F-Chart Software
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EESy Solutions

Engineering Equation Solver Newsletter

Inside this issue:

Welcome

This is the 44th issue of EESy Solutions, a newsletter with news, tips, and other updates for users of the Engineering Equation Solver software. This issue discusses improvements to the EES_REFPROP interface that allow the properties of REFPROP fluids to be obtained from EES using the same calling protocol as used for other substances in EES. The new Directive Info and Macro Command Info dialogs are discussed. Recent changes concerning how the libraries (e.g., the Incompressible Library) are loaded are reviewed. The new Duct Flow System library in the Component Library is now available.

EES has been available for more than two decades. If you have missed any of the previous issues of EESy Solutions, they can be downloaded from https://fchartsoftware.com.

Improvements to the EES_REFPROP Interface

Starting with version 11.477, EES and the EES_REFPROP interface have been improved to allow the EES_REFPROP interface to provide property data using exactly the same property commands as are used for built-in EES fluids. All that is needed is to add _RP to the name of any fluid or mixture that REFPROP recognizes. For example, the following EES command provides the specific enthalpy of propane using property data from the NIST REFPROP program.

```
h=enthalpy(Propane_RP, T=25 [C], P=100 [kPa])
```

Property calls made in this manner use the unit system specified in EES. Any valid set of independent properties can be provided, just as for the built-in EES functions. The fluid name may be a pure fluid (e.g., Propane_RP) or a predefined mixture (e.g., R466A_RP). The Property Plot command can be used to prepare property plots using REFPROP fluid data as discussed in EESy Solutions issue #43 from Fall 2022. In addition, the calculation speed associated with using the EES_REFPROP interface has been significantly increased.

An EES_REFPROP interface dated May 27, 2022 is required to use property functions with EES format or to produce property plots using REFPROP. You can determine the date of your EES_REFPROP interface using the EES_REFPROP_DATE$ function in EES.

```
D$=EES_REFPROP_Date$
```

Updating the EES_REFPROP Interface

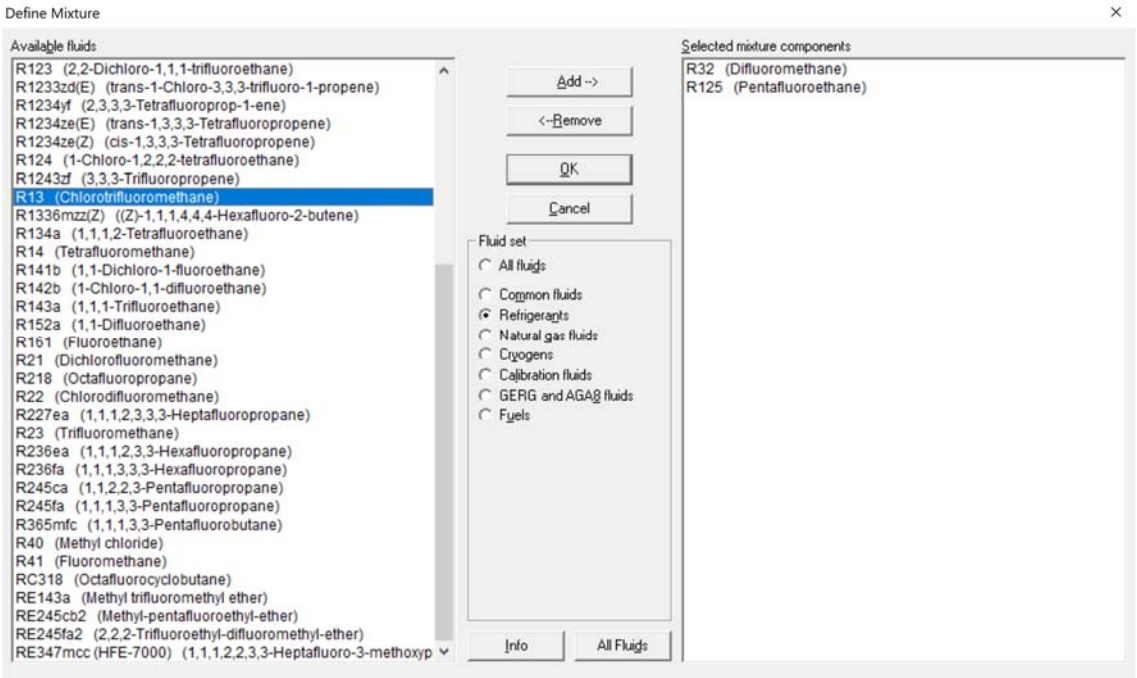
If you wish to update to the current version of the EES_REFPROP interface and you purchased your version less than one year ago, send an email to info@fchart.com to request a free update. If you purchased the interface more than one year ago, you can order the update for 20% of the current cost. The order can be placed at https://fchartsoftware.com/ees/order.php.

