

EESy Solutions

Engineering Equation Solver Newsletter

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Welcome

This is the 46th issue of EESy Solutions, a newsletter that provides news, tips, and other updates for users of the Engineering Equation Solver software. This issue discusses diagram (.dgm) files and EES Tab (.eestab) files that allow the Diagram Window and equations in EES Tabs windows, respectively, to be saved and loaded. The Directive Information Dialog allows automation of the process of entering directives, which are time-saving instructions to EES that are carried out before or after compiling the equations. The Curve Fit Table Dialog that has been added provides a powerful tool for curve fitting tabular data using either pre-defined or user-defined curve fits. The data can be weighted according to uncertainty and visualized with a plot.

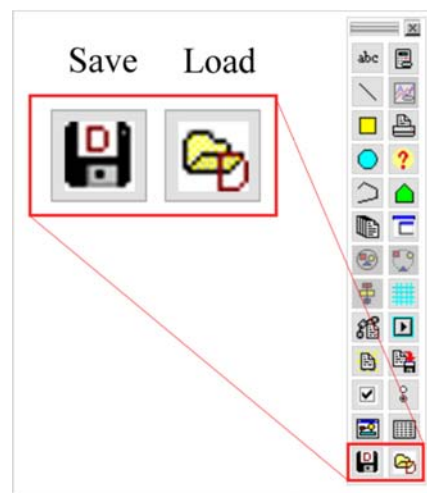
EES has been commercially available for more than two decades. Previous issues of EESy Solutions can be downloaded from <https://fchartsoftware.com>.

Diagram (.dgm) Files

Starting with version 11.774, the Professional license allows a Diagram Window in an EES program to be saved and loaded. This is done using the Save Diagram to File and Read Diagram from File buttons on the Diagram Window Toolbar. These buttons are accessible when the Diagram Window is in development mode.

With Diagram (.dgm) files, you can save a Diagram Window that you've developed in one EES file and load it in another. Diagram files can also be loaded automatically using the \$Include directive just as you might load libraries or variable information files. As of EES version 11.695, the Professional license of EES allows you to divide your EES program into separate tabs. Each tab can now have its own Diagram Window, that is loaded automatically using the \$Include directive.

Diagram (.dgm) files join several other useful files in EES including Variable Info (.var) files and EES Tab (.eestab) files that together allow EES tabs to provide powerful new ways to use EES. An example of this capability is provided on page 2. The EES code for this example is provided with EES (version 11.822 or newer) in the file named Heat Exchanger with DGM files in the Examples folder. It can be accessed from the Examples menu by selecting Diagram Window and the menu item name Solving a Heat Exchange problem using .DGM files.

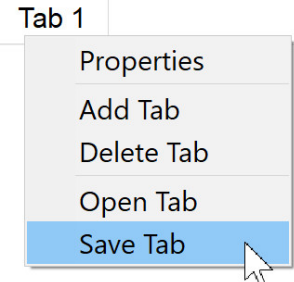


The Save and Load Diagram buttons on the Diagram Window Toolbar

EES Tab (.eestab) Files

EESy Solutions #45 discussed the recently-added ability to allow the Equations Window to contain separate tabs. Each tab can hold code segments or independent EES programs that are stored in a single EES file. Another use for an Equations Window tab is to provide the means to import a program segment into an existing EES program that can be used in several tabs.

In order to save a tab, right click on an existing tab and select Save Tab. Navigate to the folder where you would like to save the .eestab file. To load equations and variable information into a tabbed window, select Open Tab from the popup window that is displayed when you right-click on the tab.



Save Tab option

Example using .dgm and .eestab files

As an example, you might have an EES file that you've developed to calculate the conductance of a heat exchanger for a set of operating conditions with water. In a separate file you have a simulation of a heat exchanger exchanging heat from water to a heat transfer fluid. It would be convenient to have the conductance calculation program included in the same EES file as the simulation program.

The conductance calculation program and its associated Diagram Window are shown below.

```

Main
$UnitSystem SI Mass J K Pa

SIfNot DiagramWindow
  T_H_in = converttemp(C,K,80 [C])
  T_H_out = converttemp(C,K,53 [C])
  V_dot_H = 0.92 [gpm]*convert(gpm,m^3/s)
  T_C_in = converttemp(C,K,20.5 [C])
  V_dot_C = 1.5 [gpm]*convert(gpm, m^3/s)
$EndIf

FS = "Water"
T_bar = (T_H_in + T_C_in)/2
rho = density(Water,T=T_bar,P=Po#)
c_cp(Water,T=T_bar,P=Po#)
C_dot_H = V_dot_H*rho
C_dot_C = V_dot_C*rho
q_dot = C_dot_H*(T_H_in - T_H_out)
q_dot = C_dot_C*(T_C_out - T_C_in)
C_dot_min = min(C_dot_H,C_dot_C)
q_dot_max = C_dot_min*(T_H_in - T_C_in)
eff = q_dot/q_dot_max
NTU=HX('counterflow', eff, C_dot_H, C_dot_C, 'NTU')
UA = NTU*C_dot_min
  
