

EESy Solutions

Engineering Equation Solver Newsletter

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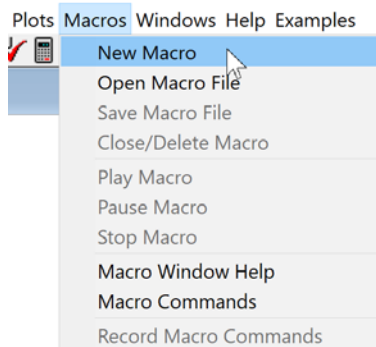
Welcome

This is the 43rd issue of EESy Solutions, a newsletter that provides news, tips, and other updates for users of the Engineering Equation Solver software. This issue discusses the new Macros menu and the associated improvements to the Macros feature in EES. EES can now generate property plots using **REFPROP** provided that the REFPROP program is installed and the EES_REFPROP interface is present. Finally, the Annual License of EES provides a new low-cost option for licensing EES.

EES has been commercially 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>.

The Macros Menu

A macro is a set of instructions to EES that allows the user to automate the operation of EES. This capability is only available with the Professional license. It is similar to scripting instructions in other programs. Macro commands can instruct EES to open a file, run a program, create tables, make plots, save data, and more. The capability to create and run macros in EES has existed for some time, but recently, capability to save macros within EES files and the Macros menu have been added. The Macros menu allows easy access to the Macros Window. Select New Macro from the Macros menu and EES will open the Macro Window and create a new tabbed window where you enter your macro commands.