The standard EES_REFPROP interface is a 32-bit dynamic link library (DLL) that works with the 32-bit REFPROP program. 64-bit versions of EES and the EES_REFPROP interface are available and they can be used with the 64-bit version of REFPROP. If you have previously purchased the EES_REFPROP interface and are using the 64-bit version of EES, you may wish to upgrade to the 64-bit EES_REFPROP interface. Calculation speeds can be significantly improved with the 64-bit version.

Defining a Mixture

Previous versions of the EES_REFPROP interface require a Call to the EES_REFPROP. A mixture can be specified from within EES and properties for that mixture from REFPROP. The EES_REFPROP interface can still be used with a Call EES_REFPROP statement. However, the newer version of the EES_REFPROP interface allows you to use any fluid or predefined mixture in REFPROP in exactly the same way as you would use an EES built-in fluid. The list of fluids and predefined mixtures that are available by default in REFPROP is extensive and can be accessed by selecting the Substance menu from REFPROP. If you want to simulate a mixture that is not one of the predefined mixture options then you can define your own and save the .mix file.

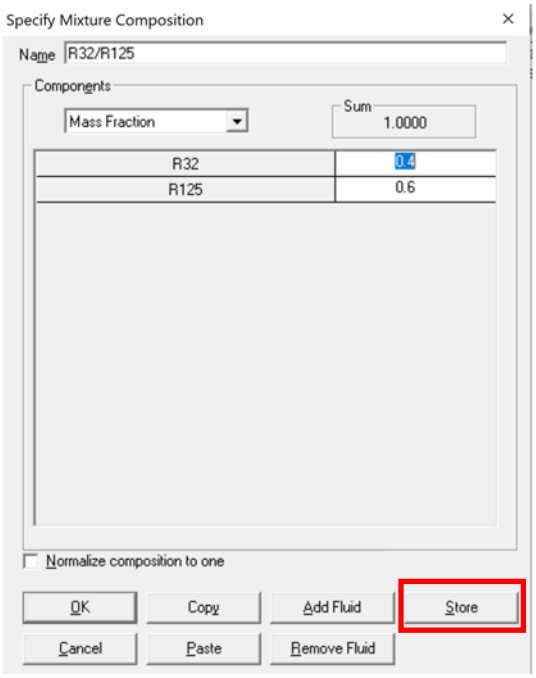
For example, we can define a mixture that is 40% R32 with the balance R125. This mixture is similar to R410B, but is not one that appears in the predefined mixture list in REFPROP. Open REFPROP and construct the mixture by selecting Define New Mixture from the Substance menu. Add R32 and R125 to the selected mixture components list.



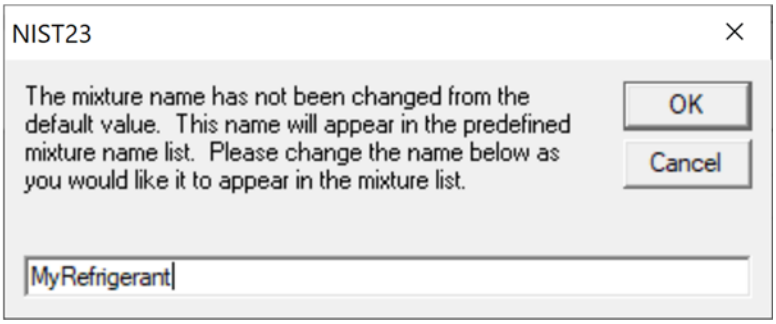
Add R32 and R125 to the selected mixture components list in REFPROP

Defining a Mixture (continued)

Then specify the composition and save the .mix file by selecting Store. You may need administrative privileges to save the file.

