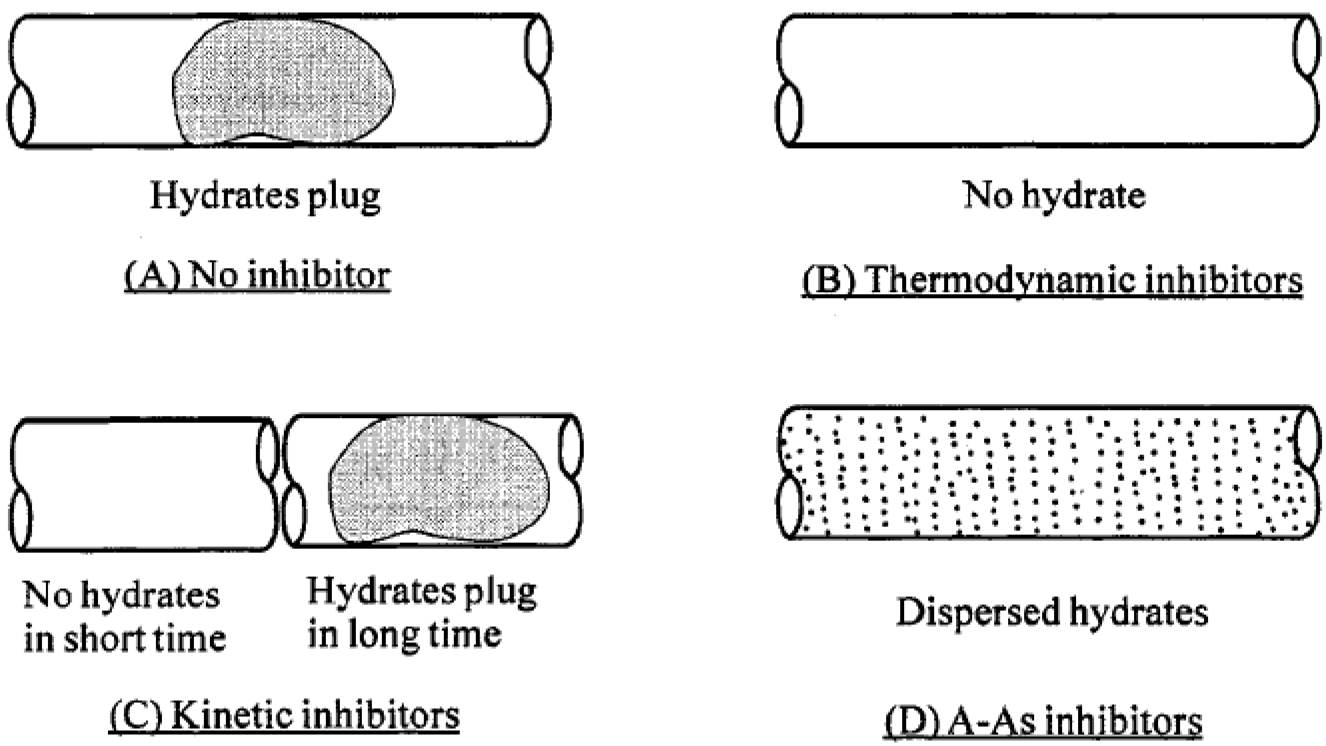


Figure 20.10 Mechanism of hydrate inhibition.

Hydrate Remediation

20.4 Hydrate Remediation

Like the kinetics of hydrate formation, hydrate dissociation is a poorly understood subject and applying laboratory observations to field predictions has proven difficult. Part of the reason is the complicated interplay of flow, heat transfer, and phase equilibria. The dissociation behaviour of hydrate depends on the hydrate size, porosity, permeability, volume of occluded water, "age" of the deposit, and local conditions such as temperature, pressure, fluids in contact with the plug, and insulation layers over the pipeline.

Hydrate remediation techniques are similar to hydrate prevention techniques, which include,

- Depressurization from two sides or one side, by reducing pressure below hydrate pressure at ambient temperature, the hydrate will become thermodynamically unstable.
- Thermodynamic inhibitors; the inhibitors can essentially melt blockages with direct hydrate contact.
- Active heating; by increasing temperature to above the hydrate dissociation temperature and providing significant heat flow to relatively quickly dissociate a blockage.
- Mechanical methods; drilling, pigging or scraping have been attempted, but are generally not recommended. thruster or pig inserted from surface vessel with coiled tubing through a work-over riser at launchers. Melting by jetting with MEG.
- Pipeline segment replacement.

20.4.1 Depressurization

Depressurization is the most common technique used to remediate hydrate blockages in production systems. Rapid depressurization should be avoided because it can result in JT cooling, which can worsen the hydrate problem and form ice. From both safety and technical standpoints, the preferred method to dissociate hydrates is to depressurize from both sides of the blockage. If only one side of a blockage is depressurized, then a large pressure differential will result across the plug, which can potentially create a high speed projectile.

When pressure surrounding a hydrate is reduced below dissociation pressure, hydrate surface temperature will cool below seabed temperature, and heat influx from the surrounding ocean will slowly melt the hydrate at the pipe boundary. Lowering pressure also drops hydrate formation temperature and helps prevent more hydrates from forming in the rest of the line. Because most gas flowlines are not insulated, hydrate dissociation can be relatively fast due to higher heat flux from pipeline surface, as compared to an insulated or buried flowline.

20.4.2 Thermodynamic Inhibitors

Thermodynamic inhibitors can be used to melt hydrate blockages. The difficulty of applying inhibitors lies in getting the inhibitor in contact with the blockage. If the injection point is located relatively close to the blockage, as may be the case in a tree or manifold, then simply injecting the inhibitor can be effective. Injecting inhibitor may not always help with dissociating a hydrate blockage, but it may prevent other hydrate blockages from occurring during remediation and restart.

If the blockage can be accessed with coiled tubing, then methanol can be pumped down the coiled tubing to the blockage. In field applications, coiled tubing has reached as far as 14800 ft in remediation operations, and industry is currently targeting lengths of 10 miles.

20.4.3 Active Heating

Active heating can remediate hydrate plugs by increasing temperature and heat flow to the blockage; however, safety concerns arise when applying heat to a hydrate blockage. During the dissociation process, gas will be released from the plug. If the gas is trapped within the plug, then the pressure can build and potentially rupture the flowline. Heating evenly applied to a flowline can provide a safe, effective remediation.

Active heating can remediate a block age within hours, whereas depressurization can take days or weeks. The ability to quickly remediate hydrate blockages can enable less conservative designs for hydrate prevention.

20.4.4 Mechanical Methods

Pigging is not recommended for removing a hydrate plug because they can compress the plug, which will compound the problem. If the blockage is complete, it will not be possible to drive a pig. For a partial blockage, pigging may create a more severe blockage.

20.4.5 Safety Considerations

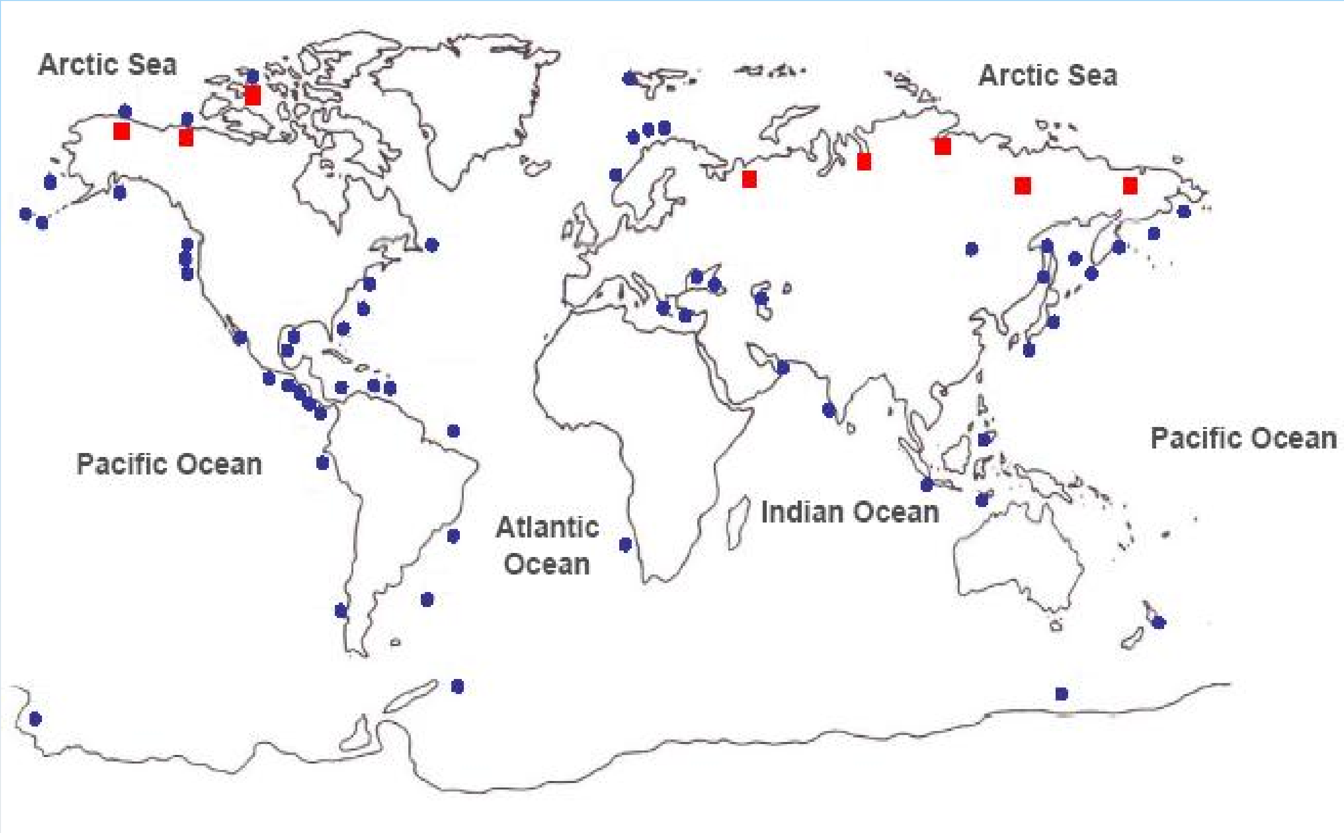
Knowledge of the location and length of a hydrate blockage is very important in determining the best approach to remediation, although the methodology is not well defined, This information facilitates both safety considerations in terms of distance from the platform and time necessary to dissociate the blockage.

When dissociating a hydrate blockage, operators should assume that multiple plugs may exist both from safety and technical standpoints. The following two important safety issues should be kept in mind:

- Single sided depressurization can potentially launch a plug like a high-speed projectile and result in ruptured flowlines, damaged equipment, release of hydrocarbons to the environment, and/or risk to personnel.
- Actively heating a hydrate blockage needs to be done such that any gas released from the hydrate is not trapped.

Table 20.3 Summary of applications, benefits & limitations of chemical Inhibitors (Pickering et al.).

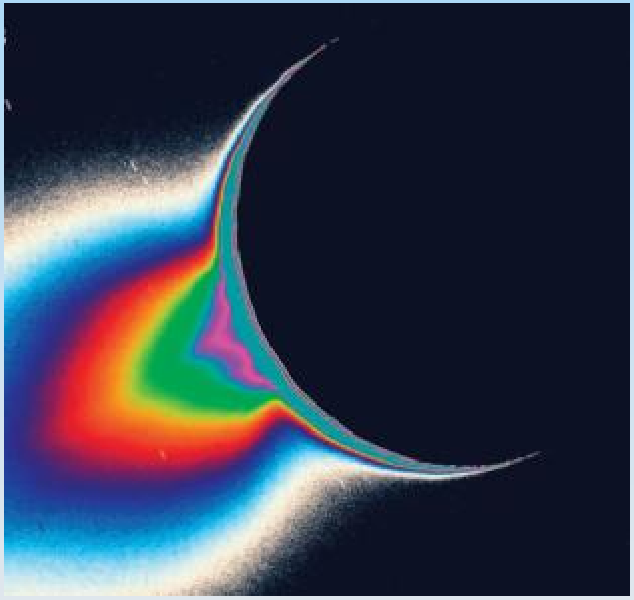
Thermodynamic Hydrate Inhibitors	Kinetic Hydrate Inhibitors	Anti-Agglomerant Inhibitors
	Applications	
1. Multiphase 2. Gas & Condensate 3. Crude Oil	1. Multiphase 2. Gas & Condensate 3. Crude Oil?	1. Multiphase 2. Condensate 3. Crude Oil
	Benefits	
1. Robust & effective 2. Well understood 3. Predictable 4. Proven track-record	1. Lower OPEX/CAPEX 2. Low volumes (< 1wt%) 3. Environmentally friendly 4. Non-toxic 5. Tested in gas systems	1. Lower OPEX/CAPEX 2. Low volumes (< 1wt%) 3. Environmentally friendly 4. Non-toxic 5. Wide range of subcooling
	Limitations	
1. Higher OPEX/CAPEX 2. High volumes (10-60 wt%) 3. Toxic / hazardous 4. Environmentally harmful 5. Volatile – losses to vapour 6. 'Salting out'	1. Limited subcoolings (<10°C) 2. Time dependency 3. Shutdowns 4. System specific – testing 5. Compatibility 6. Precipitation at higher temps 7. Limited exp. in oil systems 8. No predictive models	1. Time dependency? 2. Shutdowns? 3. Restricted to lower watercuts 4. System specific – testing 5. Compatibility 6. Limited experience 7. No predictive models


Arctic Sea
Arctic Sea
Pacific Ocean
Pacific Ocean
Atlantic Ocean
Indian Ocean

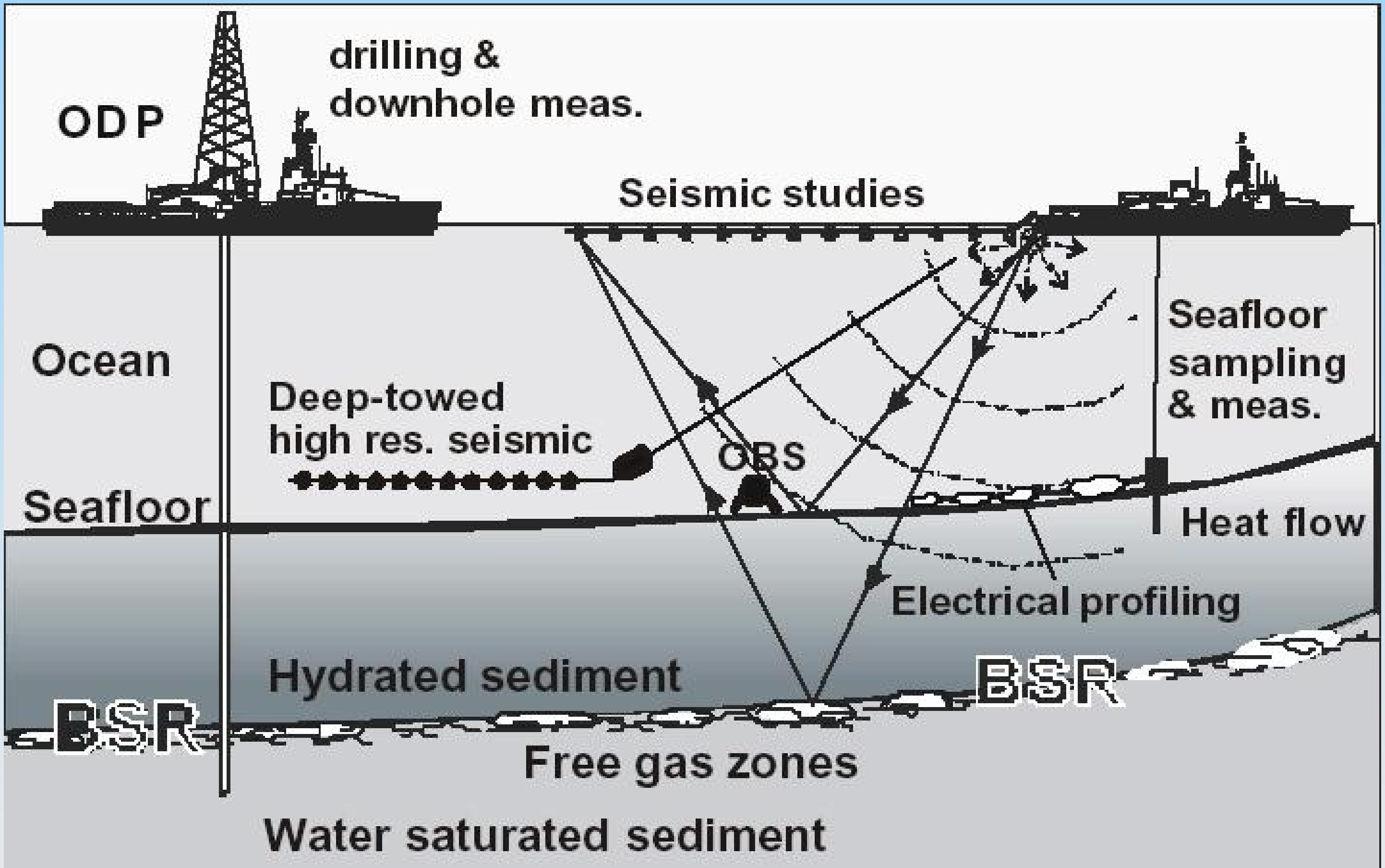
E.D. Sloan, C.A. Koh 2008

Hydrate in the Solar system

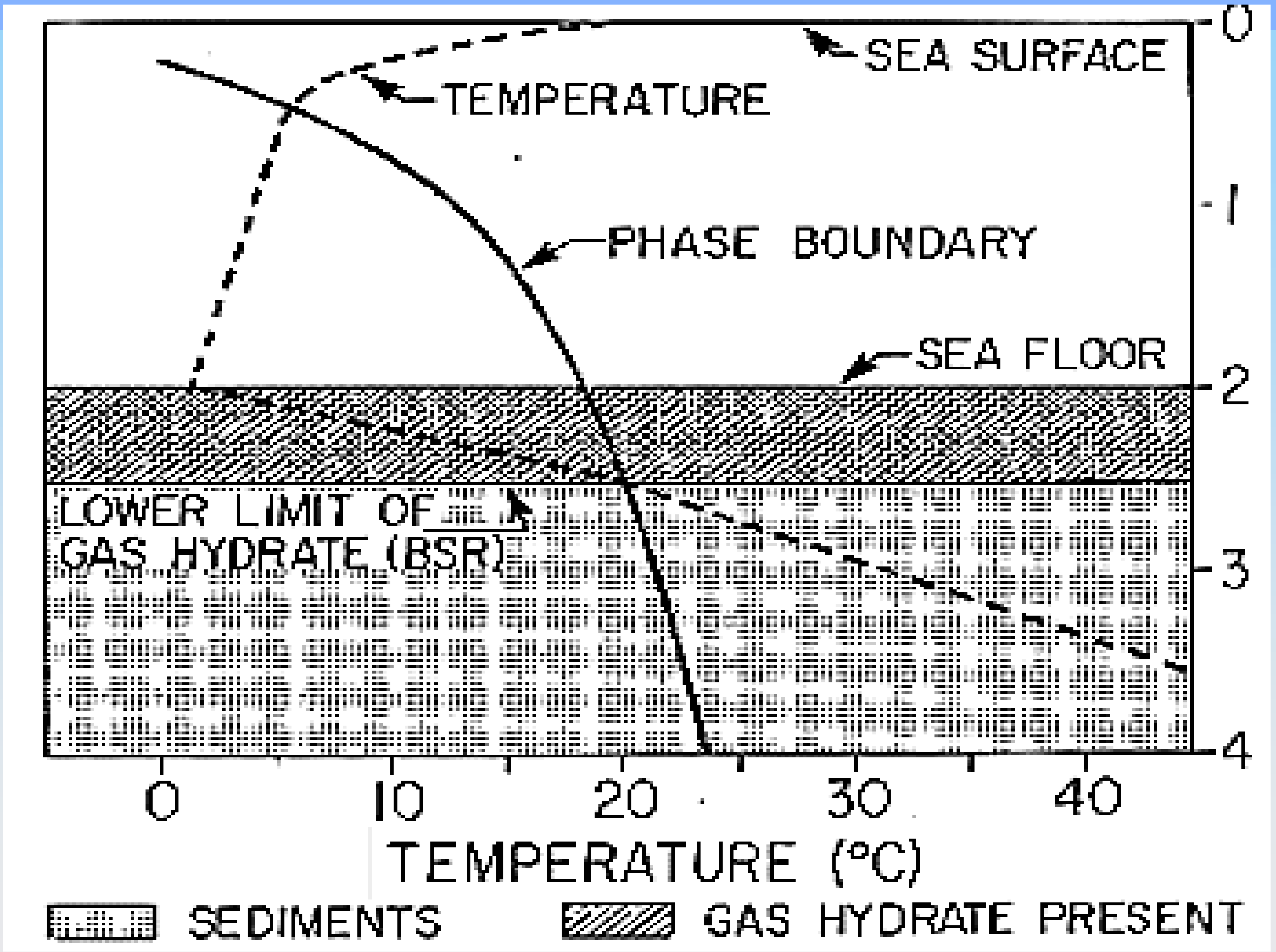
- Ubiquitous presence in the Universe?
  - CO_2 and CH_4 clathrates on Mars
  - CH_4 clathrates on Titan
  - Source of plumes on Saturn's moon Enceladus
  - Clathrates in Halley's comet

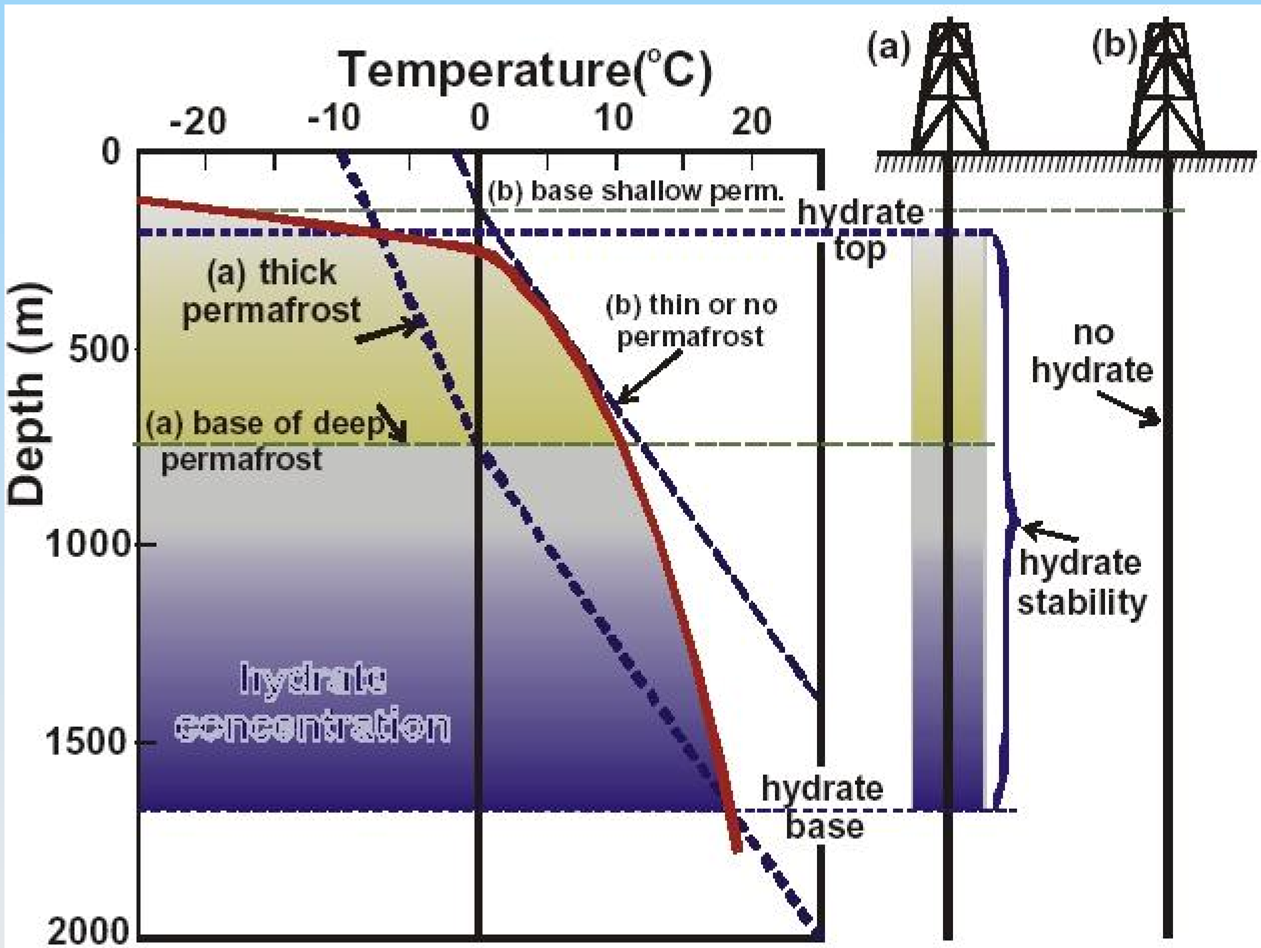


W. L. Mao Stanford University

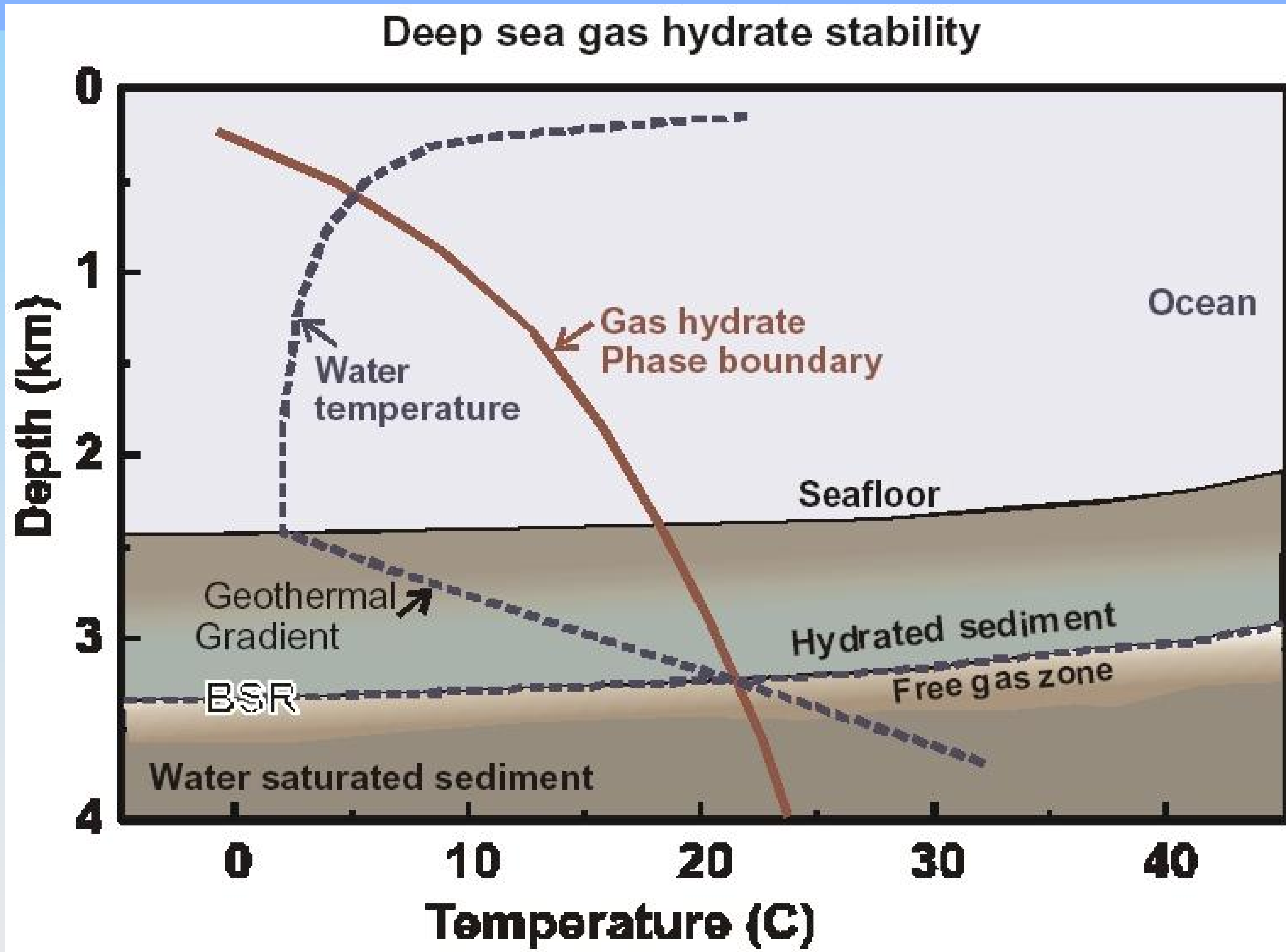


ODP
drilling &
downhole meas.
Seismic studies
Ocean
Deep-towed
high res. seismic
OBS
Seafloor
sampling
& meas.
Seafloor
Heat flow
Electrical profiling
Hydrated sediment
BSR
BSR
Free gas zones
Water saturated sediment


SEA SURFACE
TEMPERATURE
PHASE BOUNDARY
SEA FLOOR
LOWER LIMIT OF
GAS HYDRATE (BSR)
0
1
2
3
4
0
10
20
30
40
TEMPERATURE (°C)
SEDIMENTS
GAS HYDRATE PRESENT



Temperature(°C)
-20
-10
0
10
20
0
500
1000
1500
2000
Depth (m)
(b) base shallow perm.
hydrate
top
(a) thick
permafrost
(b) thin or no
permafrost
(a) base of deep
permafrost
hydrate
concentration
hydrate
base
(a)
(b)
no
hydrate
hydrate
stability


Deep sea gas hydrate stability
Depth (km)
0
1
2
3
4
Ocean
Gas hydrate
Phase boundary
Water
temperature
Seafloor
Geothermal
Gradient
Hydrated sediment
Free gas zone
BSR
Water saturated sediment
0
10
20
30
40
Temperature (C)

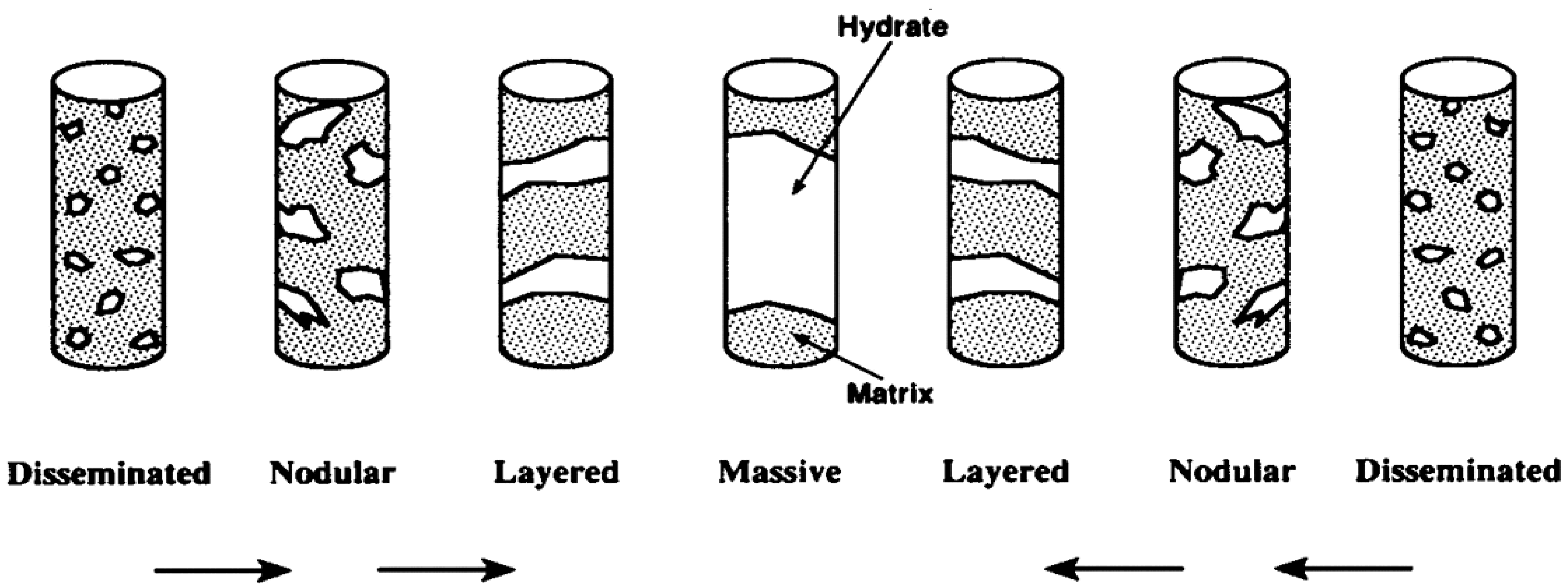


Figure 3. Proposed progression of hydrate formation. [Modified from Brooks *et al*. (1986).]

Production test of Mallik 2002 as hydrate production research well program

How can we recover natural gas hydrate?

We do not yet know how to recover gas from natural hydrate. We are not aware of a really practical proposal for how to recover methane from natural hydrate. We do know that there are formidable technical difficulties: (a) Although the total gas amounts are huge, most natural hydrate represents a quite low energy density; (b) substantial latent heat must be provided for dissociation; (c) the sediments are often fine grained, unconsolidated, and low permeability silts.

There are four main possibilities:

1. add heat and raise the temperature to out of the stability field
2. depressurize the section by pumping, especially within the free gas below the BSR. The hydrate may then dissociate downward into the low pressure gas layer. However, the dissociation latent heat still must be provided
3. add antifreeze such as methanol; it may be possible to recover the methanol with the gas for re-use
4. replace the methane in the hydrate with CO_2. An intriguing possibility is to inject the unwanted greenhouse gas CO_2 into natural methane hydrate deposits where it forms CO_2 hydrate in exchange for methane gas which, in turn, is recovered. CO_2 hydrate appears to be more energetically favourable than methane hydrate so such a replacement should occur. This an attractive way to get rid of troublesome CO_2 and recover valuable methane.

Although there are no clear answers today, it is worth remembering that many years were required to develop the technology for economic recovery of many other resources; tar sands are an example. Sometimes the answers come very quickly, sometimes only after many years. Gas hydrate is a very large potential resource, it just needs some very bright people with new ideas to find the solutions.

Liquid Hydrocarbons

The K-factor method is designed for calculations involving a gas and a hydrate. In order to extend this method to liquid hydrocarbons, the vapor-liquid K-factor should be incorporated. For the purposes of this book, these K-factors will be denoted K_V to distinguish them from the K-factor defined earlier. Therefore

$$K_{vi} = \frac{y_i}{x_i} \tag{3-8}$$

where x_i is the mole fraction of component i in the nonaqueous liquid.

1. Input the temperature, T.
2. Input the vapor composition, y_i.
3. Assume a value for the pressure, P.
4. Set the K-factors for all nonformers to infinity.
5. Given P and T, obtain K-factors from the Katz charts (or from correlations) for the hydrate-forming components in the mixture.
6. Calculate the summation:

   $$\sum y_i/K_i$$

   Note for nonformers the expression y_i/K_i is zero.
7. Does the summation equal unity?

   That is, does $\sum y_i/K_i = 1$?

   7a. Yes - Go to Step 10.
   7b. No - Go to Step 8.
8. Update the pressure estimate.

   8a. If the sum is greater than 1, reduce the pressure.
   8b. If the sum is less than 1, increase the pressure.
   8c. Use caution if the sum is significantly different from 1.
9. Go to Step 4.
10. Convergence! Current P is the hydrate pressure.
11. Stop.

Figure 3-3. Pseudocode for performing a hydrate pressure estimation using the Katz K-factor method

Computer methods

From a thermodynamic point of view, the hydrate formation process can be modeled as taking place in two steps. The first step is from pure water to an empty hydrate cage. This first step is hypothetical, but it is useful for calculation purposes. The second step is filling the hydrate lattice. The process is as follows:

pure water (α) $\rightarrow$ empty hydrate lattice (β) $\rightarrow$ filled hydrate lattice (H)

The change in chemical potential for this process is given as:

$$\mu^H - \mu^\alpha = (\mu^H - \mu^\beta) + (\mu^\beta - \mu^\alpha) \tag{4-1}$$

where μ is the chemical potential and the superscripts refer to the various phases. The first term after the equals sign represents the stabilization of the hydrate lattice. The variation in the models used to estimate this term separates the various models. The second term represents a phase change for the water and can be calculated by regular thermodynamic means. This term is evaluated as follows:

$$\frac{\mu^\beta - \mu^\alpha}{RT} = \frac{\Delta\mu(T,P)}{RT} = \frac{\Delta\mu(T_O,P_O)}{RT_O} - \int_{T_O}^{T} \frac{\Delta H}{RT^2} dT + \int_{P_O}^{P} \frac{\Delta v}{R\bar{T}} dP \tag{4-2}$$

where R is the universal gas constant, T is the absolute temperature, P is the pressure, H is the enthalpy, v is the molar volume, the subscript O represents a reference state, and the Δ terms represent the change from a pure water phase (either liquid or ice) to a hydrate phase (either Type I or II). The bar over the temperature in the last term indicates that this is an average

The first model for calculating hydrate formation was that of van der Waals and Platteeuw (1959). They postulated a statistical model for hydrate formation. The concentration of the nonwater species in the hydrate was treated in a manner similar to the adsorption of a gas onto a solid. For a single guest molecule, this term is evaluated as follows:

$$\mu^{H} - \mu^{\beta} = RT\sum_{i} \nu_i \ln(1 - Y_i) \qquad (4\text{-}3)$$

where ν_i is the number of cavities of type i and Y is a probability function. The Y is the probability that a cavity of type i is occupied by a guest molecule and is given by:

$$Y_i = \frac{c_i P}{1 + c_i P} \qquad (4\text{-}4)$$

The c_i in this equation is a function of the guest molecule and the cage occupied, and P is the pressure. Although it is not obvious from this discussion, the c_i's are also functions of the temperature.

Parrish and Prausnitz

The approach of the original van der Waals and Platteeuw (1959) method provided a good basis for performing hydrate calculations, but it was not suf-

ficiently accurate for engineering calculations. One of the first models with the rigor required for engineering calculations was that of Parrish and Prausnitz (1972). There are two major differences between the original van der Waals and Platteeuw (1959) model and that proposed by Parrish and Prausnitz (1972). First, they extended the model to multicomponent mixtures of hydrate formers. This is done as follows:

$$\mu^{H} - \mu^{\beta} = RT\sum_{i} \nu_i \ln\left(1 - \sum_{K} Y_{Ki}\right) \qquad (4\text{-}5)$$

where the second sum is over all components. The probability function for a component becomes:

$$Y_{Ki} = \frac{c_i P_K}{1 + \sum_{j} c_{ij} P_j} \qquad (4\text{-}6)$$

Second, Parrish and Prausnitz (1972) replaced the partial pressure in Equation 4-6 with the fugacity. There is no simple definition for the thermodynamic concept of fugacity. Usual definitions given in thermodynamics textbooks rely on the chemical potential, which is an equally abstract quantity. For our purposes, we can consider the fugacity as a "corrected" pressure, which accounts for nonidealities. Substituting the fugacity into Equation 4-6 results in:

$$Y_{Ki} = \frac{c_i \hat{f}_K}{1 + \sum_j c_{ij} \hat{f}_j} \tag{4-7}$$

where $\hat{f}_i$ is the fugacity of component i in the gaseous mixture. This allowed their model to account for nonidealities in the gas phase and thus to extend the model to higher pressures. In addition, some of the parameters in the

Ng and Robinson

The next major advance was the model of Ng and Robinson (1977). Their model could be used to calculate the hydrate formation in equilibria with a hydrocarbon liquid. First this required an evaluation of the change in enthalpy and change in volume in Equation 4-2, or at least an equivalent version of this equation.