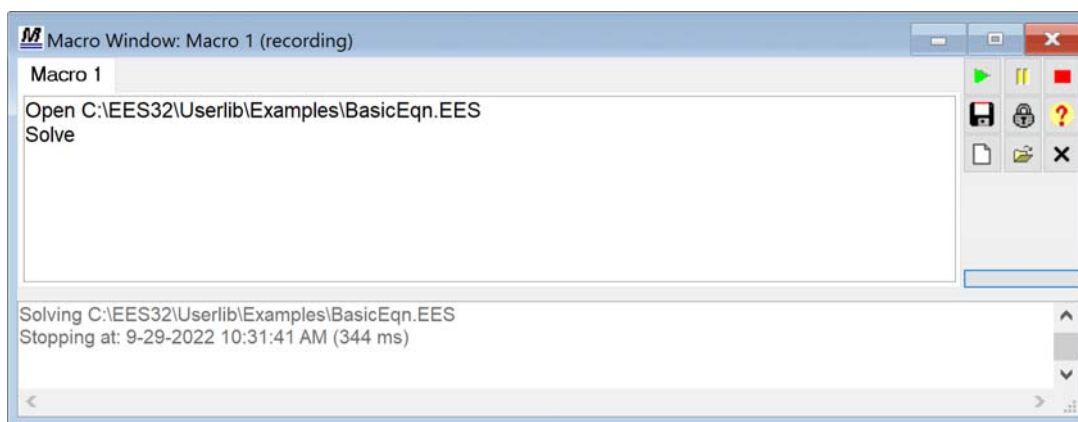
Macros Menu



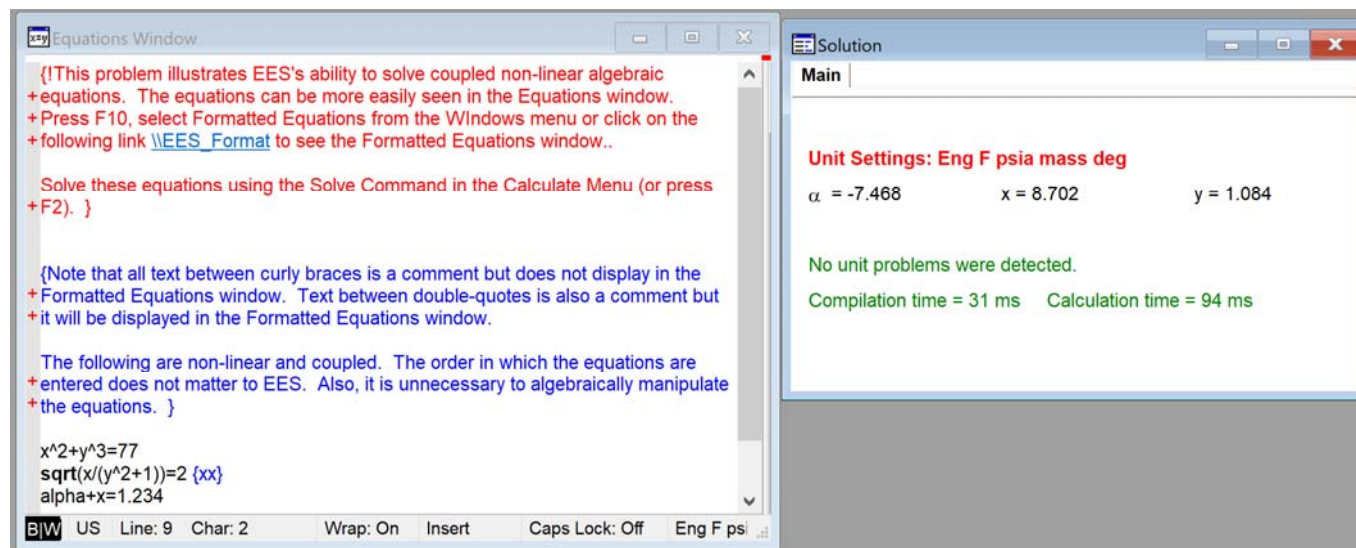
Macros Window

The Macros Menu (continued)

For example, we can instruct EES to open an EES program using the Open macro command and then Solve the program using the Solve macro command. Run the Macro with the green arrow button either on the Macro Window or the EES tool bar and you should see that the program BasicEqn.ees is opened and solved. The results of executing these commands are echoed to you in the lower log window.



Macro that opens and solves an EES program



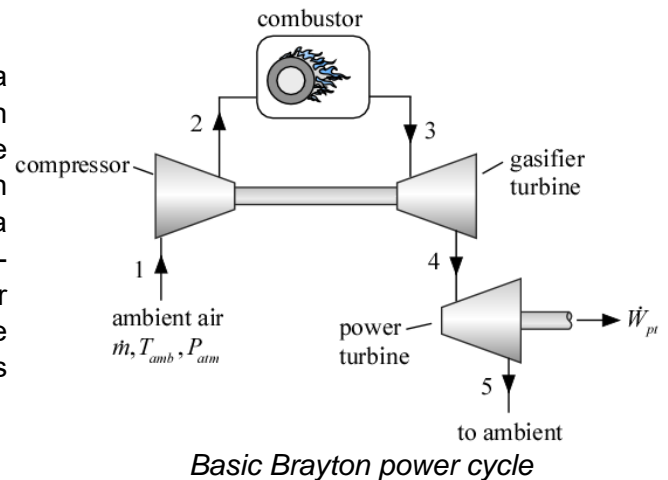
Run the Macro to open the file BasicEqn.ees and solve it

Macro commands are listed in the Help menu, which can be accessed by selecting Macro Commands from the Macro menu. They are also listed in Appendix D of Mastering EES.

The easiest way to access the correct macro command is to record the equivalent macro command associated with your own interactions with EES. This can be done by selecting Record Macro Commands from the Macros menu or by clicking the Lock/Unlock button in the Macros Window.