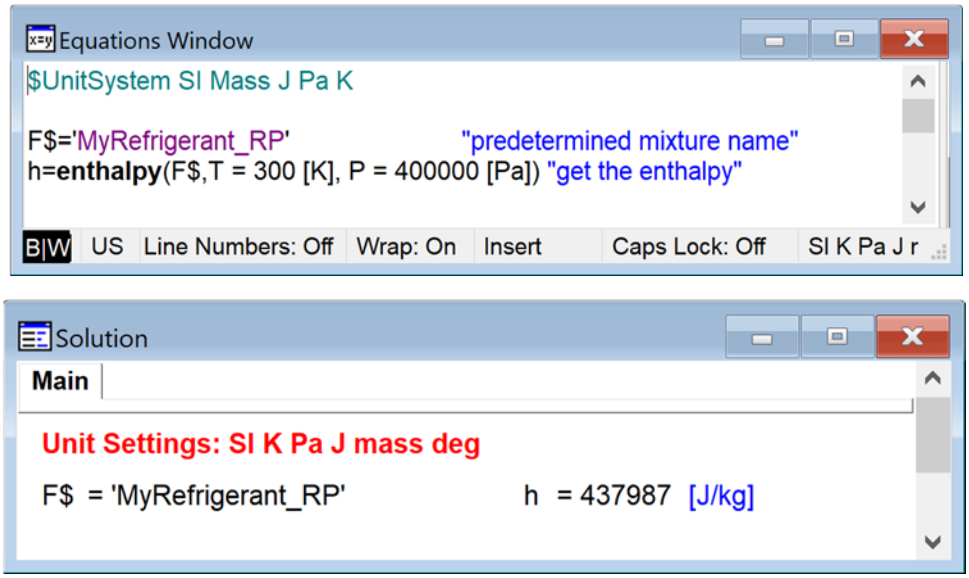


Specify the mixture composition in REFPROP



Store the .mix file with the name of your mixture

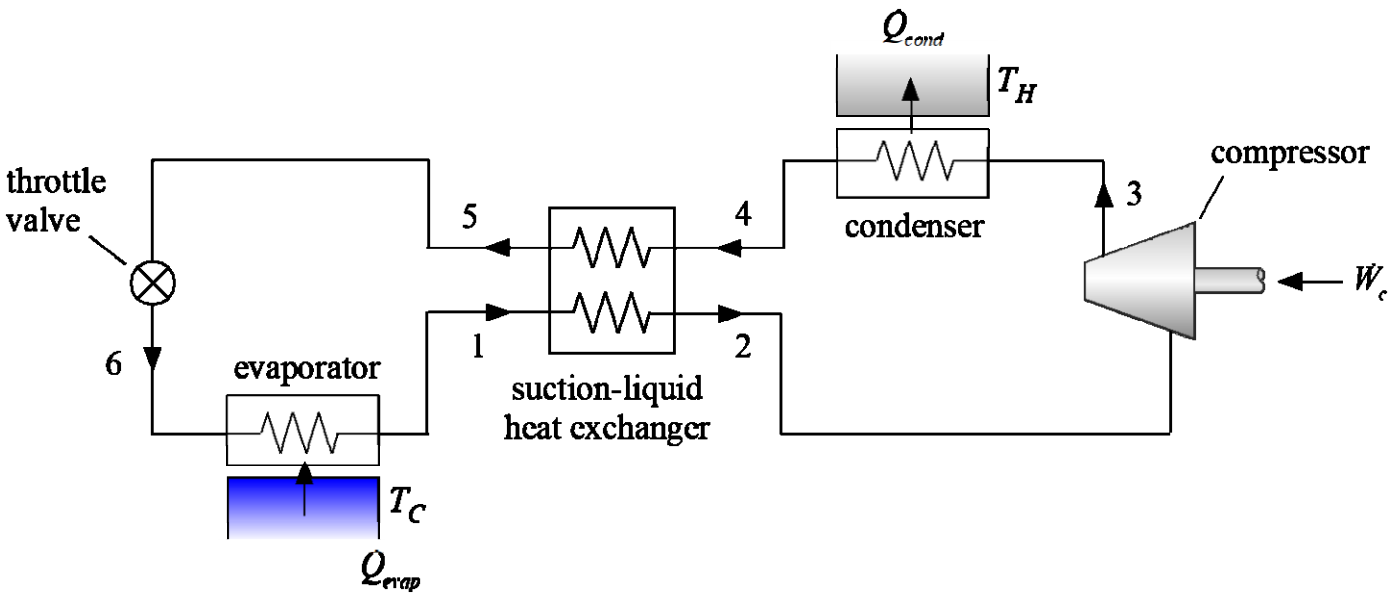
If the .mix file is saved in the /Mixtures folder of your REFPROP installation, EES will automatically find the mixture and it can be called from within EES simply by adding _RP to its name.



Access the new mixture from within EES using the name + _RP

Example with EES_REFPROP Interface

We will illustrate the use of the new EES_REFPROP interface by developing a simple model of a vapor compression cycle with a suction-liquid heat exchanger. The refrigerant is the mixture of 40% R32 and 60% R125 that was defined in the previous section.



Vapor compression cycle with a suction-liquid heat exchanger.

The operating conditions for the cycle are T_C = -5°C and T_H = 25°C. The compressor has a displacement rate of 70 cc/s, a volumetric efficiency of 78% and an isentropic efficiency of 72%. The superheat and subcool are 3°C and 5°C, respectively. The approach temperature differences for the condenser, evaporator, and suction-liquid heat exchanger are 5°C, 4°C, and 2°C, respectively. These input parameters are entered in EES.