In the model of Ng and Robinson (1977), the fugacities were calculated using the equation of state of Peng and Robinson (1976). This equation of state is applicable to both gases and the nonaqueous liquid. Again, small adjustments were made to the parameters in the model to reflect the switch to the Peng-Robinson equation. Similarly, the Soave (1972) or any other equation of state applicable to both the gas and liquid could be used; however, the Soave and Peng-Robinson equations (or modifications of them) have become the workhorses of this industry.

It is important to note that later versions of the Parrish and Prausnitz method were also designed to be applicable to systems containing liquid formers.

Calculations

Now that one has these equations, how does the calculation proceed? For now we only consider the conditions for incipient solid formation. For example, given the temperature, at what pressure will a hydrate form for a given mixture?

First you perform the calculations assuming the type of hydrate formed. Use the equations outlined previously to calculate the free energy change for this process. This is an iterative procedure that continues until the following is satisfied:

$$\mu^H - \mu^\alpha = 0$$

Commercial Software Packages

Several software packages that are dedicated to hydrate calculations are available. Two of these are *EQUI-PHASE Hydrate* from D.B. Robinson and

Associates in Edmonton, Alberta, and a program by INFOCHEM in London, England. Also, the package *CSMHYD* is available with the book by Professor E.D. Sloan (Sloan, 1998) or by contacting him directly at the Colorado School of Mines in Golden, Colorado.

Most of the popular, general-purpose process simulation programs include the capability to predict hydrate formation. This often includes warnings about streams where hydrate formation is possible. These include *Hysys* from Hyprotech (Calgary, Alberta), *Prosim* from Bryan Research & Engineering (Bryan, Texas), and *Aspen* from Aspen Technology (Cambridge, Massachusetts).

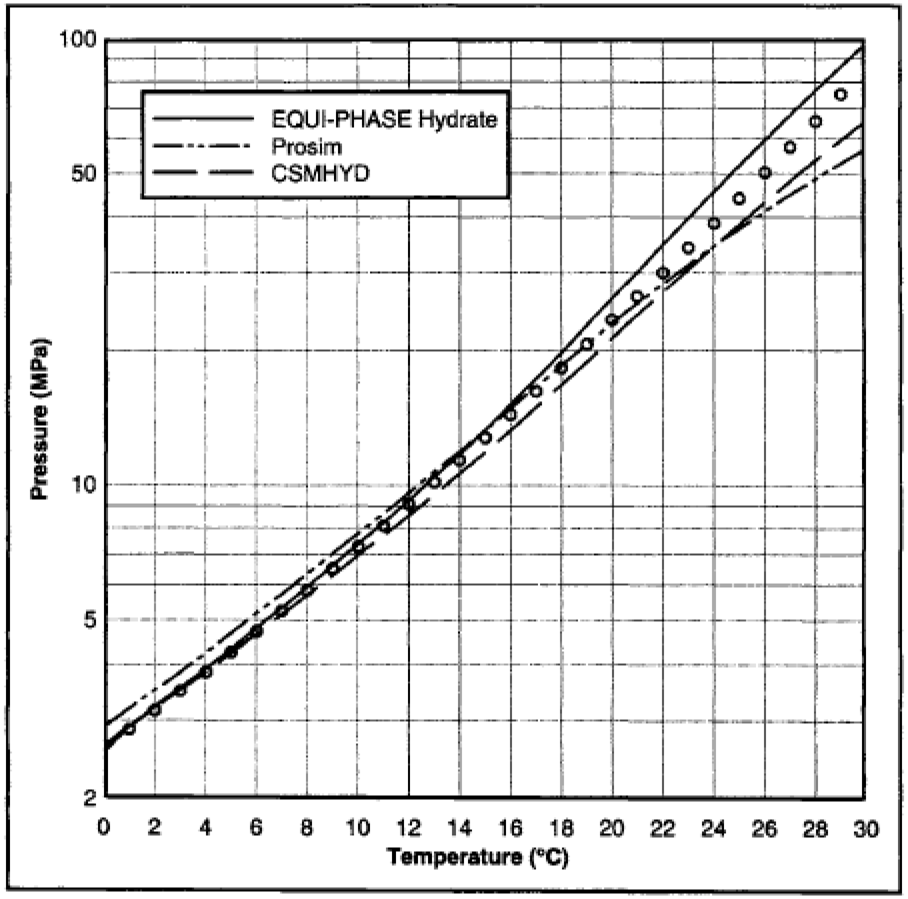


Figure 4-2. Hydrate locus for methane (points from correlation)

At pressure greater than 10 MPa, none of the three software packages is highly accurate. *EQUI-PHASE Hydrate* predicts a hydrate temperature that is consistently less than the correlation. At extreme pressures, the error is as much as 1°C. On the other hand, both *Prosim* and *CSMHYD* predict that the hydrate forms at higher temperatures than the correlation. At very high pressure, the errors from *Prosim* become quite large. For example, at 50 MPa (7,250 psia), the difference is larger than 2°C. With *CSMHYD*, for pressure up to 50 MPa, the errors are less than 2°C; however, as the pressure continues to increase, so does the observed error.

Ethane

Figure 4-3 shows the hydrate locus for pure ethane. This figure demonstrates that this locus is different from that of methane. First, ethane tends to form a hydrate at a lower pressure than methane. More significantly,

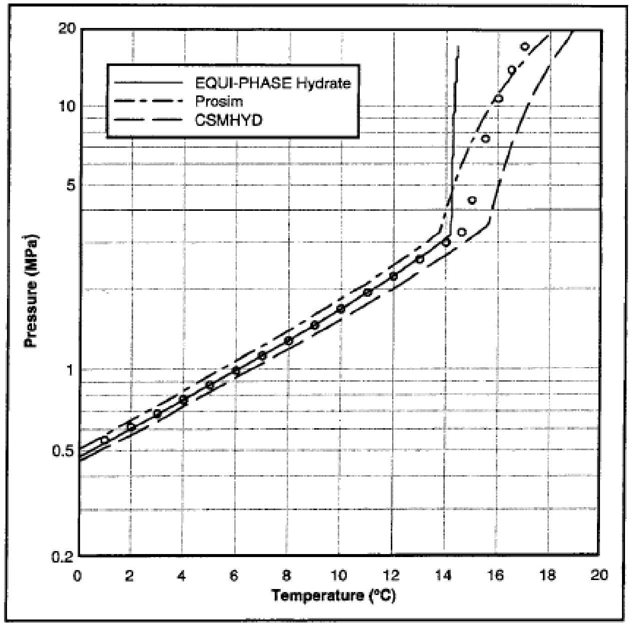


Figure 4-3. Hydrate loci of ethane (points from correlation)

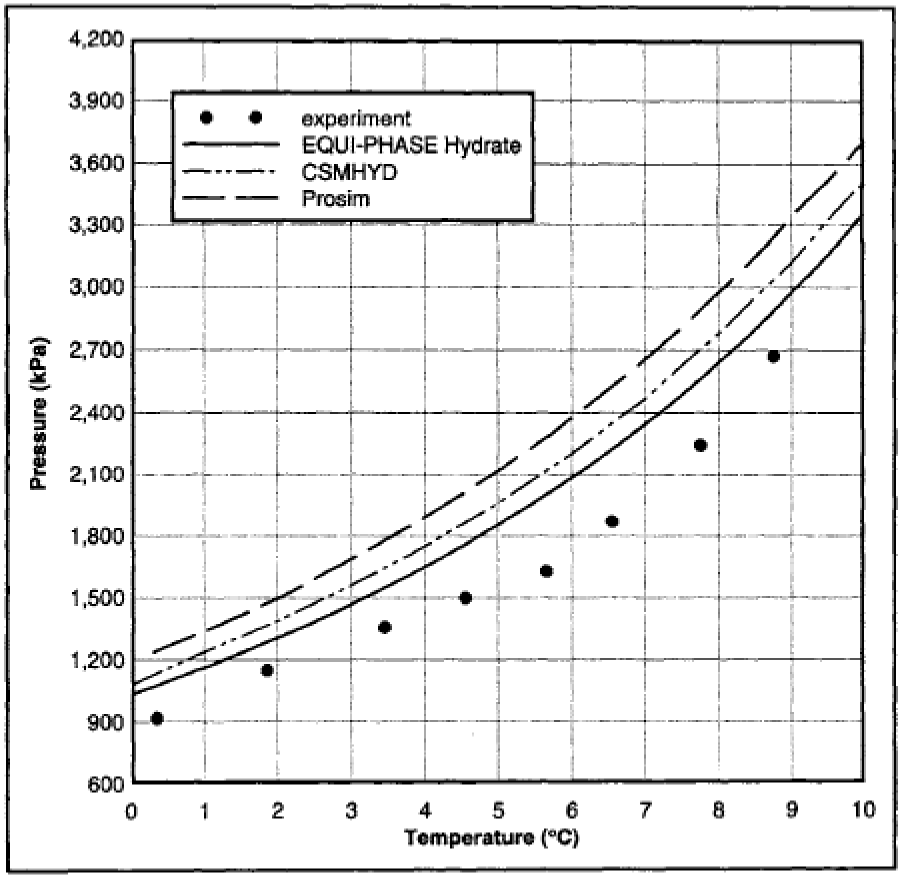


Figure 4-6. Hydrate locus for a synthetic natural gas mixture (CH_4 97.25 mol%, C_2H_6 1.42%, C_3H_8 1.08%, I-C_4H_{10} 0.25%)

Physical properties

Table 8-1
Molar Masses of Some Hydrates at 0°C

	Hydrate Type	Saturation		Molar Mass (g/mol)
		Small	Large	
Methane	I	0.8723	0.9730	17.74
Ethane	I	0.0000	0.9864	19.39
Propane	II	0.0000	0.9987	19.46
Isobutane	II	0.0000	0.9987	20.24
CO_2	I	0.7295	0.9813	21.59
H_2S	I	0.9075	0.9707	20.87

Note: Calculated using Equation 8-1.
The saturation values were calculated using *CSMHYD*.

$$M = \frac{N_W M_W + \sum_{j=1}^{c} \sum_{i=1}^{n} Y_{ij} \nu_i M_j}{N_W + \sum_{j=1}^{c} \sum_{i=1}^{n} Y_{ij} \nu_i} \qquad (8\text{-}1)$$

where N_W is the number of water molecules per unit cell (46 for Type I and 136 for Type II), M_W is the molar mass of water, Y_{ij} is the fractional occupancy of cavities of type i by component j, ν_i is the number of type i cavities, n is the number of cavity types (2 for both Type I and II, but 3 for Type H), and c is the number of components in the cell.

Density

The density of a hydrate, ρ, can be calculated using the following formula:

$$\rho = \frac{N_W M_W + \sum_{j=1}^{c} \sum_{i=1}^{n} Y_{ij} \nu_i M_j}{N_A V_{cell}} \tag{8-2}$$

where N_W is the number of water molecules per unit cell (46 for Type I and 136 for Type II), N_A is Avogadro's number (6.023×10^{23} molecules/mole), M_W is the molar mass of water, Y_{ij} is the fractional occupancy of cavities of type i by component j, ν_i is the number of type i cavities, V_{cell} is the volume of the unit cell (see Table 2-1), n is the number of cavity types (2 for both Types I and II, but 3 for Type H), and c is the number of components in the cell.

Equation 8-2 can be reduced for a single component in either a Type I or Type II hydrate to:

$$\rho = \frac{N_W M_W + (Y_1 \nu_1 + Y_2 \nu_2) M_j}{N_A V_{cell}} \tag{8-3}$$

Table 8-2
Densities of Some Hydrates at 0°C

	Hydrate Type	Density (g/cm^3)	Density (lb/ft^3)
Methane	I	0.913	57.0
Ethane	I	0.967	60.3
Propane	II	0.899	56.1
Isobutane	II	0.934	58.3
CO_2	I	1.107	69.1
H_2S	I	1.046	65.3
Ice	—	0.917	57.2
Water	—	1.000	62.4

Note: Calculated using Equation 8-3. The saturation values were calculated using *CSMHYD*. Properties of ice and water from Keenan et al. (1978).

Table 8-3
Enthalpies of Fusion for Some Gas Hydrates

	Hydrate Type	Enthalpy of Fusion (kJ/g)	Enthalpy of Fusion (kJ/mol)	Enthalpy of Fusion (MBtu/lb)
Methane	I	3.06	54.2	23.3
Ethane	I	3.70	71.8	30.9
Propane	II	6.64	129.2	55.5
Isobutane	II	6.58	133.2	57.3
Ice	—	0.333	6.01	143

Note: Original values from Sloan (1998). Molar enthalpies of fusion converted to specific values (i.e., per unit mass) using the molar masses from Table 8-1.

Properties of ice and water from Keenan et al. (1978).

to a gas). For water, this is 2.83 kJ/g or 51.0 kJ/mol. This process is probably more comparable to the formation of a hydrate than the simple melting of ice.

One method for estimating the effect of temperature on the heat of fusion is the so-called Clapeyron approach. A Clapeyron-type equation is applied to the three-phase locus. The Clapeyron-type equation used in this application is:

$$\frac{d\,ln\,P}{d1/T} = \frac{\Delta H}{zR} \qquad (8\text{-}4)$$

Heat Capacity

Limited experimental data are available for the heat capacity of hydrates. Table 8-4 lists some values. For comparison, ice is also included in this table. Over the narrow range of temperatures that hydrates can exist, it is probably safe to assume that these values are constants.

Thermal Conductivity

There have been limited studies into the thermal conductivity of hydrates; however, they show that hydrates are much less conductive than ice. The thermal conductivity of ice is 2.2 W/m·K, whereas the thermal conductivities of hydrates of hydrocarbons are in the range 0.50 ± 0.01 W/m·K.

Mechanical Properties

In general, the mechanical properties of hydrates are comparable to those of ice. In the absence of additional information, it is safe to assume that the mechanical properties of the hydrate equal those of ice. One should not

Table 8-4
Heat Capacities for Some Gas Hydrates

	Hydrate Type	Heat Capacity (J/g·°C)	Heat Capacity (J/mol·°C)	Heat Capacity (Btu/lb·°F)
Methane	I	2.25	40	0.54
Ethane	I	2.2	43	0.53
Propane	II	2.2	43	0.53
Isobutane	II	2.2	45	0.53
Ice	—	2.06	37.1	0.492

Note: Original values from Makogon (1997).
Properties of ice and water from Keenan et al. (1978).

Volume of Gas in Hydrate

The purpose of this section is to demonstrate the volume of gas encaged in a hydrate. Therefore, we examine only the methane hydrate.

The following are the properties of the methane hydrate at 0°C: the density is 913 kg/m^3, the molar mass (molecular weight) is 17.74 kg/kmol, and methane concentration is 14.1 mole percent; this means there are 141 molecules of methane per 859 molecules of water in the methane hydrate. The density and the molar mass are from earlier in this chapter and the concentration is from Chapter 2.

This information can be used to determine the volume of gas in the methane hydrate. From the density, 1 m^3 of hydrate has a mass of 913 kg. Converting this to moles 913/17.74 = 51.45 kmol of hydrate, of which 7.257 kmol are methane.

The ideal gas law can be used to calculate the volume of gas when expanded to standard conditions (15°C and 1 atm or 101.325 kPa).

$$V = nRT/P = (7.257)(8.314)(15+273)/101.325 = 171.5\,\text{Sm}^3$$

Therefore 1 m^3 of hydrate contains about 170 Sm^3 of methane gas. Or in American Engineering Units, this converts to 1 ft^3 of hydrate contains 170 SCF of gas—not a difficult conversion. And 1 ft^3 of hydrate weighs about 14.6 lb, so 1 lb of hydrate contains 11.6 SCF of methane.

By comparison, 1 m^3 of liquid methane (at its boiling point 111.7 K or −161.5°C) contains 26.33 kmol, which converts to 622 m^3 of gas at standard conditions. Alternately, 1 m^3 compressed methane at 7 MPa and 300 K (27°C) (1,015 psia and 80°F) contains 3.15 kmol or 74.4 Sm^3 of methane gas. The properties of pure methane are from Wagner and de Reuck (1996).

To look at this another way, to store 25,000 Sm^3 (0.88 MMSCF) of methane requires about 150 m^3 (5,300 ft^3) of hydrates. This compares with 40 m^3 (1,400 ft^3) of liquefied methane or 335 m^3 (11,900 ft^3) of compressed methane.

Session 15:
Pigging and Slug Catchers

Different flow pattern in a vertical flow

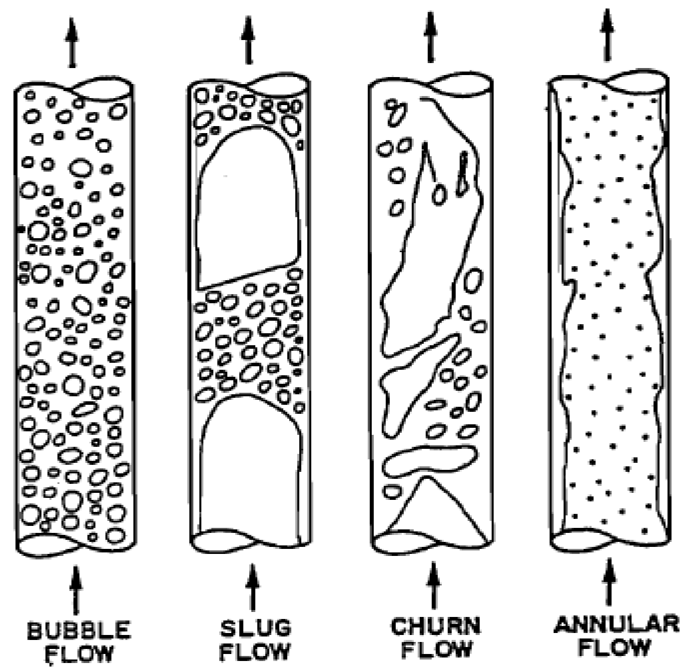
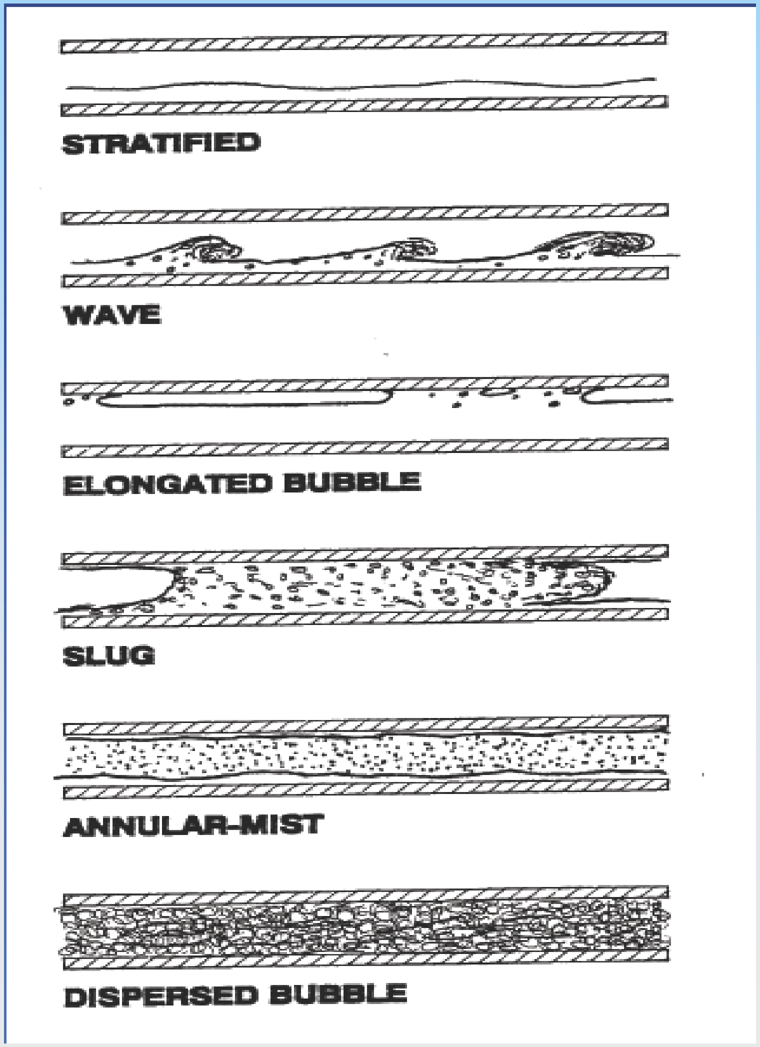
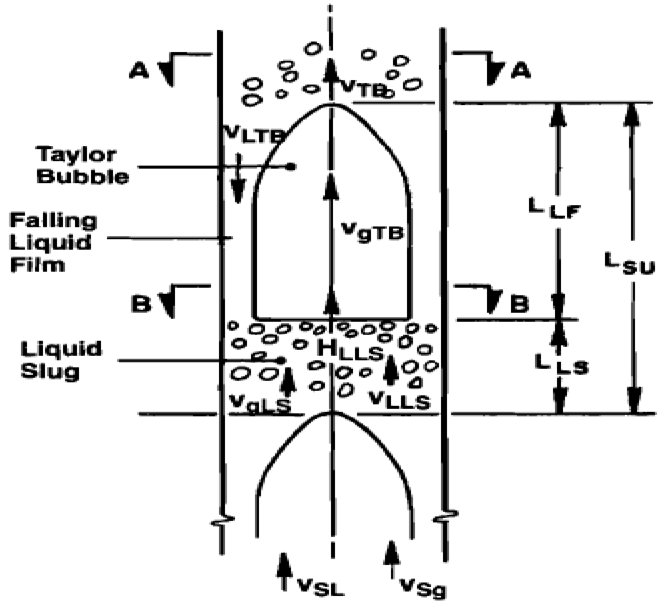


Fig. 4.21—Flow patterns in upward two-phase flow.[30] (Reproduced with permission of the American Inst. of Chemical Engineers.)

Different flow pattern in a horizontal flow



Hydrodynamic parameters in a slug flow



v_{SL} = superficial liquid velocity
v_{Sg} = superficial gas velocity
v_{LLS} = in-situ liquid velocity in liquid slug
v_{gLS} = in-situ gas velocity in liquid slug
v_{LTB} = in-situ liquid velocity in liquid film
v_{gTB} = in-situ gas velocity in Taylor bubble
v_{TB} = Taylor-bubble transitional velocity
H_{LLS} = liquid holdup in liquid slug
L_{LS} = length of liquid slug
L_{LF} = length of liquid film
L_{SU} = length of slug unit

Fig. 4.25—Fully developed slug flow.[67]

Total pressure gradient as a function of slug parameters.

$$\left(\frac{dp}{dL}\right)_{el} = \rho_{LS} g \left(\frac{L_{LS}}{L_{SU}}\right), \quad \text{(4.298)}$$

where the slip density for the gas/liquid mixture in the liquid slug is

$$\rho_{LS} = \rho_L H_{LLS} + \rho_g (1 - H_{LLS}). \quad \text{(4.299)}$$

The acceleration pressure-gradient component is related to the amount of energy required to accelerate the liquid film, which is initially flowing downward, to the existing upward in-situ liquid velocity in the liquid slug.

$$\left(\frac{dp}{dL}\right)_{acc} = \rho_L \frac{H_{LTB}}{L_{SU}} (v_{LTB} + v_{TB})(v_{LTB} + v_{LLS}). \quad \text{(4.300)}$$

For a fully developed Taylor bubble, H_{LTB} and v_{LTB} are the average liquid holdup and film velocity in the entire film zone, respectively.

The friction pressure gradient is obtained from

$$\left(\frac{dp}{dL}\right)_f = \frac{2f'}{d_h} \rho_{LS} (v_{Sg} + v_{SL})^2 \left(\frac{L_{LS}}{L_{SU}}\right), \quad \text{(4.301)}$$

where the Fanning friction factor, f', is determined by the method presented in Chap. 2. The corresponding Reynolds number for the slug body is determined by Eq. 4.280, where ρ_{TP} is replaced by ρ_{LS}, the slug-body slip density given by Eq. 4.299.

The total pressure gradient for the slug-flow pattern then can be expressed by combining Eqs. 4.298 through 4.301 to obtain

$$\left(\frac{dp}{dL}\right)_T = \left[\frac{2f'}{d_h} \rho_{LS} (v_{Sg} + v_{SL})^2 L_{LS} + \rho_{LS} g L_{LS} + \rho_L H_{LTB} (v_{LTB} + v_{TB})(v_{LTB} + v_{LLS})\right] \frac{1}{L_{SU}}. \quad \text{(4.302)}$$

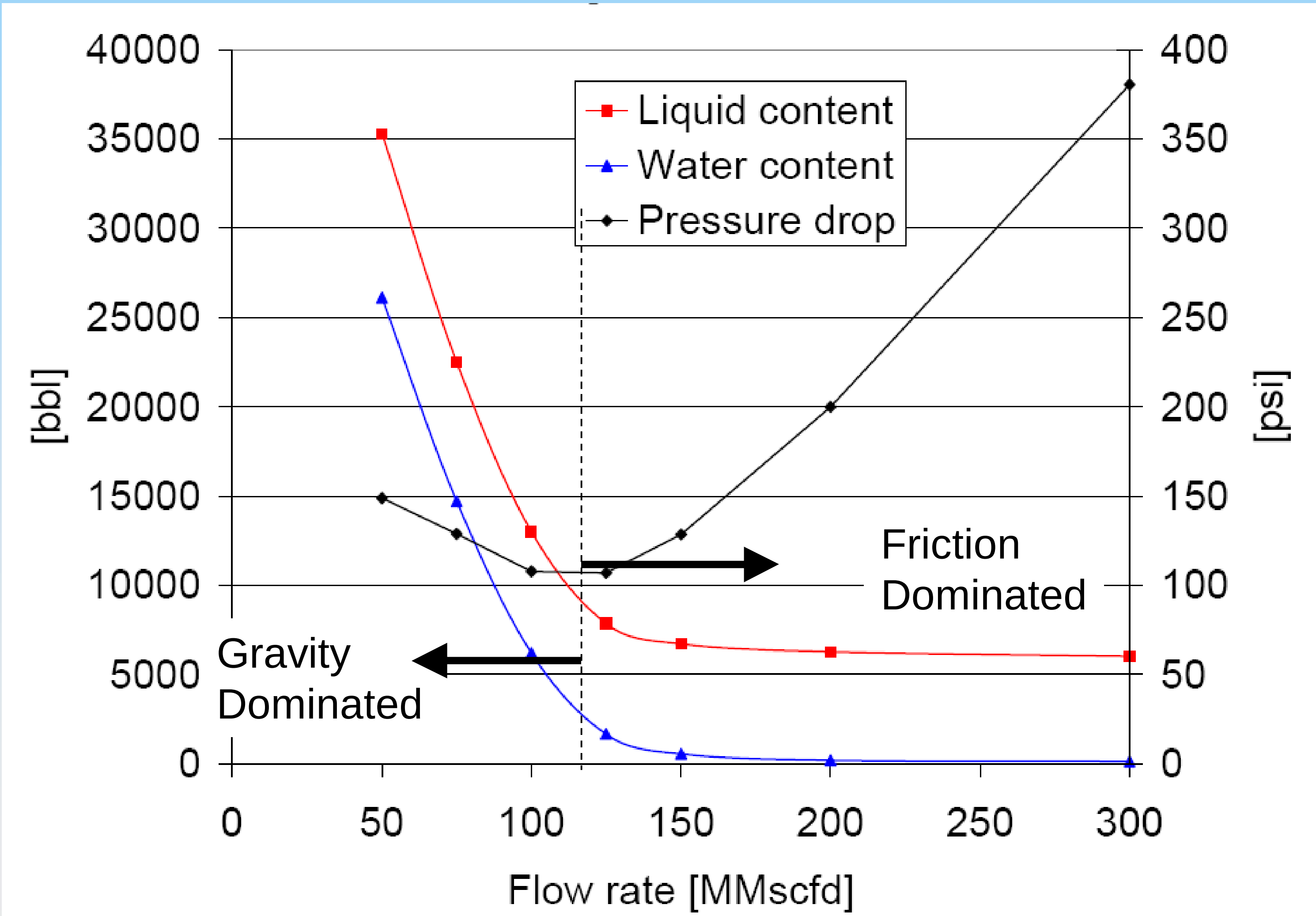
Various types of slugs

- Terrain slugs
- Hydrodynamic slugs
- Riser based slugs
- Pigging slugs

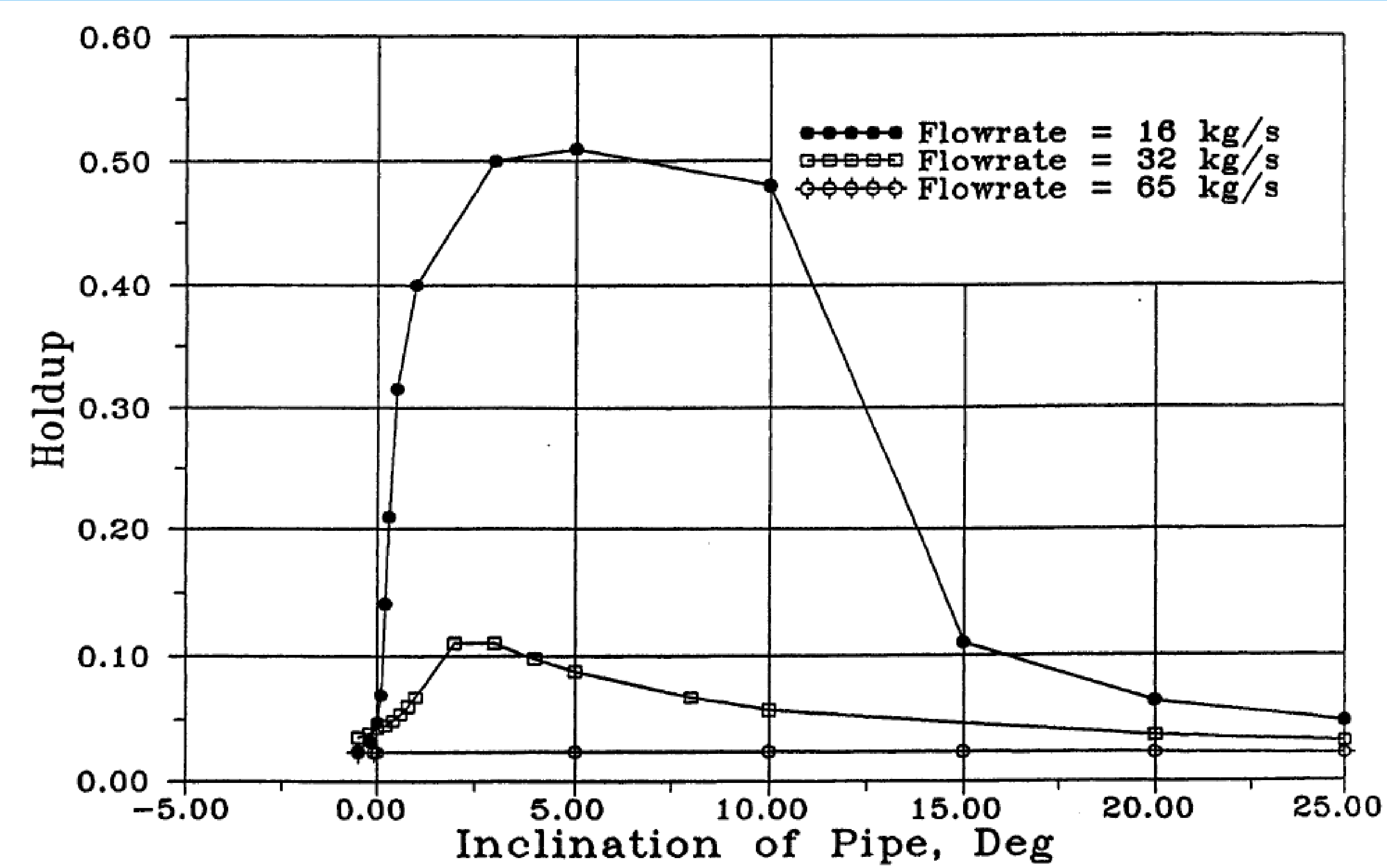
Why slug flow?

- Frequently observed
- Leads to higher pressure gradient
- Causes Mechanical damage
- Can decrease the production rate
- Leads to a chaotic and intermittent flow

At Low Flow Rates Liquid Accumulates in the Flowline Increasing the Pressure Drop



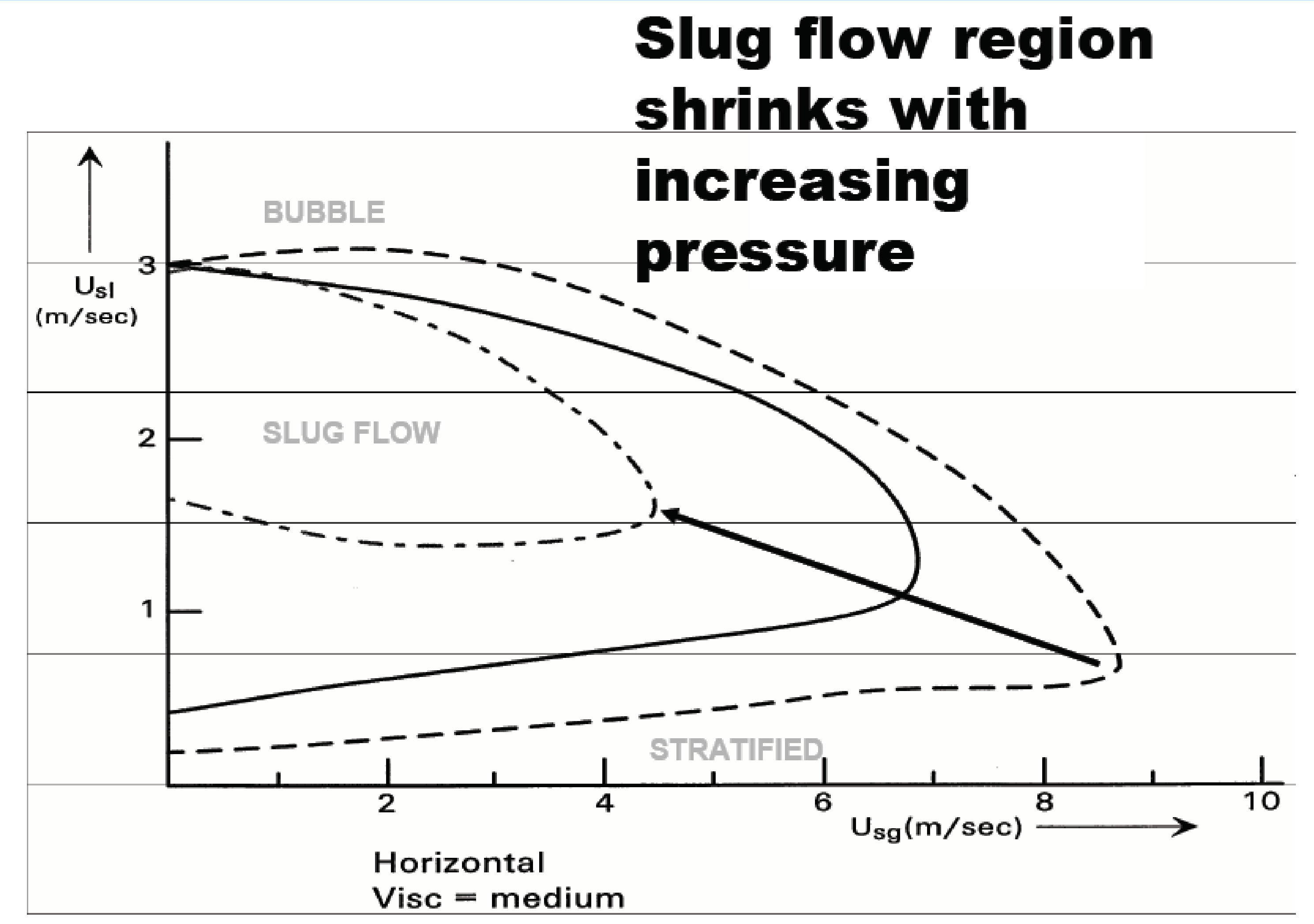
Liquid Holdup Depends on Flowline Geometry and Flowrate



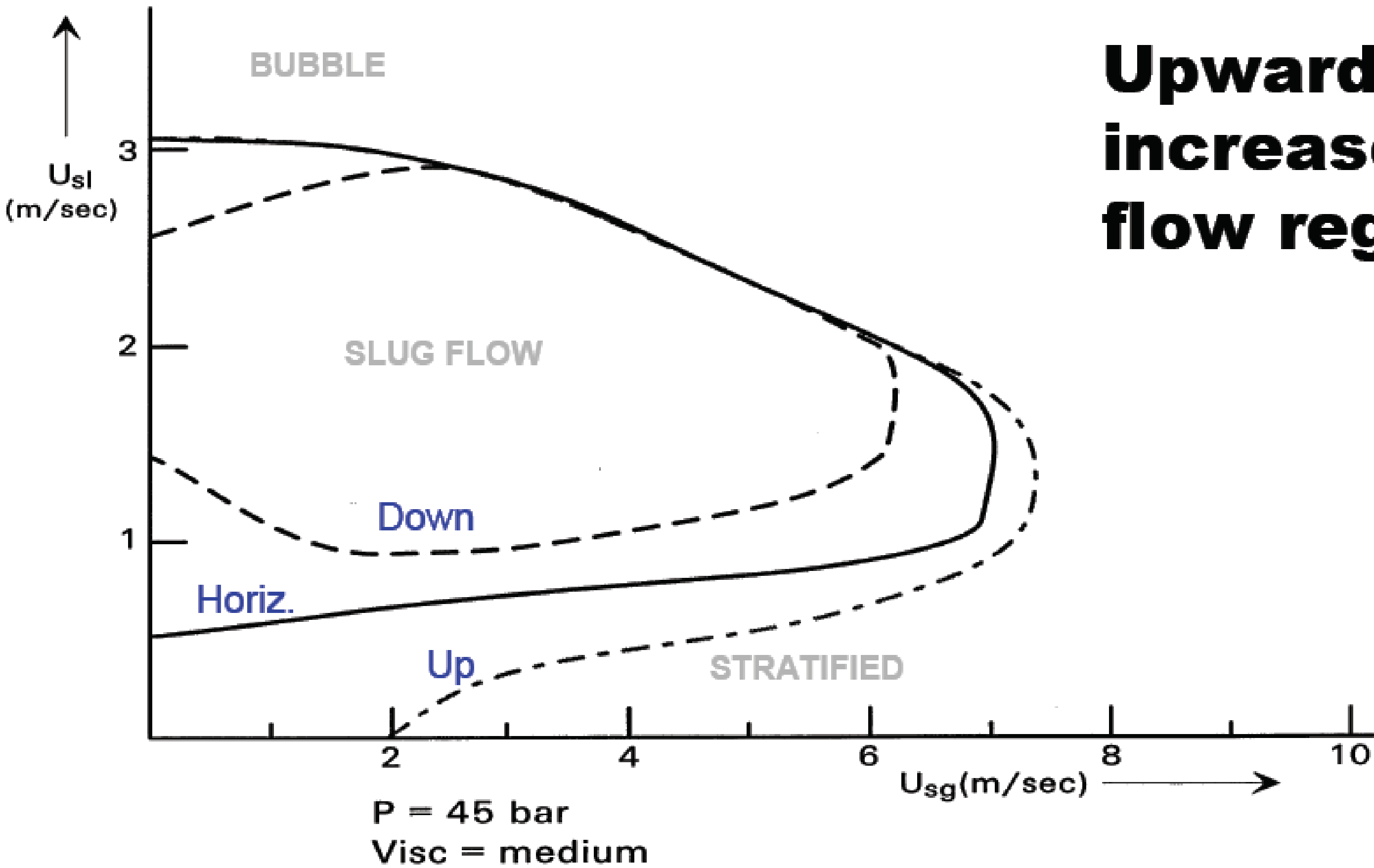
Liquid Holdup Can Lead to Liquid Slugging