```

EES Code to Calculate Conductance

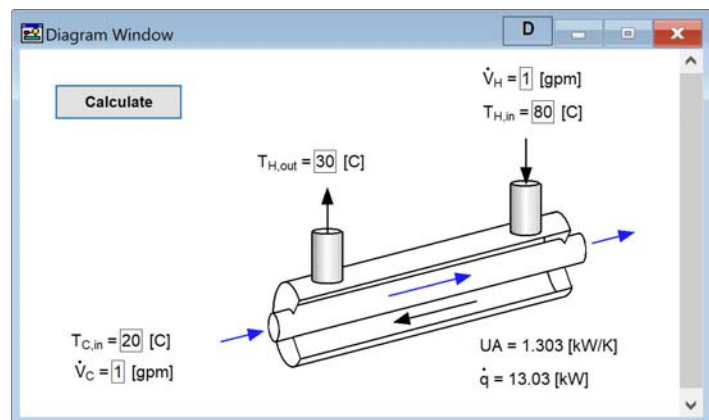
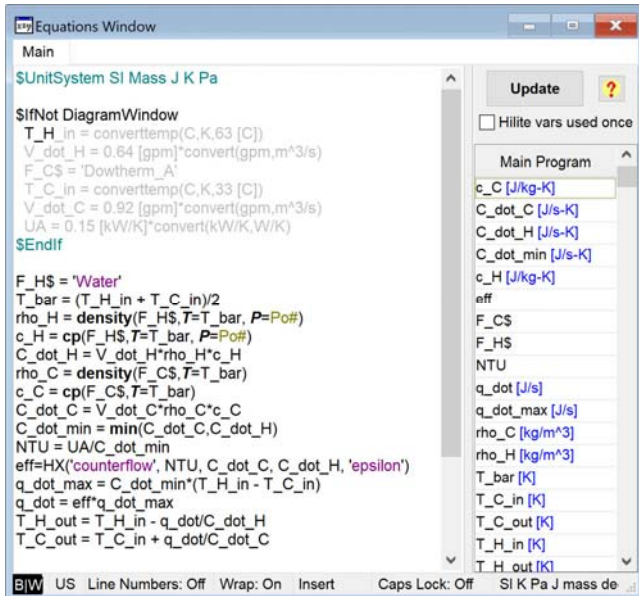


Diagram Window for Conductance EES Code

In order to transfer the conductance calculation program to another EES file, you need to open the program and then save the Diagram in a .dgm file and the equations in an .eestab file, as discussed previously. We will save these as UACalc.dgm and UACalc.eestab, respectively. We may also want to save the characteristics (units, guess values, etc.) of the variables. This can be done by selecting the save button in the Variable Information Window; we will save this file as UACalc.var.

Example using .dgm and .eestab files (cont.)

Separately, you have a different EES code that uses a conductance to simulate a heat exchanger. This code also has a Diagram Window, as shown below.



```

Equations Window
Main
$UnitSystem SI Mass J K Pa

$IfNot DiagramWindow
  T_H_in = converttemp(C,K,63 [C])
  V_dot_H = 0.64 [gpm]*convert(gpm,m^3/s)
  F_CS$ = 'Dowtherm_A'
  T_C_in = converttemp(C,K,33 [C])
  V_dot_C = 0.92 [gpm]*convert(gpm,m^3/s)
  UA = 0.15 [kW/K]*convert(kW/K,W/K)
$EndIf

F_H$ = 'Water'
T_bar = (T_H_in + T_C_in)/2
rho_H = density(F_H$,T=T_bar,P=Po#)
c_H = cp(F_H$,T=T_bar,P=Po#)
C_dot_H = V_dot_H*rho_H*c_H
rho_C = density(F_CS$,T=T_bar)
c_C = cp(F_CS$,T=T_bar)
C_dot_C = V_dot_C*rho_C*c_C
C_dot_min = min(C_dot_C,C_dot_H)
NTU = UA/C_dot_min
eff=HX('counterflow', NTU, C_dot_C, C_dot_H, 'epsilon')
q_dot_max = C_dot_min*(T_H_in - T_C_in)
q_dot = eff*q_dot_max
T_H_out = T_H_in - q_dot/C_dot_H
T_C_out = T_C_in + q_dot/C_dot_C
  