An Example Macro

Let's explore Macros more carefully by developing a Macro to automatically create meaningful connection lines between the state points in a property plot. The figure to the right shows a simple Brayton power cycle in which a gasifier turbine drives the compressor and a power turbine produces power. The cycle is air-breathing, meaning that air is pulled into the compressor from the atmosphere and exhausted to the atmosphere from the power turbine. The EES code that simulates this cycle is shown below.



```

Equations Window
$UnitSystem SI K Pa J Mass Radian
$TabStops 0.5 3 in

"Input conditions"
T_amb=converttemp(C,K,20[C])           "ambient temperature"
P_atm=1 [atm]*convert(atm,Pa)         "atmospheric pressure"
PR=5 [-]                               "pressure ratio"
T_t_in = 1400 [K]

"State 1"
T[1]=T_amb                             "temperature"
P[1]=P_atm                             "pressure"
s[1]=entropy(Air,T=T[1],P=P[1])        "specific entropy"
h[1]=enthalpy(Air,T=T[1])              "specific enthalpy"

"State 2"
P[2]=PR*P[1]                           "pressure"
s[2]=s[1]                               "entropy balance on reversible compressor"
h[2]=enthalpy(Air,s=s[2],P=P[2])      "specific enthalpy leaving reversible compressor"
W_dot_c\m_dot=h[2]-h[1]                "work per mass required by reversible compressor"
T[2]=temperature(Air,h=h[2])           "temperature leaving reversible compressor"

"State 3"
T[3]=T_t_in                             "no pressure loss"
P[3]=P[2]                               "specific enthalpy"
h[3]=enthalpy(Air,T=T[3])              "specific entropy"
s[3]=entropy(Air,T=T[3],P=P[3])        "heat transfer per mass provided in combustor"
Q_dot_c\m_dot = h[3]-h[2]

"State 4"
s[4]=s[3]                               "entropy balance on reversible gasifier turbine"
h[4]=enthalpy(Air,s=s[4],P=P[4])      "specific enthalpy leaving reversible gasifier turbine"
W_dot_gt\m_dot=(h[3]-h[4])            "work per mass associated with reversible gasifier turbine"
W_dot_gt\m_dot = W_dot_c\m_dot        "energy balance on gasifier turbine and compressor"
T[4]=temperature(Air,h=h[4])           "temperature leaving gasifier turbine"

"State 5"
P[5]=P_atm                             "exit pressure"
s[5]=s[4]                               "entropy balance on reversible power turbine"
h[5]=enthalpy(Air,s=s[5],P=P[5])      "specific enthalpy leaving reversible power turbine"
W_dot_pt\m_dot=(h[4]-h[5])            "work per mass associated with reversible power turbine"
T[5]=temperature(Air,h=h[5])           "temperature leaving power turbine"

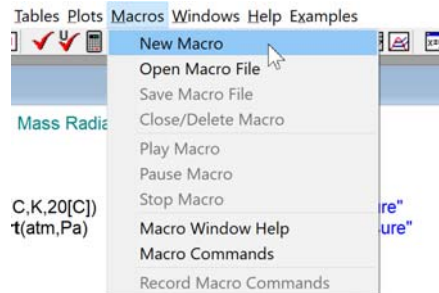
eta = W_dot_pt\m_dot/Q_dot_c\m_dot     "efficiency of cycle"

```

EES program that simulates a Brayton cycle

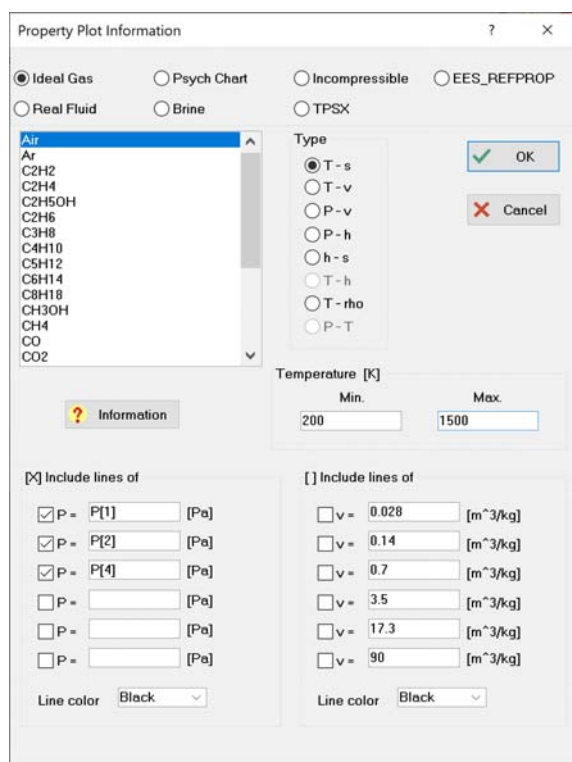
An Example Macro (continued)

From the Macros menu, select New Macro. A new Macro Window will appear. By default, the Macro will be saved with the EES file. We need to put the commands in the Macro Window that will carry out all of the steps that would have to be done manually in order to generate a T - s diagram for the cycle with state points and meaningful connection lines. These include running the EES code, deleting the plot that currently exists, creating the correct property plot for air with the right isobars, overlaying the state points, and then finally generating data that connect the state points in thermodynamically meaningful ways and plotting it.

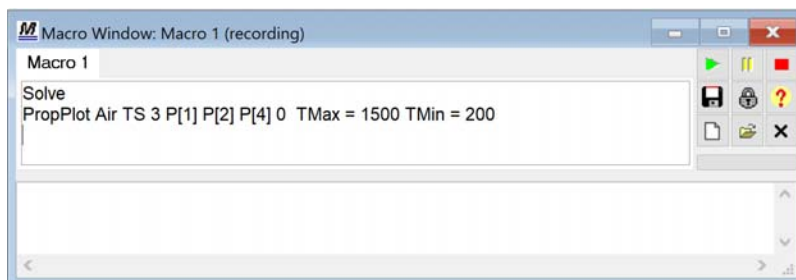


New Macro option in the Macros menu

Some of these Macro commands can be generated automatically by selecting the Record Macro Commands from the Macros menu and then carrying out the commands manually. For example, we can Solve the Equations and then set up a property plot for air by selecting Property Plot from the Plots menu and manipulating the resulting dialog as shown in the figure. The Macro commands corresponding to these steps are echoed in the Macro Window, as shown below.