Equations Window

```
$UnitSystem SI Mass J Pa K

F$='MyRefrigerant_RP'                    "predetermined mixture name"
T_H = converttemp(C,K,25 [C])            "ambient temperature"
T_C = converttemp(C,K,-5 [C])            "cold space temperature"
eta_c = 0.72 [-]                         "isentropic efficiency of compressor"
eta_vol = 0.78 [-]                       "volumetric efficiency of compressor"
V_dot_disp = 70 [cm^3/s]*convert(cm^3/s,m^3/s)        "displacement rate of compressor"
DT_sc = 5 [K]                            "degree of sub-cooling"
DT_sh = 3 [K]                            "degree of super-heating"
DT_evap = 4 [K]                          "evaporator approach"
DT_cond = 5 [K]                          "condenser approach"
DT_sl = 2 [K]                            "suction-liquid heat exchanger approach"
```

B|W US Line Numbers: Off Wrap: On Insert Caps Lock: Off SI K Pa J mass deg Warnings: On

Input parameters.

Example with EES_REFPROP Interface (continued)

The state points in the cycle are determined and the properties obtained using the fluid 'MyRefrigerant_RP' which acts like any built-in EES fluid. The evaporator cooling load, compressor power, and COP are computed at the end of the program.

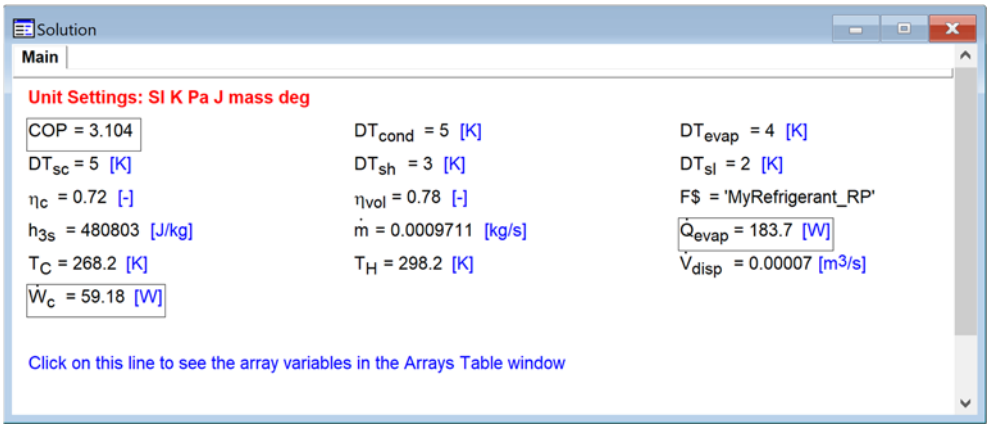
Equations Window

```
"condenser exit"
T[4]=T_H+DT_cond
P[4]=pressure(F$,x=0,T=T[4]+DT_sc)
h[4]=enthalpy(F$,T=T[4],P=P[4])
s[4]=entropy(F$,T=T[4],P=P[4])
v[4]=volume(F$,T=T[4],P=P[4])

"evaporator exit"
T[1]=T_C-DT_evap
P[1]=pressure(F$,x=1,T=T[1]-DT_sh)
h[1]=enthalpy(F$,T=T[1],P=P[1])
s[1]=entropy(F$,T=T[1],P=P[1])
v[1]=volume(F$,T=T[1],P=P[1])

"compressor inlet"
T[2]=T[4]-DT_sl
P[2]=P[1]
h[2]=enthalpy(F$,T=T[2],P=P[2])
s[2]=entropy(F$,T=T[2],P=P[2])
v[2]=volume(F$,T=T[2],P=P[2])

"throttle inlet"
P[5] = P[4]
h[4] - h[5] = h[2] - h[1]
T[5] = temperature(F$,P=P[5],h=h[5])
s[5]=entropy(F$,P=P[5],h=h[5])
v[5]=volume(F$,P=P[5],h=h[5])

"throttle exit"
P[6]=P[1]
h[6]=h[5]
T[6]=temperature(F$,P=P[6],h=h[6])
s[6]=entropy(F$,P=P[6],h=h[6])
v[6]=volume(F$,P=P[6],h=h[6])

"compressor exit"
P[3]=P[4]
h_3s=enthalpy(F$,P=P[3],s=s[2])
h[3]=h[2]+(h_3s-h[2])/eta_c
T[3]=temperature(F$,h=h[3],P=P[3])
s[3]=entropy(F$,h=h[3],P=P[3])
v[3]=volume(F$,h=h[3],P=P[3])

m_dot=V_dot_disp*eta_vol/v[2]
Q_dot_evap=m_dot*(h[1]-h[6])
W_dot_c = m_dot*(h[3]-h[2])
COP=Q_dot_evap/W_dot_c
```