```

EES Code to Simulate Heat Exchanger

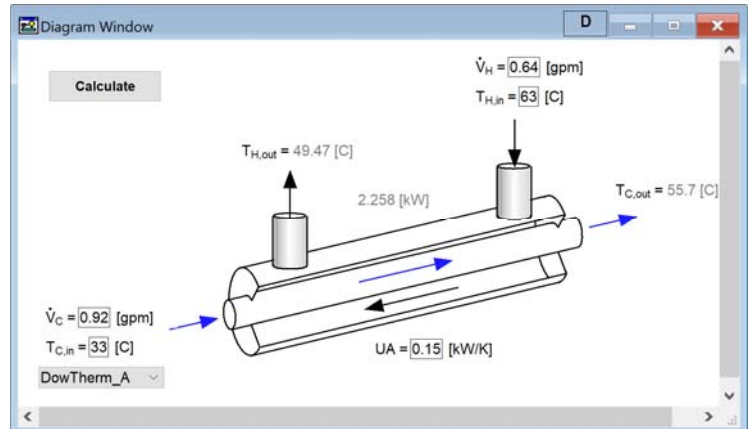
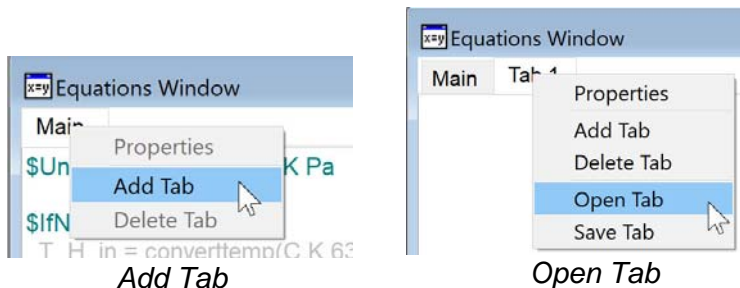
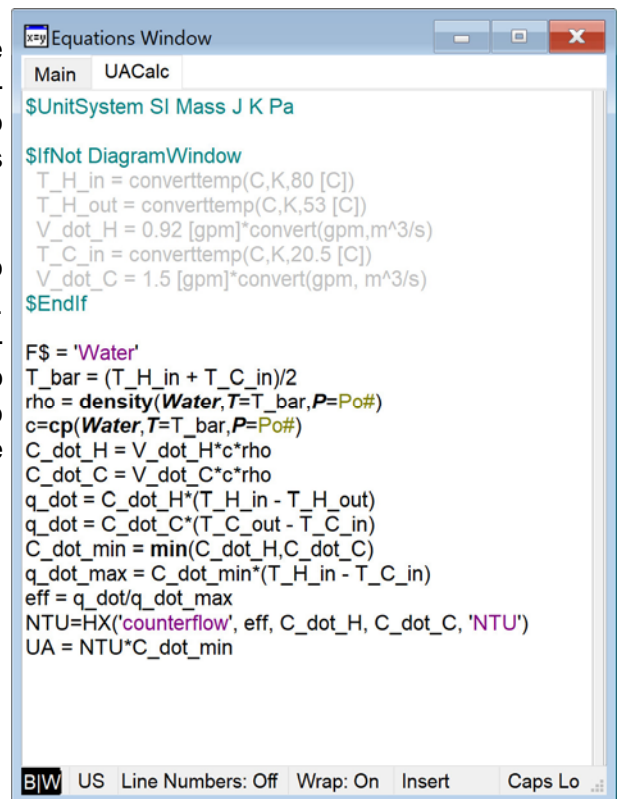


Diagram Window for Heat Exchanger Simulation

We may want to save the Diagram Window and Variable Information file for this program as well so that we can toggle between these programs as needed by selecting the tab in the Equations window. These files are saved as UAUse.dgm and UAUse.var, respectively.

To add the saved EES Tab to this file, first make a new tab by right-clicking on the Main Tab and selecting Add Tab. The name you provide doesn't matter as it will be overwritten when you open a saved tab. Right click the new tab and select Open Tab, navigate to the file UACalc.eestab and you will see that the tab has been populated with the saved code.

```

Equations Window
Main  UACalc
$UnitSystem SI Mass J K Pa

$IfNot DiagramWindow
  T_H_in = converttemp(C,K,80 [C])
  T_H_out = converttemp(C,K,53 [C])
  V_dot_H = 0.92 [gpm]*convert(gpm,m^3/s)
  T_C_in = converttemp(C,K,20.5 [C])
  V_dot_C = 1.5 [gpm]*convert(gpm,m^3/s)
$EndIf

F$ = 'Water'
T_bar = (T_H_in + T_C_in)/2
rho = density(Water,T=T_bar,P=Po#)
c = cp(Water,T=T_bar,P=Po#)
C_dot_H = V_dot_H*rho*c
C_dot_C = V_dot_C*rho*c
q_dot = C_dot_H*(T_H_in - T_H_out)
q_dot = C_dot_C*(T_C_out - T_C_in)
C_dot_min = min(C_dot_H,C_dot_C)
q_dot_max = C_dot_min*(T_H_in - T_C_in)
eff = q_dot/q_dot_max
NTU=HX('counterflow', eff, C_dot_H, C_dot_C, 'NTU')
UA = NTU*C_dot_min
  
```

EES Code with UACalc tab included.

Example: Using .dgm and .eestab files (cont.)

\$Include directives are placed at the top of each of the tabs in order to ensure that the correct variable information and correct diagram appears with the tab. The result is shown below. As you click on the tabs, you should see the Diagram Window change appropriately. Now click on the UACalc tab and then on the Calculate button to calculate the UA value. Click on the Main tab. Note that the UA value that you just calculated in the UACalc tab is automatically entered as an input on the Diagram Window. Click the Calculate button to simulate the heat exchanger with this UA value.