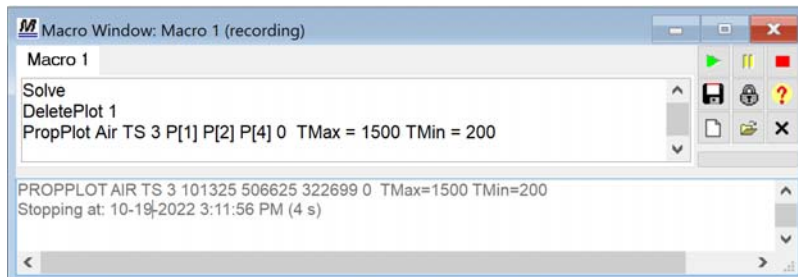


Property Plot dialog



Macro Window with commands recorded

Running the Macro (with the green arrow) will subsequently solve the equations and generate a property plot automatically. In order to avoid generating many copies of the same plot, it is a good idea to add a DeletePlot command, as shown below.



Macro Window with DeletePlot command

Each time the Macro is run, the commands are executed and reported in the log window at the bottom of the Macro window.

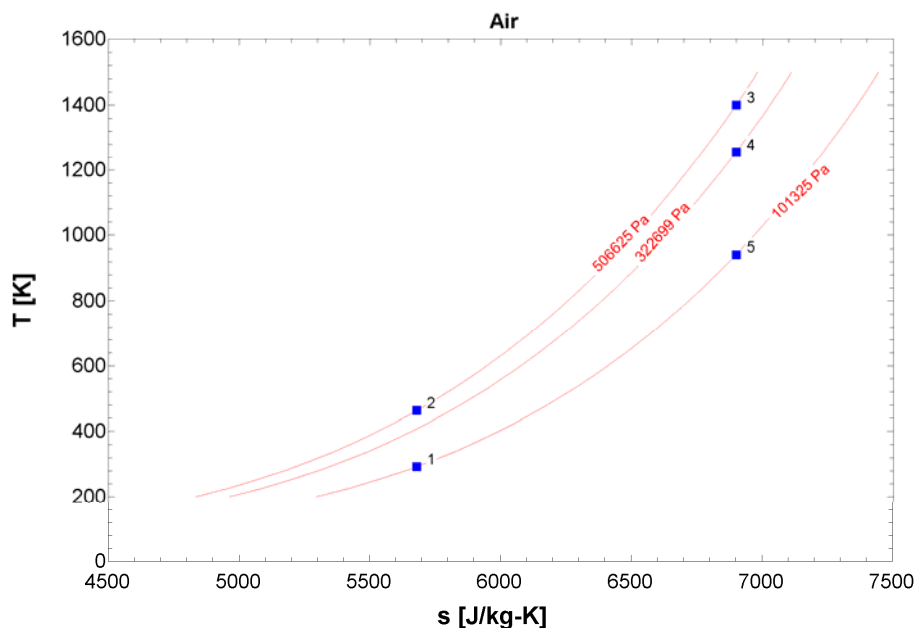
An Example Macro (continued)

Next we will overlay our state points onto the plot. Select **Overlay Plot** from the **Plots** menu and manipulate the dialog so that points with labels (but not lines) are placed onto the plot. Hit **OK** and you will see the **OverlayPlot** command recorded in the Macro window.

```
Macro Window: Macro 1 (recording)
Macro 1
Solve
DeletePlot 1
PropPlot Air TS 3 P[1] P[2] P[4] 0 TMax = 1500 TMin = 200
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=1..5 Line=0 Symbol=9 Color=Blue PointLabels
```

Macro Window with *OverlayPlot* command

The resulting plot is shown below.



