Diameter of the pipe, inches

Omaterial - orifice material, SS (stainless steel 300 series) or CS (carbon steel)

Pmaterial - pipe material, SS (stainless steel 300 series) or CS (carbon steel)

Cd - discharge coefficient, if less than 0.5, will be calculated

Cp - specific heat of gas mixture

MW - molecular weight of gas mixture

density - upstream flowing density of gas mixture

viscosity - upstream flowing viscosity of gas mixture

Return – desired return value from the function, selected from the following:

“PPH” – calculated flow rate in pounds per hour (PPH)

“Re” - Reynolds number

“Cd” - calculated discharge coefficient

“Beta” - beta ratio at flowing conditions

Limitations and Assumptions:

- Values are based on method outlined in ASME PTC 19.5.

References: ASME PTC 19.5 (2004)

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gasEnthalpy:

Enthalpy of gas turbine exhaust gases

Returns: The enthalpy of gas turbine exhaust gases, in Btu/lb.

Required Inputs:

GTfuel_KSCFH – gas turbine fuel flow (natural gas only), in standard cubic feet per hour x 1000 (KSCFH)

airflow_KPPH – air flow through gas turbine compressor, in standard cubic feet per hour x 1000 (KSCFH)

injflow_KPPH – water injection flow into compressor and/or combustion chamber, pounds per hour x 1000 (KPPH)
DryBulbTemp_DegF – ambient dry bulb temperature, Deg F
CIT_DegF – compressor inlet temperature, Deg F
WetBulbTemp_DegF – ambient wet bulb temperature, Deg F
Press_PSIA – absolute station barometric pressure, PSIA
ExhaustTemp_DegF – temperature of exhaust gases, Deg F
xMethane – molar percent of methane (CH₄) in gas mixture
xEthane – molar percent of ethane (C₂H₆) in gas mixture
xPropane – molar percent of propane (C₃H₈) in gas mixture
xiButane – molar percent of isoButane (C₄H₁₀) in gas mixture
xnButane – molar percent of n-Butane (C₄H₁₀) in gas mixture
xiPentane – molar percent of isoPentane (C₅H₁₂) in gas mixture
xnPentane – molar percent of n-Pentane (C₅H₁₀) in gas mixture
xHexane – molar percent of hexane (C₆H₁₄) in gas mixture
xHeptane – molar percent of heptane (C₇H₁₆) in gas mixture
xOctane – molar percent of octane (C₈H₁₈) in gas mixture
xCO2 – molar percent of carbon dioxide (CO₂) in gas mixture
xNitrogen – molar percent of nitrogen (N₂) in gas mixture
xOxygen – molar percent of oxygen (O₂) in gas mixture
xHelium – molar percent of helium (He) in gas mixture
xHydrogen – molar percent of hydrogen (H₂) in gas mixture

References: ASME PTC 4.4

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Air_DBPTRH: Air properties given dry bulb temperature, barometric pressure and relative humidity

Returns: The selected air property, based on the value of “Return”, as shown below.

Required Inputs:

DryBulbTemp_F – dry bulb temperature of the air, Deg F

Press_PSIA – absolute pressure of the air, PSIA

RelHum_Perc – relative humidity of the air, in percent (%)

Return – desired return value from the function, selected from the following:

“**TWB**” - air wet bulb temperature, Deg F

“**SH**” - specific humidity (aka humidity ratio) of the air, lb-water/lb-dry-air

“**TDP**” - dew point temperature of the air, Deg F

“**DS**” - degree of saturation, ratio

“**SV**” – specific volume of the moist air, ft³/lb

“PW” – vapor pressure of the air, PSIA
“PWS” – saturated vapor pressure of the air, PSIA
“H” – enthalpy of the moist air, btu/lb

References: ANSI/ASHRAE Standard 41.6-1994 (RA 2006)

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Air_DBPTWB: Air properties given dry bulb temperature, barometric pressure and wet bulb temperature

Returns: The selected air property, based on the value of “Return”, as shown below.