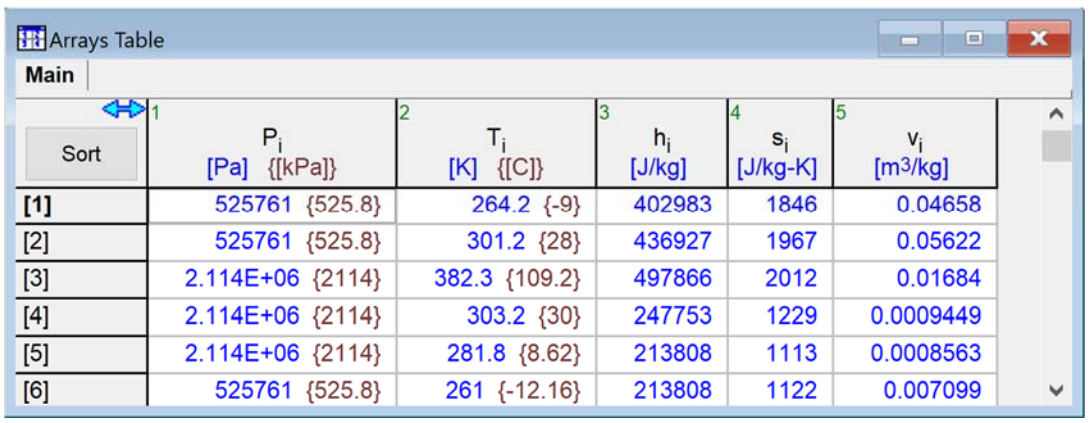
Cycle simulation

Example with EES_REFPROP Interface (continued)

The solution is shown in the Solutions Window with the state points listed in the Arrays Table.



Solutions Window



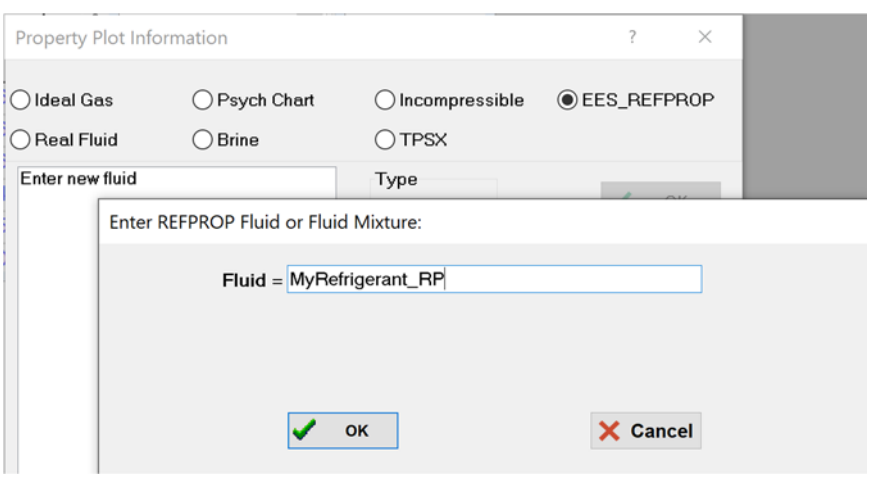
Arrays Table

Main

Sort	1 P_i [Pa] {[kPa]}	2 T_i [K] {[C]}	3 h_i [J/kg]	4 s_i [J/kg-K]	5 v_i [m3/kg]
[1]	525761 {525.8}	264.2 {-9}	402983	1846	0.04658
[2]	525761 {525.8}	301.2 {28}	436927	1967	0.05622
[3]	2.114E+06 {2114}	382.3 {109.2}	497866	2012	0.01684
[4]	2.114E+06 {2114}	303.2 {30}	247753	1229	0.0009449
[5]	2.114E+06 {2114}	281.8 {8.62}	213808	1113	0.0008563
[6]	525761 {525.8}	261 {-12.16}	213808	1122	0.007099