The screenshot shows the software interface with the Main tab selected. The Equations Window on the left contains the following code:

```

$UnitSystem SI Mass J K Pa
$Include 'UAUse.var'
$Include 'UAUse.dgm'

SIfNot DiagramWindow
  T_H_in = converttemp(C,K,63 [C])
  V_dot_H = 0.64 [gpm]*convert(gpm,m^3/s)
  F_CS = 'Dowtherm_A'
  T_C_in = converttemp(C,K,33 [C])
  V_dot_C = 0.92 [gpm]*convert(gpm,m^3/s)
  UA = 0.15 [kW/K]*convert(kW/K,W/K)
$EndIf

F_HS = 'Water'
T_bar = (T_H_in + T_C_in)/2
rho_H = density(F_HS,T_bar,P=Po#)
c_H = cp(F_HS,T_bar,P=Po#)
C_dot_H = V_dot_H*rho_H*c_H
rho_C = density(F_CS,T_bar)
c_C = cp(F_CS,T_bar)
C_dot_C = V_dot_C*rho_C*c_C
C_dot_min = min(C_dot_C,C_dot_H)
NTU = UA/C_dot_min
eff=HX('counterflow', NTU, C_dot_C, C_dot_H, 'epsilon')
q_dot_max = C_dot_min*(T_H_in - T_C_in)
q_dot = eff*q_dot_max
T_H_out = T_H_in - q_dot/C_dot_H
T_C_out = T_C_in + q_dot/C_dot_C
    
```

The Diagram Window on the right shows a schematic of a heat exchanger with the following parameters:

- Hot fluid inlet temperature: $T_{H,in} = 80$ [C]
- Hot fluid inlet flow rate: $\dot{V}_H = 0.64$ [gpm]
- Coolant inlet temperature: $T_{C,in} = 23$ [C]
- Coolant inlet flow rate: $\dot{V}_C = 1.2$ [gpm]
- Hot fluid outlet temperature: $T_{H,out} = 30$ [C]
- Coolant outlet temperature: $T_{C,out} = 49.67$ [C]
- Heat transfer rate: $\dot{q} = 8.336$ [kW]
- Overall heat transfer coefficient: $UA = 0.5238$ [kW/K]

Main Tab - Simulates a Heat Exchanger given a Conductance

The screenshot shows the software interface with the UACalc tab selected. The Equations Window on the left contains the following code:

```

$UnitSystem SI Mass J K Pa
$Include 'UACalc.var'
$Include 'UACalc.dgm'

SIfNot DiagramWindow
  T_H_in = converttemp(C,K,80 [C])
  T_H_out = converttemp(C,K,53 [C])
  V_dot_H = 0.92 [gpm]*convert(gpm,m^3/s)
  T_C_in = converttemp(C,K,20.5 [C])
  V_dot_C = 1.5 [gpm]*convert(gpm, m^3/s)
$EndIf

FS = 'Water'
T_bar = (T_H_in + T_C_in)/2
rho = density(Water,T_bar,P=Po#)
c = cp(Water,T_bar,P=Po#)
C_dot_H = V_dot_H*c*rho
C_dot_C = V_dot_C*c*rho
q_dot = C_dot_H*(T_H_in - T_H_out)
q_dot = C_dot_C*(T_C_out - T_C_in)
C_dot_min = min(C_dot_H,C_dot_C)
q_dot_max = C_dot_min*(T_H_in - T_C_in)
eff = q_dot/q_dot_max
NTU=HX('counterflow', eff, C_dot_H, C_dot_C, 'NTU')
UA = NTU*C_dot_min
    
```

The Diagram Window on the right shows a schematic of a heat exchanger with the following parameters:

- Hot fluid inlet temperature: $T_{H,in} = 80$ [C]
- Hot fluid inlet flow rate: $\dot{V}_H = 0.64$ [gpm]
- Coolant inlet temperature: $T_{C,in} = 23$ [C]
- Coolant inlet flow rate: $\dot{V}_C = 1.2$ [gpm]
- Hot fluid outlet temperature: $T_{H,out} = 30$ [C]
- Coolant outlet temperature: $T_{C,out} = 49.67$ [C]
- Heat transfer rate: $\dot{q} = 8.336$ [kW]
- Overall heat transfer coefficient: $UA = 0.5238$ [kW/K]