Required Inputs:

DryBulbTemp_F – dry bulb temperature of the air, Deg F

Press_PSIA – absolute pressure of the air, PSIA

WetBulbTemp_F – wet bulb temperature of the air, Deg F

Return – desired return value from the function, selected from the following:

“RH” – relative humidity of the air in percent, %

“SH” - specific humidity (aka humidity ratio) of the air, lb-water/lb-dry-air

“TDP” - dew point temperature of the air, Deg F

“DS” - degree of saturation, ratio

“SV” – specific volume of the moist air, ft³/lb

“PW” – vapor pressure of the air, PSIA

“PWS” – saturated vapor pressure of the air, PSIA

“H” – enthalpy of the moist air, btu/lb

References: ANSI/ASHRAE Standard 41.6-1994 (RA 2006)

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Air_DBPTSH: Air properties given dry bulb temperature, barometric pressure and specific humidity

Returns: The selected air property, based on the value of “Return”, as shown below.

Required Inputs:

DryBulbTemp_F – dry bulb temperature of the air, Deg F

Press_PSIA – absolute pressure of the air, PSIA

SpecHum_lblb – specific humidity (aka humidity ratio) of the air, lb-water/lb-dry-air

Return – desired return value from the function, selected from the following:

“RH” – relative humidity of the air in percent, %
“TWB” - air wet bulb temperature, Deg F
“TDP” - dew point temperature of the air, Deg F
“DS” - degree of saturation, ratio
“SV” – specific volume of the moist air, ft³/lb
“PW” – vapor pressure of the air, PSIA
“PWS” – saturated vapor pressure of the air, PSIA
“H” – enthalpy of the moist air, btu/lb

References: ANSI/ASHRAE Standard 41.6-1994 (RA 2006)

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Relhumidity: Humidity of ambient air given dry bulb temperature and dew point

Returns: An estimate of the relative humidity of the air.

Required Inputs:

Tdrybulb_DegF – dry bulb temperature of the air, Deg F
Tdewpt_DegF – dew point temperature of the air, Deg F

Limitations and Assumptions:

- Good for dry bulb temperatures between 32 F and 199.4 F.

References: ANSI/ASHRAE Standard 41.6-1994 (RA 2006)

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Barometer_psia: Station barometric pressure given elevation

Returns: Station barometric pressure, PSIA, based on standard atmosphere and normal sea-level pressure of 14.696 PSIA.

Required Inputs:

Elevation_ft – station elevation, ft

References: N/A

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Tdb_DegF – ambient dry bulb temperature, Deg F

References: N/A

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CurveFit:

Y-value given polynomial curve coefficients

Returns: y-value of polynomial curve

Required Inputs:

- X** – x-value on curve which corresponds to the desired y-value
- A0** – polynomial curve coefficient for x^0 (the constant value)
- A1** – polynomial curve coefficient for x^1 (x)
- A2** – polynomial curve coefficient for x^2
- A3** – polynomial curve coefficient for x^3
- A4** – polynomial curve coefficient for x^4
- A5** – polynomial curve coefficient for x^5
- A6** – polynomial curve coefficient for x^6

References: N/A

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Interp:

Interpolation result for a set of data points

Returns: y-value which corresponds to the given x-value using a straight line interpolation between the two closest values in the given value pairs.

Required Inputs:

- x** – x-value for which the corresponding y-value is desired
- x1, y1** – first pair of values; the one with the lowest value of x
- x2, y2** – second pair of values
- x3, y3** – third pair of values
- x4, y4** – fourth pair of values
- x5, y5** – fifth pair of values
- x6, y6** – sixth pair of values
- n** – the number of pairs to use in the calculation

Limitations and Assumptions:

- All inputs are required. The first 'n' number of pairs are used in the calculation. For pairs above 'n' which are not used, any value can be used as a placeholder (i.e. 0,0).
- The pairs of values must be ordered such that the following is true:
 $x_0 < x_1 < x_2 < x_3 < x_4 < x_5$

References: N/A

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EvapEff:

Evaporative cooling efficiency

Returns: The effectiveness of an evaporative cooler

Required Inputs:

Tdb_DegF – ambient dry bulb temperature upstream of the cooler, Deg F

Twb_DegF – ambient wet bulb temperature upstream of the cooler, Deg F

CIT_DegF – dry bulb temperature downstream of the cooler (i.e. the compressor inlet temperature), Deg F