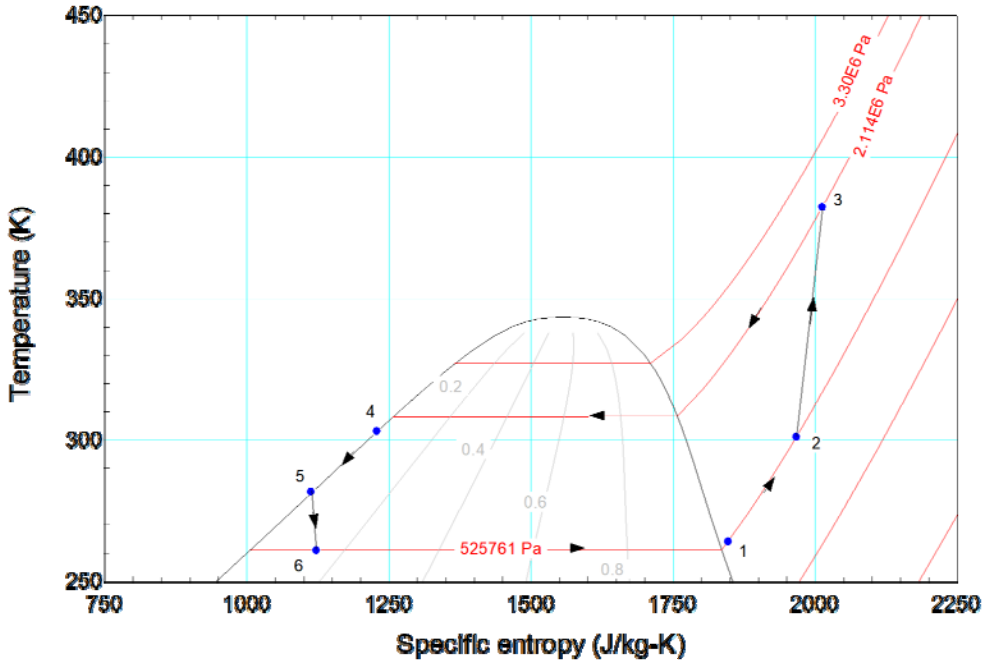
Arrays Table

The cycle can be examined using a property plot, for example a T-s diagram. Any REFPROP fluid or mixture can be used as the basis for a property plot in EES by selecting Property Plot from the Plots menu. Select the EES_REFPROP radio button and enter the name of the fluid followed by _RP.



Enter Name of Mixture in Property Plot Dialog

Example with EES_REFPROP Interface (continued)

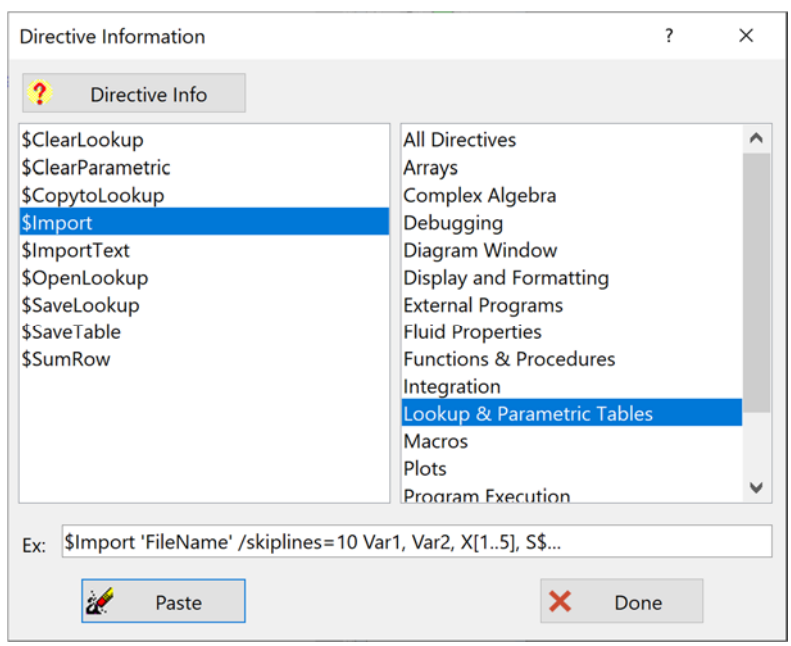


T-s Diagram for Example Cycle

Directive Information Dialog

EES compiles the information in the Equations Window before calculations are initiated into a form that allows for efficient computation. The information in the Equations Window consists mostly of equations, but it can also contain directives, which are instructions to the EES compiler that are acted on during the compilation process. Directives are identified with a $ symbol as the first character.

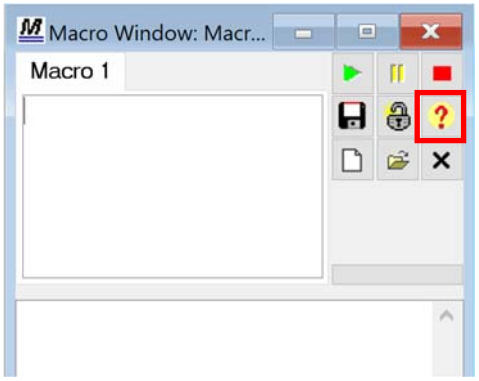
There are a large number of directives that can be used to accomplish tasks as simple as controlling the tab locations in the Equations Window or as complicated as controlling the order in which the equations are solved. The Directive Info command in the Options menu provides a dialog that lists all of the directives, indexed by their function. Selecting a category in the list on the right side causes the associated subset of directives to populate the list on the left. The Directive Info button accesses the online help and the Paste button will paste the contents of the example text into the Equations window at the cursor position.