- There are two types of slugging:
  - Hydrodynamic: Induced by the holdup and superficial velocities
  - Terrain: Induced by geometry changes in which liquid can accumulate
- In Real Flowlines, Hydrodynamic and Terrain Slugs Can Interact:
  - Difficult to predict slug length and frequency
- Slugging can lead to surges of liquid that can overwhelm slugcatchers
- Liquid holdup leads to increased pressure drops and reduced flow
- Pigs can be used to periodically remove liquid from the flowline

Hydrodynamic Slugging is Predicted by a Flow Map



Hydrodynamic Slugging Depends on the Inclination of the Flowline



Upward flow increases slug flow region

Hydrodynamic Slugging is Well Understood

- The frequency of hydrodynamic slugging can be estimated from the Shea correlation:

$$F_{sL} = \frac{0.68 \cdot U_{SL}}{D^{1.2} \cdot L^{0.6}}$$

F_{sL} = slug frequency (1/s) (= no of slugs/observation time period)

D = pipeline diameter (m)

L = pipeline length (m)

U_{sL} = superficial liquid velocity (m/s)

- Mild terrain effects can be accounted for with a fudge factor "Delay Constant"

Shea, R.H., Rasmussen, J., Hedne, P. and Malnes, D.: Holdup predictions for wet-gas pipelines compared. Oil & Gas Journal, May 19, 1997

Terrain Slugging is More Complex

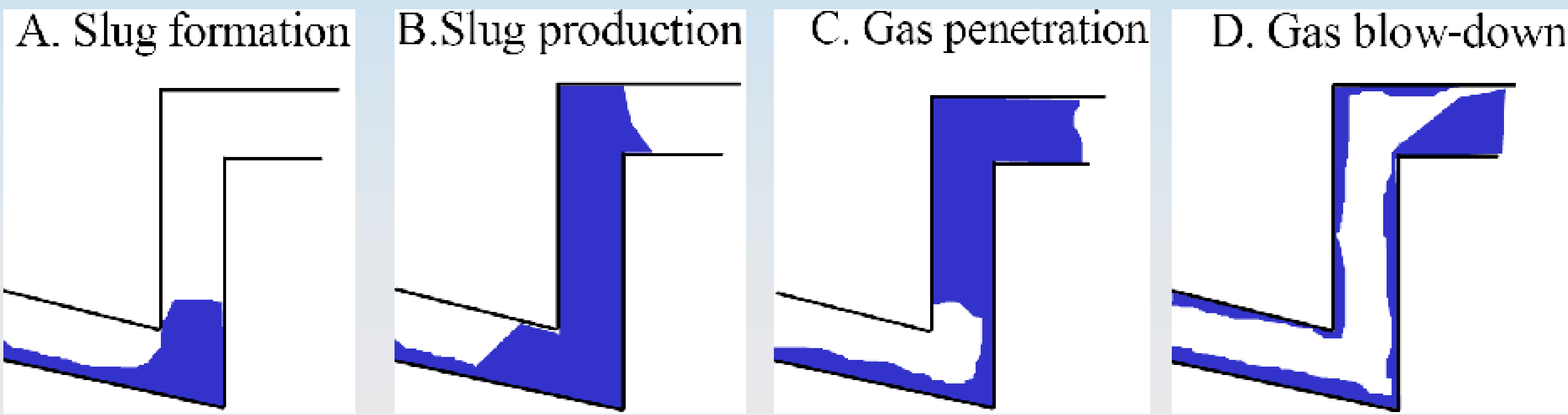
Terrain or "severe" slugging causes large surges in pressure and liquid

A: Liquid bridges a low spot in the flowline

B: Upstream pressure builds up

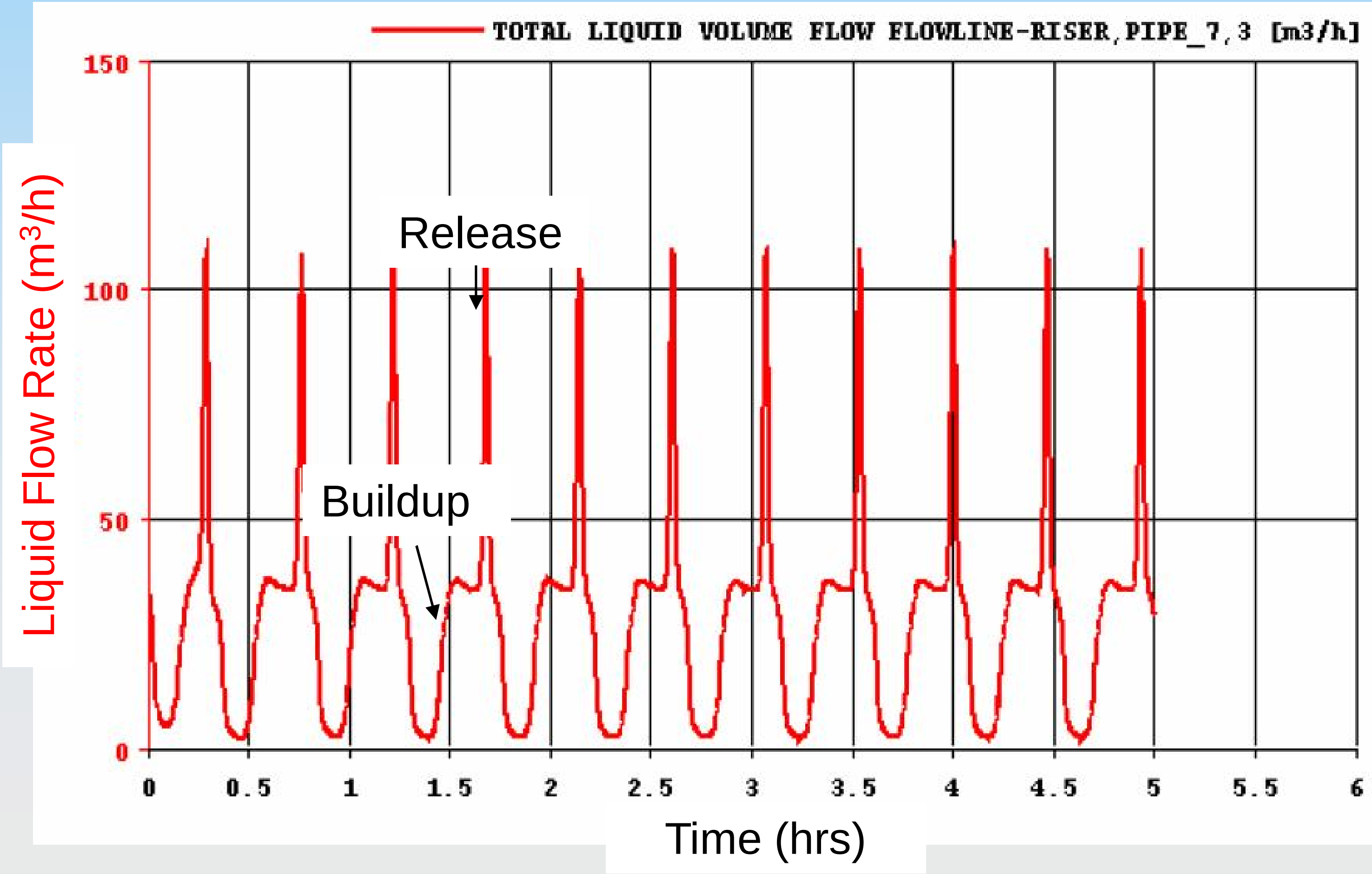
C: Pressure pushes liquid accumulation out of the low spot

D: The pressure accumulation is released

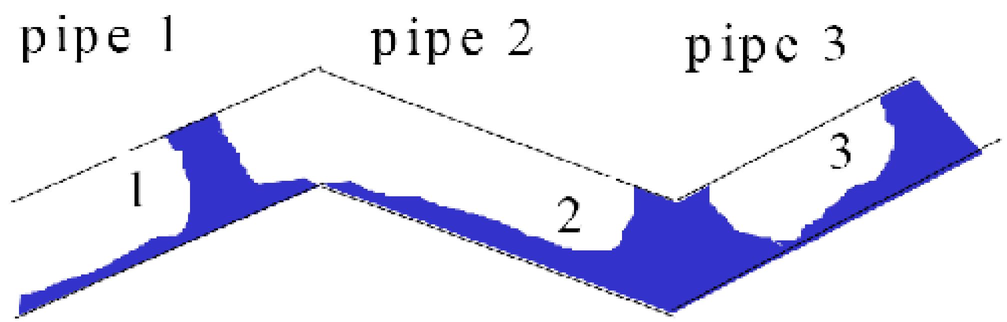


Terrain Slugging is often Periodic

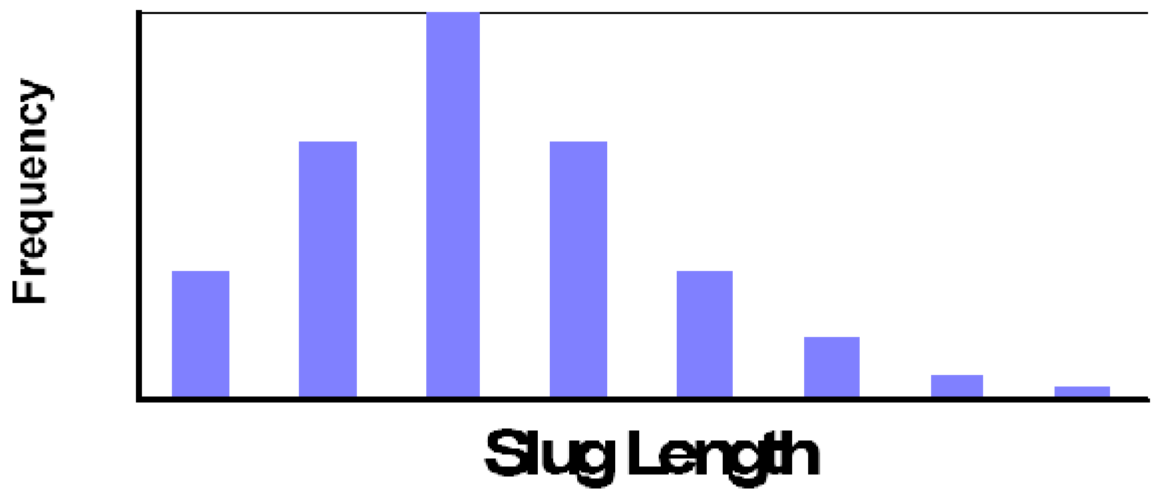
- Often characterized by a buildup and release of the liquid



Hydrodynamic Slugs Can Interact with the Terrain Slugs



a.-terrain effect and slug-slug interaction

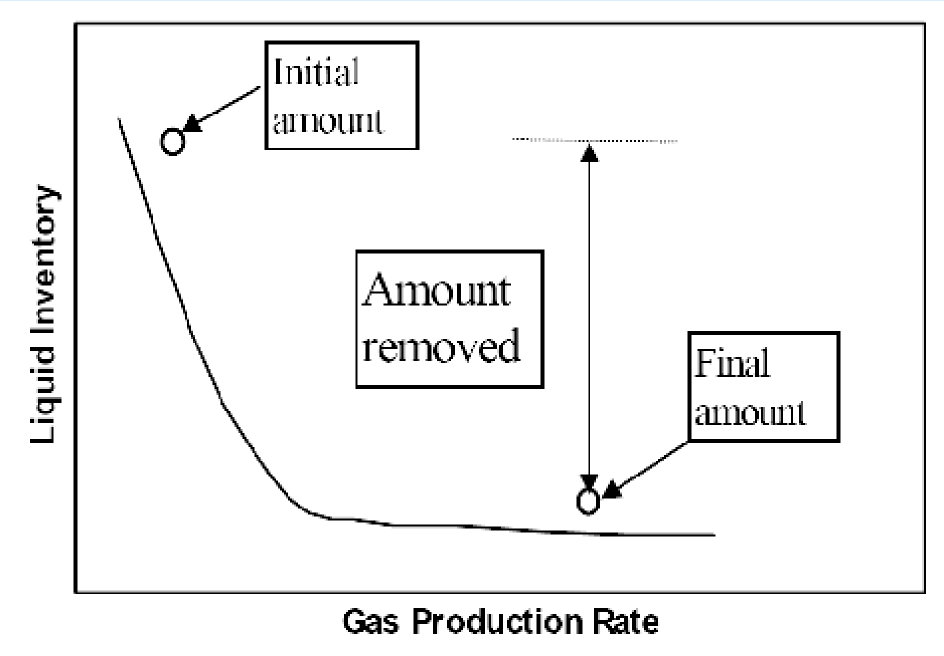


b.-slug distribution

Slugging can be Induced by Transient Operations

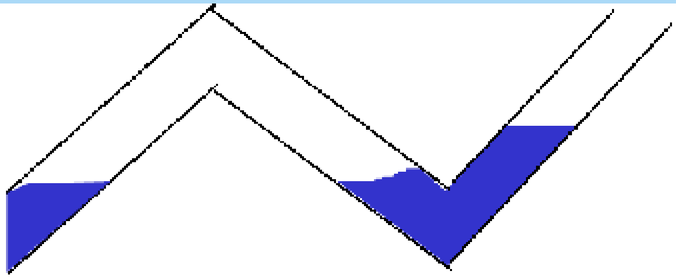
Rate Changes:

- Increasing flowrate reduces holdup

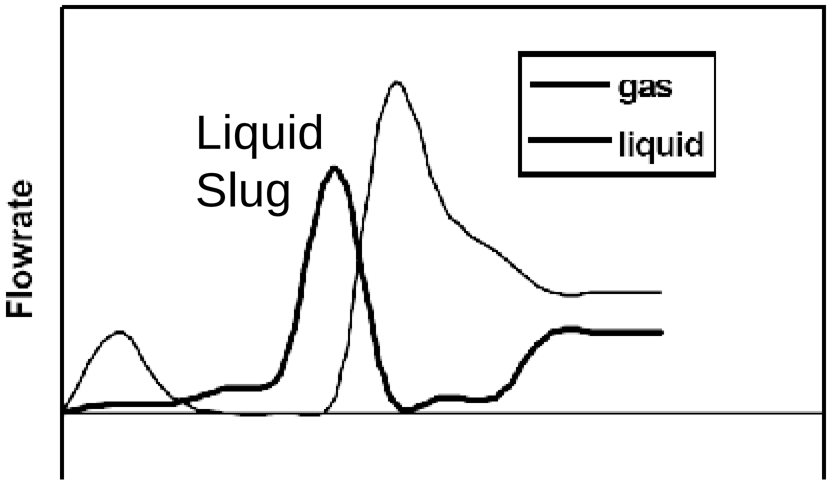


Restart:

- During shutin, liquid settles in dips



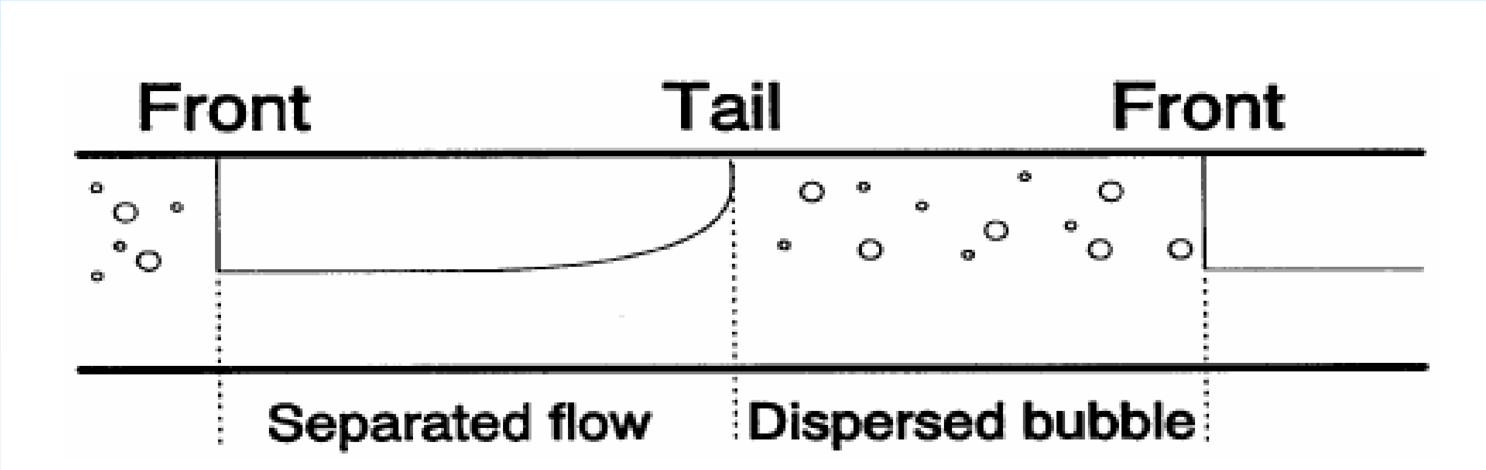
A-Liquid Distribution After Shutdown



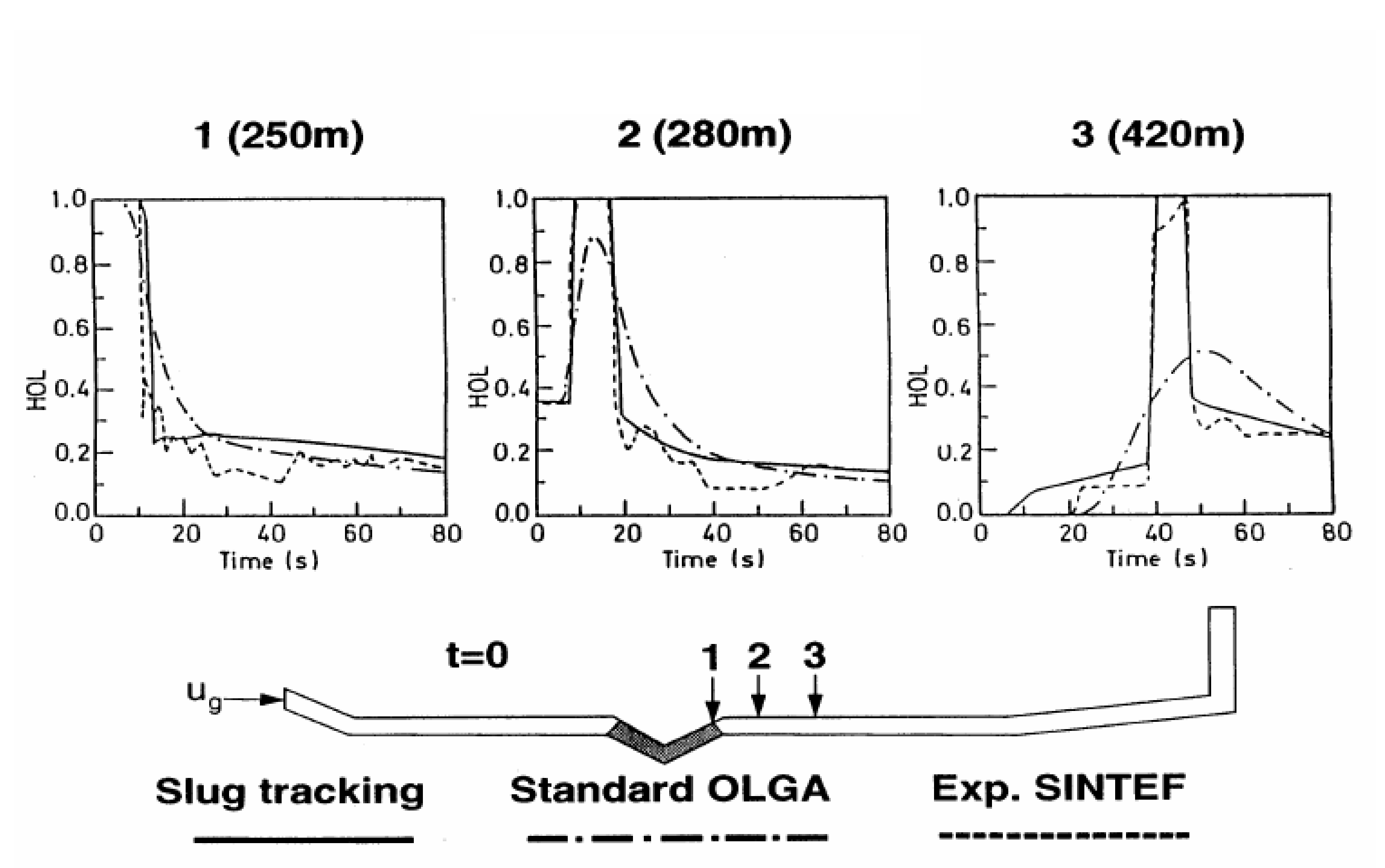
B-Gas and Liquid Outlet Flow

Modeling Slug Flow

- Accurate modeling slug formation and behavior is complex
- Requires tracking of the slug front and tail of each slug
- Slugs grow in inclined flow and shrink in declined flow



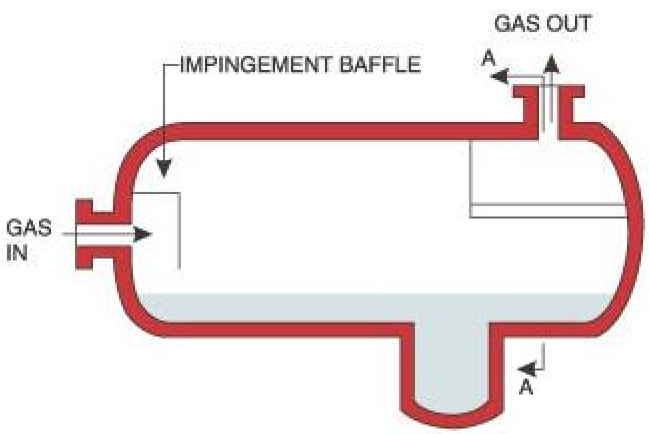
Without “Slugtracking” OLGA is Poor at Predicting Slug Length and Frequency



Slug catches: a simple multiphase separator

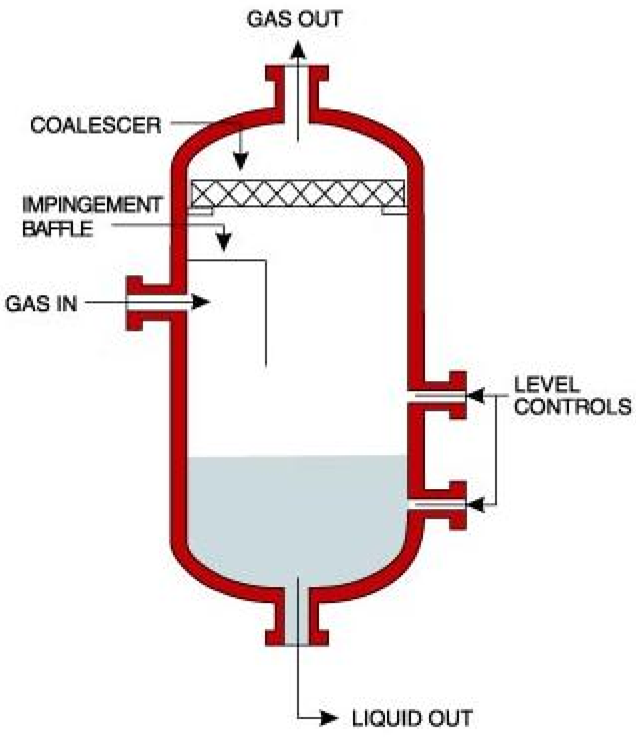
Slug Catchers Can be Huge

- Often the largest part of a gas terminal.
- Must be able to catch the largest slugs from the pipeline and allow time for the liquid to be processed.



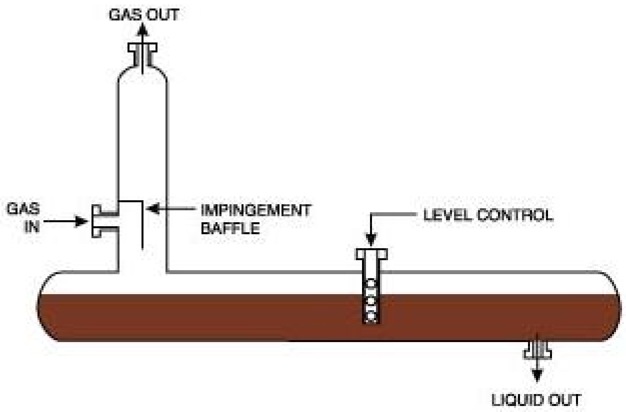
Horizontal Slug Catcher Vessel

- Can give small particle separation (10 microns) where there is more liquid and lower gas flow.
- Useful as three phase separator.
- Becomes expensive and heavy when large sizes are required.
- Good separation up to 5 - 700 bbls. slug size.



Vertical Slug Catcher Vessel

- Useful where small particle separation (10 microns) is required and gas flow is large in relation to liquid slug size.
- Equipment is expensive and heavy when large sizes are required.
- Good separation -- useful up to 5 - 700 bbls. slug size.



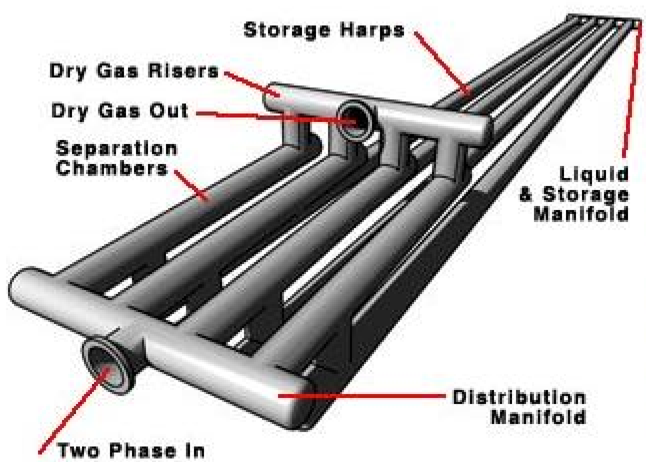
Pipe Fitting Type Slug Catcher

This type of separation equipment typically has an impingement plate to knock out bulk liquids and a vertical column to form a gravity type separator, but it usually has insufficient area to effectively remove small particles. Normally, it is just used to catch the slugs of liquid and hold them. For economic reasons, these slug catchers are usually designed as pipe and fittings, rather than as pressure vessels.

The pipe fitting type slug catcher provides good slug separation and slug storage volume at a reasonable cost. Small particle separation is poor, but it improves at low flow rates. A slug catcher of this type can be used to protect a centrifugal type separator and the combination will give separation and slug storage capacity.

- Very economical where small liquid slugs are to be caught.
- Particle separation is poor and relatively unpredictable.
- Catches slugs up to 150 - 200 bbls.

Harp type slug catcher



Slug Catcher Anatomy

The separator/slug catcher consists of several modules — distribution header, separation chambers, dry gas risers, storage harps, and liquids and sludge manifolds.

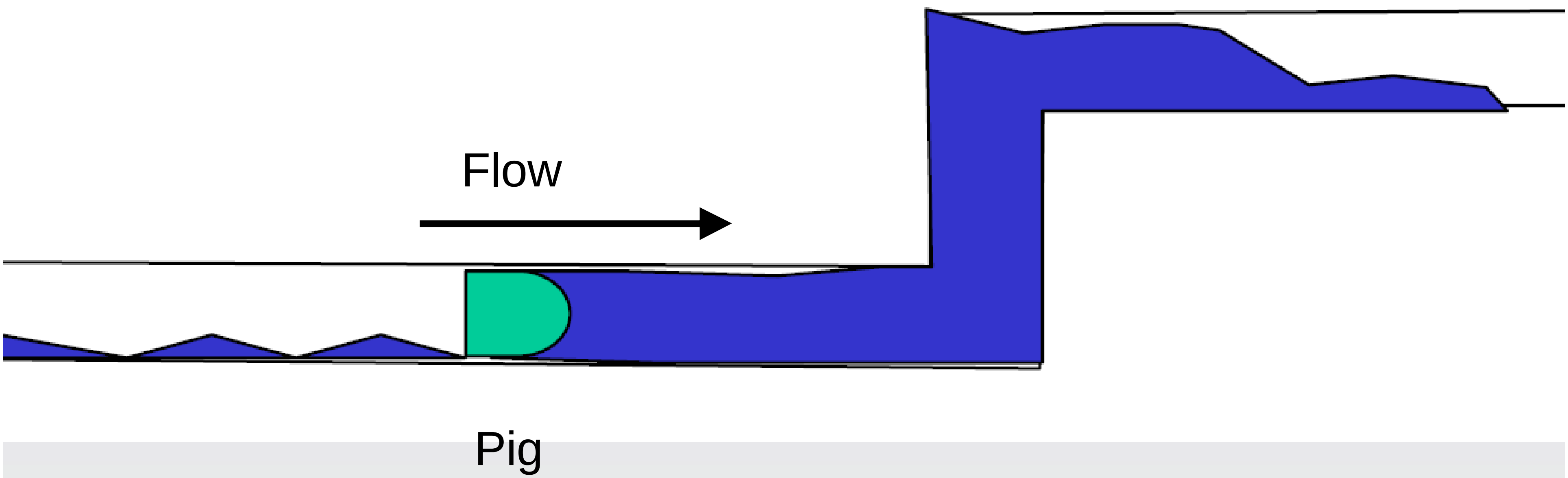
The **distribution manifold** takes the incoming gas/liquid stream, slows it down, and splits it into several smaller streams to allow uniform flow into the separation chambers.

In the **separation chambers**, the majority of the gas liquid separation is accomplished. The required length, size and number of these chambers is a combined function of gas flow, gas chemistry and other known conditions.

The Slug catcher for Troll has a Capacity of 2400 m^3

Pigging

- Gas lines in particular are periodically pigged to remove accumulated liquid
- The large liquid slug is caught in a large separator called a “Slug Catcher”



Types of Pigs

- Spheres:
  - Easy to handle.
  - Can be re-inflated to compensate for wear.
  - Negotiate irregular bends.
  - Little energy for movement < 2psi.

- Foam Pigs:
  - Inexpensive and versatile.
  - Can be fitted with brushes to remove deposits.

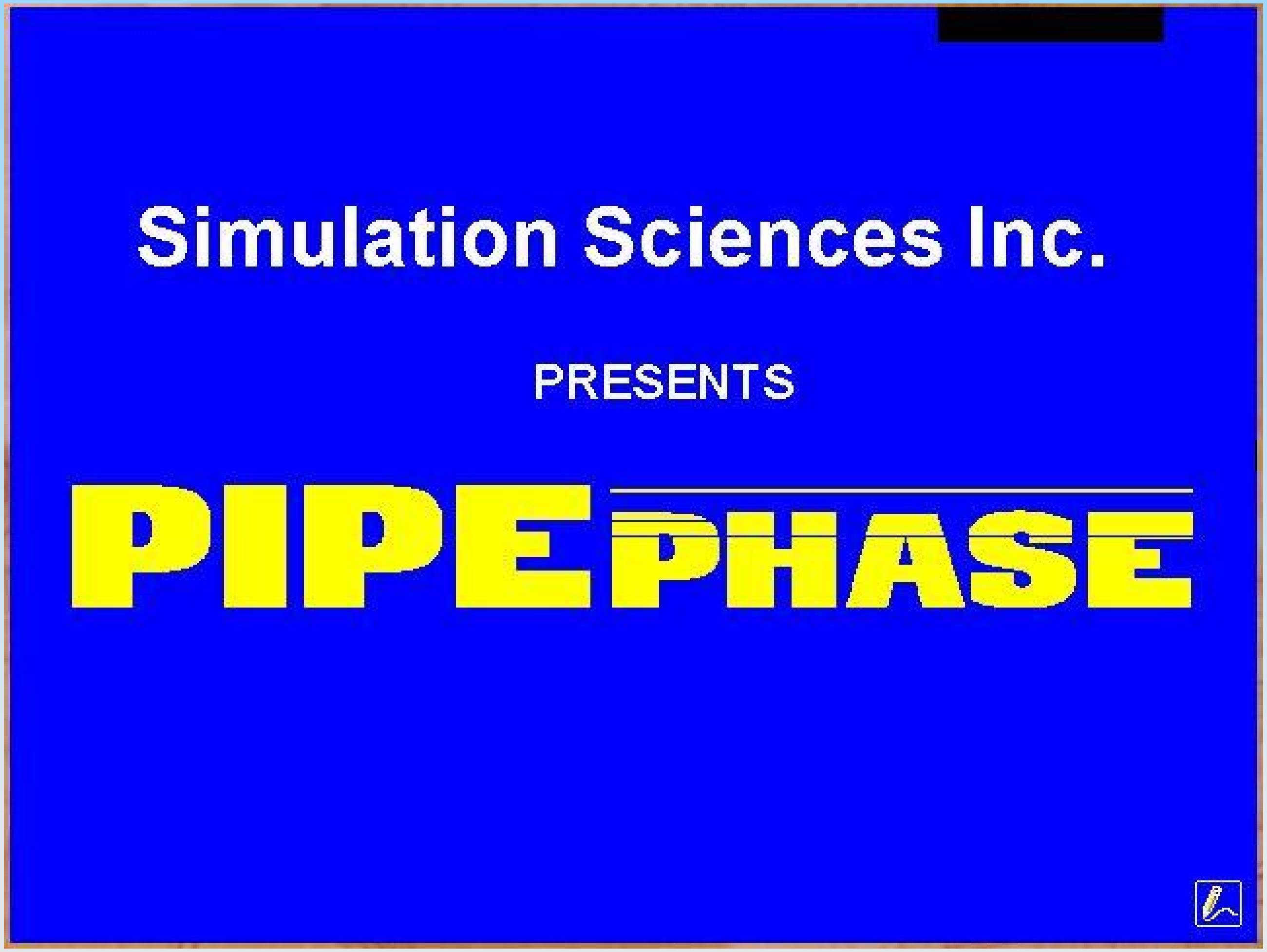
- Steel Pigs:
  - Durable with replaceable sealing elements.
  - Can also be equipped with brushes and blades.

- Solid-Cast Pigs:
  - Light in weight, allow for longer and more efficient sealing.