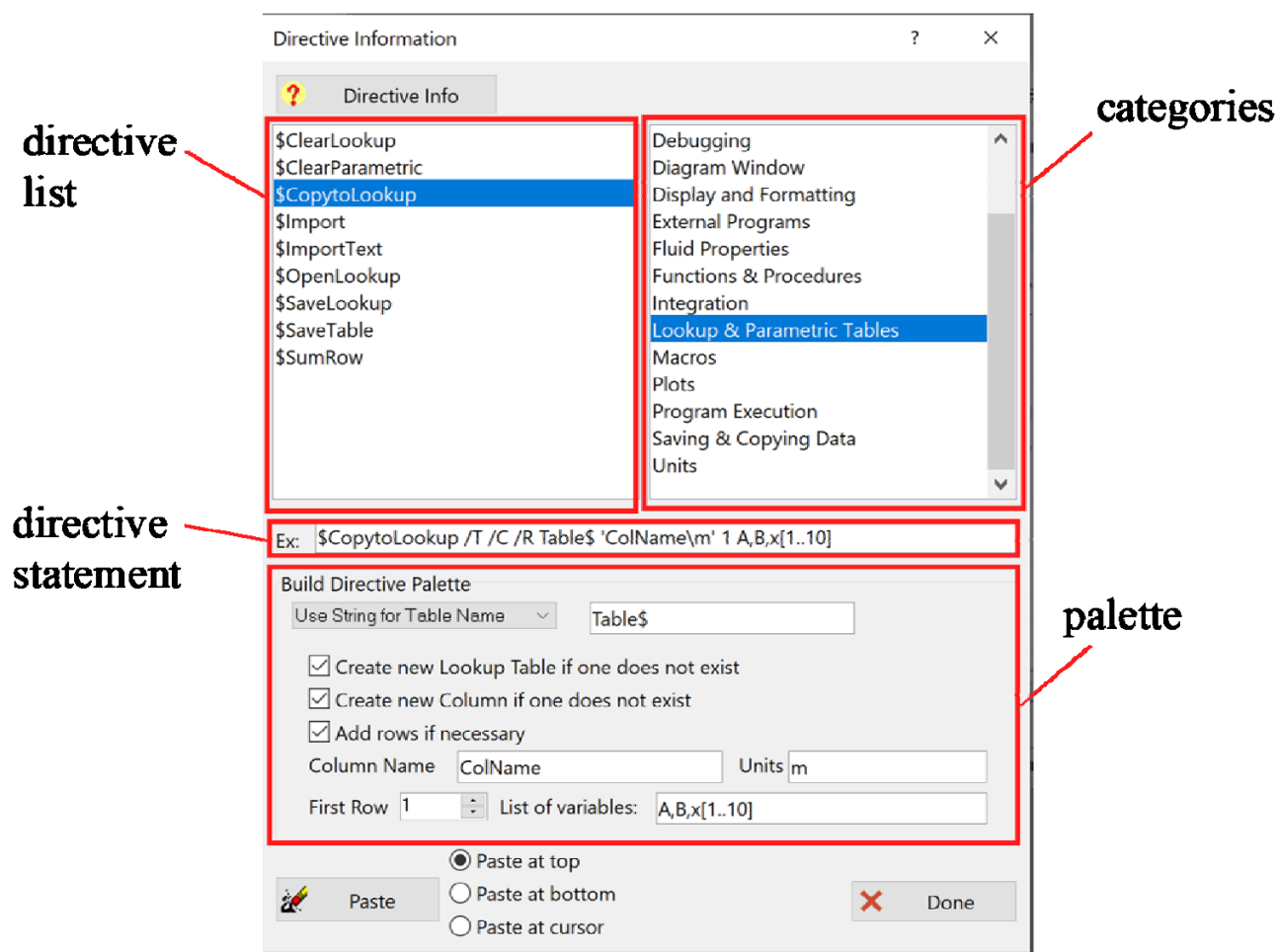
UACalc Tab - Determines a Conductance given Test Conditions

Directive Information Dialog

Directives are instructions to EES that are carried out either before or after the equations themselves are compiled and solved. They can accomplish simple things like setting the font or tabs in the Equations Window or more complex tasks like making or overwriting plots, opening tables, etc. The Directive Information Dialog can be accessed from the Options menu and it has been improved and expanded in order to facilitate the construction of any directive.

The Directive Information Dialog has two list boxes at the top corresponding to categories of directives (right) and the specific directives that fall into each directive (left). When a directive is selected from the box on the left, either a Build Directive Palette is populated in a pane at the bottom of the Dialog (as shown below) or a button is shown that allows you to move to the appropriate EES dialog to construct your directive (as shown on the next page).

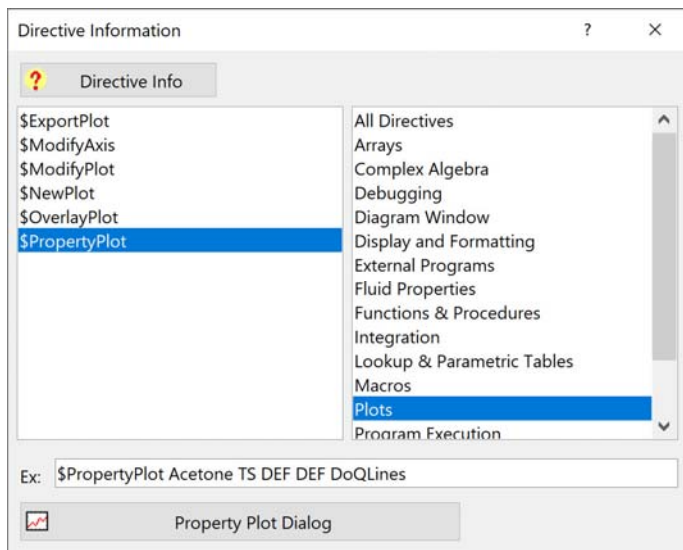
The directive statement shown in the edit box will be adjusted as you manipulate items in the Build Directive Palette. When you are happy with it, you can select the Paste button to paste the directive into the Equations Window.