T-s Plot with State Points

Points 2 and 3 lie on an isobar and connecting them with a straight line is not appropriate. They need to be connected with a curved line that follows the isobar. Straight lines can be used for joining the other state points (1-2, 3-4, and 4-5). **OverlayPlot** commands are copied and modified in the Macro for this purpose.

```
Macro 1
Solve
DeletePlot 1
PropPlot Air TS 3 P[1] P[2] P[4] 0 TMax = 1500 TMin = 200
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=1..5 Line=0 Symbol=9 Color=Blue PointLabels

//line joining state 1 to 2
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=1..2 Line=9 Symbol=0 Color=Blue

//line joining state 3 to 4
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=3..4 Line=9 Symbol=0 Color=Blue

//line joining state 4 to 5
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=4..5 Line=9 Symbol=0 Color=Blue
```

Macro with additional *OverlayPlot* commands to join states 1-2, 3-4, and 4-5

An Example Macro (continued)

In order to plot the curve along the isobar connecting states 2 and 3, we will programmatically (in the macro) create a Lookup Table to hold these data, fill it with T-s data along the isobar, overlay these data onto the plot, and finally delete the Lookup Table. These commands can be obtained directly by entering the macro commands or, more conveniently, carrying out these actions with the Record Macro Commands option selected. The result is shown below as well as the resulting plot.

```

Macro Window: Macro 1
Macro 1
Solve
DeletePlot 1
PropPlot Air TS 3 P[1] P[2] P[4] 0 TMax = 1500 TMin = 200
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=1..5 Line=0 Symbol=9 Color=Blue PointLabels

//line joining state 1 to 2
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=1..2 Line=9 Symbol=0 Color=Blue

//line joining state 3 to 4
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=3..4 Line=9 Symbol=0 Color=Blue

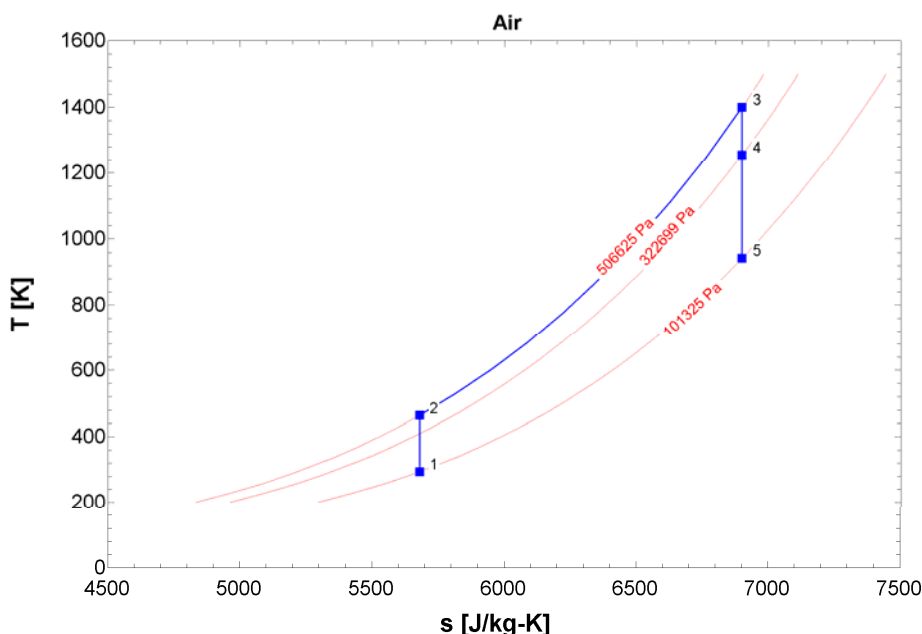
//line joining state 4 to 5
OverlayPlot Name='T-s: Air' Table=ARR1 X=s[i] Y=T[i] Rows=4..5 Line=9 Symbol=0 Color=Blue

//isobar joining state 2 to 3
N=10
Lookup$='Ts23'
NewLookup Lookup$ Rows=N Cols=2
i=0
repeat
  i=i+1
  s23=s[2]+(i-1)*(s[3]-s[2])/(N-1)
  T23=Temperature(Air,s=s23,P=P[2])
  Lookup[Lookup$,i,1]=s23
  Lookup[Lookup$,i,2]=T23
until (i=N)
OverlayPlot Name='T-s: Air' Table='Ts23' X=Column1 Y=Column2 Rows=1..10 Line=9 Symbol=0 Color=Blue
DELETELOOKUP 'Ts23'

OVERLAYXYPlot7 TABLE='TS23' X=Column1 Y=Column2 =1..10 1..10 LINE=9 SYMBOL=0 COLOR=BLUE
DELETELOOKUP TS23
Stopping at: 10-20-2022 10:44:40 AM (1.984 s)

```

Macro Window with commands to plot the data along the isobar connecting states 2 and 3