Pigging a way to keep the pipeline hygienic

Double pigging system

Session 16
PIPEPHSE and OLGA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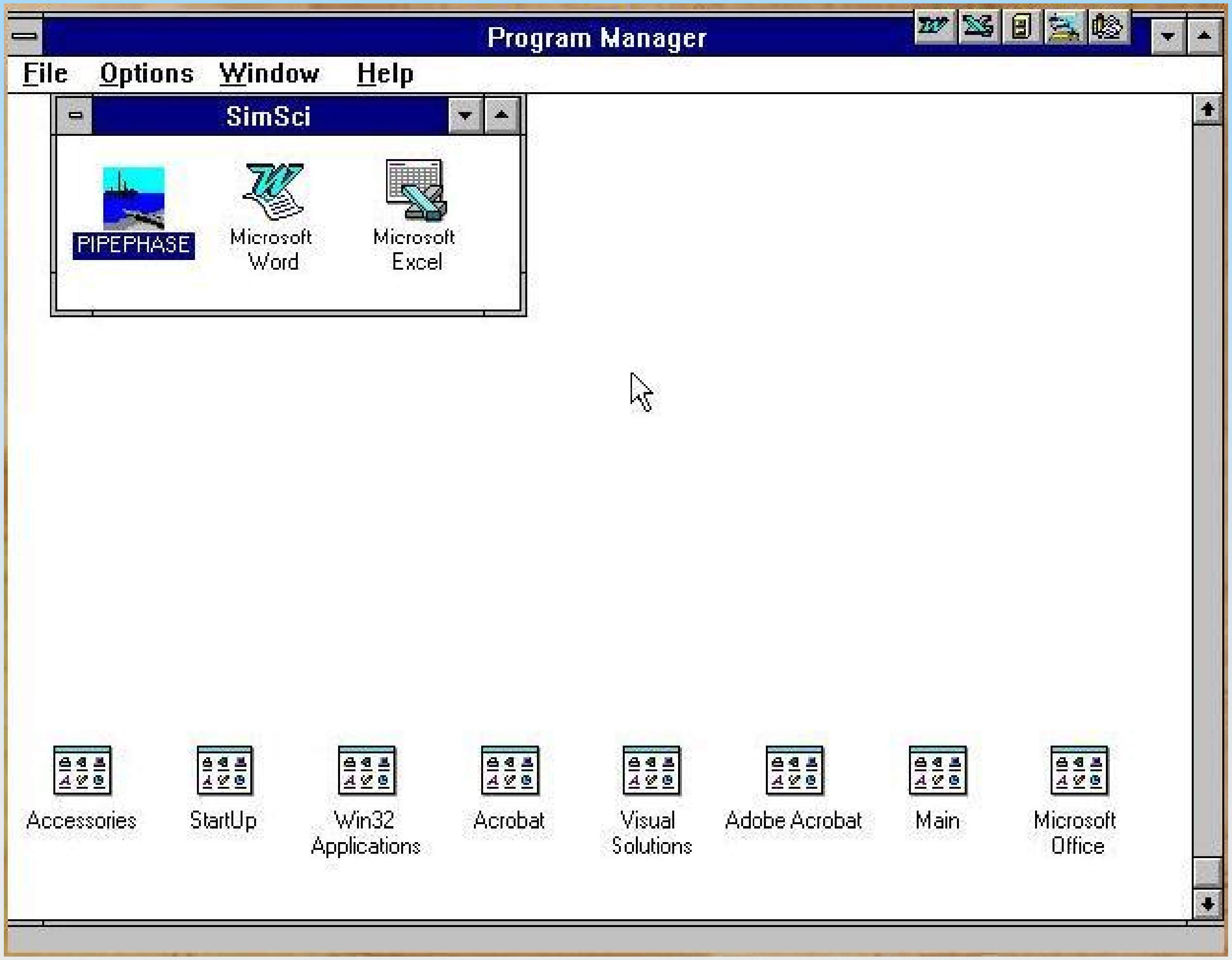

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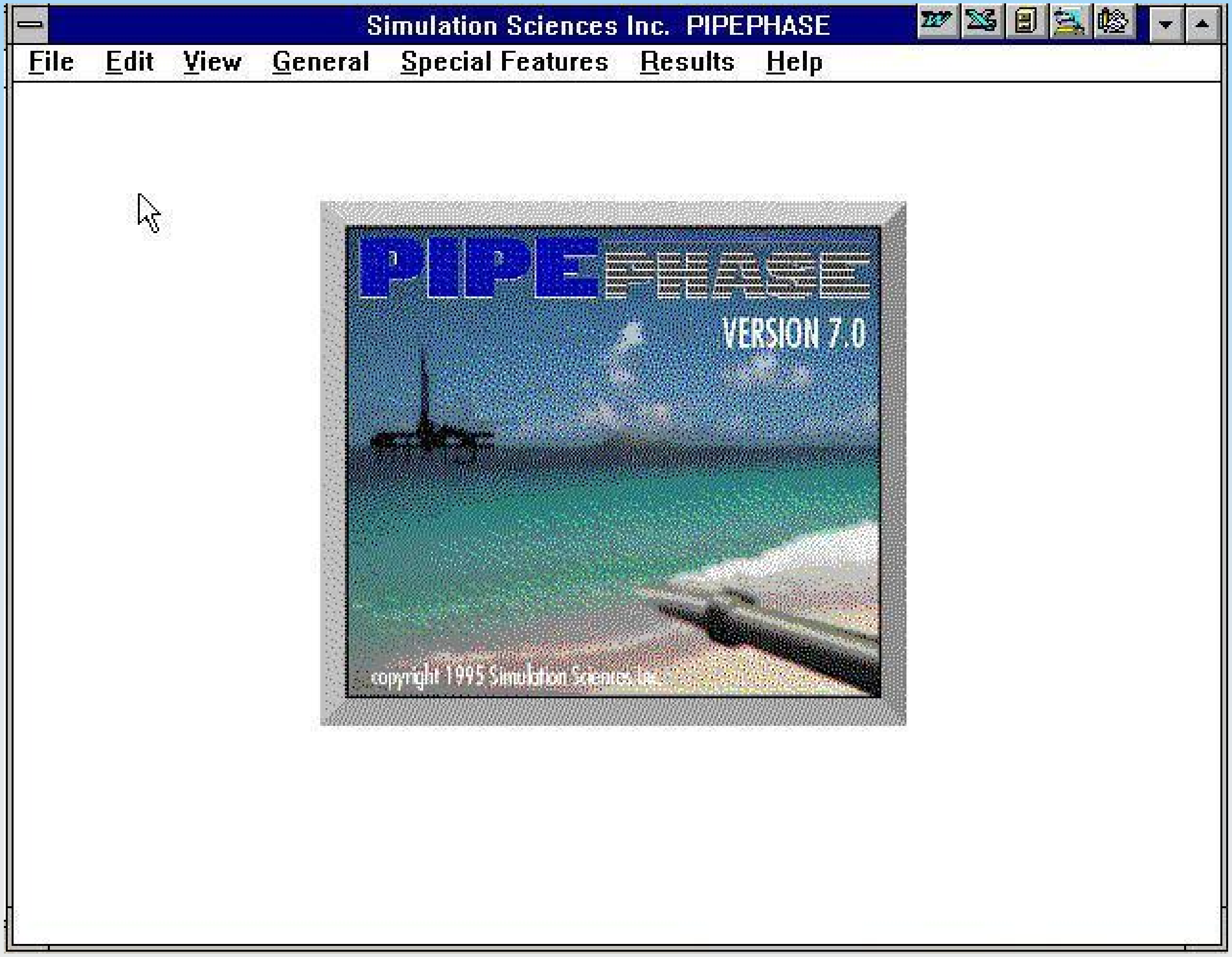
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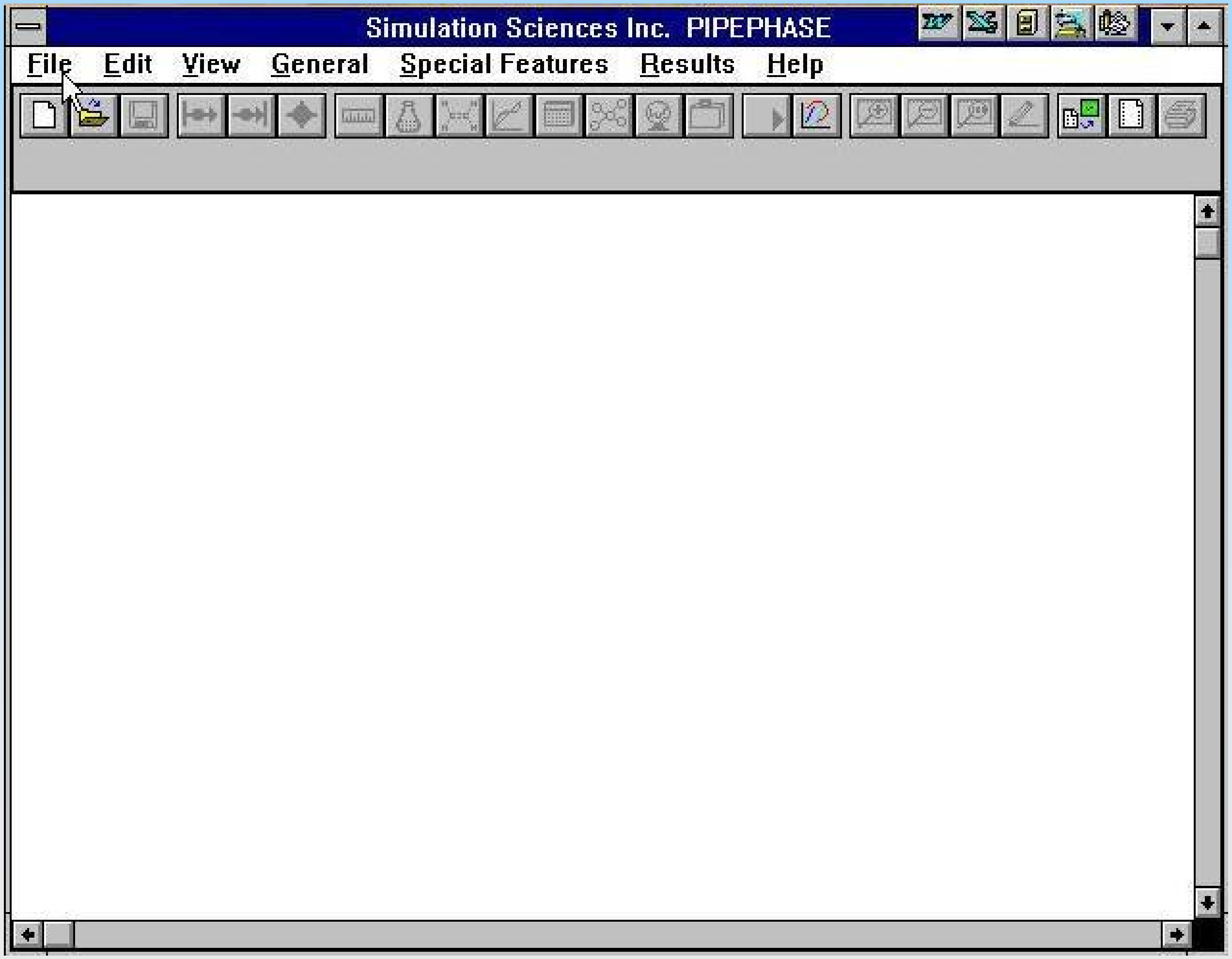