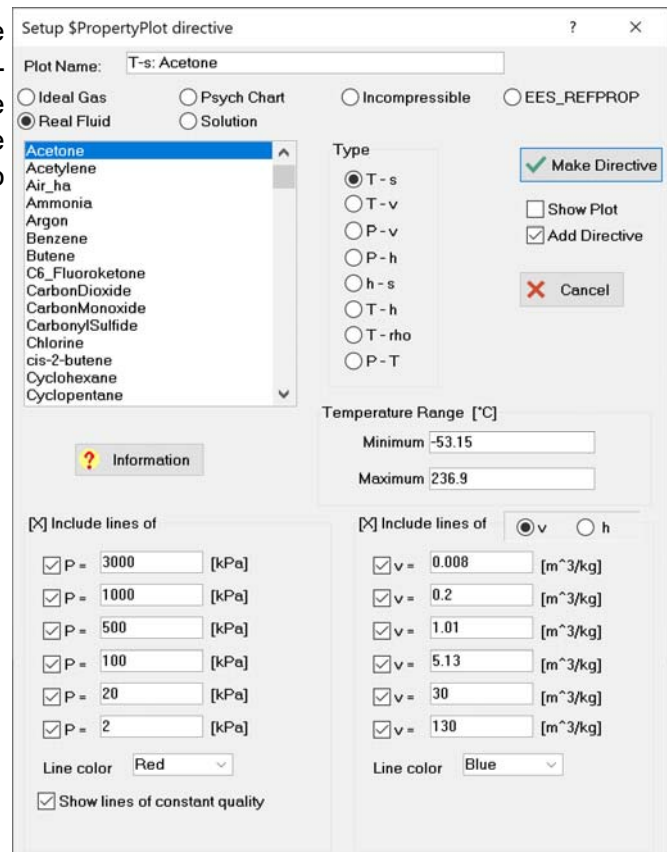
Directive Information Dialog with Build Directive Palette for the \$CopytoLookup directive

Directive Information Dialog (cont.)

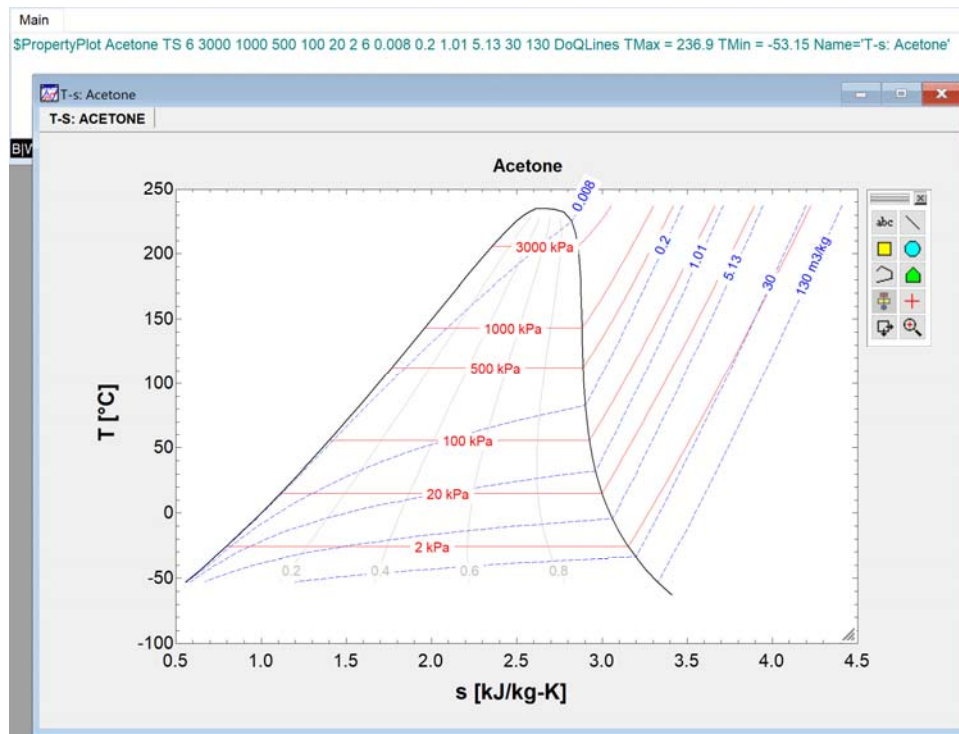
In some cases, the Directive Information Palette will be replaced with a button that takes you to the appropriate pre-existing EES Dialog. For example, when the \$PropertyPlot directive is selected, the button will take you to the Property Plot Dialog, which can be used to set up the \$PropertyPlot directive statement.



Directive Information Dialog for the \$PropertyPlot



Property Plot Dialog to set up the directive



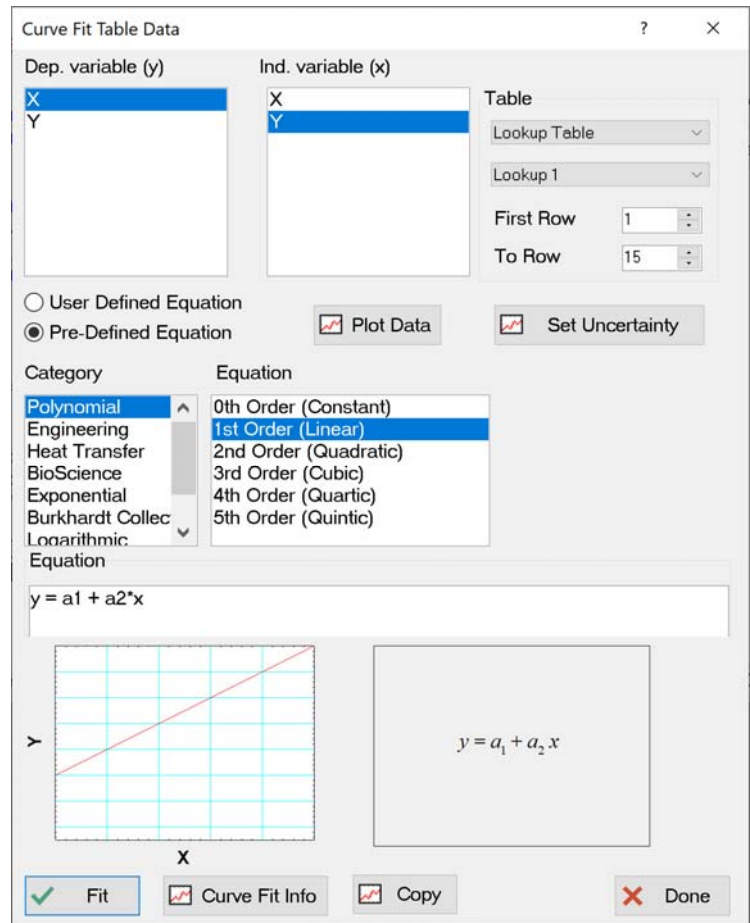
Property Plot generated by the \$PropertyPlot directive