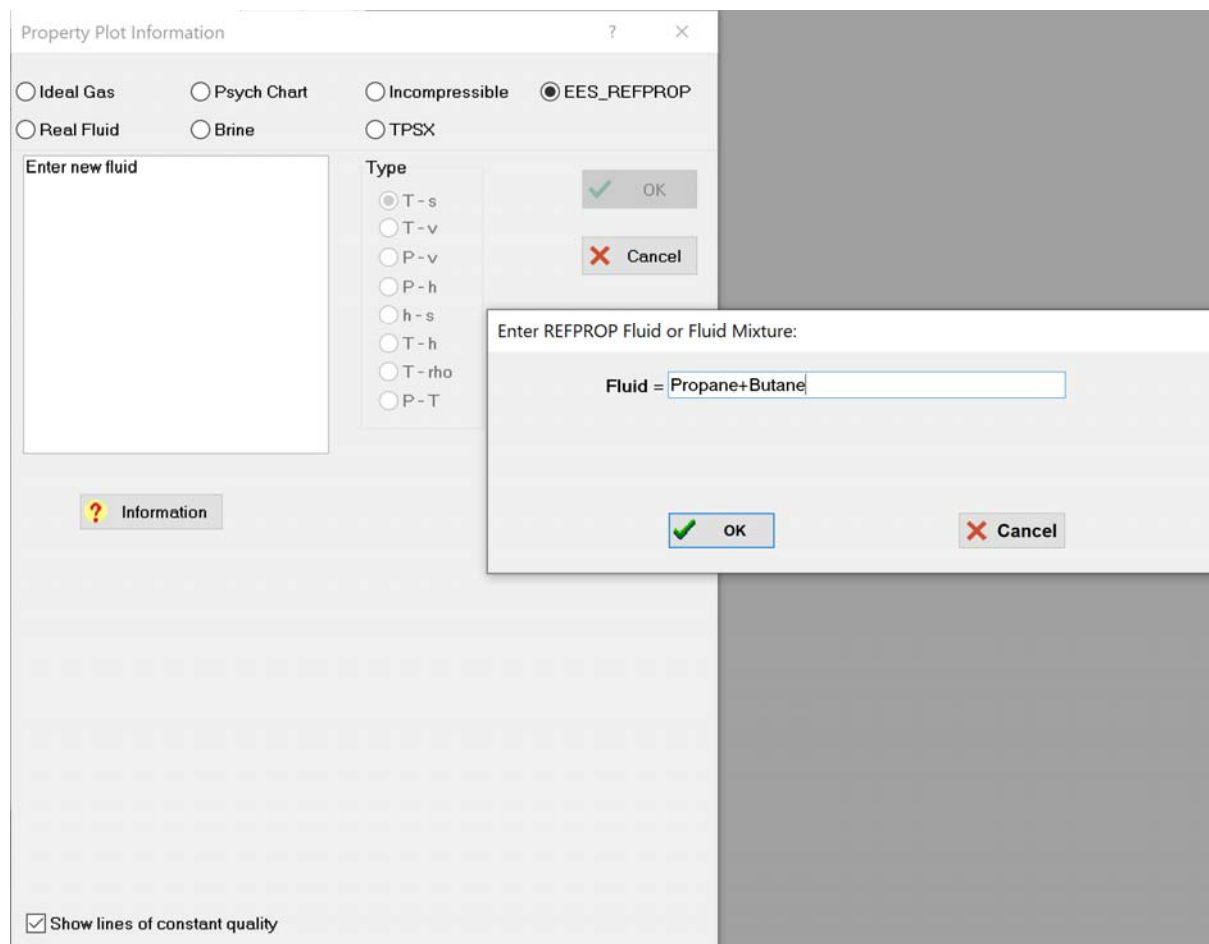


Resulting T-s Plot for the cycle

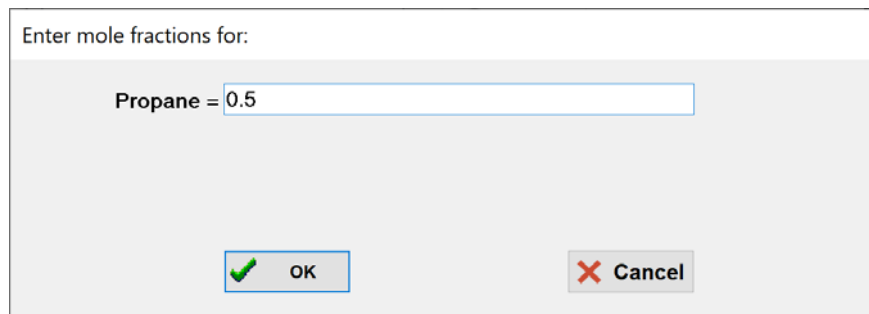
Property Plots for REFPROP Data

Starting with EES V11.366, the Property Plot dialog can be used to plot data from [REFPROP](#) that uses the EES_REFPROP interface. This capability requires EES_REFPROP interface dated May 27, 2022 or later. The current date associated with your EES_REFPROP interface can be obtained using the EES_REFPROP_Date\$ function. You may need to [update the EES_REFPROP interface](#).