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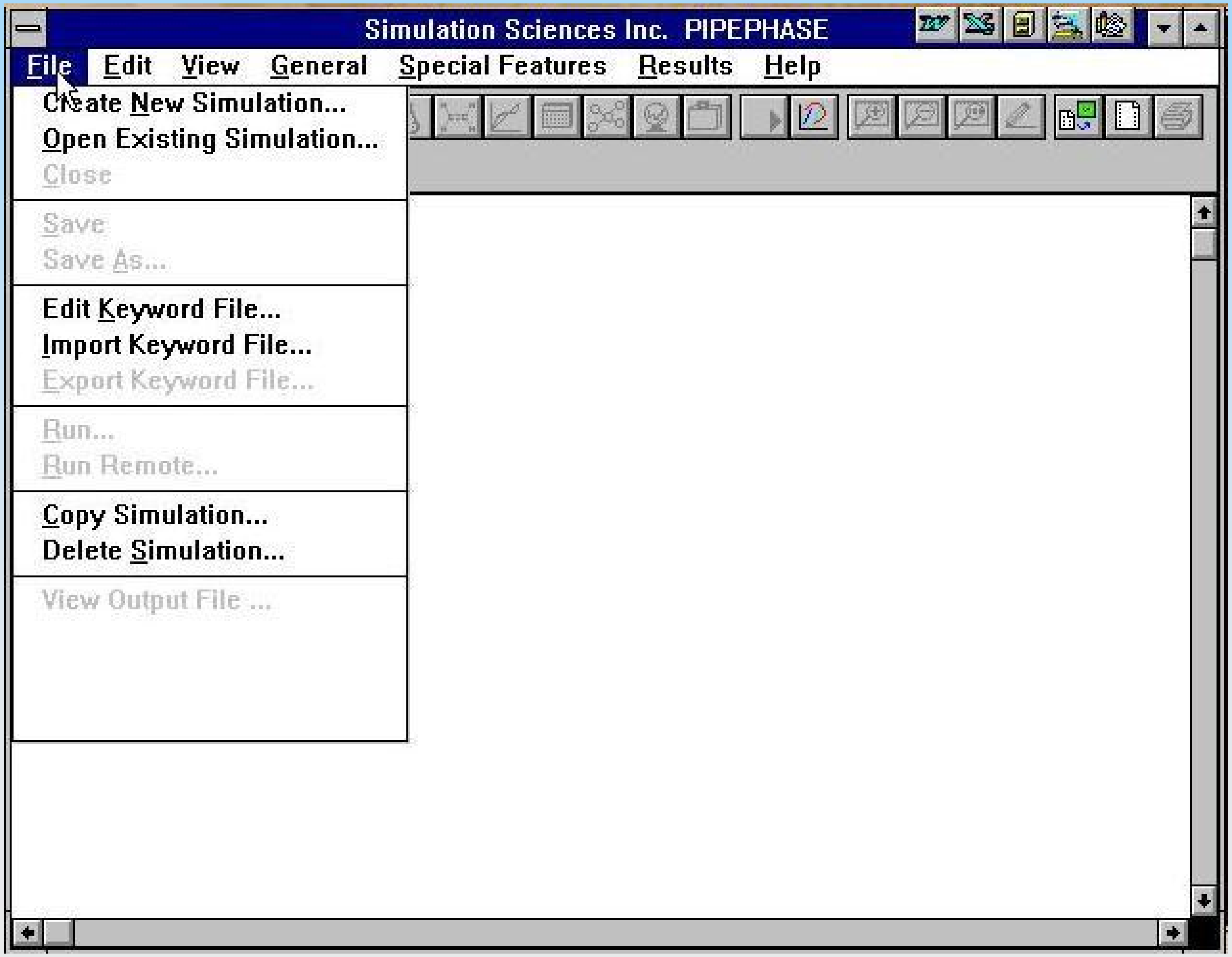
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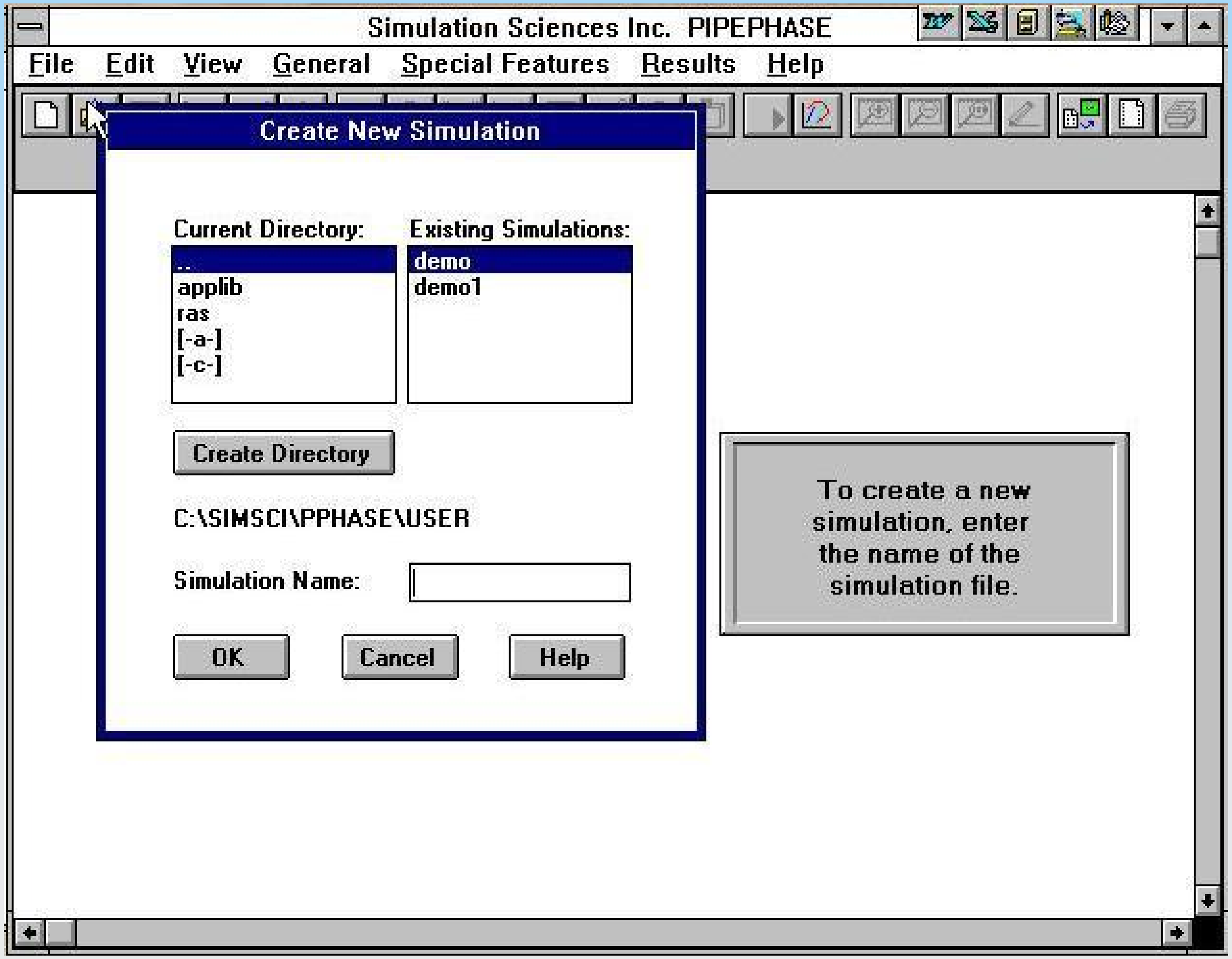
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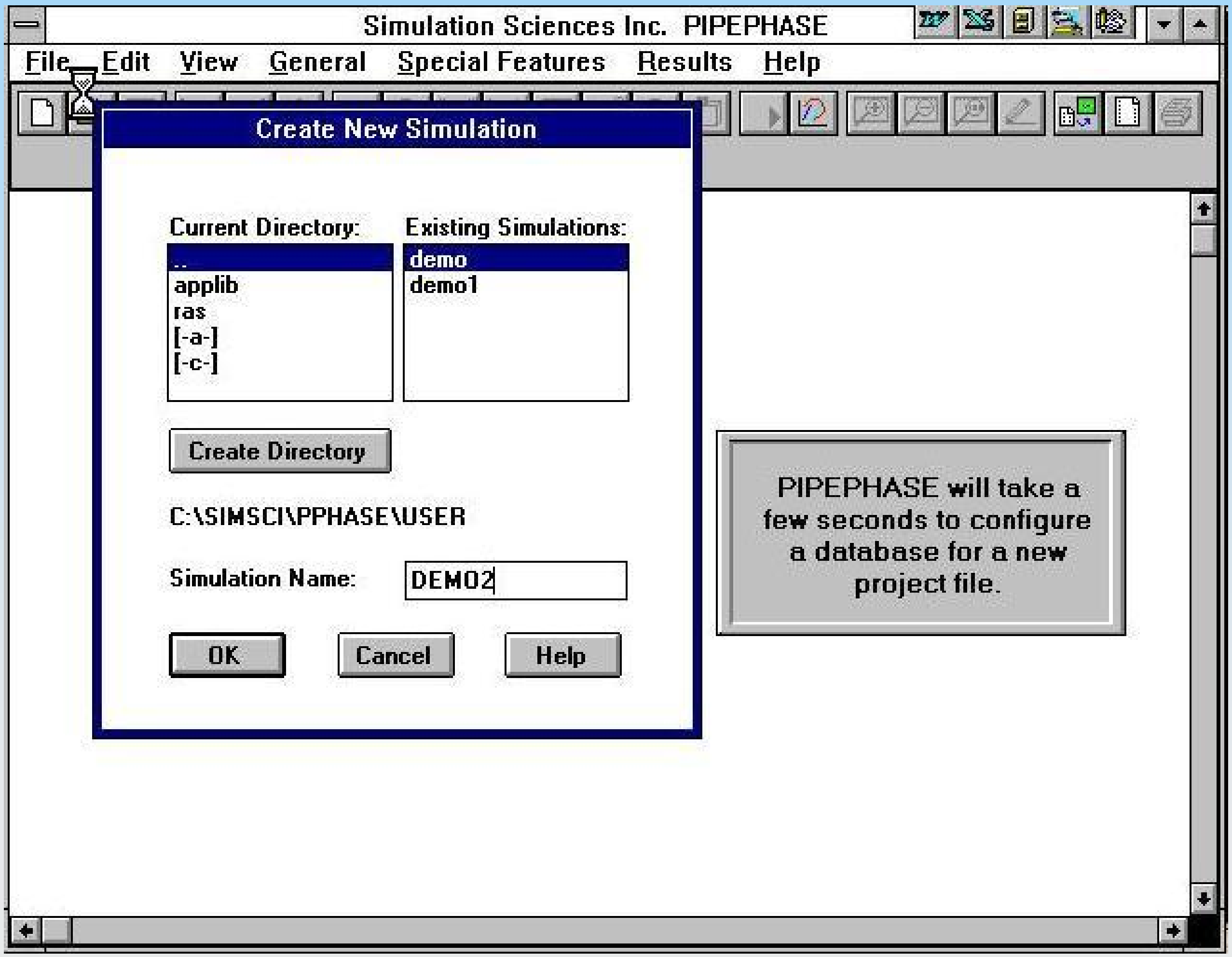
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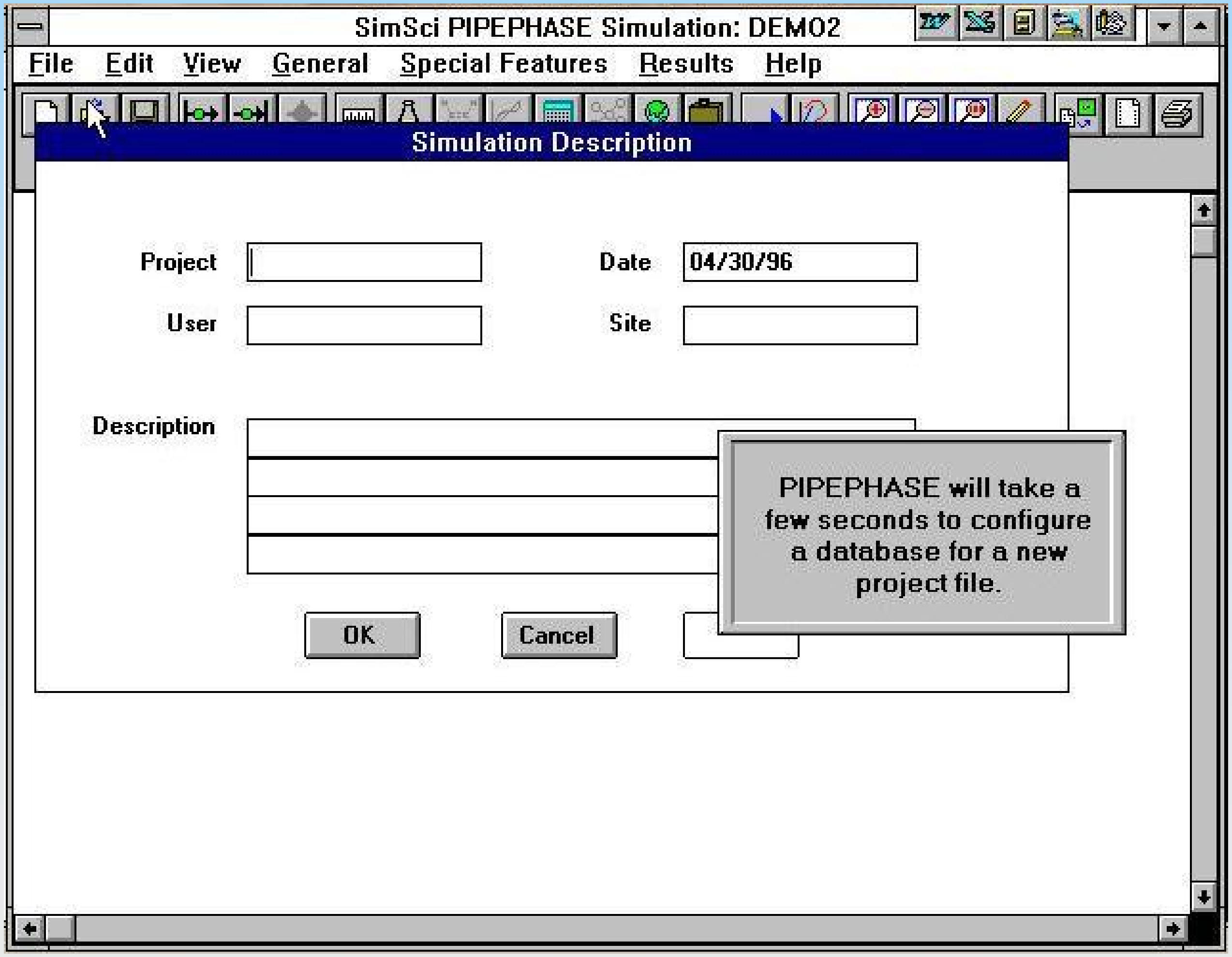
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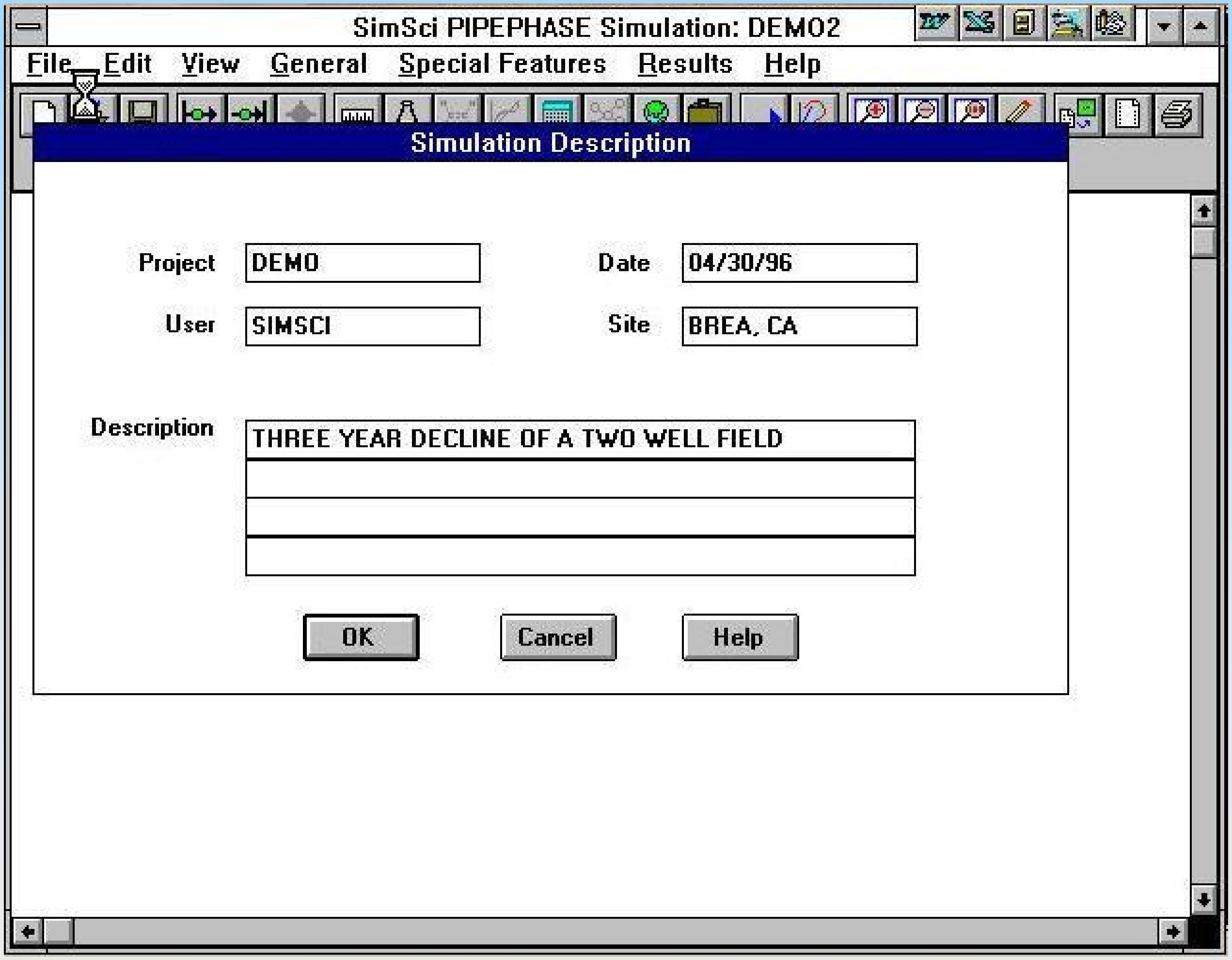
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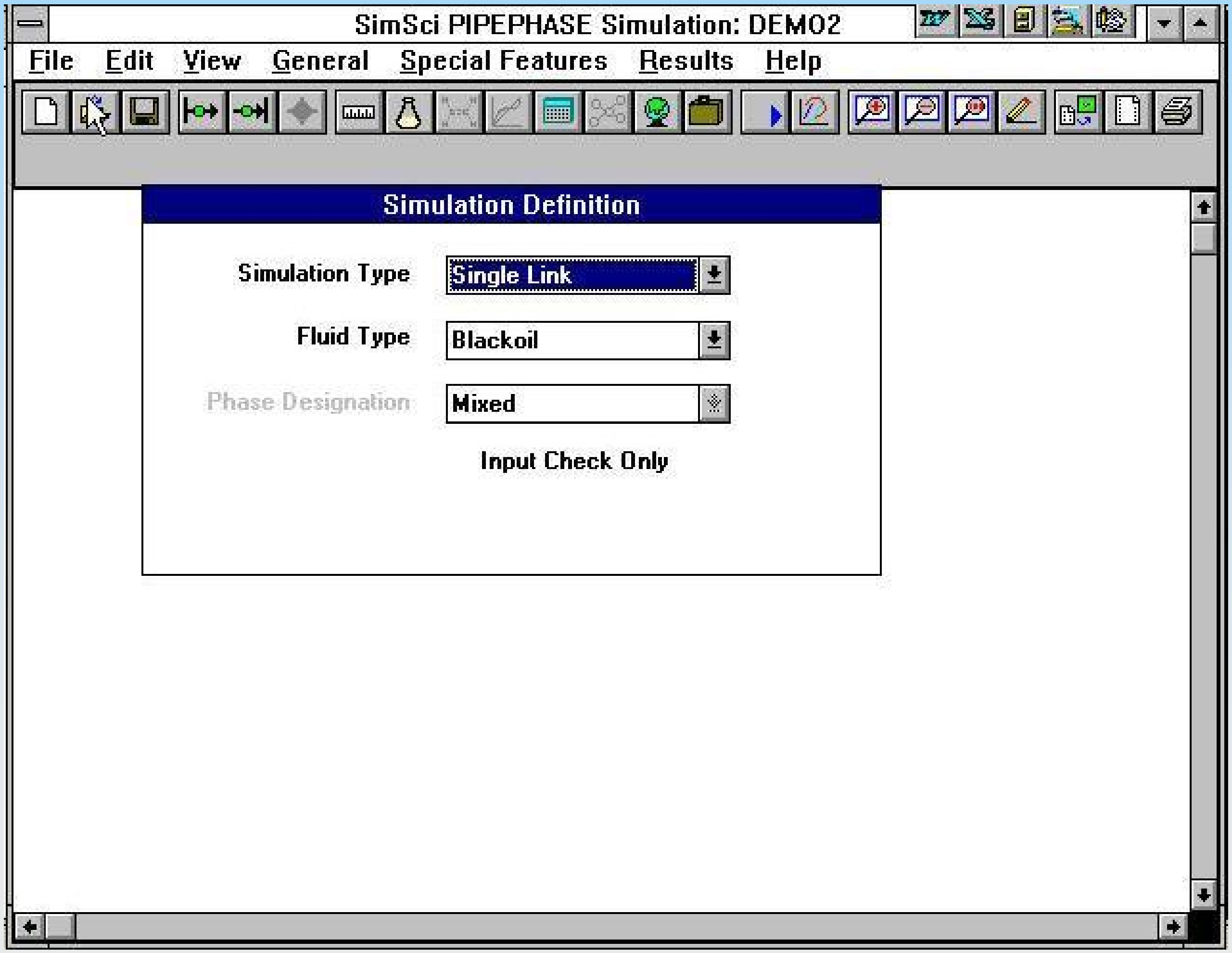
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Fluid Type
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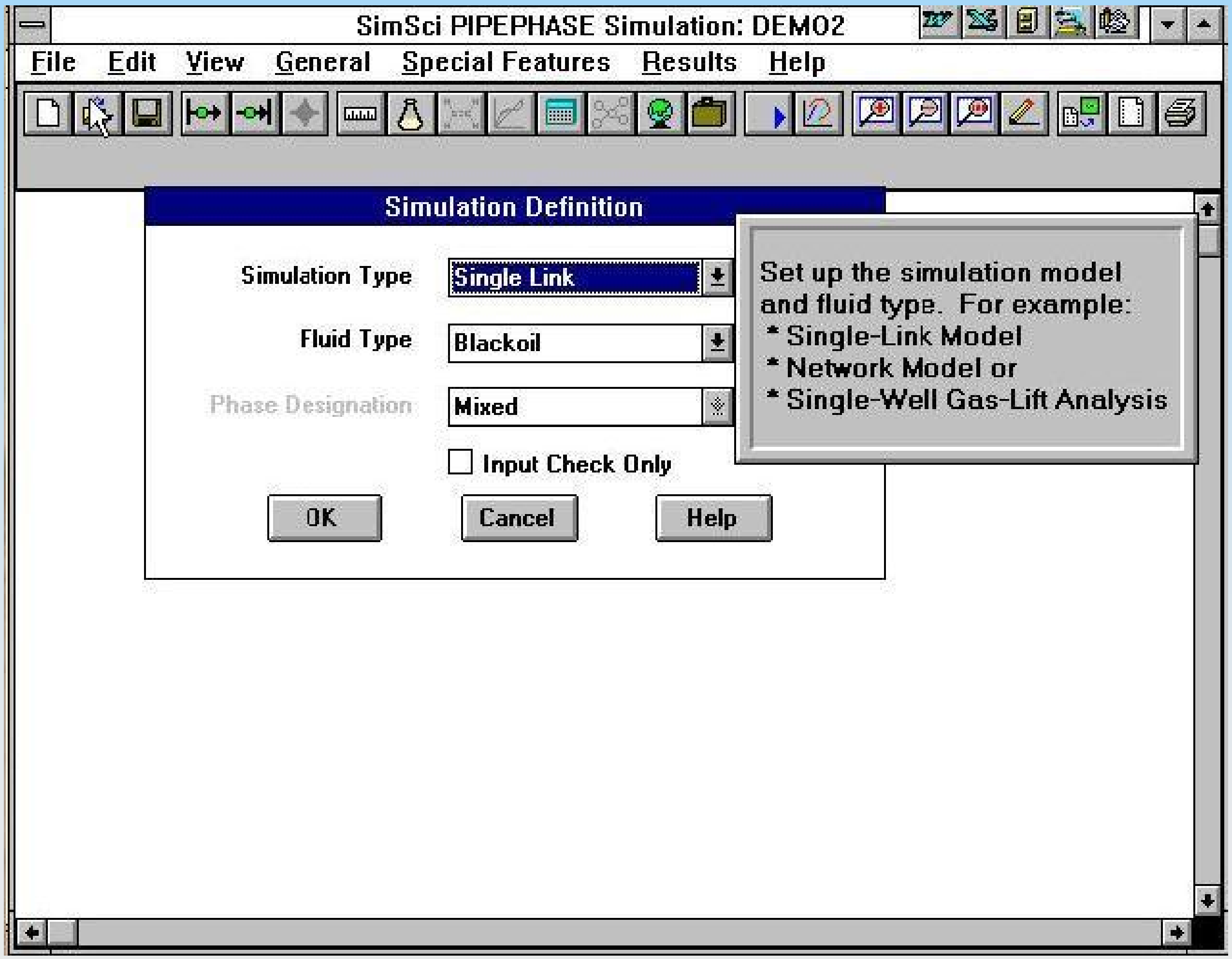
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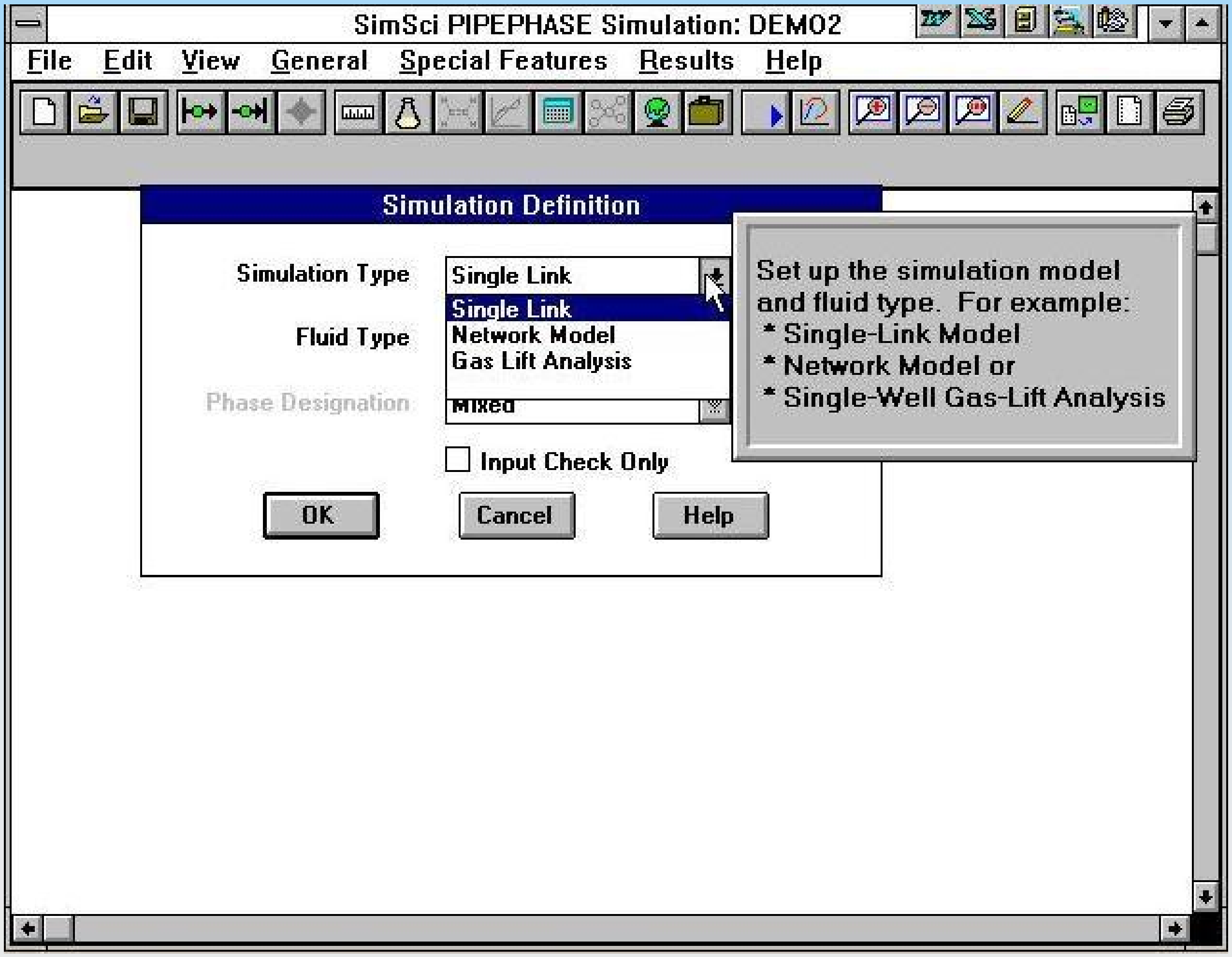
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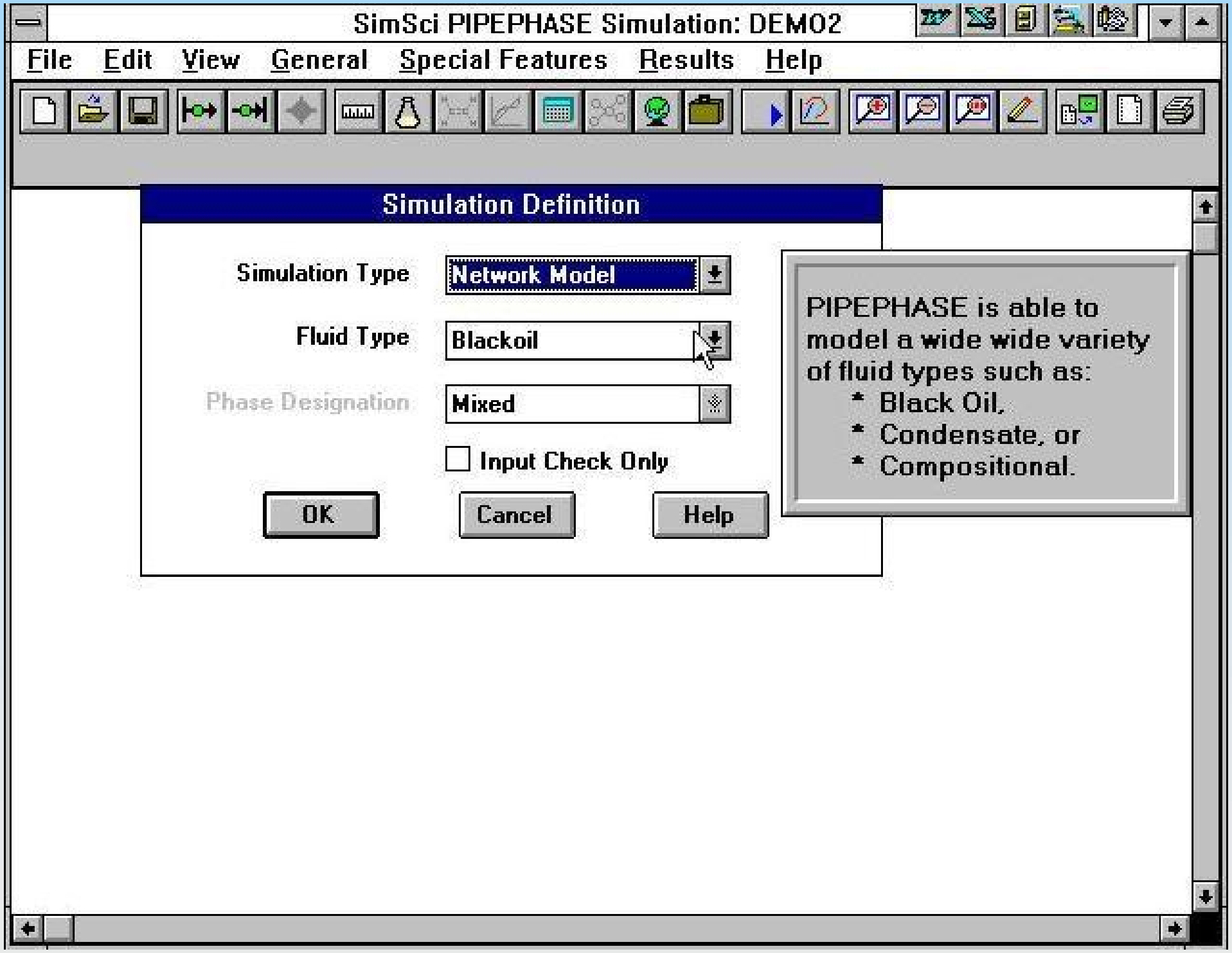
* Network Model or
* Single-Well Gas-Lift Analysis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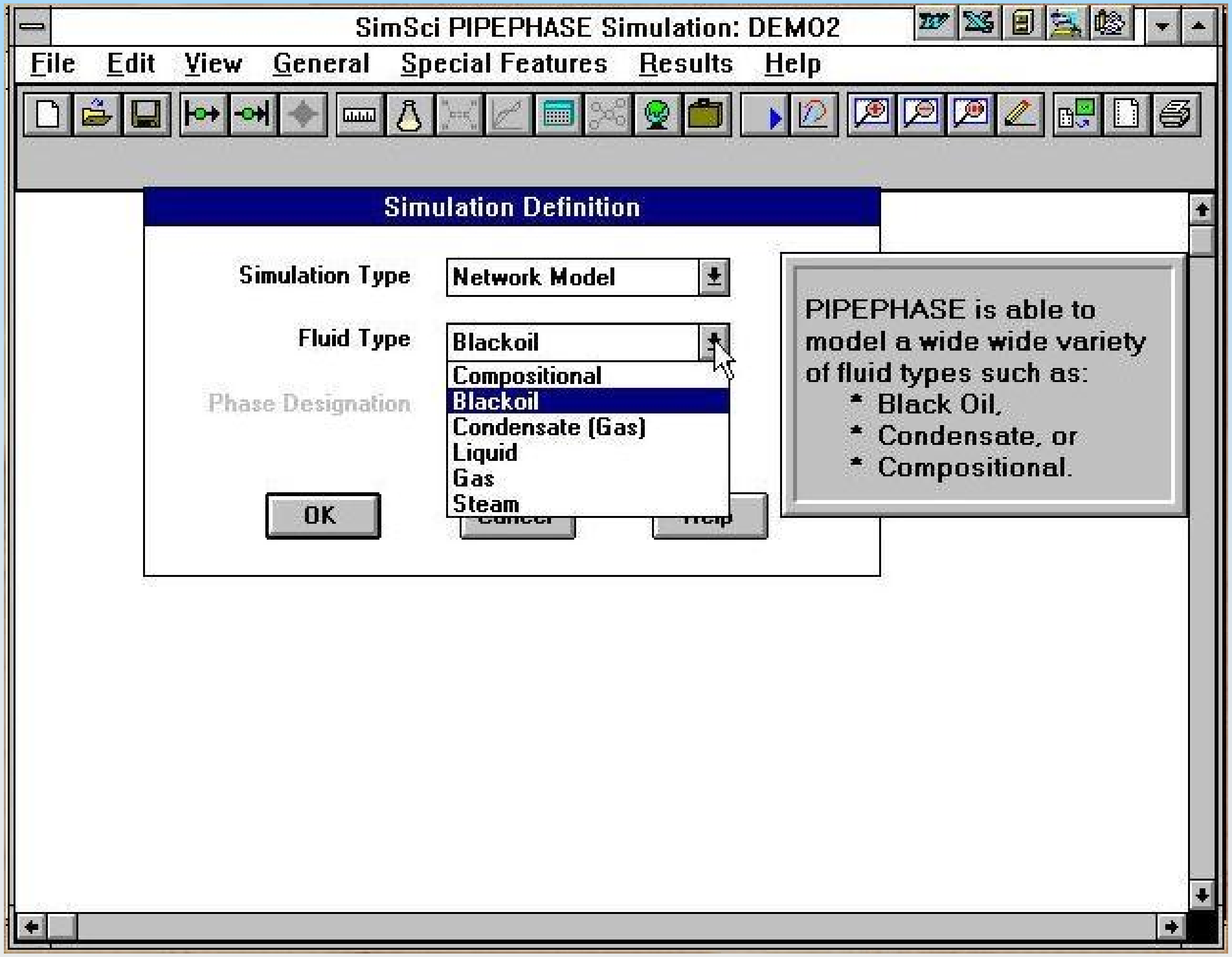
* Condensate, or
* Compositional.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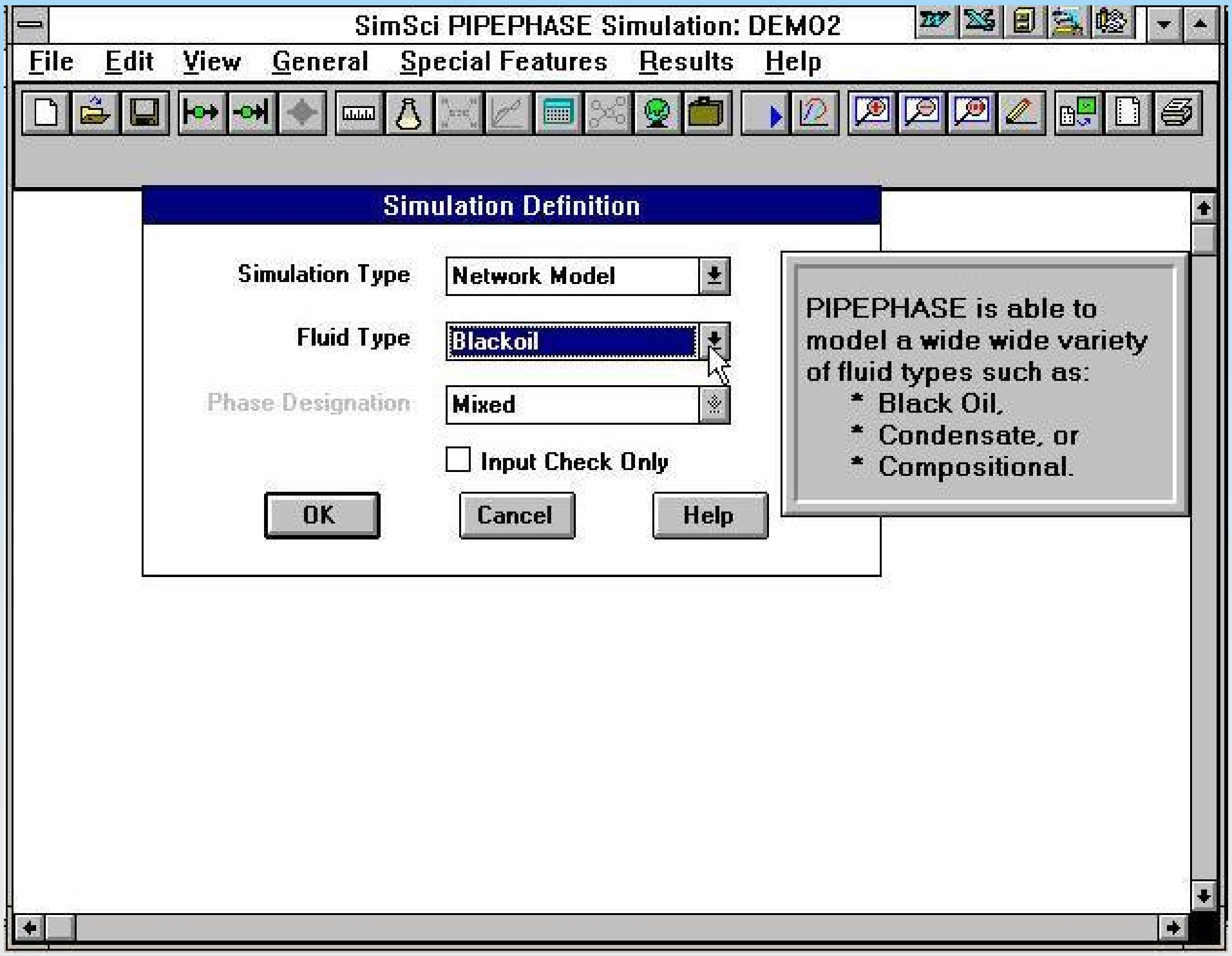
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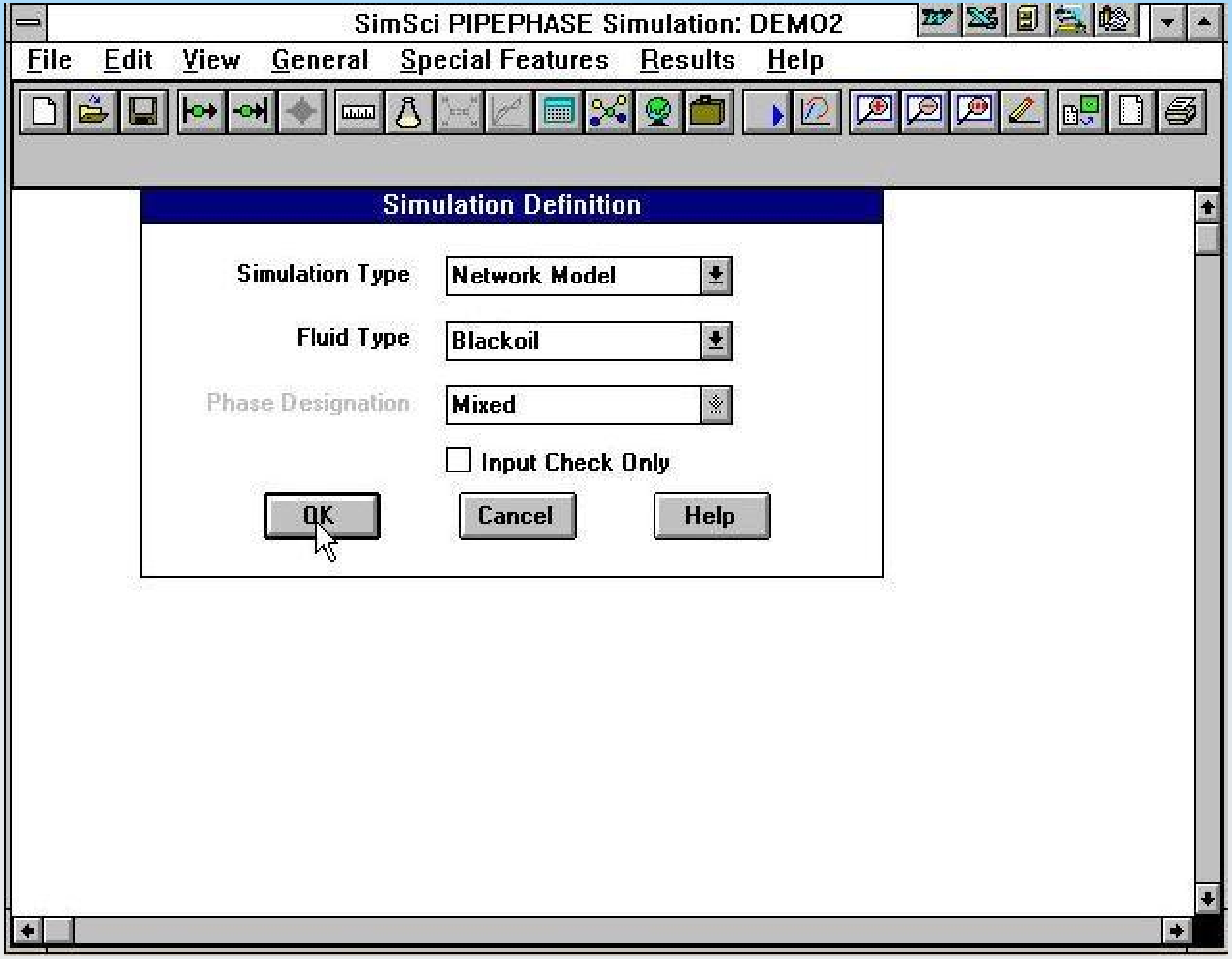
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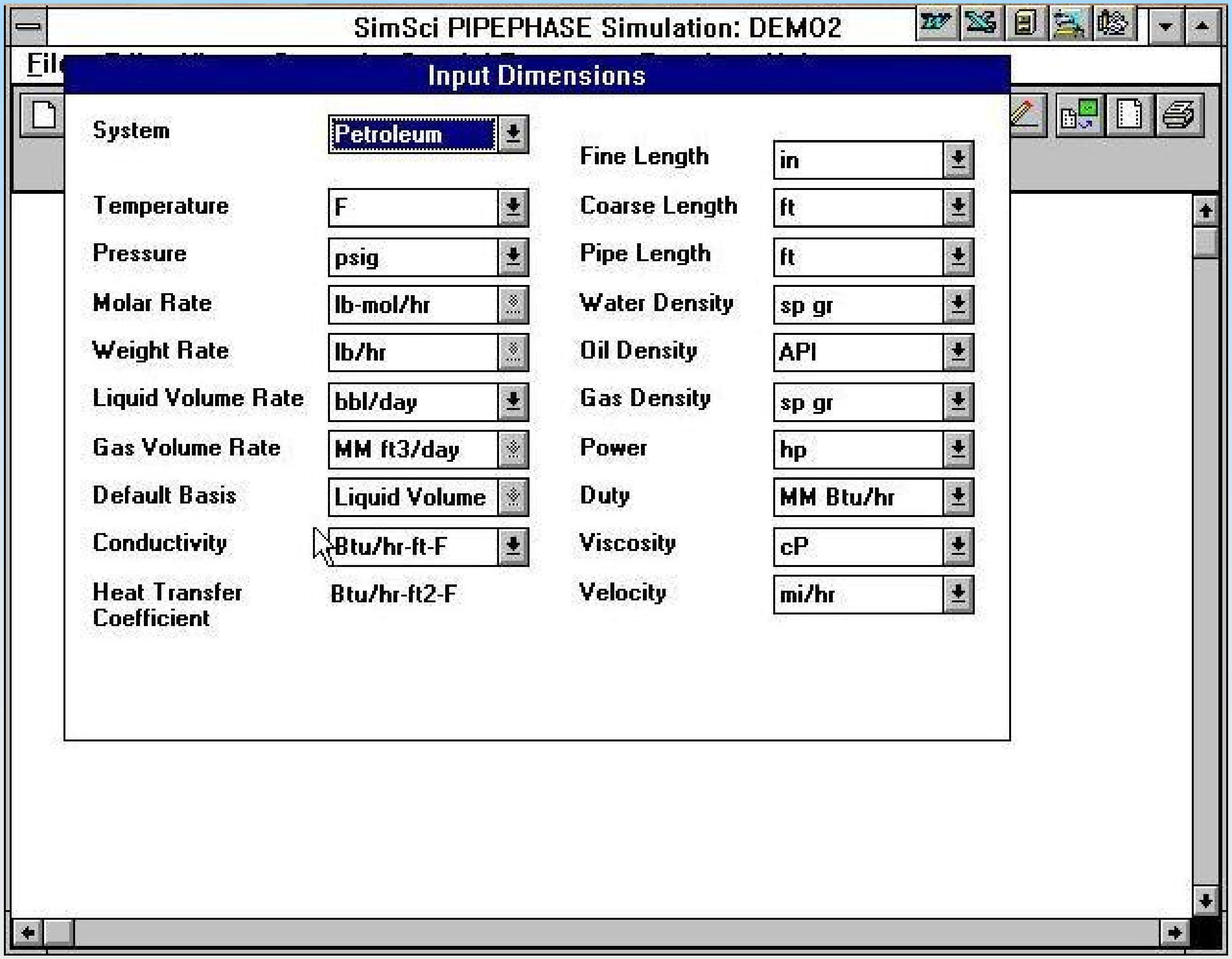
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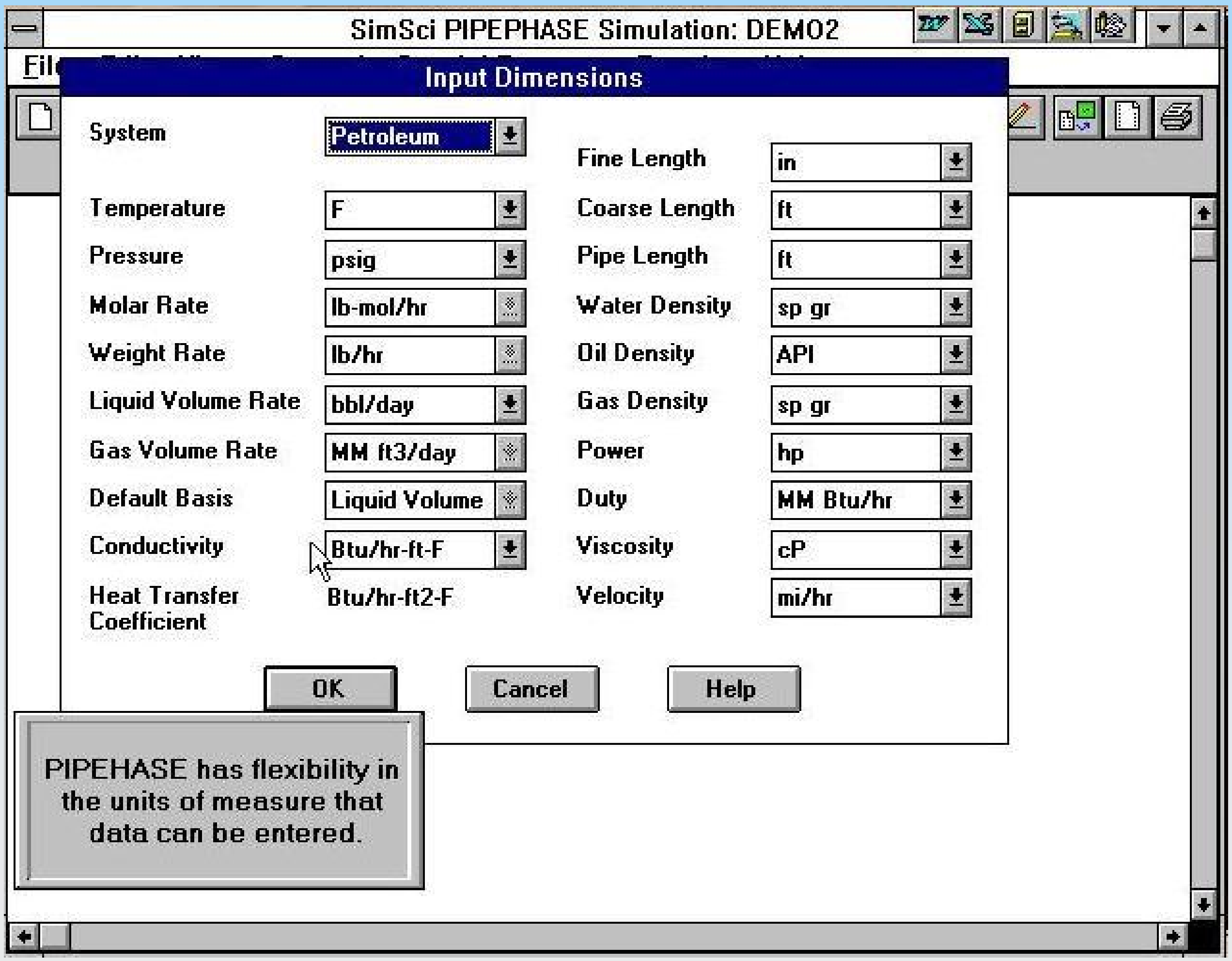
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Btu/hr-ft2-F
Fine Length
in
Coarse Length
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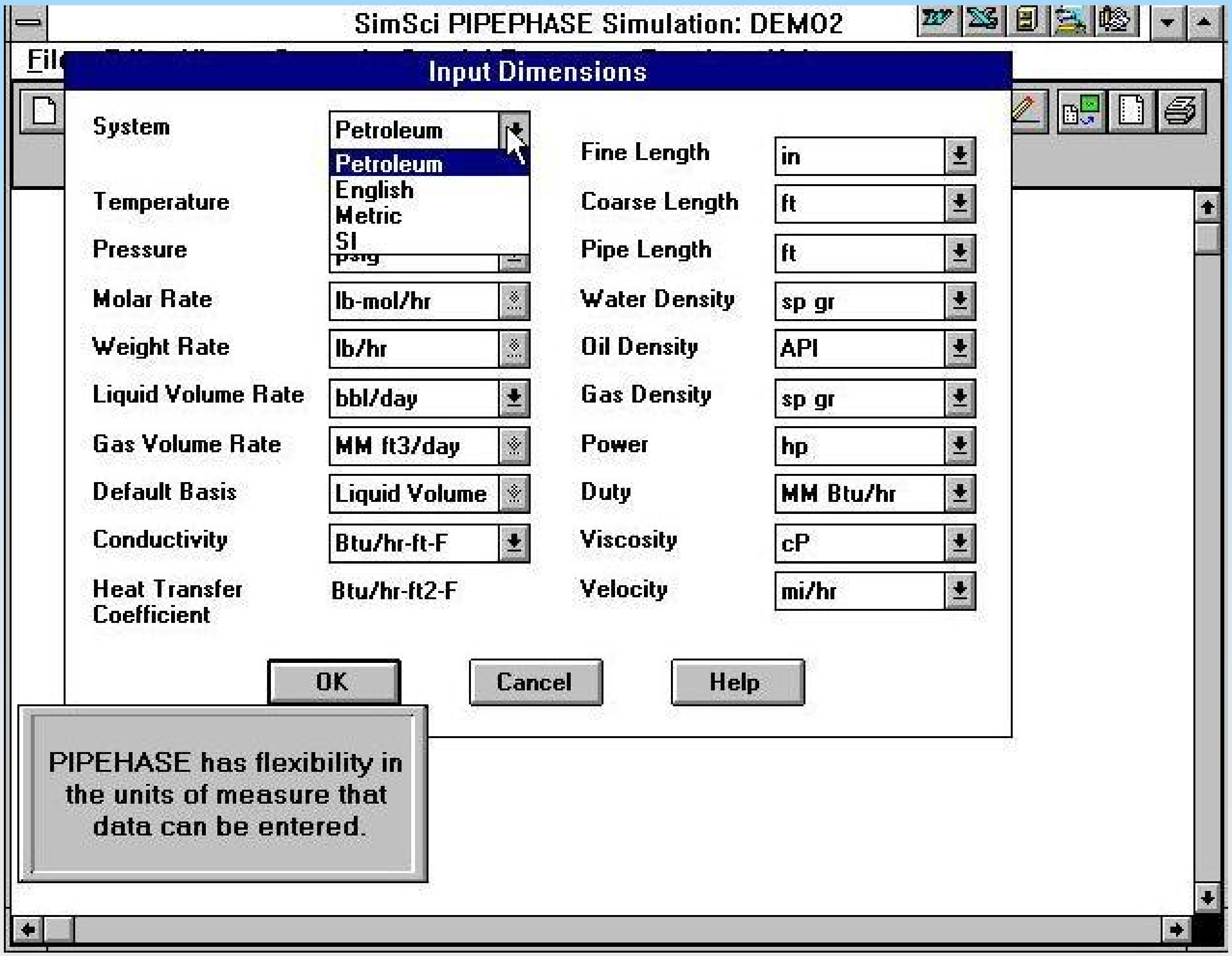
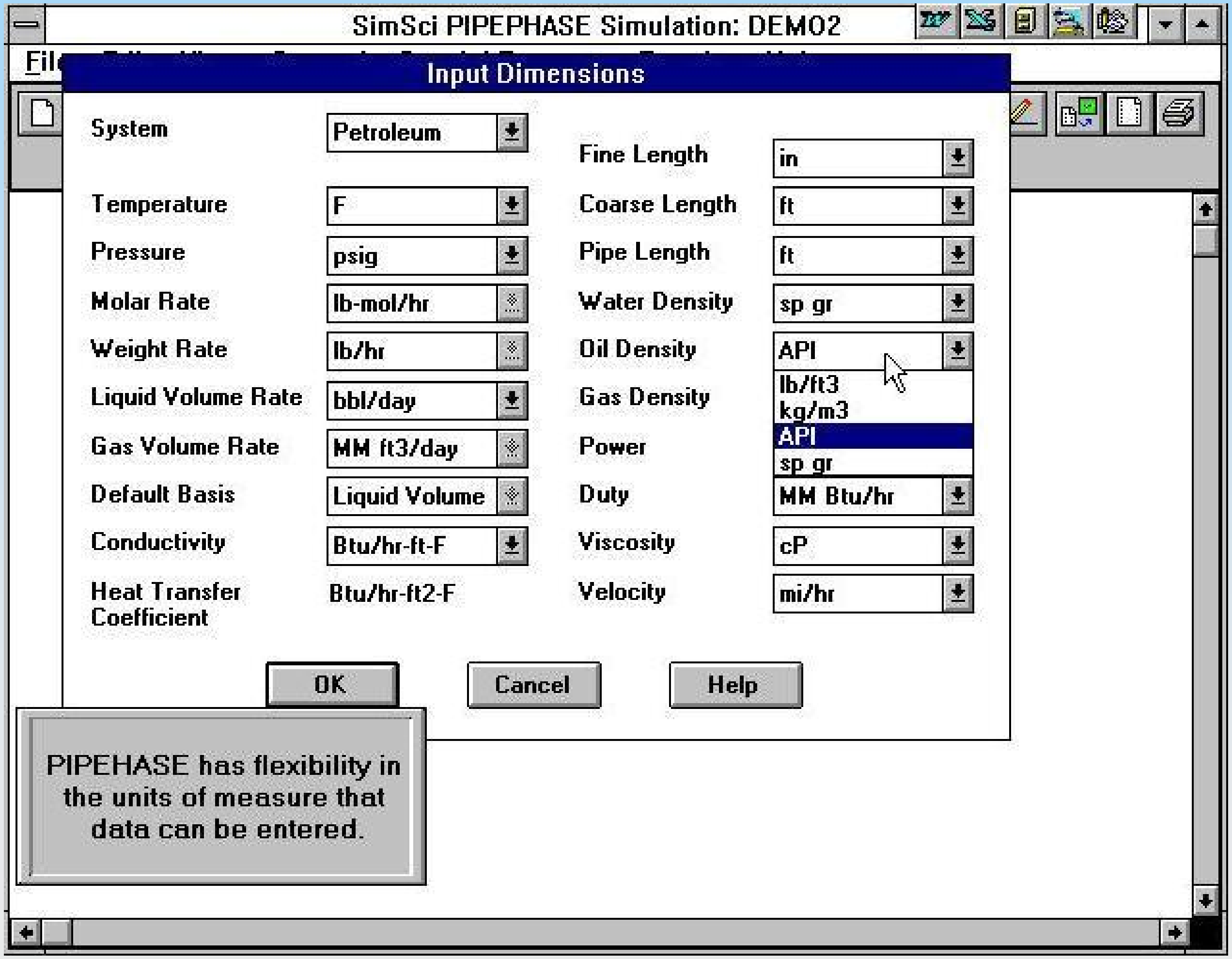
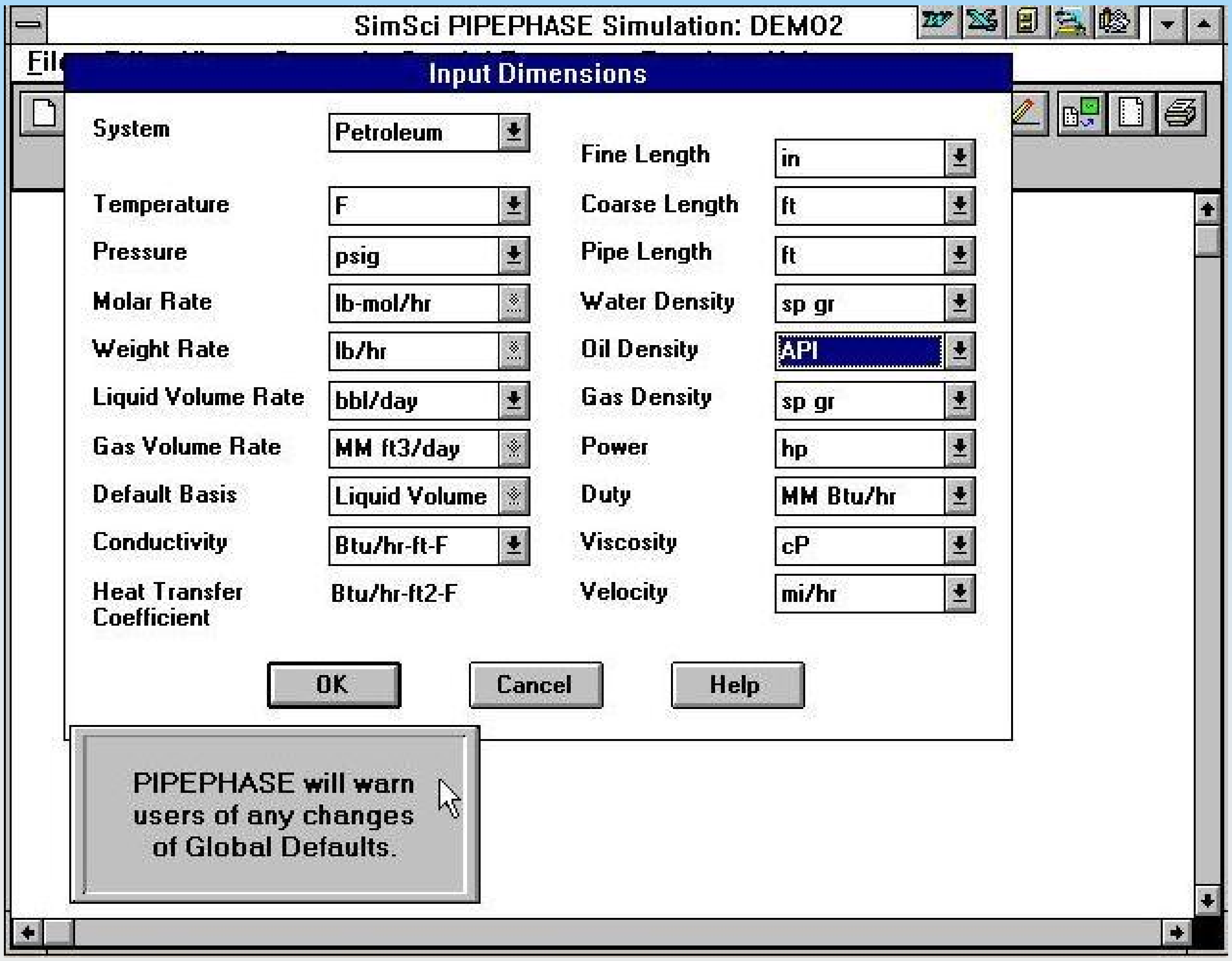
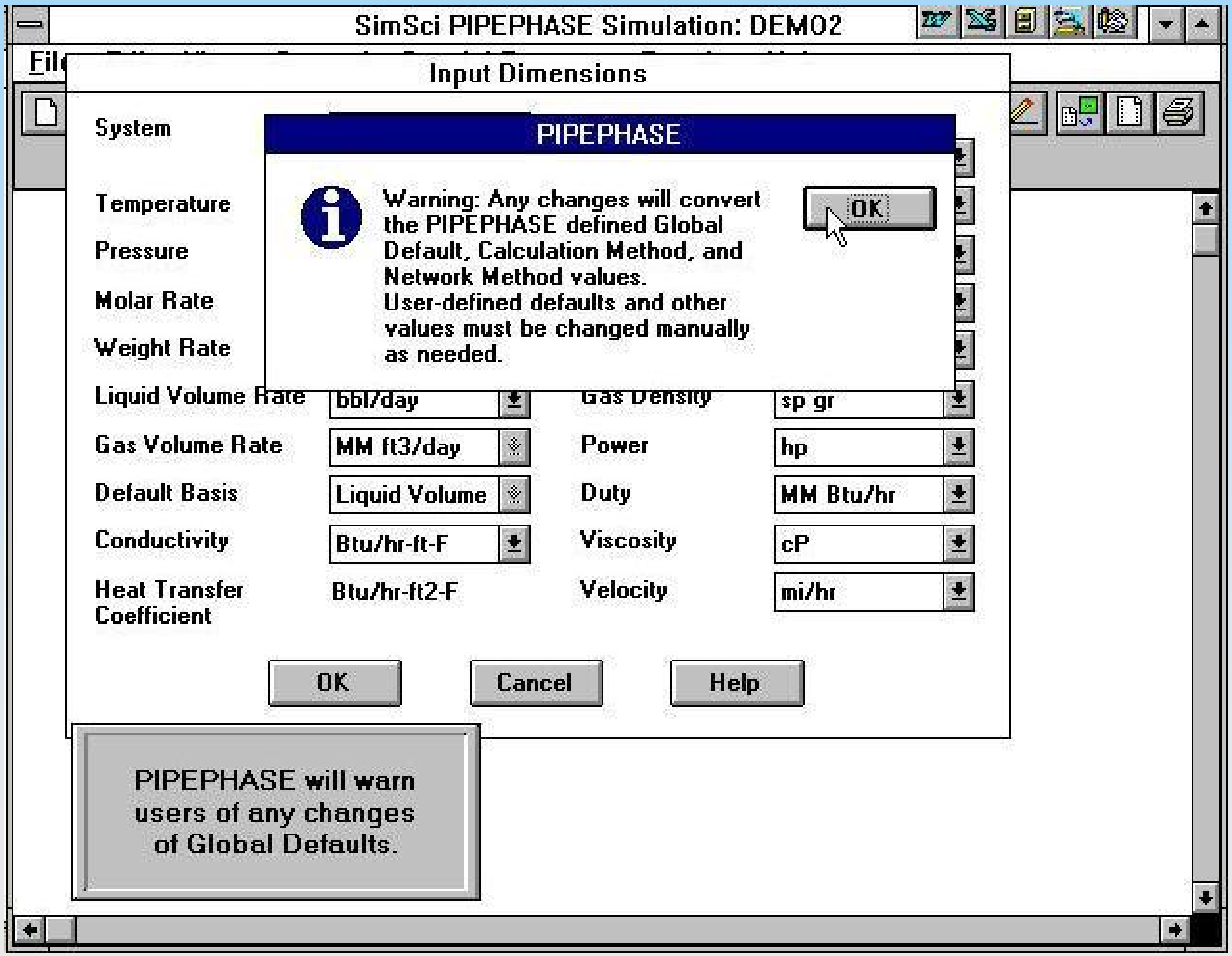
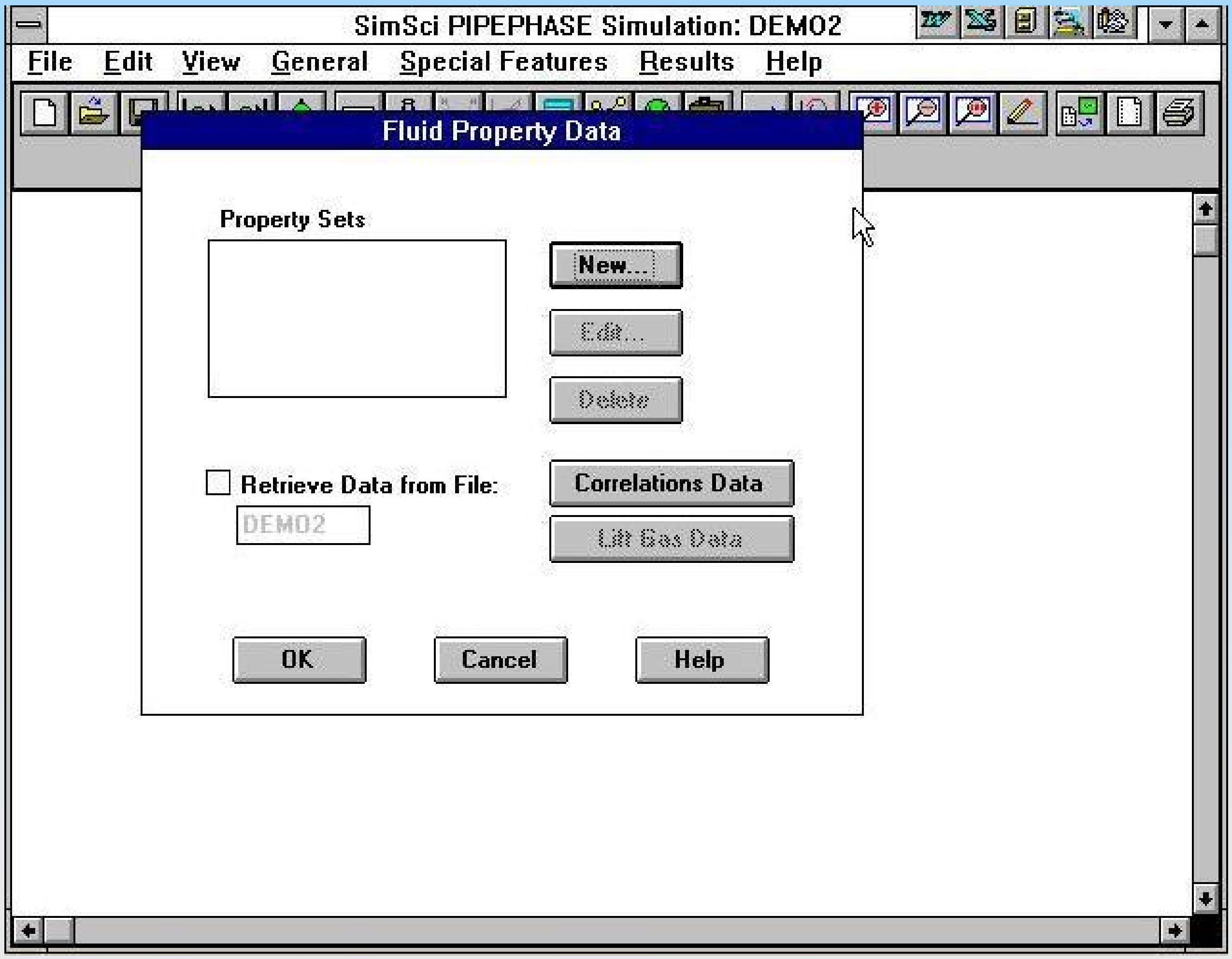
Pipe Length
ft
Water Density
sp gr
Oil Density
API
Gas Density
sp gr
Power
hp
Duty
MM Btu/hr
Viscosity
cP
Velocity
mi/hr
OK
Cancel
Help
PIPEHASE has flexibility in the units of measure that data can be entered.