Curve Fit Table Dialog

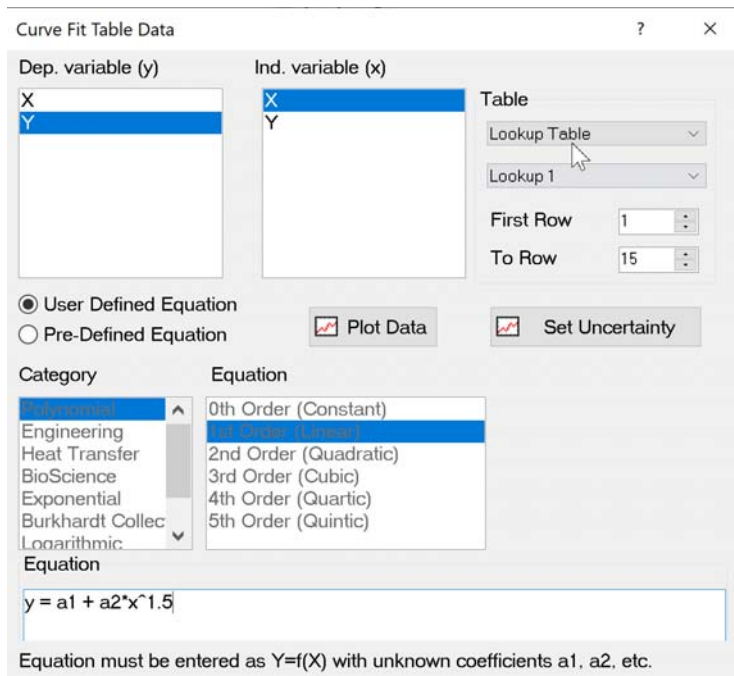
A data set that exists in a Lookup, Parametric, or Array Table can also be used as the basis for a curve fit by selecting Curve Fit Table Data from the Tables menu.

The top right of Curve Fit Table Dialog allows selection of the data that are to be fit. By selecting the Plot Data button, a Curve Fit Table Dialog Plot is created allowing you to visualize the data. Once generated, the curve fit itself can be overlaid onto this plot. If there are uncertainty data available for the data set then weighting factors can be applied to each data point using the Set Uncertainty button.

The curve fit type can be either a pre-defined curve fit that is selected from the Category and Equation list boxes or a user-defined equation. As you select different pre-defined equations the selected equation in the Equation box and a picture showing the general equation shape appear at the bottom right of the dialog. At any time you can edit the coefficients in the Equation box in order to modify a pre-defined equation.



Curve Fit Table Data Dialog with the pre-defined equation 1st order selected



Curve Fit Table Data Dialog with user defined equation

For example, the form of the 1st Order (Linear) equation can be modified by changing the power on the independent variable from 1 to 1.5. This changes the selection from Pre-Defined to User Defined Equation. Any user defined equation can be entered provided that it is an explicit function of the independent variable (x) with unknown coefficients entered as a1, a2, etc. Up to 9 unknown coefficients can be included.

Curve Fit Table (cont.)

Selecting the Curve Fit Info button (for a pre-defined equation) or the Fit button (for a user defined equation) will bring up the Curve Fit Table Information Dialog where guess values and limits for each of the coefficients as well as other parameters for the curve fitting process can be entered. Note that setting the step used for a specific coefficient to zero will cause that coefficient to be held constant during the curve fit process.

Once the parameters in the Curve Fit Table Information are set appropriately, selecting OK will initiate the fitting process for a user defined equation or return you to the Curve Fit Table dialog for a pre-defined equation where selecting the Fit button initiates the fitting process. If the fitting process converges to a solution then the equation box will be populated by the best-fit equation. Select the Overlay Curve Fit button to overlay the best fit curve onto the Curve Fit Table Dialog Plot. Note that the Curve Fit Table Dialog Plot will persist even after the Curve Fit Table Dialog is closed. It will be erased the next time the Curve Fit Table dialog is used unless it is renamed.