Select Property Plot from the Plots menu to bring up the Property Plot dialog. Select the EES_REFPROP radio button. You will need to select a fluid and, if it is a mixture, enter its composition.



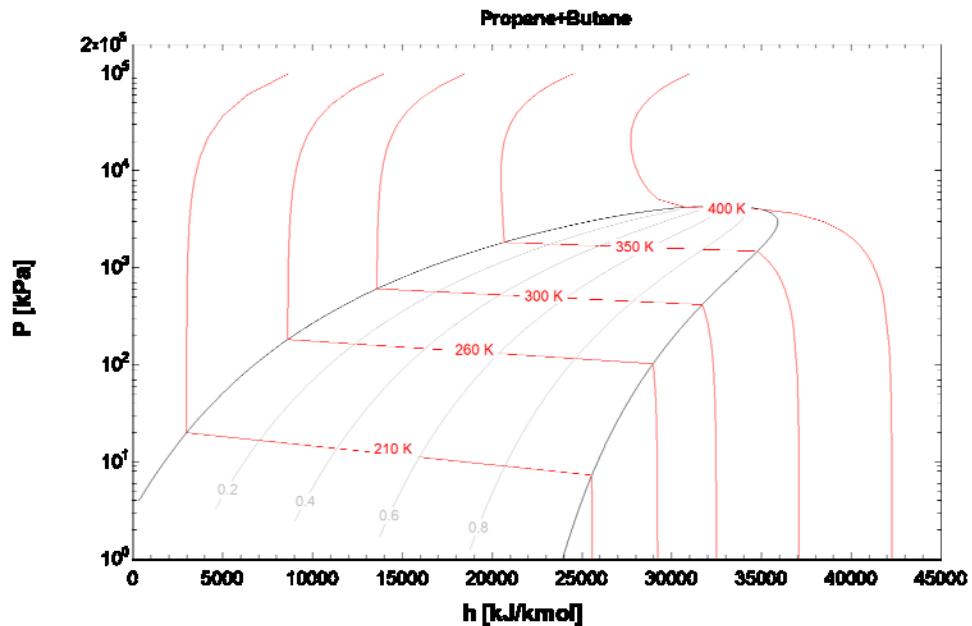
Property Plot dialog for EES_REFPROP with fluid definition dialog



Dialog to enter composition of a mixture

Property Plots for REFPROP Data (continued)

Once the fluid has been defined it will appear in the list of fluids in the Property Plot dialog allowing you to create any of the typical property plots. For example, a P - h dialog is shown below.



P - h diagram for a 50% mixture of propane & butane

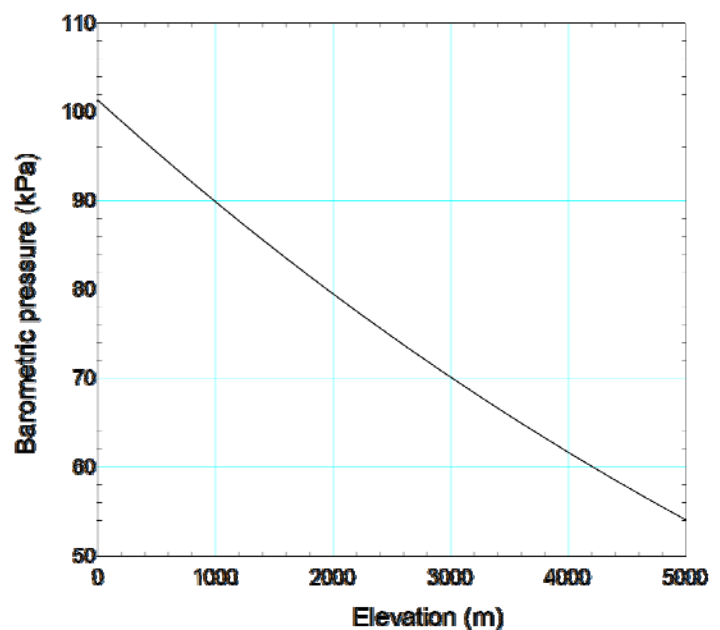
Barometric Pressure Function

The BarometricPressure function in EES provides the standard barometric pressure as a function of elevation above sea level. For example, the code below is used to develop the plot of barometric pressure as a function of elevation.

```

UnitSystem SI C kPa
h=1000 [m]
P=BarometricPressure(h)
  