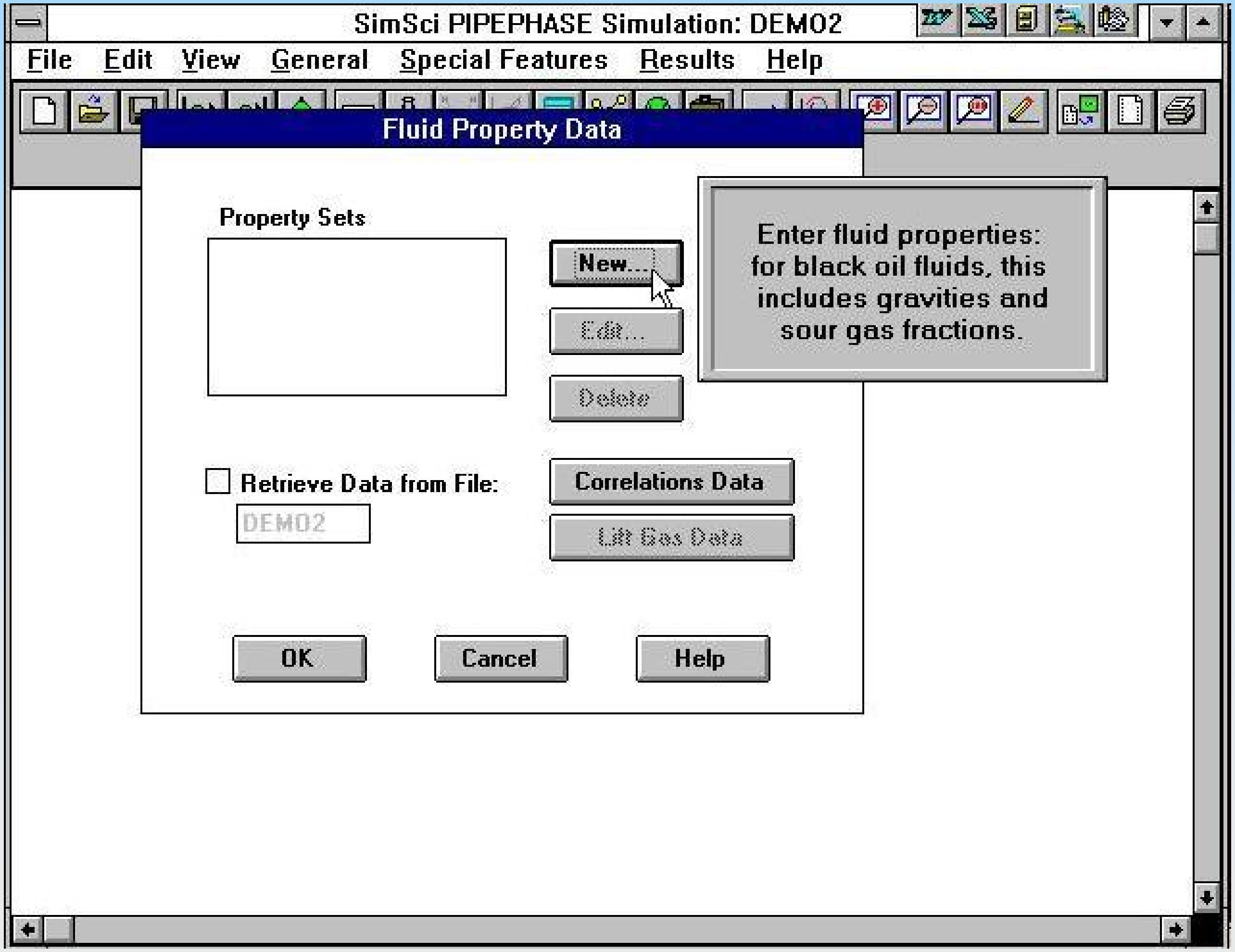

SimSci PIPEPHASE Simulation: DEMO2
Input Dimensions
System
Petroleum
Petroleum
English
Metric
SI
Temperature
Pressure
Molar Rate
lb-mol/hr
Weight Rate
lb/hr
Liquid Volume Rate
bbl/day
Gas Volume Rate
MM ft3/day
Default Basis
Liquid Volume
Conductivity
Btu/hr-ft-F
Heat Transfer Coefficient
Btu/hr-ft2-F
Fine Length
in
Coarse Length
ft
Pipe Length
ft
Water Density
sp gr
Oil Density
API
Gas Density
sp gr
Power
hp
Duty
MM Btu/hr
Viscosity
cP
Velocity
mi/hr
OK
Cancel
Help
PIPEHASE has flexibility in the units of measure that data can be entered.

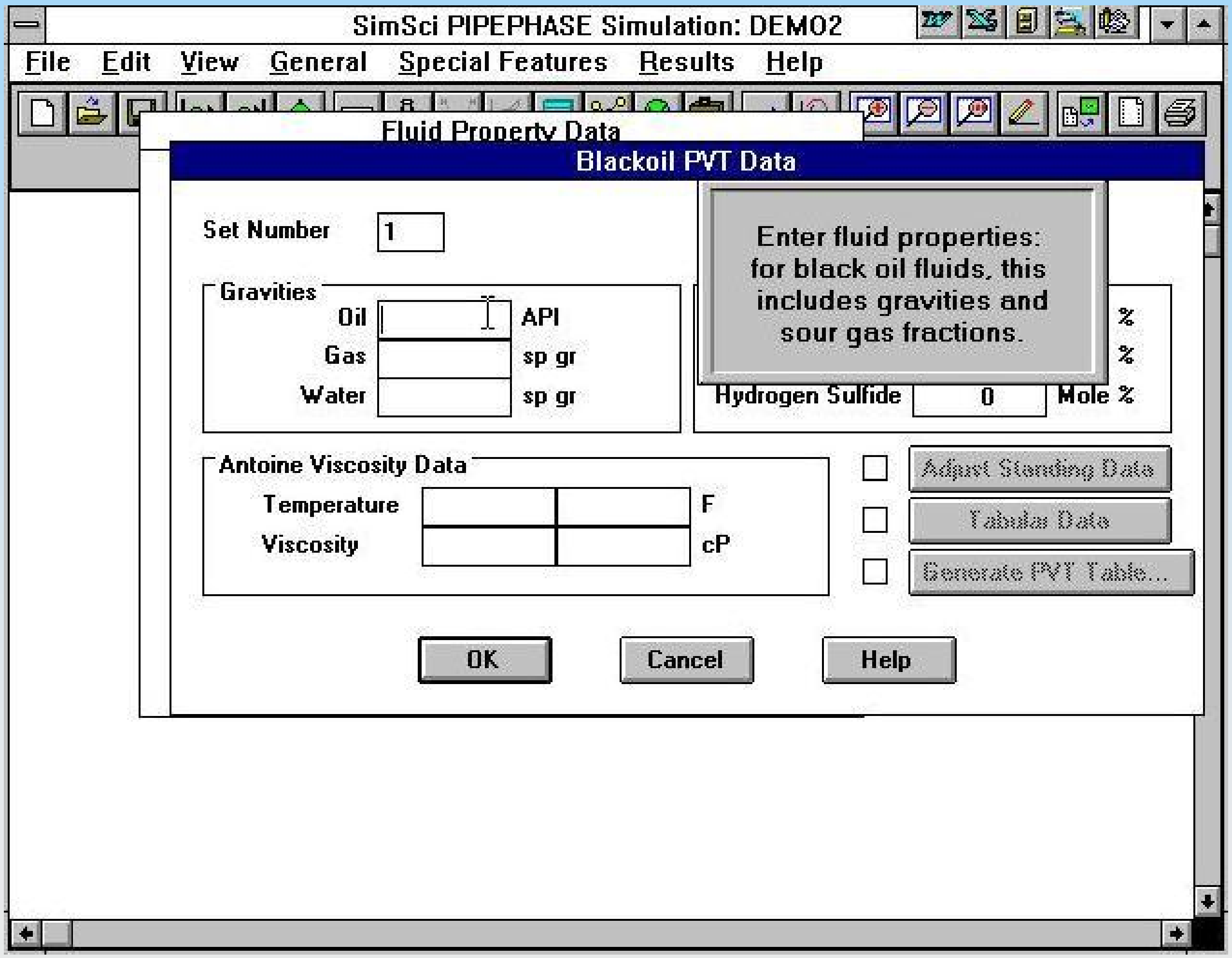

SimSci PIPEPHASE Simulation: DEMO2
Input Dimensions
System
Petroleum
Temperature
F
Pressure
psig
Molar Rate
lb-mol/hr
Weight Rate
lb/hr
Liquid Volume Rate
bbl/day
Gas Volume Rate
MM ft3/day
Default Basis
Liquid Volume
Conductivity
Btu/hr-ft-F
Heat Transfer Coefficient
Btu/hr-ft2-F
Fine Length
in
Coarse Length
ft
Pipe Length
ft
Water Density
sp gr
Oil Density
API
lb/ft3
kg/m3
API
sp gr
Gas Density
Power
Duty
MM Btu/hr
Viscosity
cP
Velocity
mi/hr
OK
Cancel
Help
PIPEHASE has flexibility in the units of measure that data can be entered.

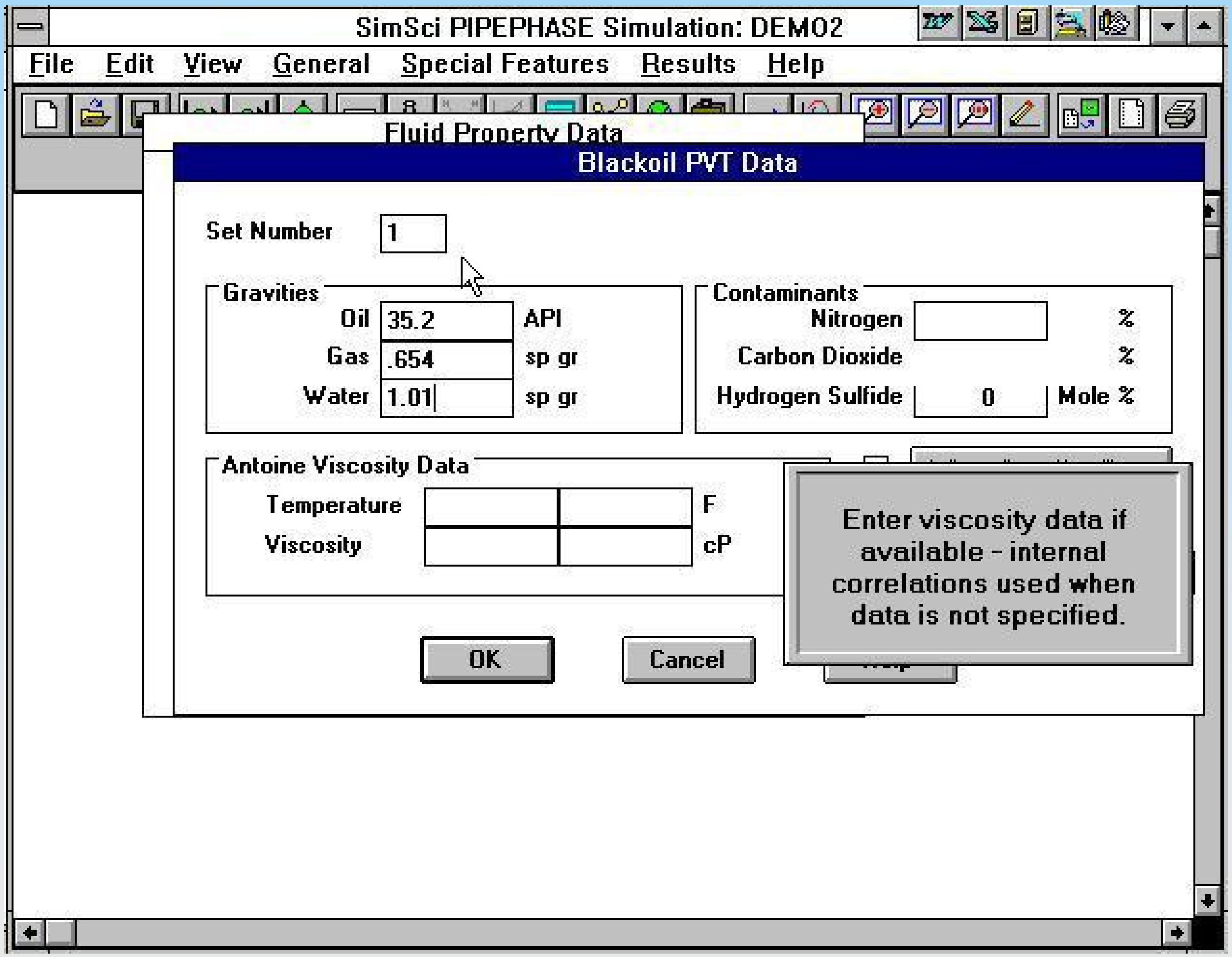

SimSci PIPEPHASE Simulation: DEMO2
Input Dimensions
System
Petroleum
Temperature
F
Pressure
psig
Molar Rate
lb-mol/hr
Weight Rate
lb/hr
Liquid Volume Rate
bbl/day
Gas Volume Rate
MM ft3/day
Default Basis
Liquid Volume
Conductivity
Btu/hr-ft-F
Heat Transfer Coefficient
Btu/hr-ft2-F
Fine Length
in
Coarse Length
ft
Pipe Length
ft
Water Density
sp gr
Oil Density
API
Gas Density
sp gr
Power
hp
Duty
MM Btu/hr
Viscosity
cP
Velocity
mi/hr
OK
Cancel
Help
PIPEPHASE will warn users of any changes of Global Defaults.

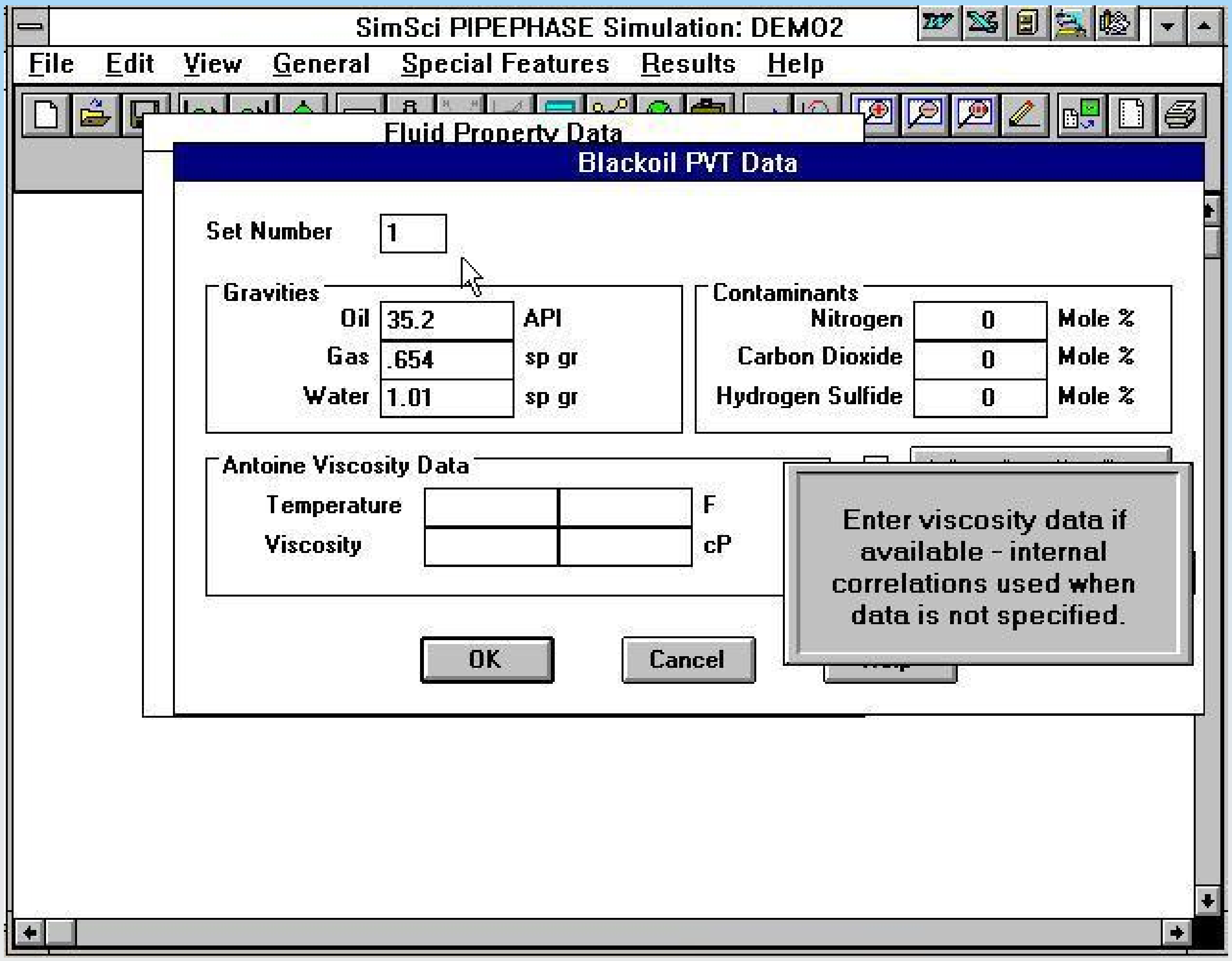

SimSci PIPEPHASE Simulation: DEMO2
Input Dimensions
System
Temperature
Pressure
Molar Rate
Weight Rate
Liquid Volume Rate
bbl/day
Gas Volume Rate
MM ft3/day
Default Basis
Liquid Volume
Conductivity
Btu/hr-ft-F
Heat Transfer Coefficient
Btu/hr-ft2-F
sp gr
Power
hp
Duty
MM Btu/hr
Viscosity
cP
Velocity
mi/hr
OK
Cancel
Help
PIPEPHASE
Warning: Any changes will convert the PIPEPHASE defined Global Default, Calculation Method, and Network Method values.
User-defined defaults and other values must be changed manually as needed.
OK
PIPEPHASE will warn users of any changes of Global Defaults.

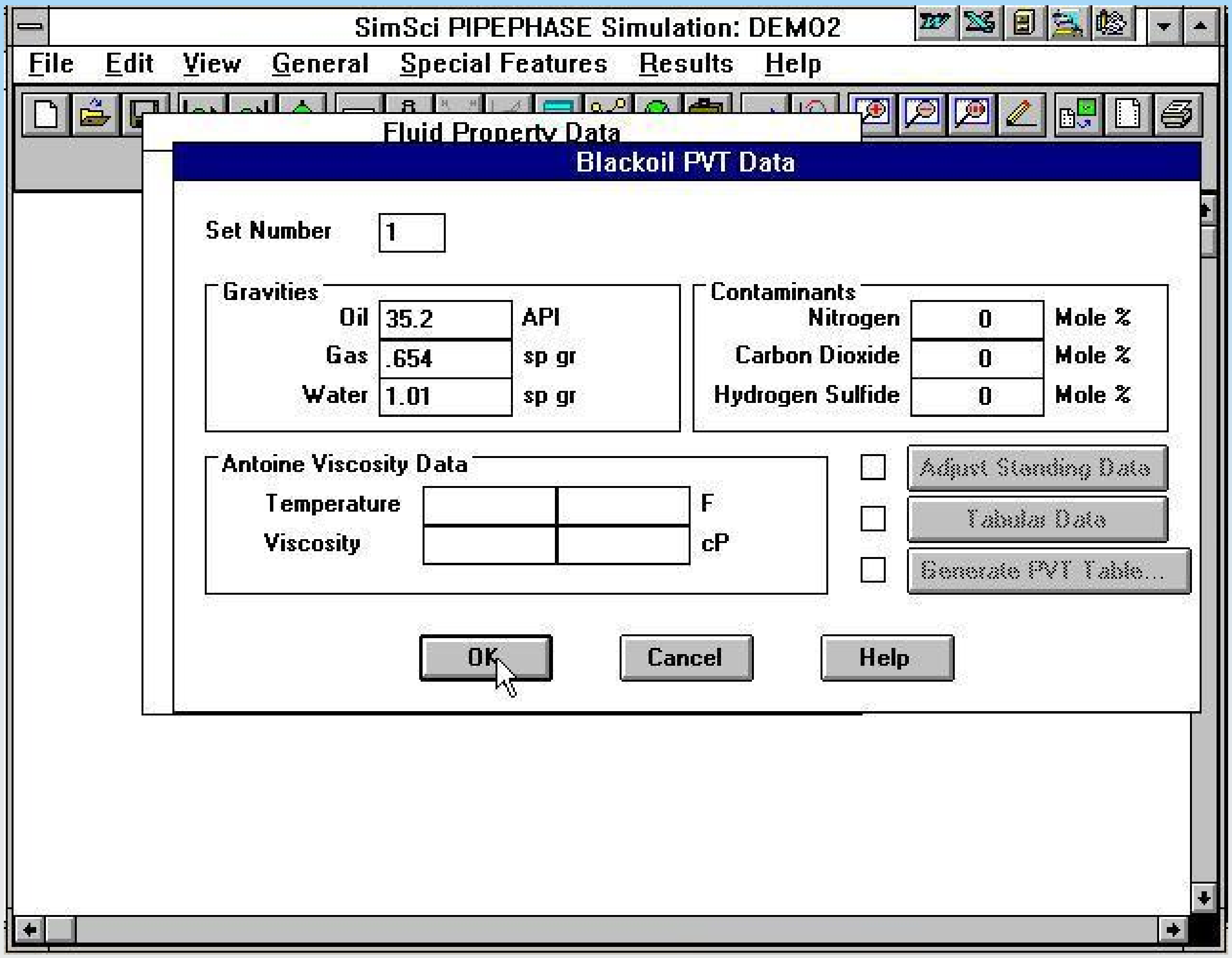

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Property Sets
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help

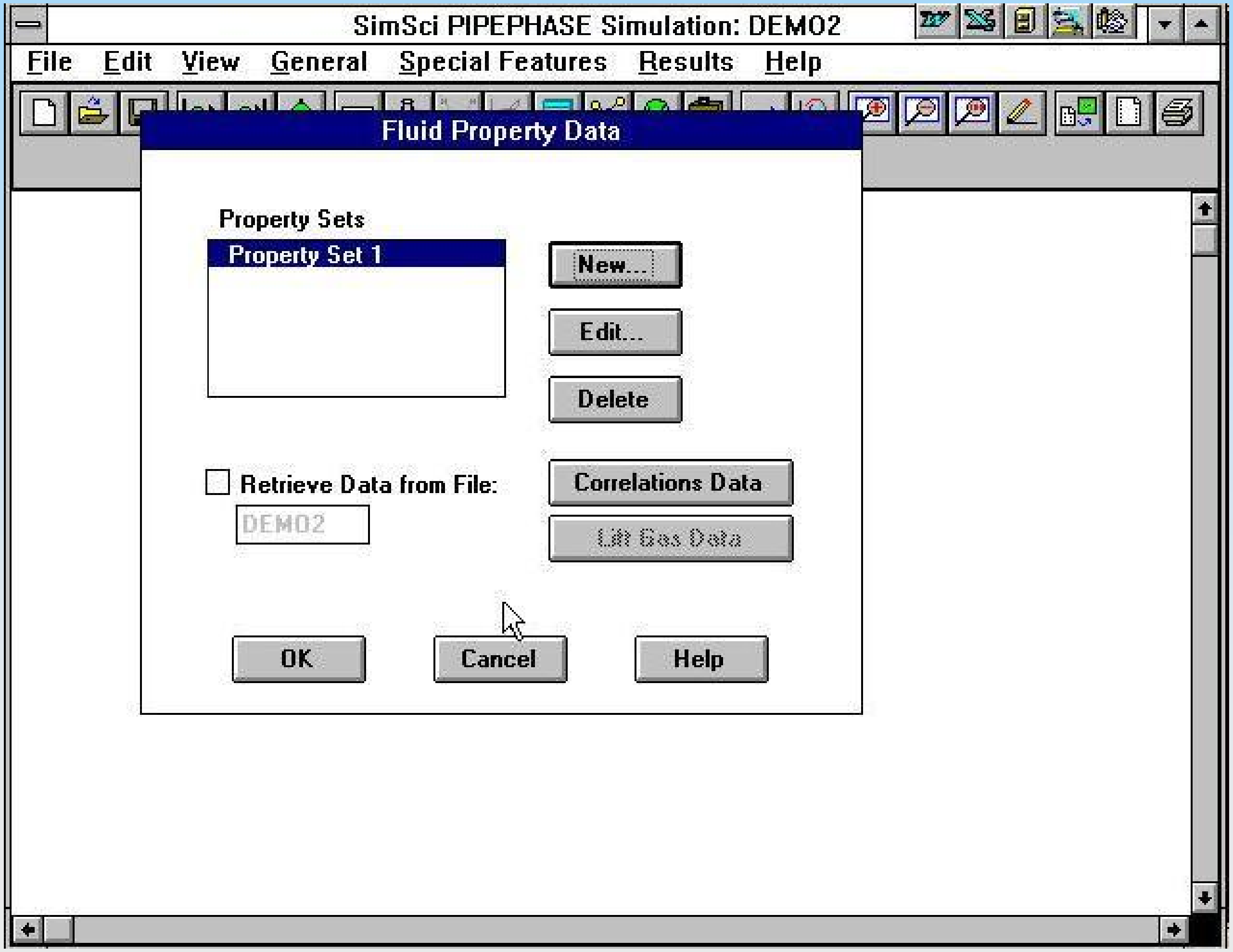

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Fluid Property Data
Property Sets
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help
Enter fluid properties: for black oil fluids, this includes gravities and sour gas fractions.

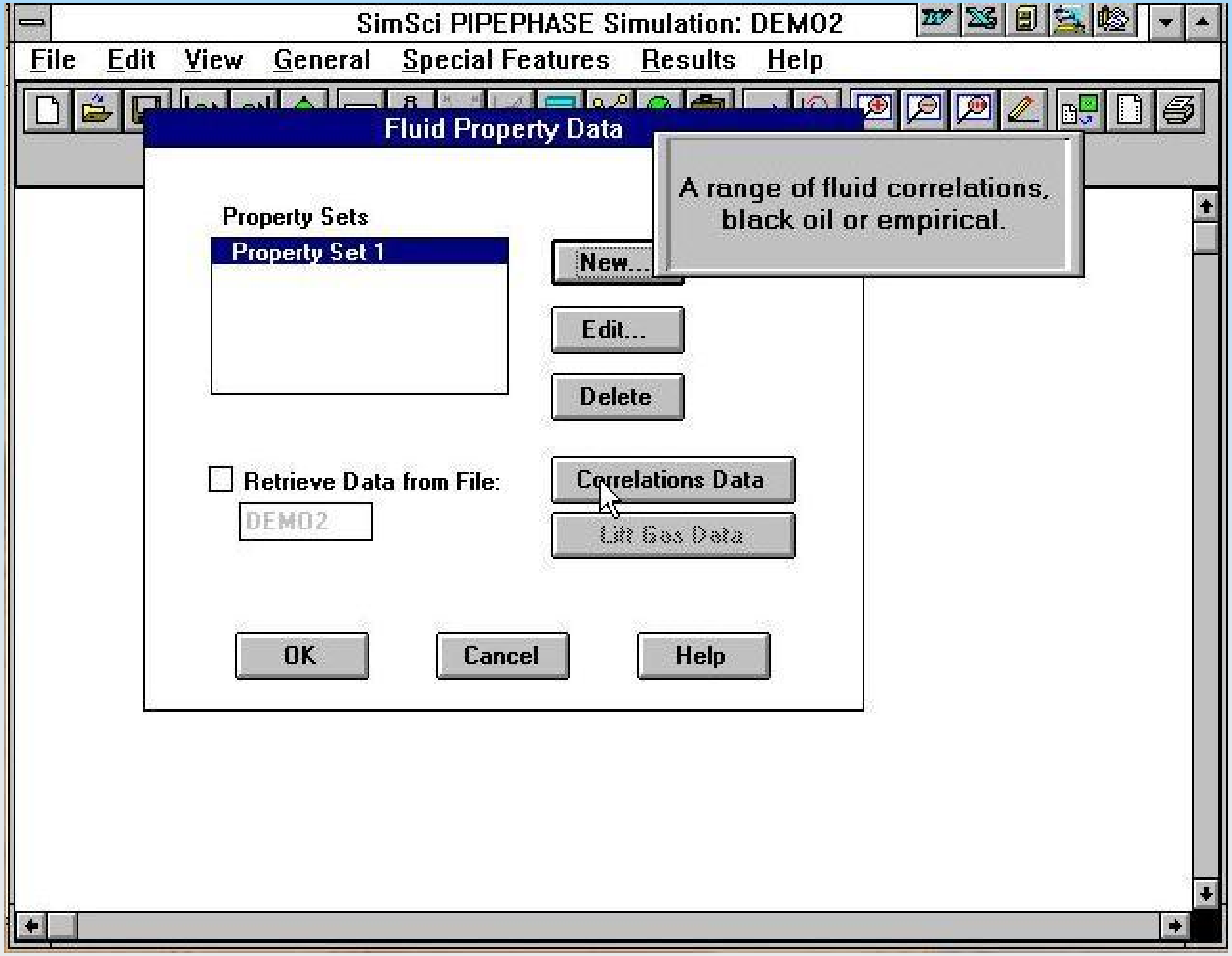

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 1
Gravities
Oil API
Gas sp gr
Water sp gr
Enter fluid properties: for black oil fluids, this includes gravities and sour gas fractions.
%
%
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
Adjust Standing Data
Tabular Data
Generate PVT Table...
OK
Cancel
Help

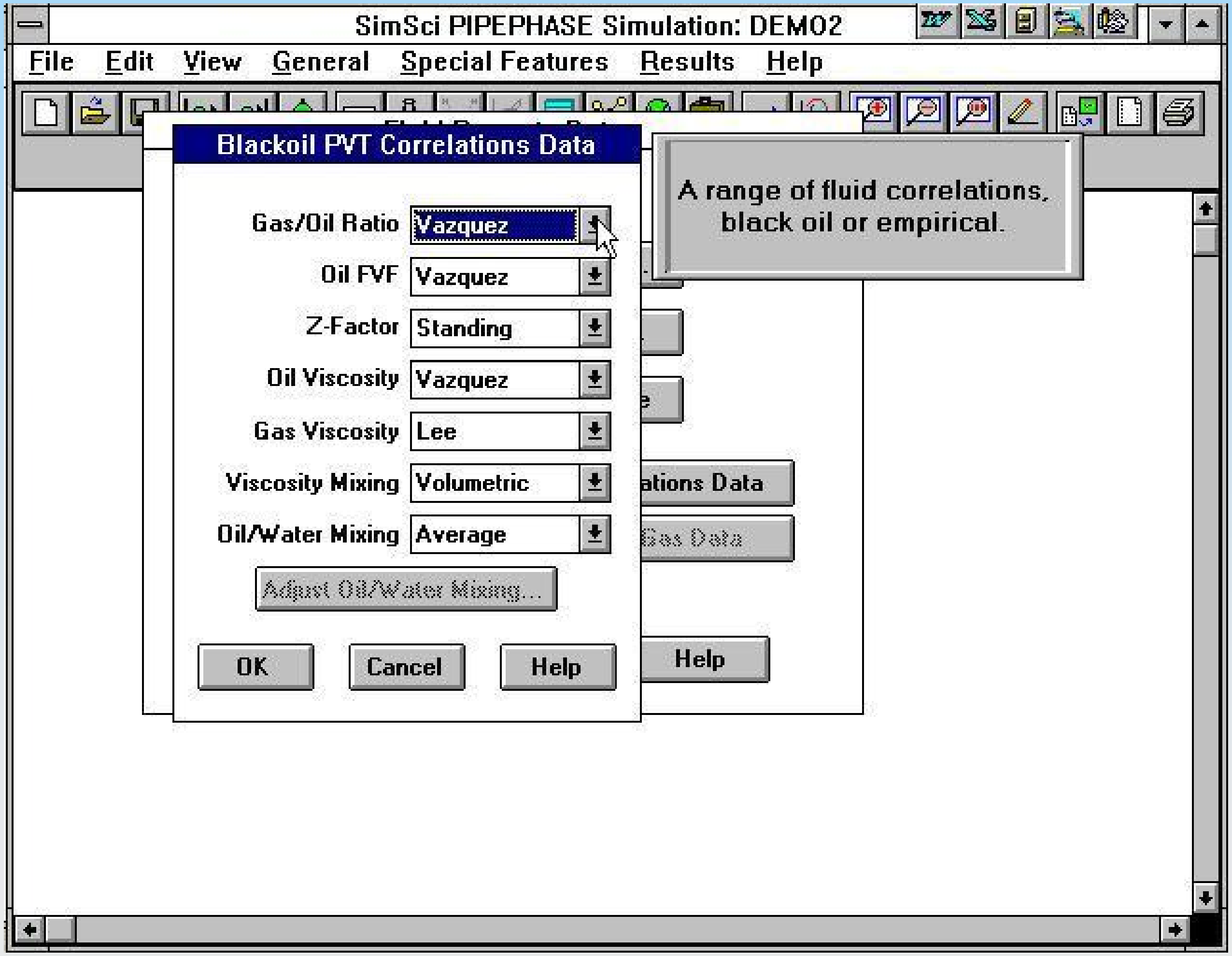

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 1
Gravities
Oil 35.2 API
Gas .654 sp gr
Water 1.01 sp gr
Contaminants
Nitrogen %
Carbon Dioxide %
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
OK
Cancel
Enter viscosity data if available - internal correlations used when data is not specified.

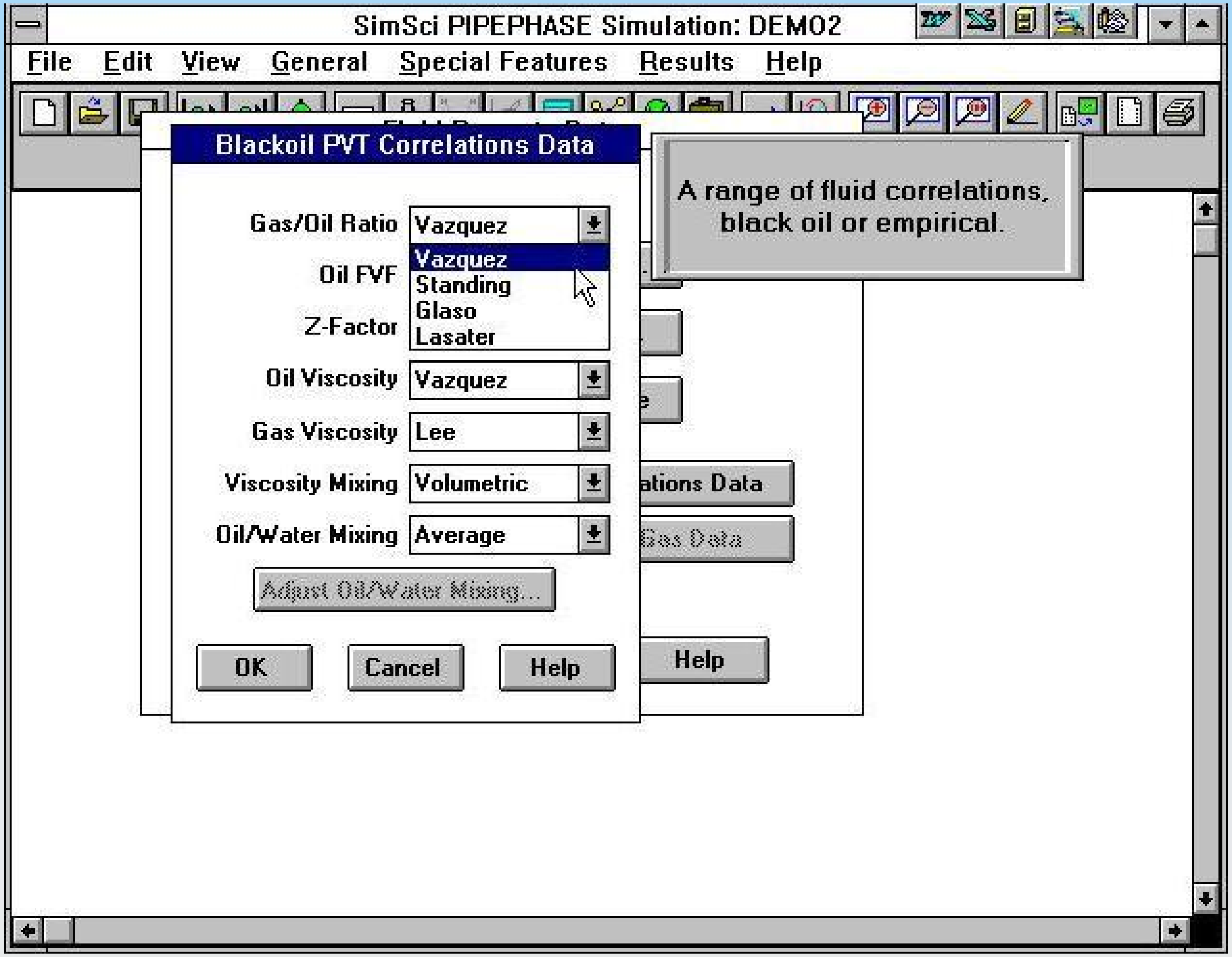

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 1
Gravities
Oil 35.2 API
Gas .654 sp gr
Water 1.01 sp gr
Contaminants
Nitrogen 0 Mole %
Carbon Dioxide 0 Mole %
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
Enter viscosity data if available - internal correlations used when data is not specified.
OK
Cancel

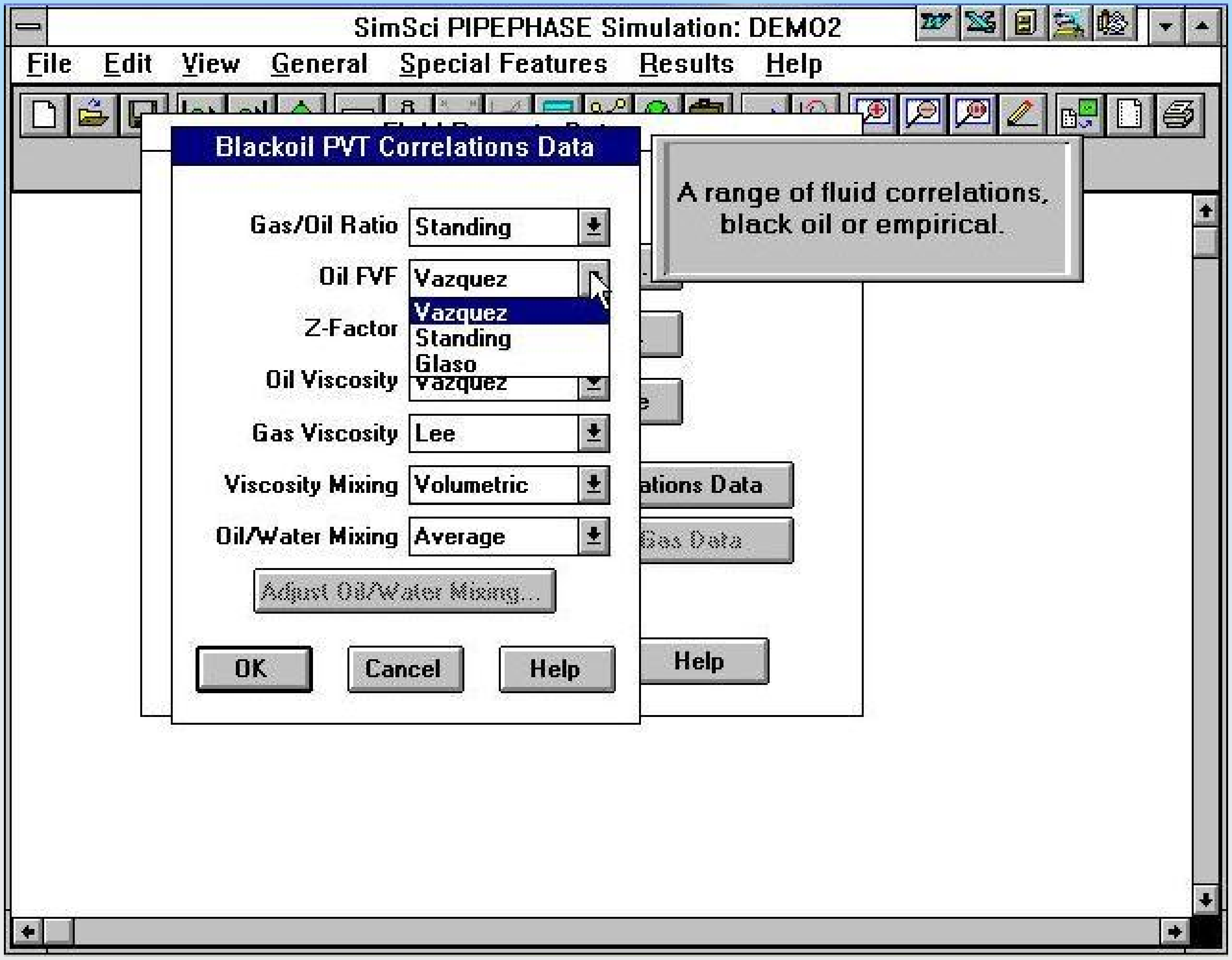

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 1
Gravities
Oil 35.2 API
Gas .654 sp gr
Water 1.01 sp gr
Contaminants
Nitrogen 0 Mole %
Carbon Dioxide 0 Mole %
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
Adjust Standing Data
Tabular Data
Generate PVT Table...
OK
Cancel
Help