References: N/A

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expectedCIT:

Expected compressor inlet temperature downstream of an evaporative cooler

Returns: The expected compressor inlet temperature after an evaporative cooler

Required Inputs:

Tdb_DegF – ambient dry bulb temperature upstream of the cooler, Deg F

Twb_DegF – ambient wet bulb temperature upstream of the cooler, Deg F

Effectiveness_percent – the expected effectiveness of the evaporative cooler, in percent (%)

References: N/A

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Comp_Eff: Axial compressor efficiency

Returns: The selected compressor efficiency, based on the value of “Return”, as shown below

Required Inputs:

- CIT_DegF** – compressor inlet temperature, Deg F
- CIP_PSIA** – compressor inlet pressure (after filters or other inlet conditioning equipment), PSIA
- COT_DegF** – compressor discharge temperature, Deg F
- COP_PSIA** – compressor discharge pressure, PSIA
- H2O_PPH** – amount of water injected into the compressor (i.e. SPRINT water flow), pounds per hour (PPH)
- ReturnPANI** – desired return value from the function, selected from the following:
 - “P” – polytropic work efficiency of the compressor, %
 - “A” – adiabatic work efficiency of the compressor, %
 - “N” – polytropic coefficient of the compressor, non-dimensional value
 - “I” – isentropic process efficiency of the compressor, %

References: N/A

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zAir: Compressibility factor of air

Returns: The compressibility factor of air at the given input conditions.

Required Inputs:

- Press_PSIA** – absolute pressure of the air, PSIA
- Temp_F** – temperature of the air, Deg F
- SpecHumRatio** – specific humidity (mixing ratio) of the air, lb-water/lb-dryair

References: Based on Kay’s Rule and values given in “Thermodynamics” by Cengel and Boles

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Tsat_P: Saturation temperature of water given pressure

Returns: The saturation temperature of water, Deg F.

Required Inputs:

- Press_PSIA** – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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Psat_T: Saturation pressure of water given temperature

Returns: The saturation pressure of water, PSIA.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for temperatures above 32 Deg F and below 705 Deg F

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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hV_P: Enthalpy of saturated water vapor given pressure

Returns: The enthalpy of saturated water vapor, Btu/lb.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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hL_P:
pressure

Enthalpy of saturated liquid water given

Returns: The enthalpy of saturated liquid water, Btu/lb.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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hV_T:
temperature

Enthalpy of saturated water vapor given

Returns: The enthalpy of saturated water vapor, Btu/lb.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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hL_T:
temperature

Enthalpy of saturated liquid water given

Returns: The enthalpy of saturated liquid water, Btu/lb.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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h_{PT}:
temperature

Enthalpy of water given pressure and

Returns: The enthalpy of water or steam, Btu/lb.

Required Inputs:

Press_PSIA – pressure of water in PSIA

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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h_{Ps}:

Enthalpy of water given pressure and entropy

Returns: The enthalpy of water and/or steam, Btu/lb.

Required Inputs:

Press_PSIA – pressure of water in PSIA

Entropy_btULbF – entropy of water in Btu/lb-F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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h_{Px} : Enthalpy of a water/steam mixture given pressure and quality

Returns: The enthalpy of water & steam mixture, Btu/lb.

Required Inputs:

Press_PsIA – pressure of water/steam mixture in PSIA

Quality_fraction – Quality (vapor fraction) of water/steam mixture as fraction

Limitations and Assumptions:

- Quality (vapor fraction) must be between zero (0) and one (1)

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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h_{Tx} : Enthalpy of a water/steam mixture given temperature and quality

Returns: The enthalpy of water & steam mixture, Btu/lb.

Required Inputs:

Temp_DegF – temperature of water/steam mixture, Deg F

Quality_fraction – Quality (vapor fraction) of water/steam mixture as fraction

Limitations and Assumptions:

- Quality (vapor fraction) must be between zero (0) and one (1)

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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vV_P : *Specific volume of saturated water vapor given pressure*

Returns: The specific volume of saturated water vapor, ft³/lb

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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vL_P : *Specific volume of saturated liquid water given pressure*

Returns: The specific volume of saturated liquid water, ft³/lb.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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v_{V_T} : *Specific volume of saturated water vapor given temperature*

Returns: The specific volume of saturated water vapor, ft³/lb.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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v_{L_T} : *Specific volume of saturated liquid water given temperature*

Returns: The specific volume of saturated liquid water, ft³/lb.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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v_{PT} : *Specific volume of water given pressure and temperature*

Returns: The specific volume of water or steam, ft³/lb.