Directive Information Dialog

Macro Command Information Dialog

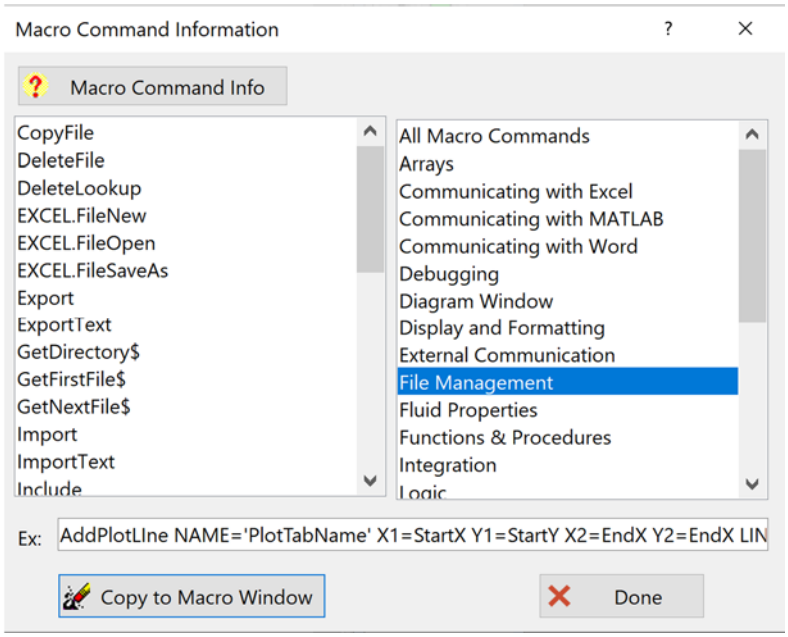
A macro is a set of instructions that can be executed with the EES Professional license. Macro commands can instruct EES to automatically open a file, solve the equations, create and solve a table, store calculated results in a file, print, plot, etc. In fact all of the capabilities that are provided with the menu commands, directives and equations in EES can also be implemented using macro commands. Macros can apply additional commands, e.g., communicating with external programs (e.g., MATLAB or EXCEL) or the serial port. Macros can also work with the operating system commands to change directories, delete files, or solve all files in a directory. There are many advantages to using macros. Macros allow a set of repetitive tasks to be scripted so that they can be re-executed with a single click. They allow two or more EES programs to be run in series where each subsequent program can use results determined by the previous program. Macros can also be used to control EES from another program. Macros are among the most useful features of EES and they even easier to use now due to the addition of the Macro Command Information Dialog.



Show Macro Commands button

The Macro Command Information Dialog can either be accessed by selecting Macro Command Info from the Macros menu or by clicking the Show Macro Commands button in the Macro Window toolbar

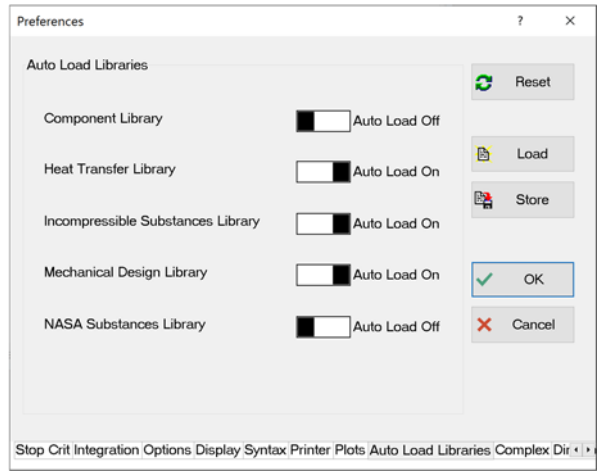
The Macro Command Information Dialog lists all of the available macro commands. It operates like the Function Information and Directive Information Dialogs. Selecting a category from the right list reduces the list of commands shown on the left to those in that category. The Macro Command Info button navigates to the help page for the selected command. Selecting the Copy button either copies the command in the example box to the Macro Window (if the dialog was called from the Macro Window) or to the clipboard (if it was called from the Macros menu).



Macro Command Information Dialog

Auto Load Libraries

Several useful libraries are provided with EES, including the Incompressible Substances, Mechanical Design, Heat Transfer, NASA Substances, and Component (Professional version) Libraries. Previously the Heat Transfer Library was automatically loaded when EES started but the others were not. Instead, other libraries had to be loaded manually using the $Load directive. A prompt was provided to load these when these categories were accessed from the Function Information Dialog.