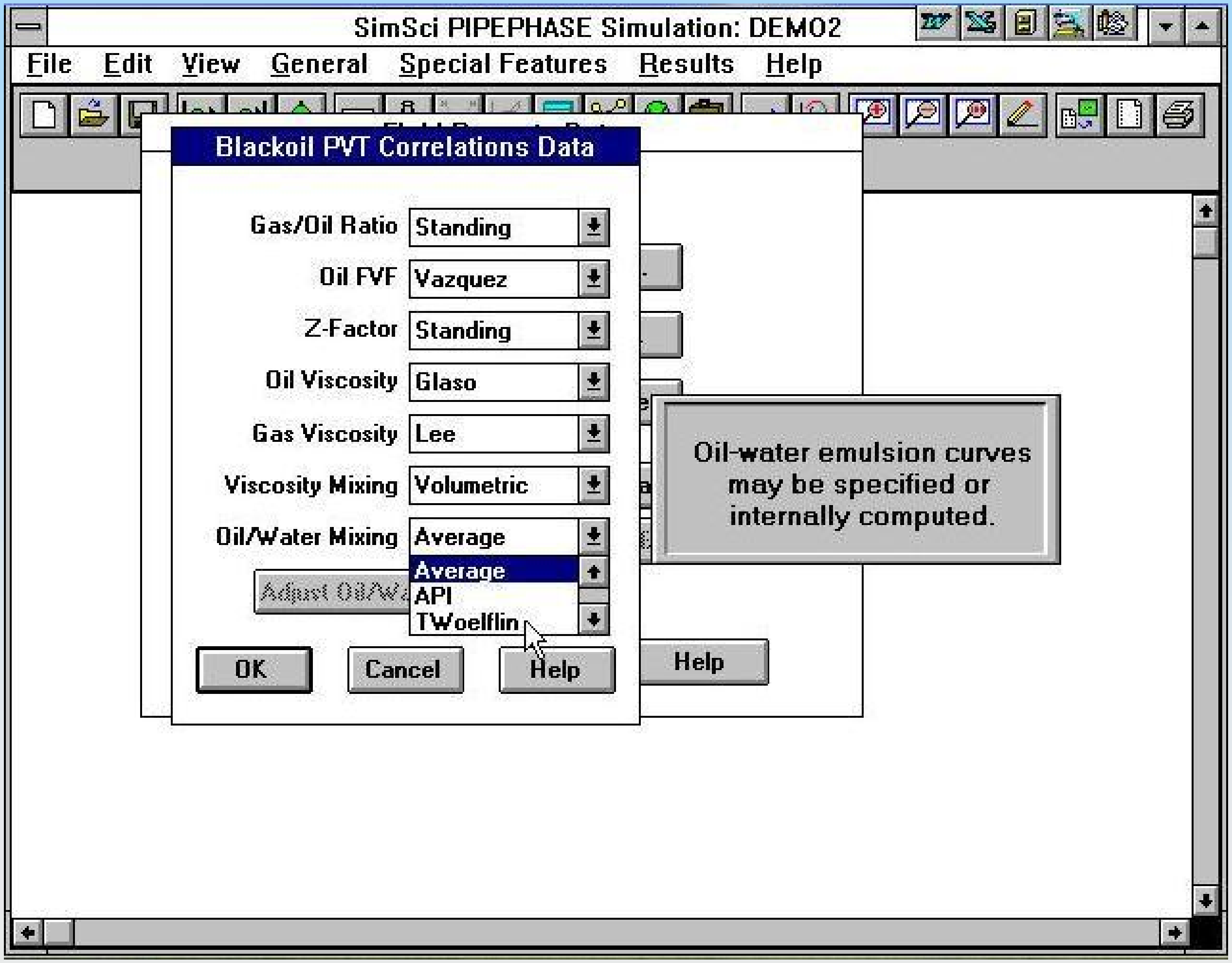

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Property Sets
Property Set 1
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help

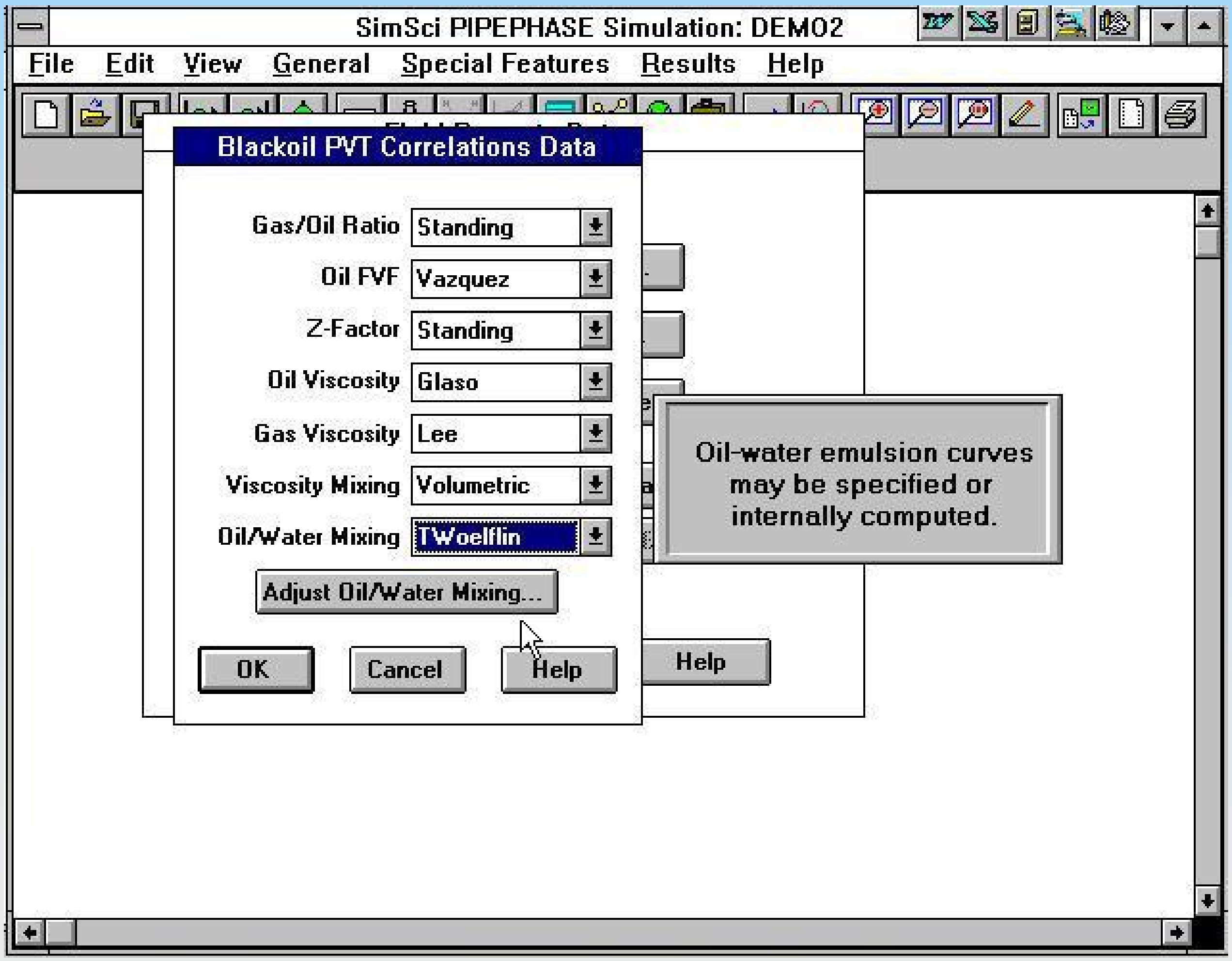

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Property Sets
Property Set 1
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help
A range of fluid correlations, black oil or empirical.

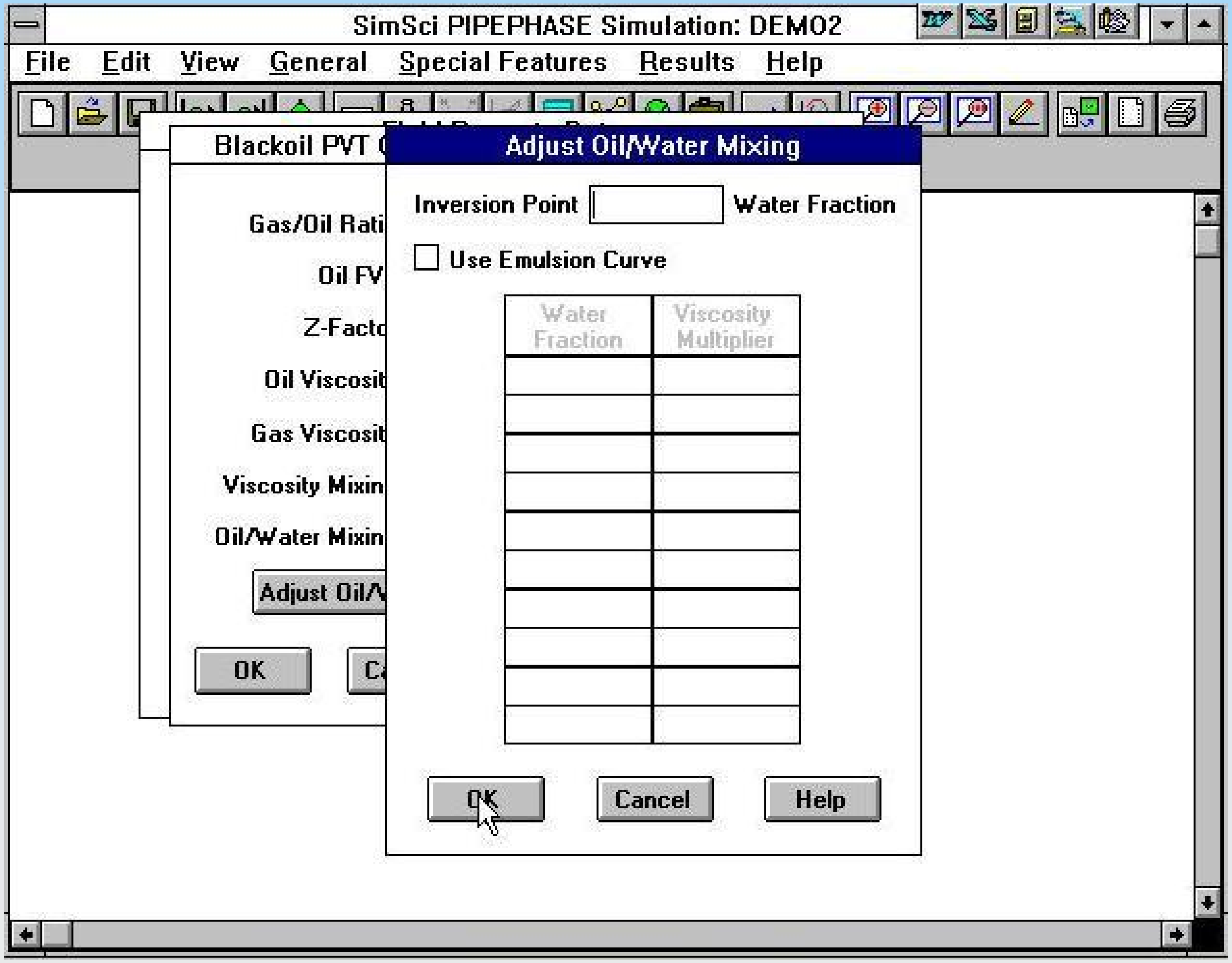

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT Correlations Data
Gas/Oil Ratio Vazquez
Oil FVF Vazquez
Z-Factor Standing
Oil Viscosity Vazquez
Gas Viscosity Lee
Viscosity Mixing Volumetric
Oil/Water Mixing Average
Adjust Oil/Water Mixing...
OK
Cancel
Help
A range of fluid correlations, black oil or empirical.

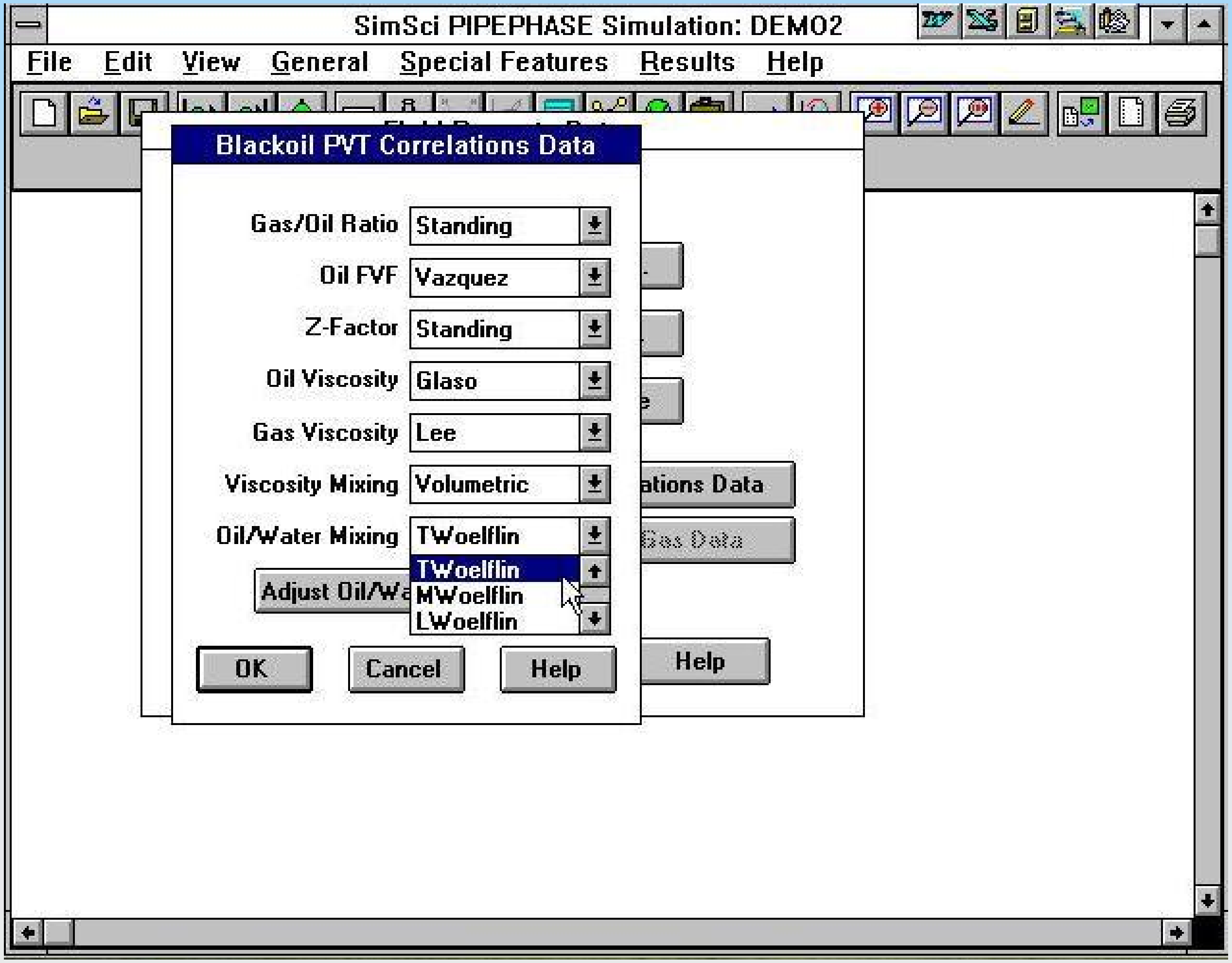

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT Correlations Data
Gas/Oil Ratio Vazquez
Vazquez
Standing
Glaso
Lasater
Oil FVF
Z-Factor
Oil Viscosity Vazquez
Gas Viscosity Lee
Viscosity Mixing Volumetric
Oil/Water Mixing Average
Adjust Oil/Water Mixing...
OK
Cancel
Help
A range of fluid correlations, black oil or empirical.

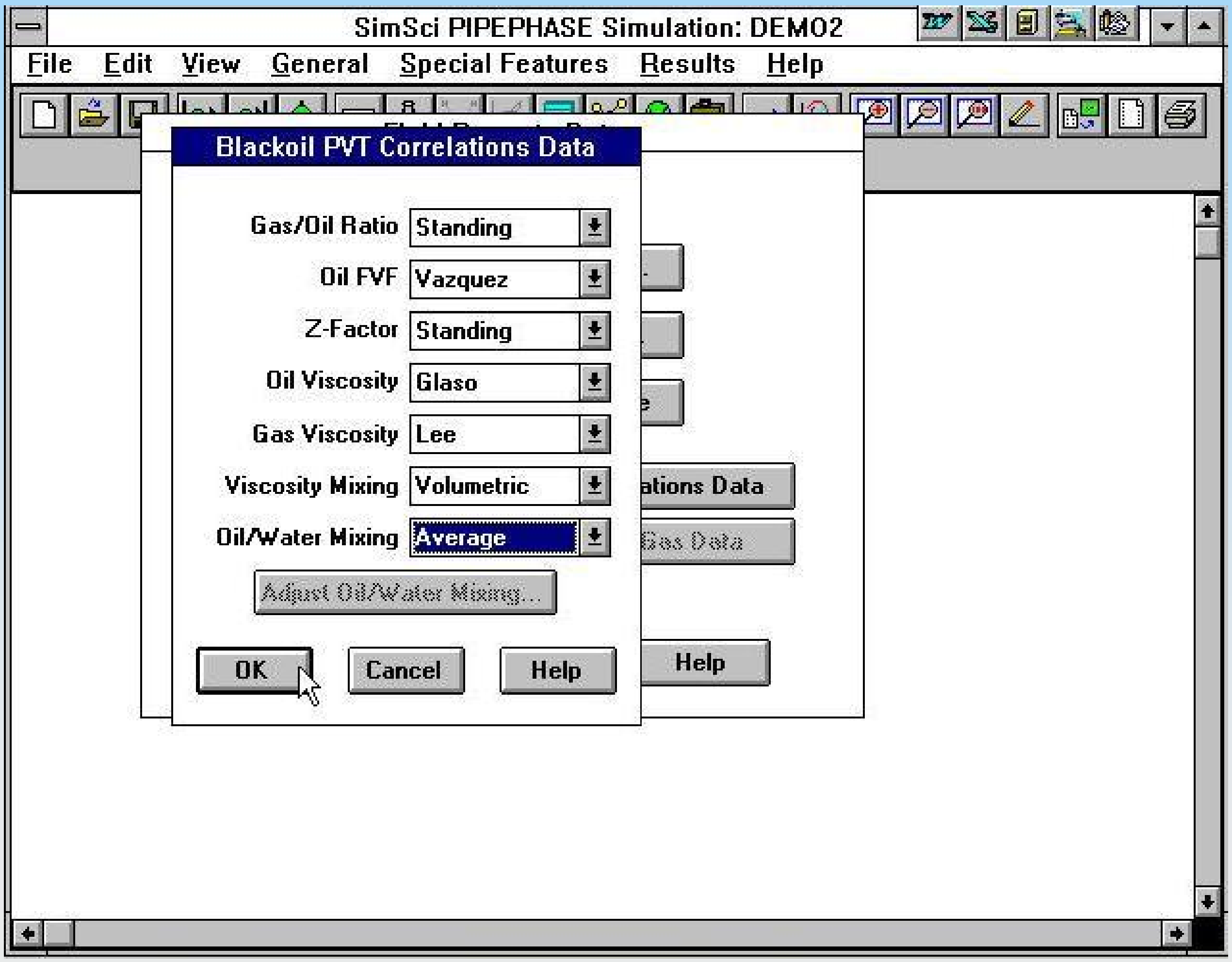

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT Correlations Data
Gas/Oil Ratio Standing
Oil FVF Vazquez
Vazquez
Standing
Glaso
Z-Factor
Oil Viscosity
Gas Viscosity Lee
Viscosity Mixing Volumetric
Oil/Water Mixing Average
Adjust Oil/Water Mixing...
OK
Cancel
Help
A range of fluid correlations, black oil or empirical.

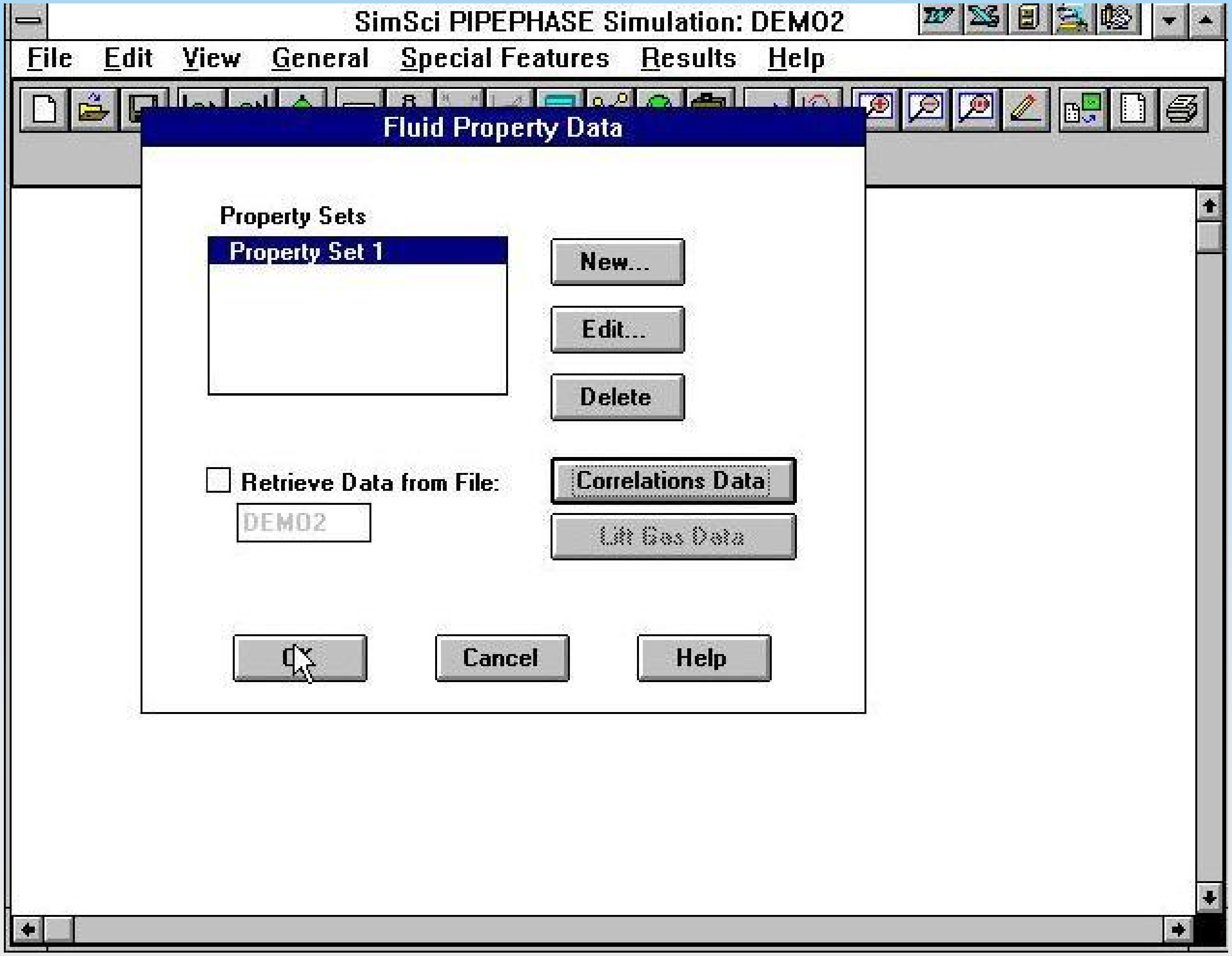

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT Correlations Data
Gas/Oil Ratio Standing
Oil FVF Vazquez
Z-Factor Standing
Oil Viscosity Glaso
Gas Viscosity Lee
Viscosity Mixing Volumetric
Oil/Water Mixing Average
Average
API
TWoelflin
OK
Cancel
Help
Help
Oil-water emulsion curves may be specified or internally computed.

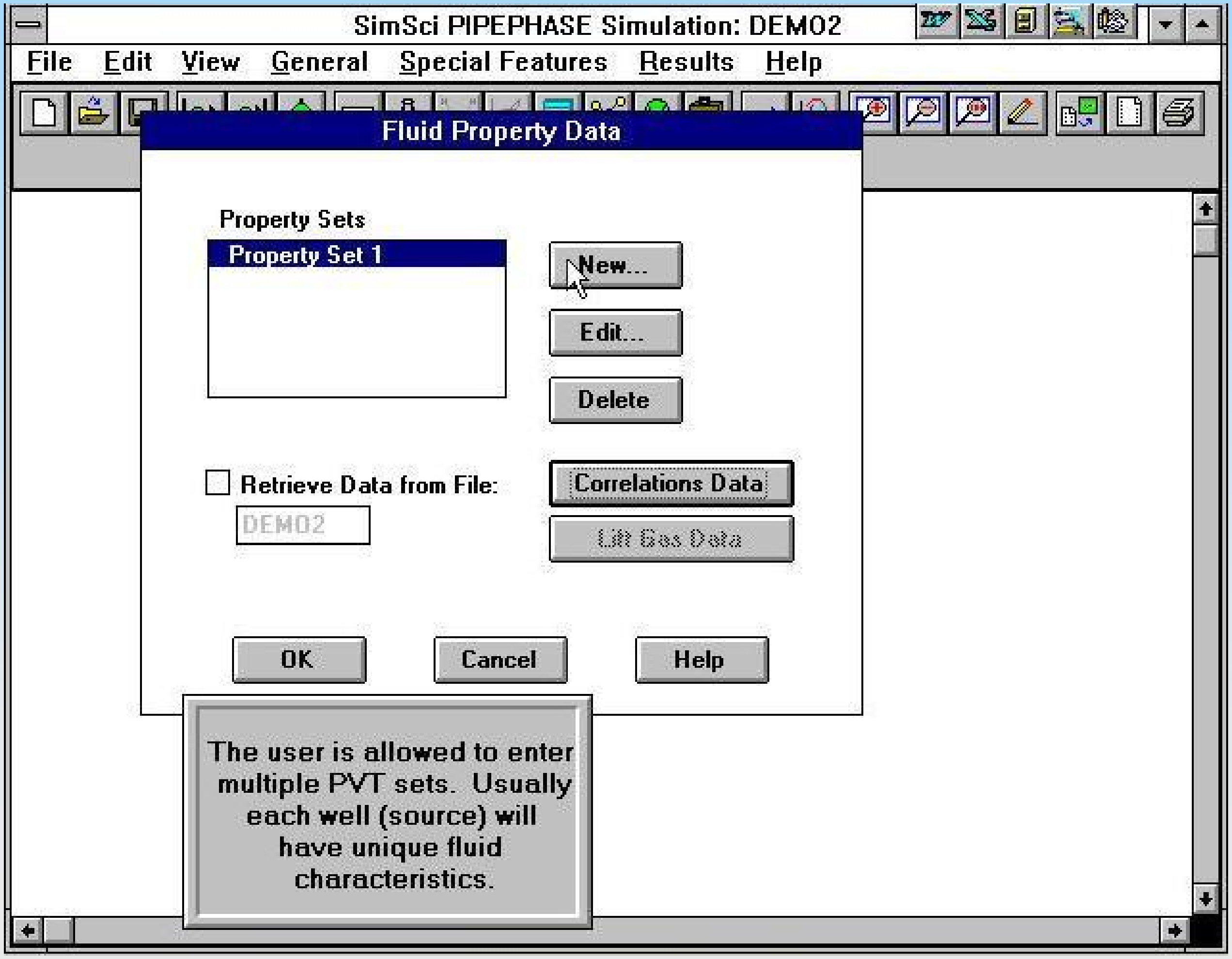

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Blackoil PVT Correlations Data
Gas/Oil Ratio
Standing
Oil FVF
Vazquez
Z-Factor
Standing
Oil Viscosity
Glaso
Gas Viscosity
Lee
Viscosity Mixing
Volumetric
Oil/Water Mixing
TWoelflin
Adjust Oil/Water Mixing...
OK
Cancel
Help
Help
Oil-water emulsion curves may be specified or internally computed.

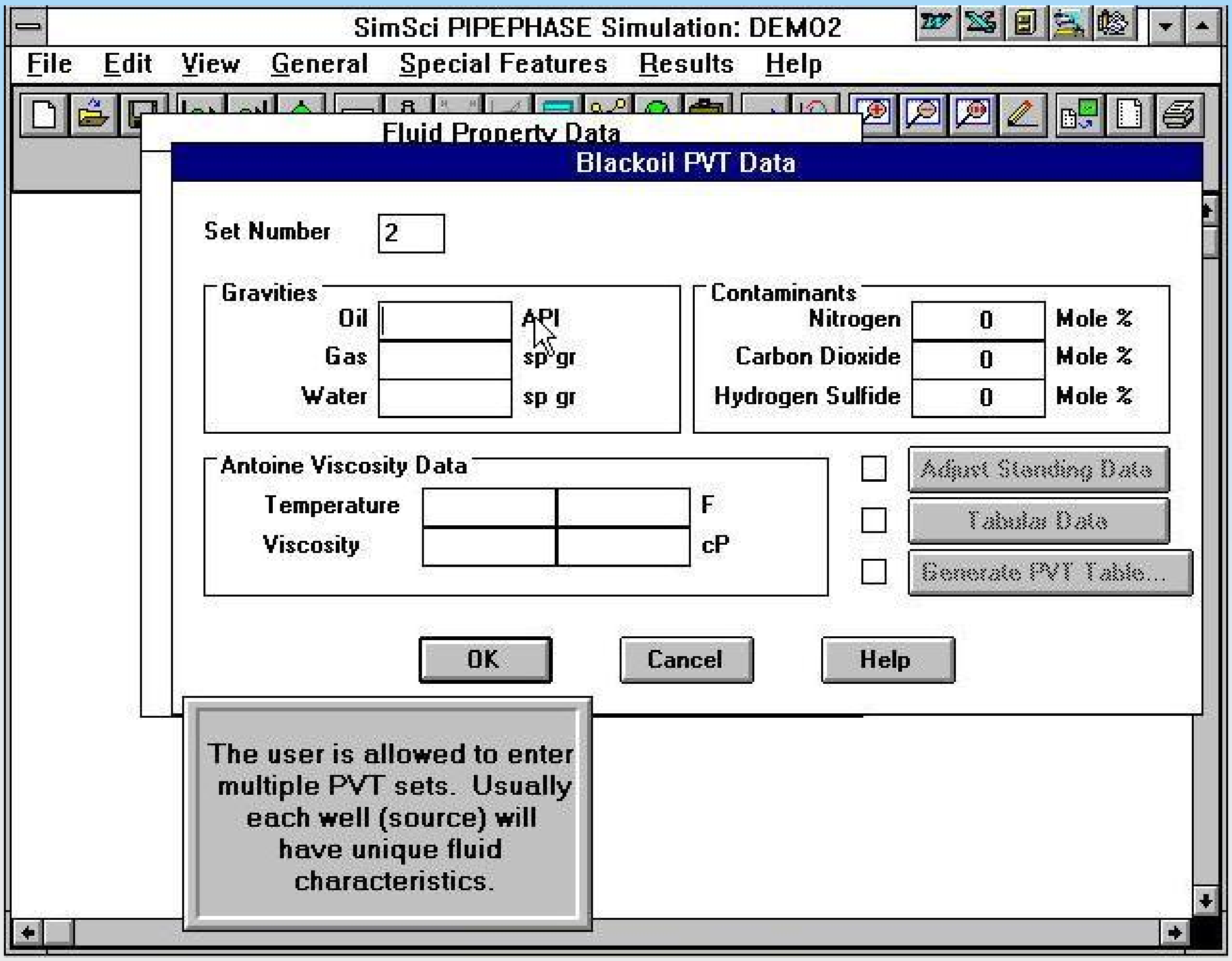

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT
Gas/Oil Rati
Oil FV
Z-Facto
Oil Viscosit
Gas Viscosit
Viscosity Mixin
Oil/Water Mixin
Adjust Oil/V
OK
Adjust Oil/Water Mixing
Inversion Point
Water Fraction
Use Emulsion Curve
Water Fraction
Viscosity Multiplier
OK
Cancel
Help

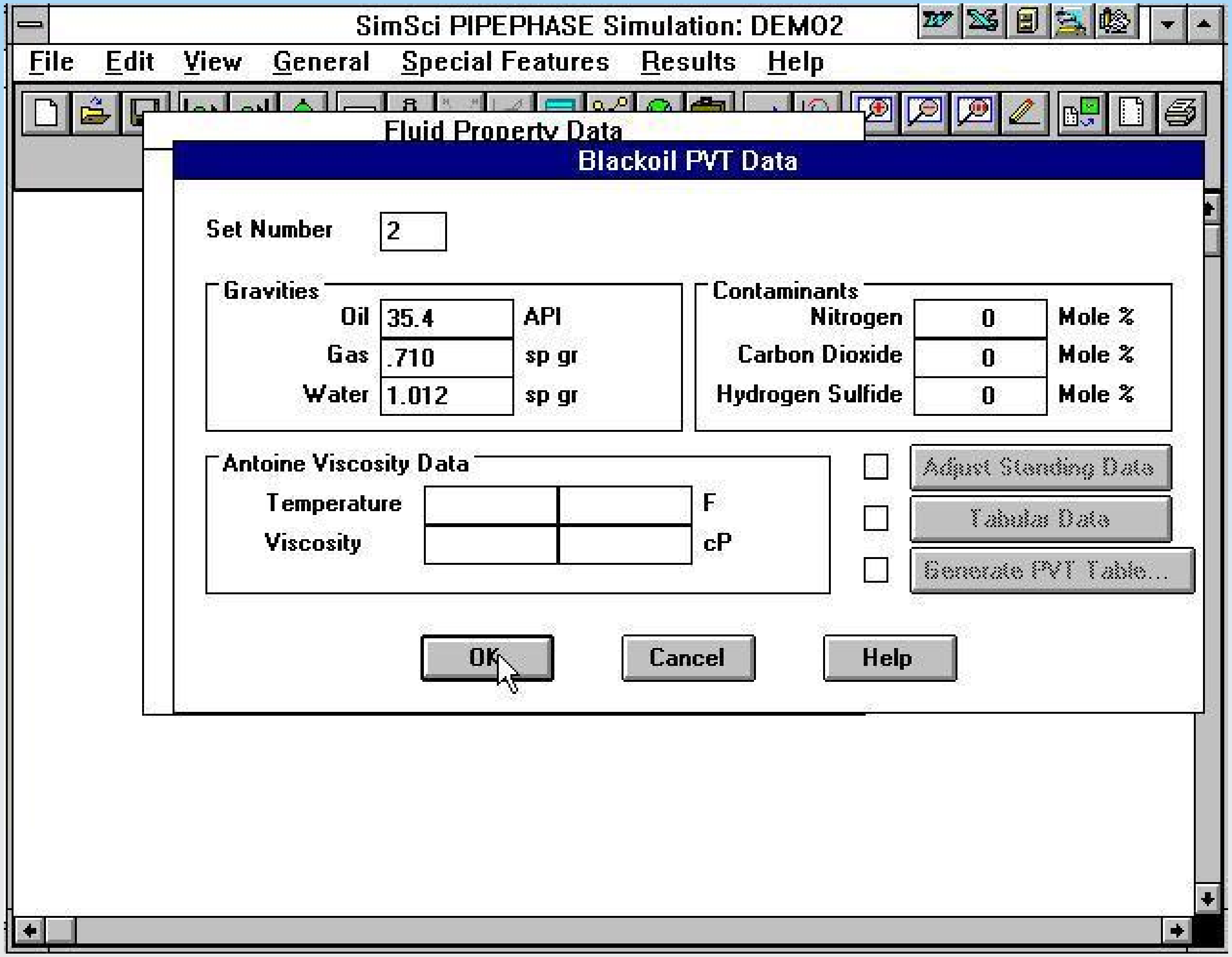

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Blackoil PVT Correlations Data
Gas/Oil Ratio
Standing
Oil FVF
Vazquez
Z-Factor
Standing
Oil Viscosity
Glaso
Gas Viscosity
Lee
Viscosity Mixing
Volumetric
Oil/Water Mixing
TWoelflin
TWoelflin
MWoelflin
LWoelflin
Adjust Oil/Wa
OK
Cancel
Help
ations Data
Gas Data
Help


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Blackoil PVT Correlations Data
Gas/Oil Ratio Standing
Oil FVF Vazquez
Z-Factor Standing
Oil Viscosity Glaso
Gas Viscosity Lee
Viscosity Mixing Volumetric
Oil/Water Mixing Average
Adjust Oil/Water Mixing...
OK
Cancel
Help

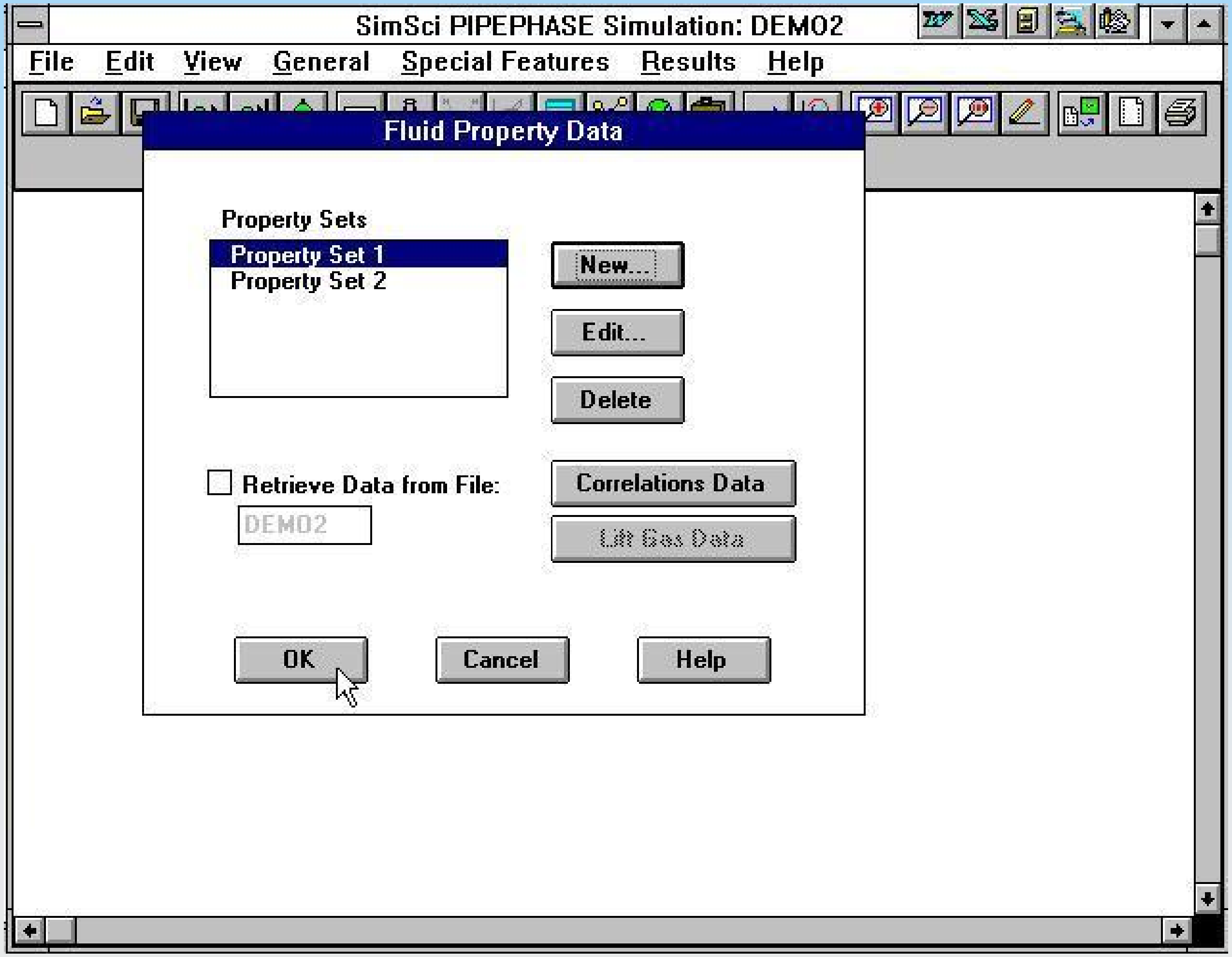

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Property Sets
Property Set 1
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help

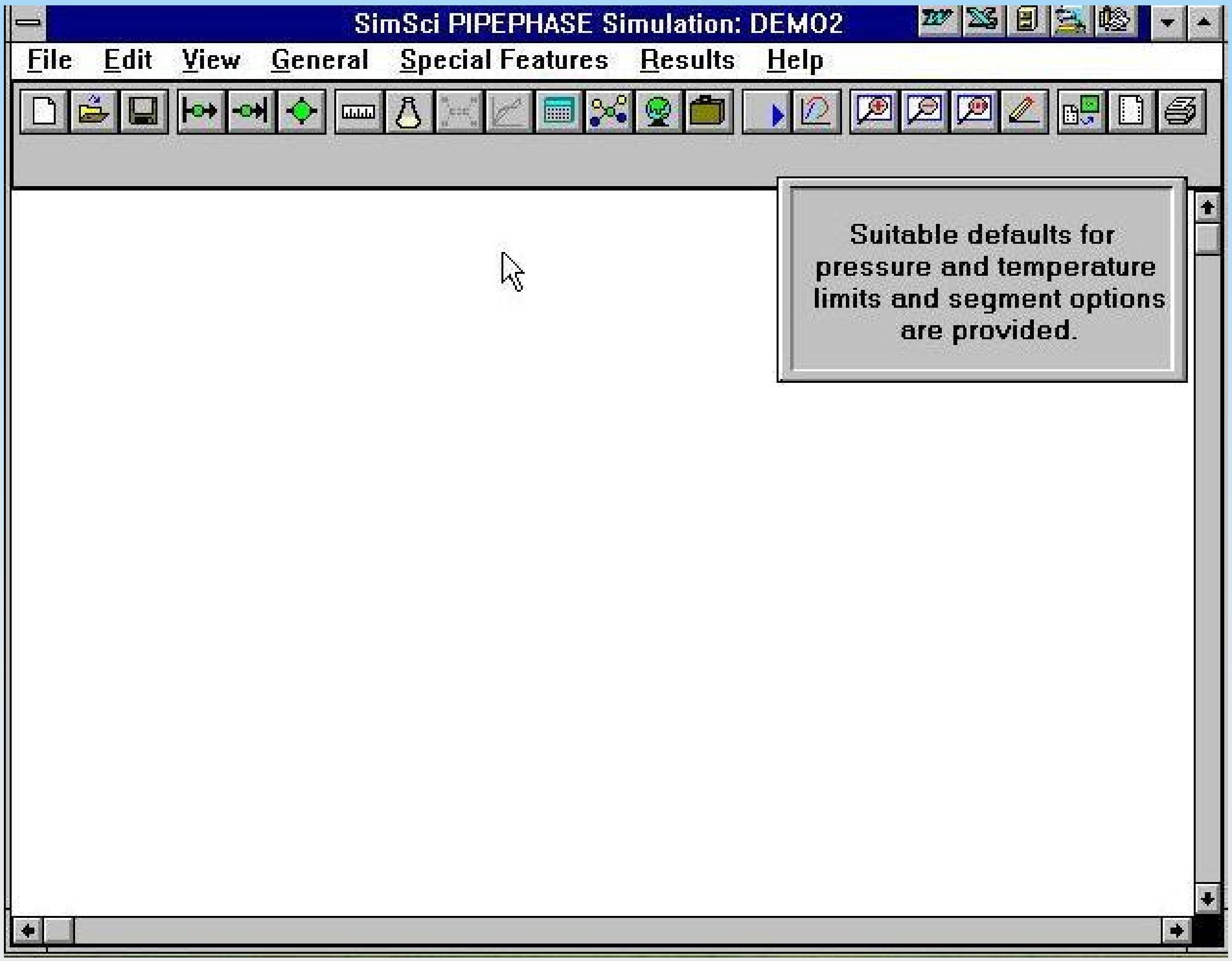

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Property Sets
Property Set 1
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help
The user is allowed to enter multiple PVT sets. Usually each well (source) will have unique fluid characteristics.