Curve Fit Table Information

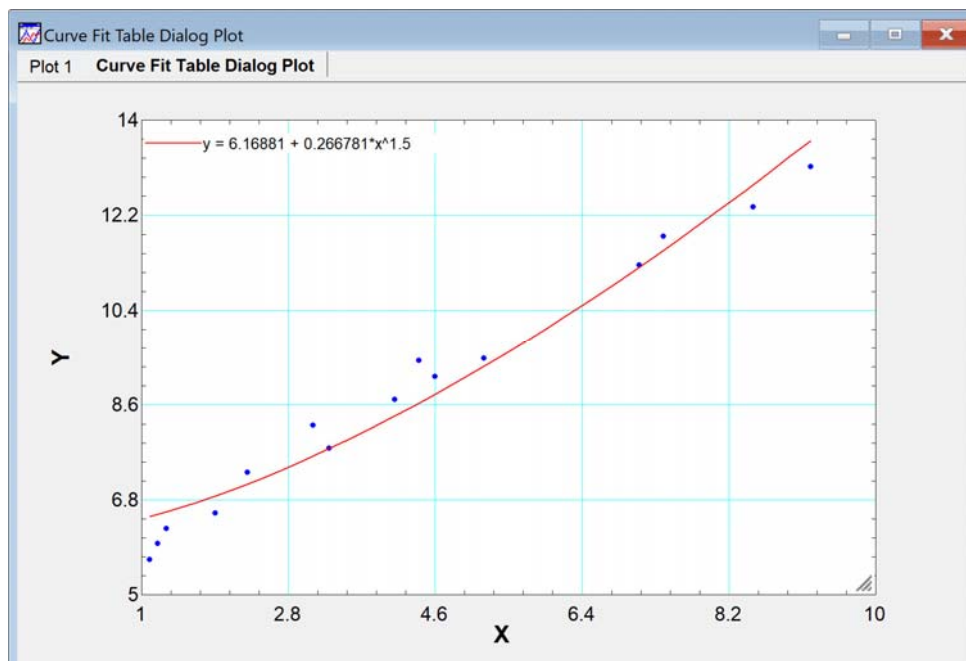
Equation to be fit:
 $y = a1 + a2 \cdot x^{1.5}$

	Guess/Value	Lower	Upper	Step (0=fixed)
a1	1.0000E+00	-infinity	infinity	1.0000E-03
a2	1.0000E+00	-infinity	infinity	1.0000E-03

Maximum Iterations = 200 Maximum number of iterations
 epsilon_1 = 1.0000E-06 Convergence tolerance for gradient
 epsilon_2 = 1.0000E-04 Convergence criteria for parameters
 epsilon_3 = 1.0000E-03 Convergence tolerance for red. Chi-square
 epsilon_4 = 1.0000E-01 Determines acceptance of L-M step
 lambda_0 = 1.0000E-02 Initial value of L-M parameter
 lambda_UP_fac = 1.1000E+01 factor for increasing lambda
 lambda_DN_fac = 9.0000E+00 factor for decreasing lambda
 Update Type Levenberg-Marquardt lambda

OK Cancel

Curve Fit Table Information Dialog



Curve Fit Table Dialog Plot

Recent Changes to EES *

- The \$ModifyAxis directive allows the characteristics of the scaling & axis of a plot to be adjusted.
- Open and Save Tab options are now available for Equation Windows Tabs.
- The \$Warnings Last directive will show only warnings that occurred in the last iteration.
- A new variable can be added to a Parametric Table by selecting *** New Variable *** from the list.
- Options to set axis scales have been added to the \$NewPlot directive and the NewPlot macro.
- The EqnWindowTab macro allows the Equations Window Tab to be adjusted.
- The \$VarInfo directive allows the characteristics of multiple variables to be set in one statement.
- The name of the Brine properties group has been changed to Solution properties.
- Plots of the boiling and freezing points of water-based solutions vs concentration can be automatically generated using the Property Plot feature.
- The Directive Information Dialog now includes a build palette that allows the user to construct the directive statement using a GUI and paste it into the Equations Window.
- The Diagram Window toolbar now allows you to save and load diagram (.dgm) files.
- Add directive buttons have been added to the Property Plot and New Plot Dialogs to generate the corresponding directive statements to automatically generate the associated plots.
- The Calculate button on the Diagram Window allows you to specify the tab to execute.
- Thermodynamic and transport property data have been added for Helium-3, THF (Tetrahydrofuran) and R150.
- If any of the independent variables in a Min/Max optimization are constrained by their bounds then their values will be shown in red font in the progress dialog.
- Upper and lower bounds of independent parameters in a Min/Max dialog can be specified as a percentage above/below the guess value.
- The Curve Fit Table option from the Tables menu allows data in a table to be curve fit. The Curve Fit Table dialog allows either user defined or pre-defined curve fits to be used and weights can be assigned to the data points. The results can be visualized using a Curve Fit Table Dialog Plot.



F-Chart Software

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Instant Update & Technical Service

EES uses a different model for updating than most other programs. Each time that there is a change in the EES program, either to correct a problem or to add a new feature, the version number is incremented by 0.001 and the latest version of EES is placed on our website. Although the program has become very robust and stable, there have been many new versions of EES released since the last EESy Solutions was distributed.

Any user who has a current subscription to Instant Update & Technical Service (IUTS) or Academic Update Service (AUS) can download the current version. All new Commercial and Professional licenses of EES are provided with a one year subscription of this service. The cost to continue IUTS or AUS after the first year is ~20% of the current cost of the program per year, provided that it is renewed within 12 months after expiration. Contact us if you wish to re-subscribe to IUTS or AUS.

* Red color indicates that this feature is for the Professional license.