```

EES code calling the BarometricPressure function

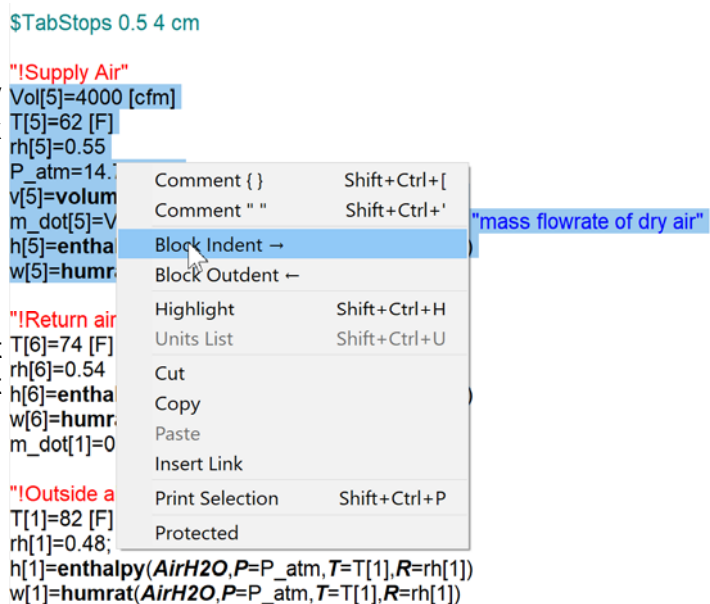


Barometric pressure as a function of elevation

Block Indent Feature

EES programs can be made more readable by using strategic indentation. The ability to block indent highlighted sections of code has been added to EES. The size of the block indent can be adjusted using the Block Indent selection in the Syntax tab of the Preferences Window.

To access this feature, highlight the text that you want to indent (or outdent) and then right click to bring up the popup menu, as shown.



Block Indent Feature

Annual EES License

Commercial and Professional single-user licenses can be purchased for \$600 and \$1200, respectively. These licenses include one year of Instant Update and Technical Service (IUTS) service after which the IUTS service can be renewed at a cost of 20% of the cost of the license per year. These licenses expire 4 years after IUTS has expired.

The Annual EES license is a new option. This cost is \$160 and the license remains active for one year at which point it expires. The license can only be purchased online from the [webstore](#). An Annual license may only be used by the registered user; it cannot be upgraded or transferred. A complete table of comparisons for the various license options can be found [here](#). Although anyone can purchase an Annual license, it is intended for students who need EES off-campus where they may not be able to access the Academic license.

Recent Changes to EES

- Thermodynamic and transport properties for liquid and vapor sodium have been added to the properties library.
- The \$Reference RXN directive shifts the reference state such that the specific enthalpy at 25°C and 101.3 kPa is the enthalpy of formation and the specific entropy is set based on the Third Law. This reference state facilitates using fluids in combustion calculations.
- Find and Replace commands have been implemented in the Macro Window.
- The CopyFile macro command can be used to copy files within a macro.
- The PropPlot macro command now allows the keyword DEF to be provided to specify the values used for constant property lines.
- String data are displayed in tables using the color specified for string in the Preferences dialog.
- Many new heat transfer fluids have been added to the Incompressible Substance Library.
- The option to connect the last point to the first point in a plot now exists in order to facilitate plotting states in a thermodynamic cycle.
- RocketProps is a python package that provides the properties for several rocket propellants. The RocketProps_EES library provides an interface to link to this program.
- The \$Reference directive can be used for properties that are determined using the EES_REFPROP interface.
- The Print command in Functions and Procedures provides the /S option which displays the printed file after calculations are completed.
- The Delete\$ and Insert\$ functions simplify string operations.
- Natural_Gas is recognized as an ideal gas mixture substance. A representative composition is provided as the default, but the composition can optionally be modified.
- Ideal gas fluid property correlations now extend to 6000 K.
- The \$ConvertEESREFPROPUnits directive accepts a /mass option which allows the composition of a mixture to be specified on a mass basis.



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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 \(IUTS\)](#) 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.