Required Inputs:

Press_PSIA – pressure of water in PSIA

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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rhoV_P: Density of saturated water vapor given pressure

Returns: The density of saturated water vapor, lb/ft³.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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rhoL_P: Density of saturated liquid water given pressure

Returns: The density of saturated liquid water, lb/ft³.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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rhoV_T:
temperature

Density of saturated water vapor given

Returns: The density of saturated water vapor, lb/ft³.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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rhoL_T:
temperature

Density of saturated liquid water given

Returns: The density of saturated liquid water, lb/ft³.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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rho_PT:

Density of water given pressure and temperature

Returns: The density of water or steam, lb/ft³.

Required Inputs:

Press_PSIA – pressure of water in PSIA

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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sV_P: Entropy of saturated water vapor given pressure

Returns: The entropy of saturated water vapor, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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sL_P: Entropy of saturated liquid water given pressure

Returns: The entropy of saturated liquid water, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of the water in PSIA

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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sV_T: Entropy of saturated water vapor given temperature

Returns: The entropy of saturated water vapor, Btu/lb-F.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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sL_T: Entropy of saturated liquid water given temperature

Returns: The entropy of saturated liquid water, Btu/lb-F.

Required Inputs:

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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s_{PT}: *Entropy of water given pressure and temperature*

Returns: The entropy of water or steam, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of water in PSIA

Temp_DegF - temperature of the water in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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s_{Ph}: *Entropy of water given pressure and enthalpy*

Returns: The entropy of water or steam, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of water in PSIA

enthalpy_btulb - enthalpy of the water in Btu/lb

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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C_{pPT}: *Isobaric specific heat of water given pressure and temperature*

Returns: The isobaric (constant pressure) specific heat of water or steam, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of water/steam in PSIA
Temp_DegF - temperature of water/steam in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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C_v_PT: *Isochoric specific heat of water given pressure and temperature*

Returns: The isochoric (constant volume) specific heat of water or steam, Btu/lb-F.

Required Inputs:

Press_PSIA – pressure of water/steam in PSIA
Temp_DegF - temperature of water/steam in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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visc_PT: *Dynamic viscosity of water given pressure and temperature*

Returns: The dynamic viscosity of water or steam, lb/ft/hr.

Required Inputs:

Press_PSIA – pressure of water/steam in PSIA
Temp_DegF - temperature of water/steam in Deg F

Limitations and Assumptions:

- none

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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cond_PT:
and temperature

Thermal conductivity of water given pressure

Returns: The thermal conductivity of water or steam, Btu/(hr-ft-F)

Required Inputs:

Press_PSIA – pressure of water/steam in PSIA

Temp_DegF - temperature of water/steam in Deg F

Limitations and Assumptions:

- Temperature greater than 32 Deg F and less than 980 Deg F
- Pressure greater than 0.089 PSIA
- Certain regions are also not allowed, the function will return -999 when out of range

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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qual_Ph:
and enthalpy

Quality of a water/steam mixture given pressure

Returns: The quality (vapor fraction) of a water and steam mixture as a fraction (value between zero (0) and one (1)).

Required Inputs:

Press_PSIA – pressure of water/steam mixture in PSIA

enthalpy_btulb - enthalpy of the water/steam mixture in Btu/lb

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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qual_Ps: Quality of a water/steam mixture given pressure and entropy

Returns: The quality (vapor fraction) of a water and steam mixture as a fraction (value between zero (0) and one (1)).

Required Inputs:

Press_PsIA – pressure of water/steam mixture in PSIA

Entropy_btulbF - entropy of the water/steam mixture in Btu/lb-F

Limitations and Assumptions:

- This function is only value for pressures between 0.09 psia and 3200 psia.

References: IAPWS IF-97 (see www.iapws.org) based on code provided by Magnus Holmgren and www.x-eng.com.

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