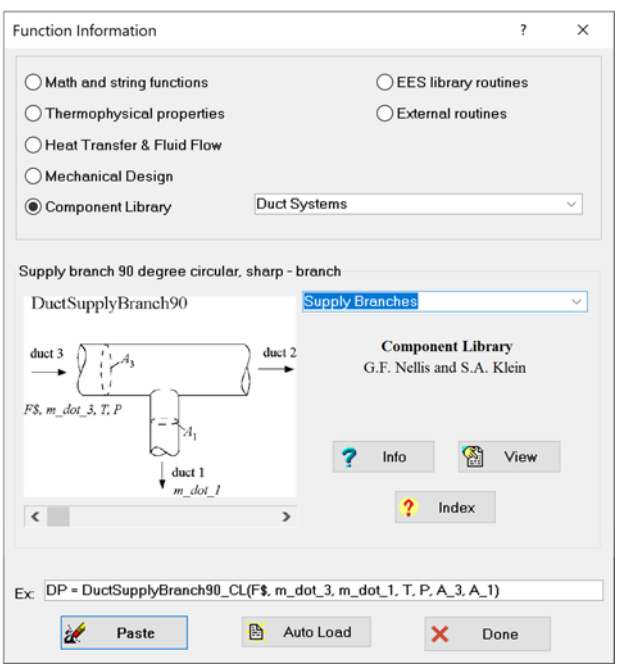


Auto Load Libraries tab

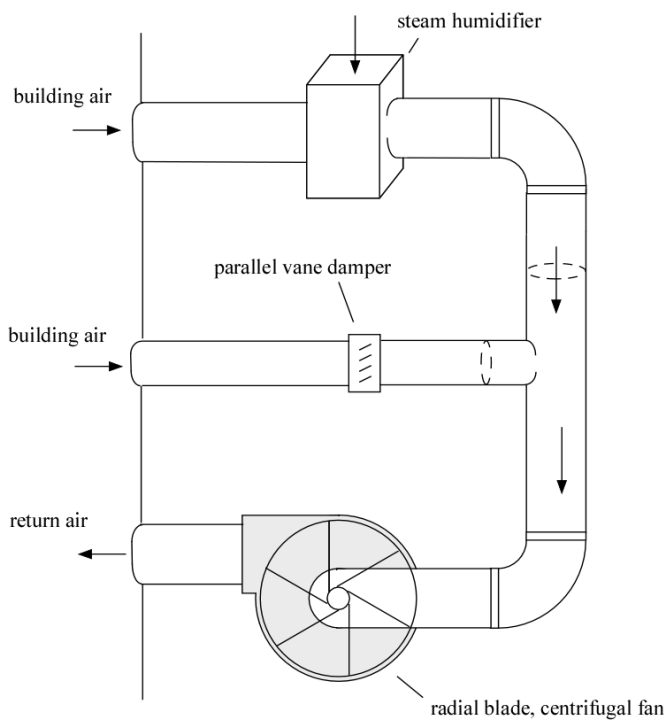
Starting in EES version 11.569, libraries can be set by the user to be automatically loaded upon startup. Libraries that are loaded at startup do not need to be manually loaded with the $Load directive. All of the libraries except the NASA Substances and Component Libraries are automatically loaded by default. The automatic load status of all of the libraries can be controlled by selecting the Auto Load Libraries tab of the Preferences dialog, which can be accessed by selecting Preferences from the Options menu.

Duct System Library

The Duct System Library within the Component Library provides many of the pieces that allow simulation of the air side of HVAC systems. These include components such as bends, contractions and expansions, supply and extraction branches, inlets and outlets, and fans and blowers. These components can be used to simulate or design air-side duct networks, as illustrated in Example 20.5 of Mastering EES, which simulates a humidification system.



Duct Systems Library



Humidification System in Example 20.5

Recent Changes to EES

- I-beams have been added to the Moment of Inertia category of the Mechanical Design library.
- The Check Box Characteristics and Radio Button Groups dialogs can be resized in the Diagram Window to allow equations to be more easily entered or viewed. The Check Box dialog provides a splitter control between the windows for checked and unchecked status.
- The Modify Plot dialog provides an indicator for a smoothed plot that shows how many data points are used in a moving average or the order of the polynomial .
- Many of the EES dialogs can now be resized to better show the data.
- Property data for Novec_7100, Novec_7200 and Novec_7500 are provided in the Incompressible: Heat Transfer Fluids library. The corresponding real fluid properties (HFE7100, HFE7200, and HFE7500) are no longer available.
- Property data for PAO_mil-c-87252 and Coolanol_25R have been added to the Incompressible: Heat Transfer Fluids library.
- The Heaviside function has been added.
- The Professional license provides the option to automatically update the values in a Lookup table that have been set with equations in the Lookup table.
- Macro commands CompilationTime and CalculationTime have been added to the Professional version.
- Thermodynamic and transport properties for ideal gas Krypton (Kr), Xenon (Xe), and Neon (Ne) have been added.
- EES variable values can be inserted into Diagram Window Formatted Text, Diagram Window Tables and the Report Window with either its units or its alternate units.
- Properties for R456a, propylene glycol, R1234ze(E) and R1123 have been added.
- Units can be assigned to array elements using Array Range Notation by appending the units (within brackets) to the end of the assignment, e.g., Power=[31,52,46] [kW].
- Thermodynamic and transport properties of liquid and vapor sodium and potassium have been added.

F-Chart Software

PO Box 44042
Madison, WI, 53744

Phone: 608-274-4262
Internet: http://fchartsoftware.com
E-mail: info@fchart.com

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) can download the latest version. All new non-academic Commercial and Professional licenses of EES are provided with one year of IUTS. The fee to continue IUTS for these licenses after the first year is 20% of the current cost of the program per year if renewed within 12 months after expiration. Contact us if you wish to re-subscribe to IUTS. Academic licenses can be updated if Academic Update Service has been purchased.