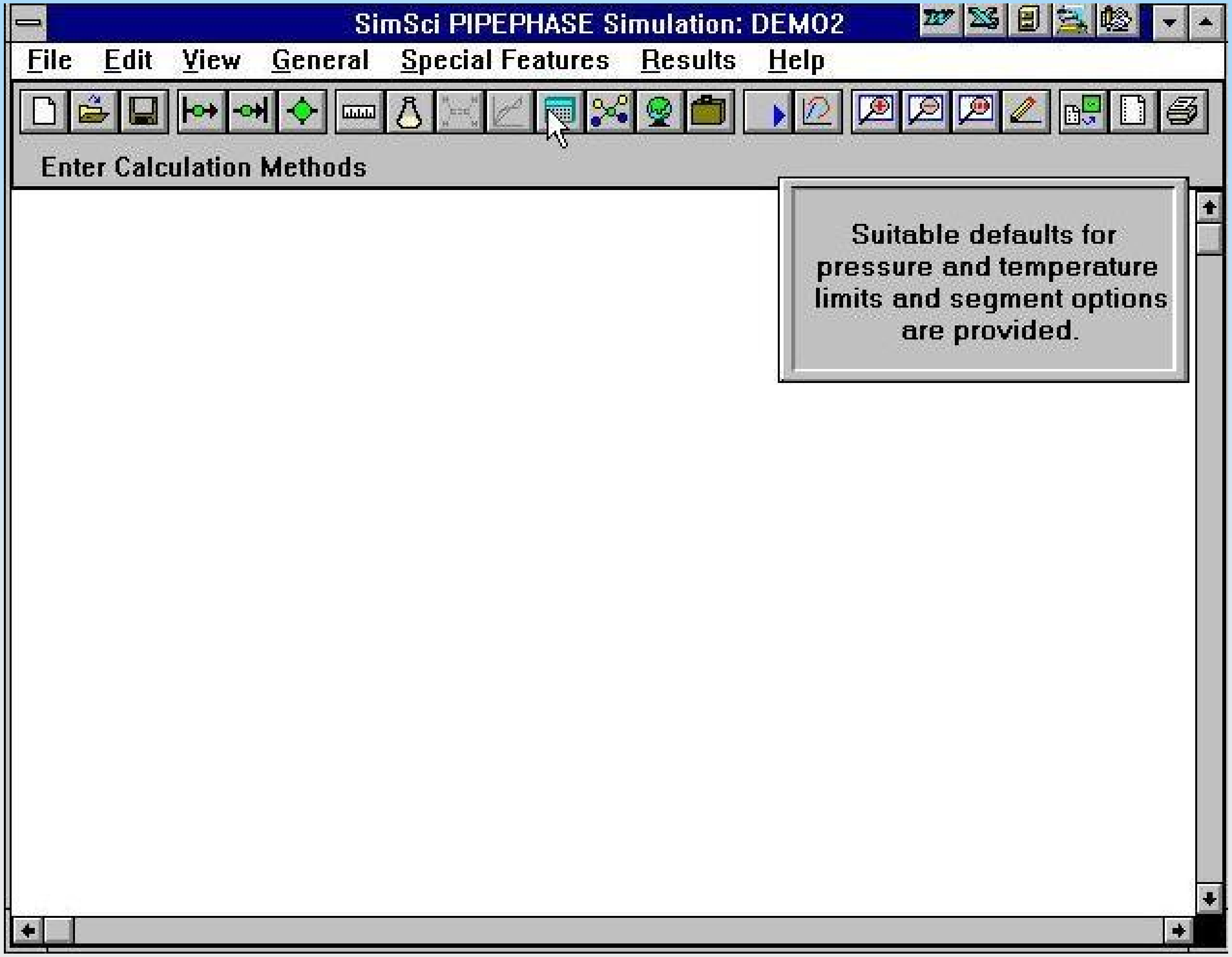

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 2
Gravities
Oil API
Gas sp gr
Water sp gr
Contaminants
Nitrogen 0 Mole %
Carbon Dioxide 0 Mole %
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
Adjust Standing Data
Tabular Data
Generate PVT Table...
OK
Cancel
Help
The user is allowed to enter multiple PVT sets. Usually each well (source) will have unique fluid characteristics.

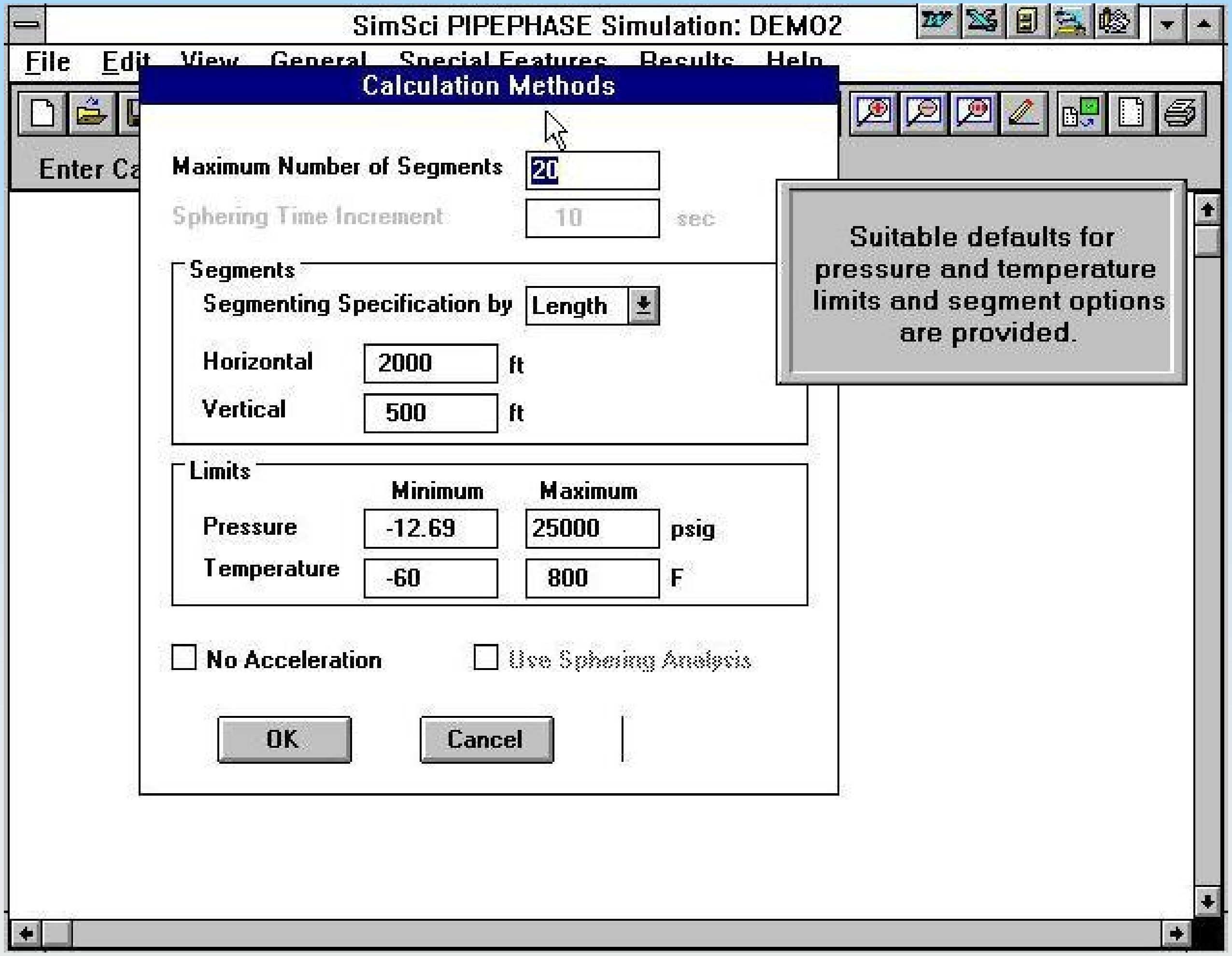


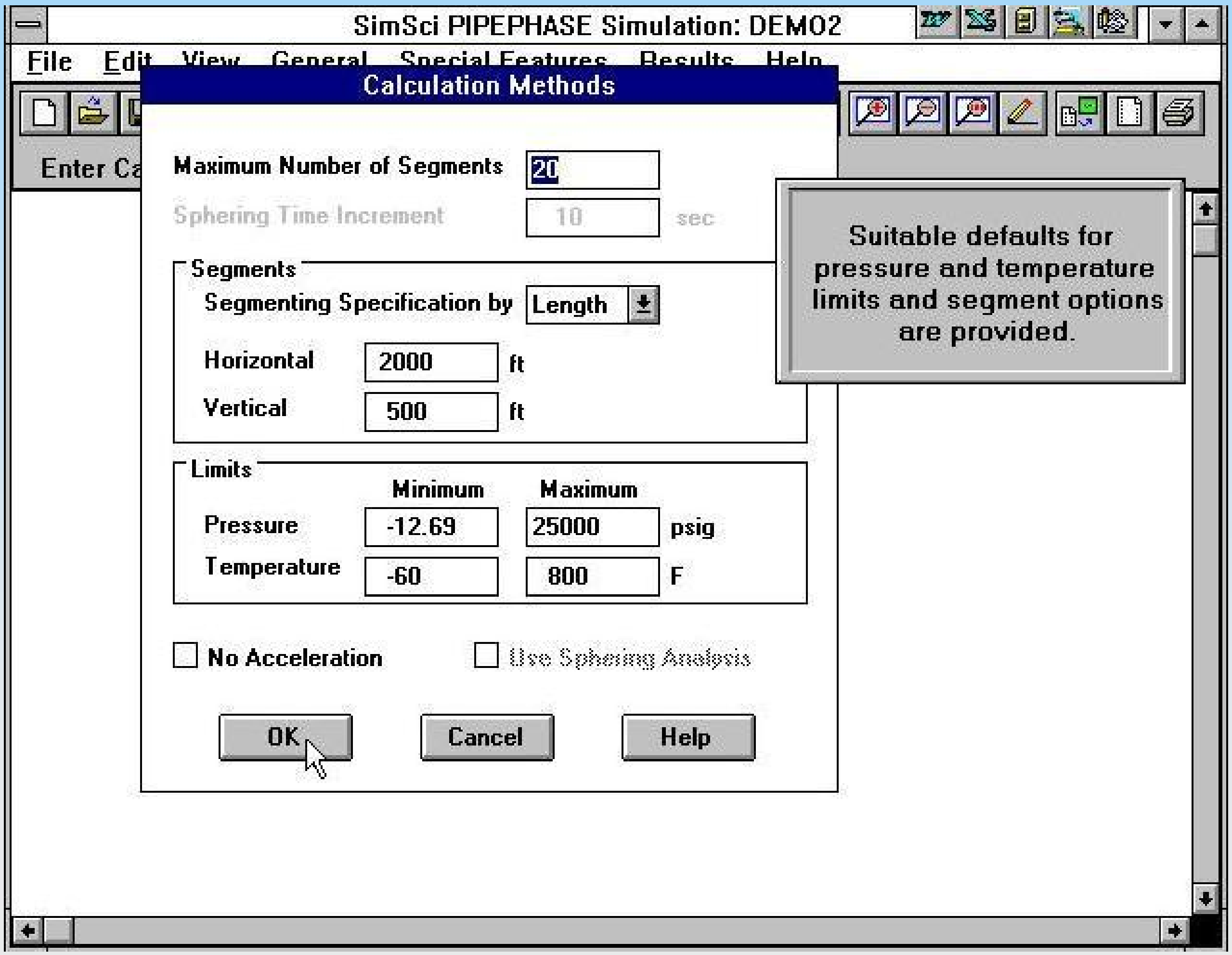
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Fluid Property Data
Blackoil PVT Data
Set Number 2
Gravities
Oil 35.4 API
Gas .710 sp gr
Water 1.012 sp gr
Contaminants
Nitrogen 0 Mole %
Carbon Dioxide 0 Mole %
Hydrogen Sulfide 0 Mole %
Antoine Viscosity Data
Temperature F
Viscosity cP
Adjust Standing Data
Tabular Data
Generate PVT Table...
OK
Cancel
Help

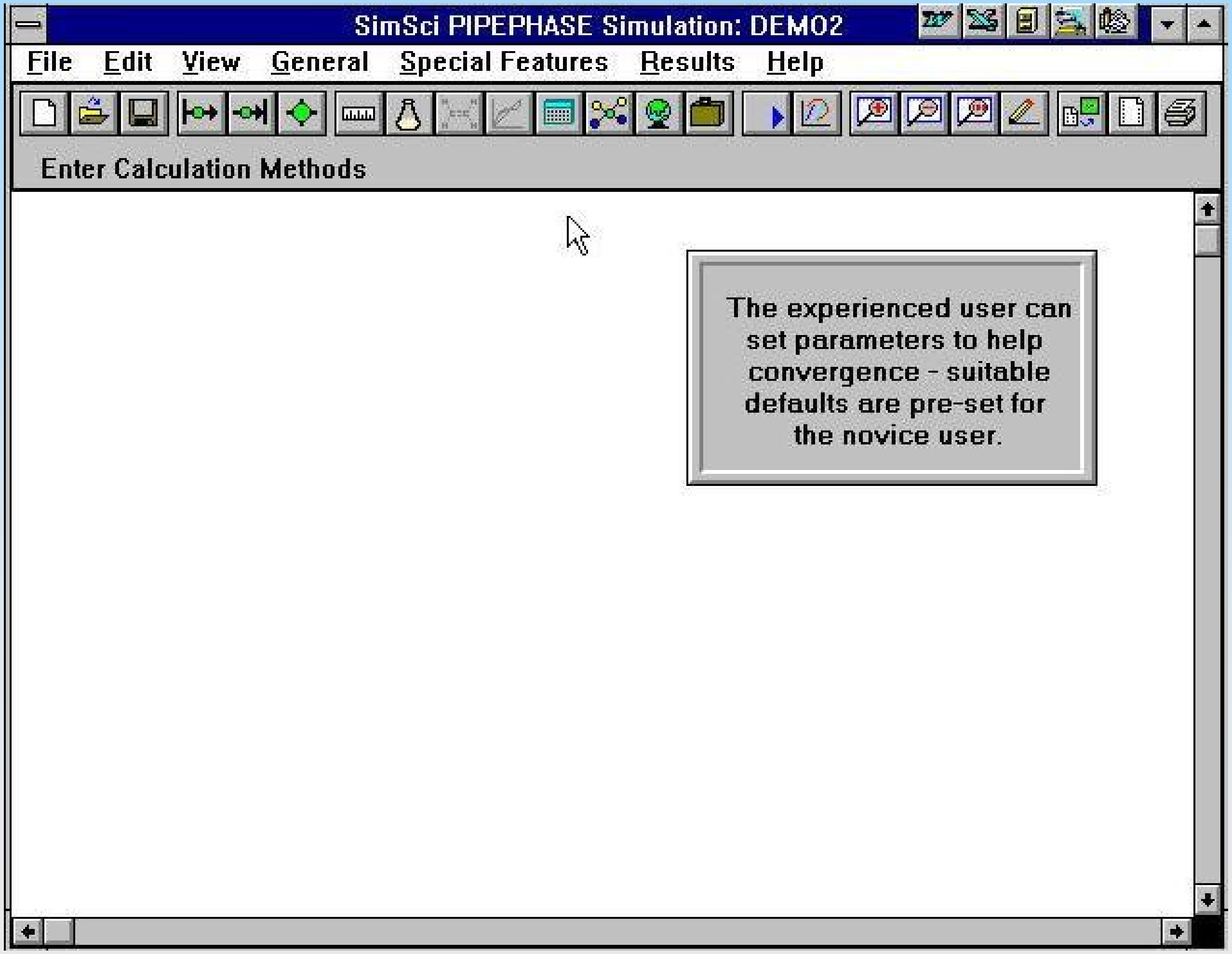

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Fluid Property Data
Property Sets
Property Set 1
Property Set 2
New...
Edit...
Delete
Retrieve Data from File:
DEMO2
Correlations Data
Lift Gas Data
OK
Cancel
Help

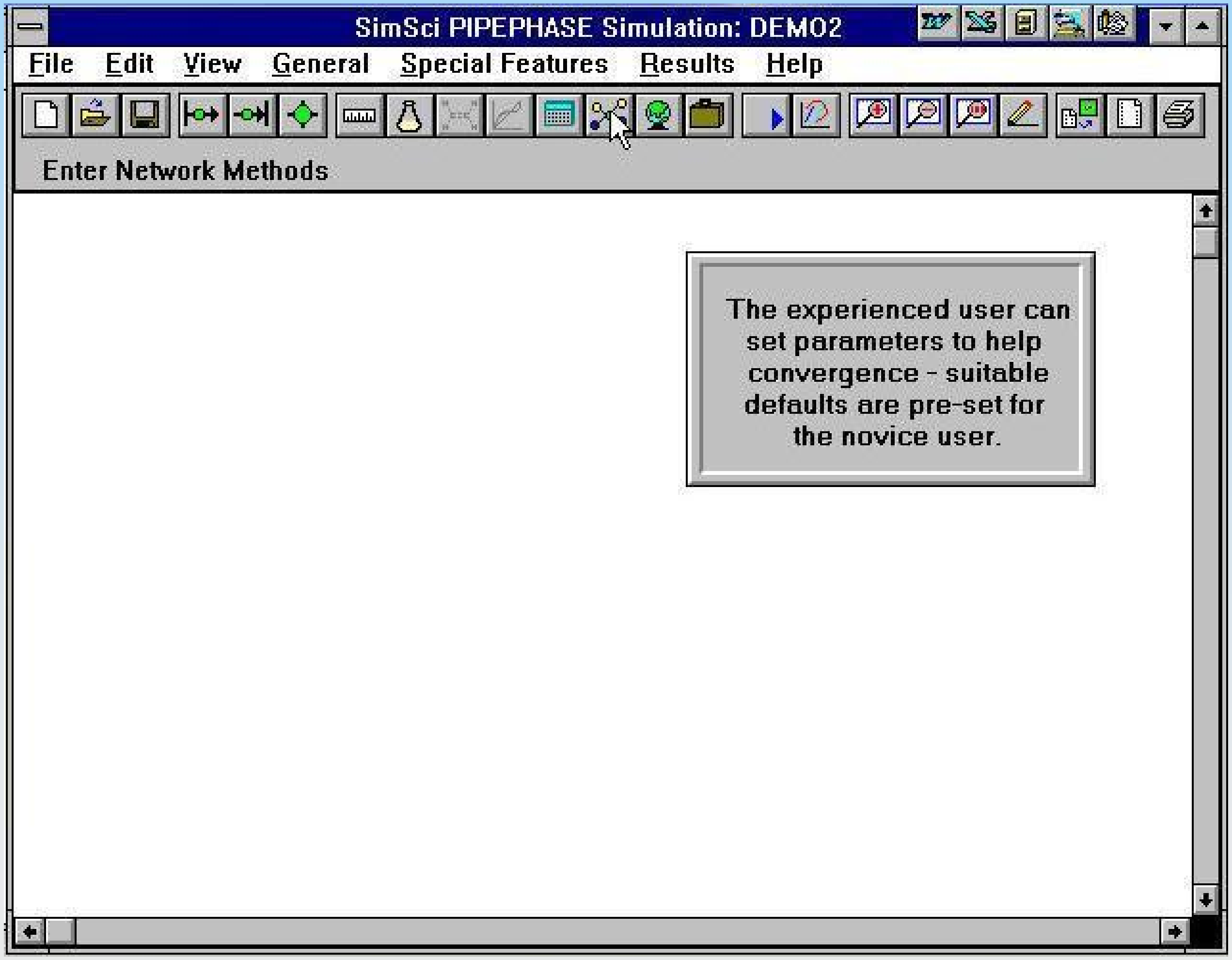

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Suitable defaults for pressure and temperature limits and segment options are provided.

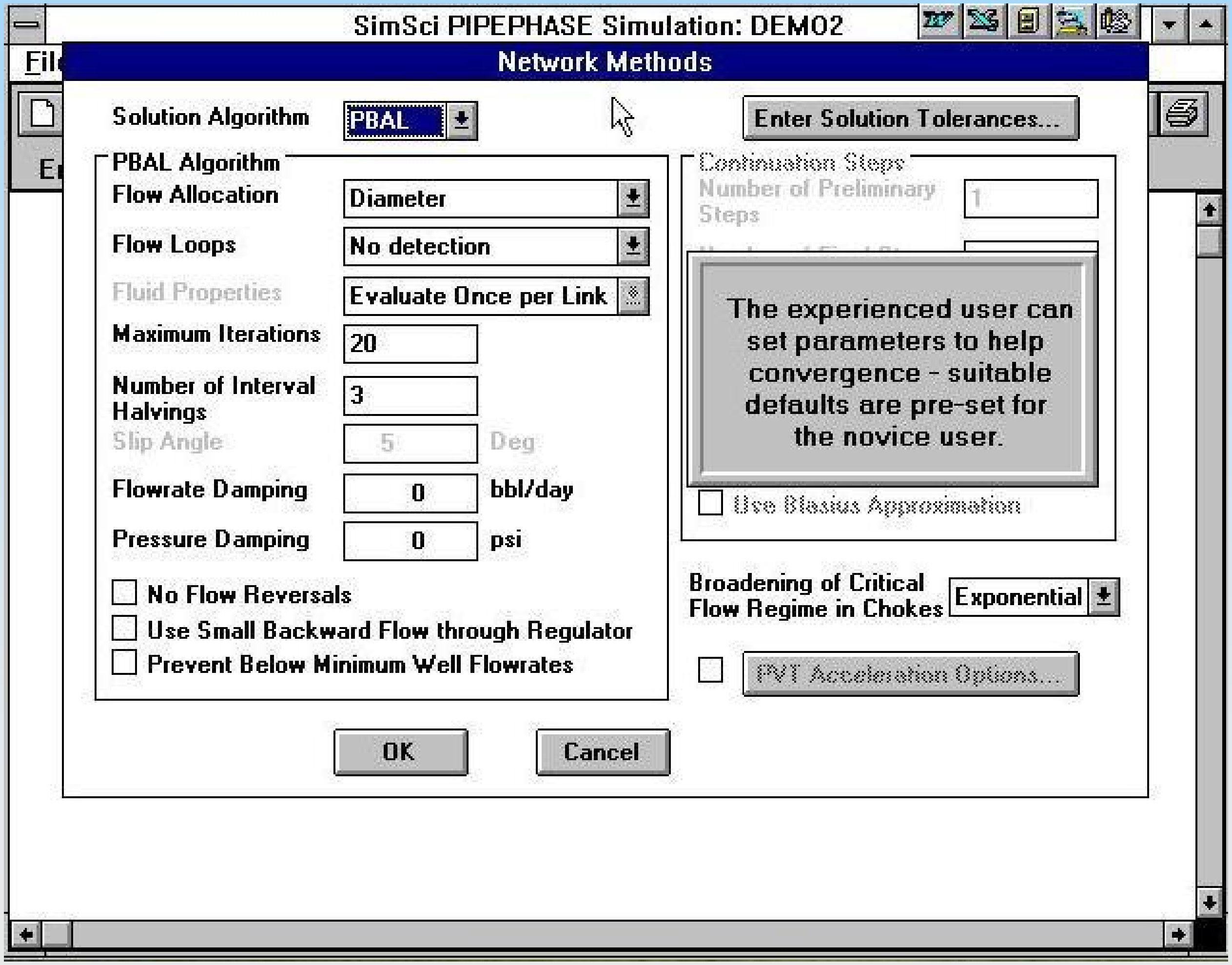

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter Calculation Methods
Suitable defaults for pressure and temperature limits and segment options are provided.

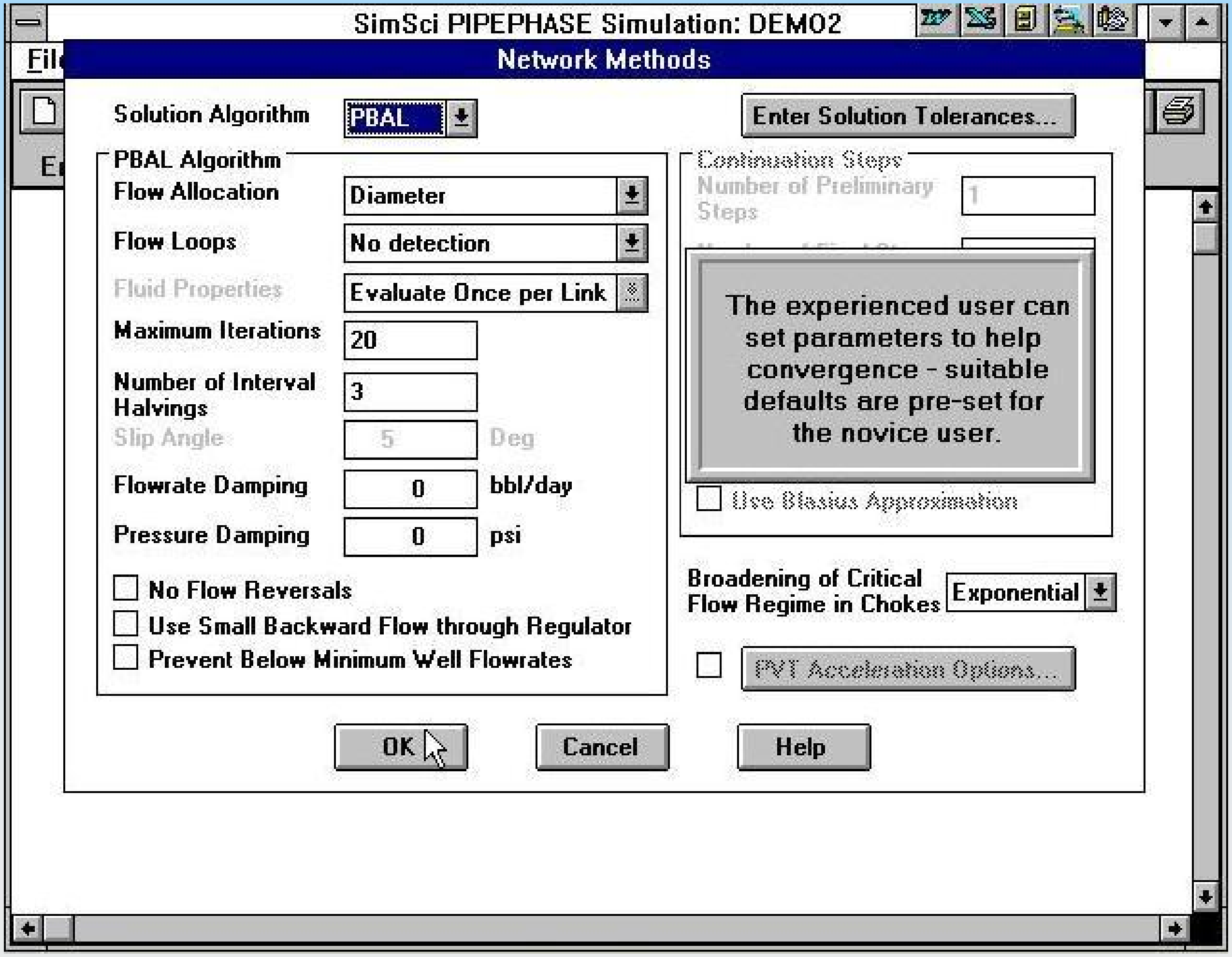

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Calculation Methods
Enter Ca
Maximum Number of Segments
20
Sphering Time Increment
10
sec
Segments
Segmenting Specification by
Length
Horizontal
2000
ft
Vertical
500
ft
Limits
Minimum
Maximum
Pressure
-12.69
25000
psig
Temperature
-60
800
F
No Acceleration
Use Sphering Analysis
OK
Cancel
Suitable defaults for pressure and temperature limits and segment options are provided.

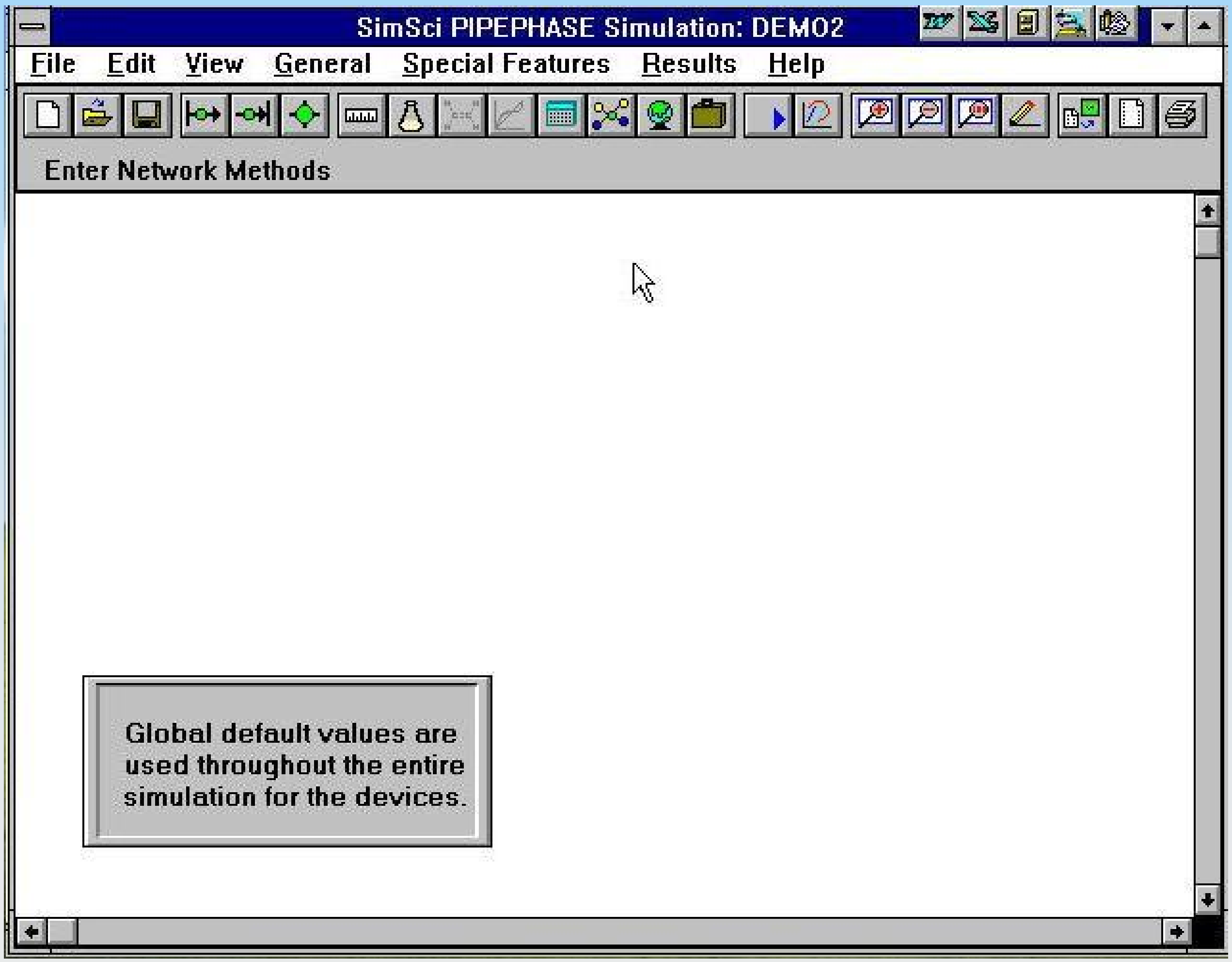

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Calculation Methods
Maximum Number of Segments
20
Sphering Time Increment
10
sec
Segments
Segmenting Specification by
Length
Horizontal
2000
ft
Vertical
500
ft
Limits
Minimum
Maximum
Pressure
-12.69
25000
psig
Temperature
-60
800
F
No Acceleration
Use Sphering Analysis
OK
Cancel
Help
Suitable defaults for pressure and temperature limits and segment options are provided.

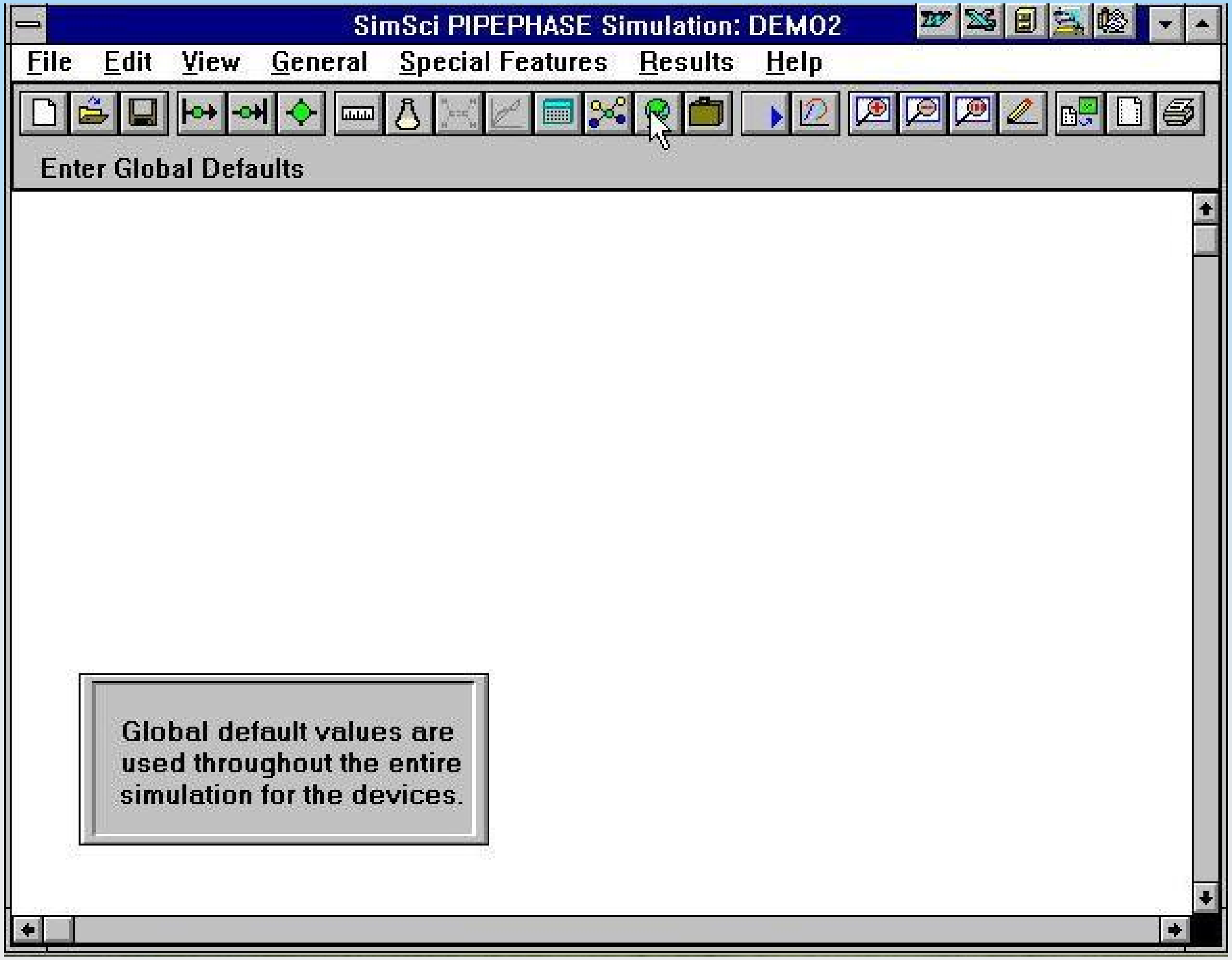

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter Calculation Methods
The experienced user can set parameters to help convergence - suitable defaults are pre-set for the novice user.

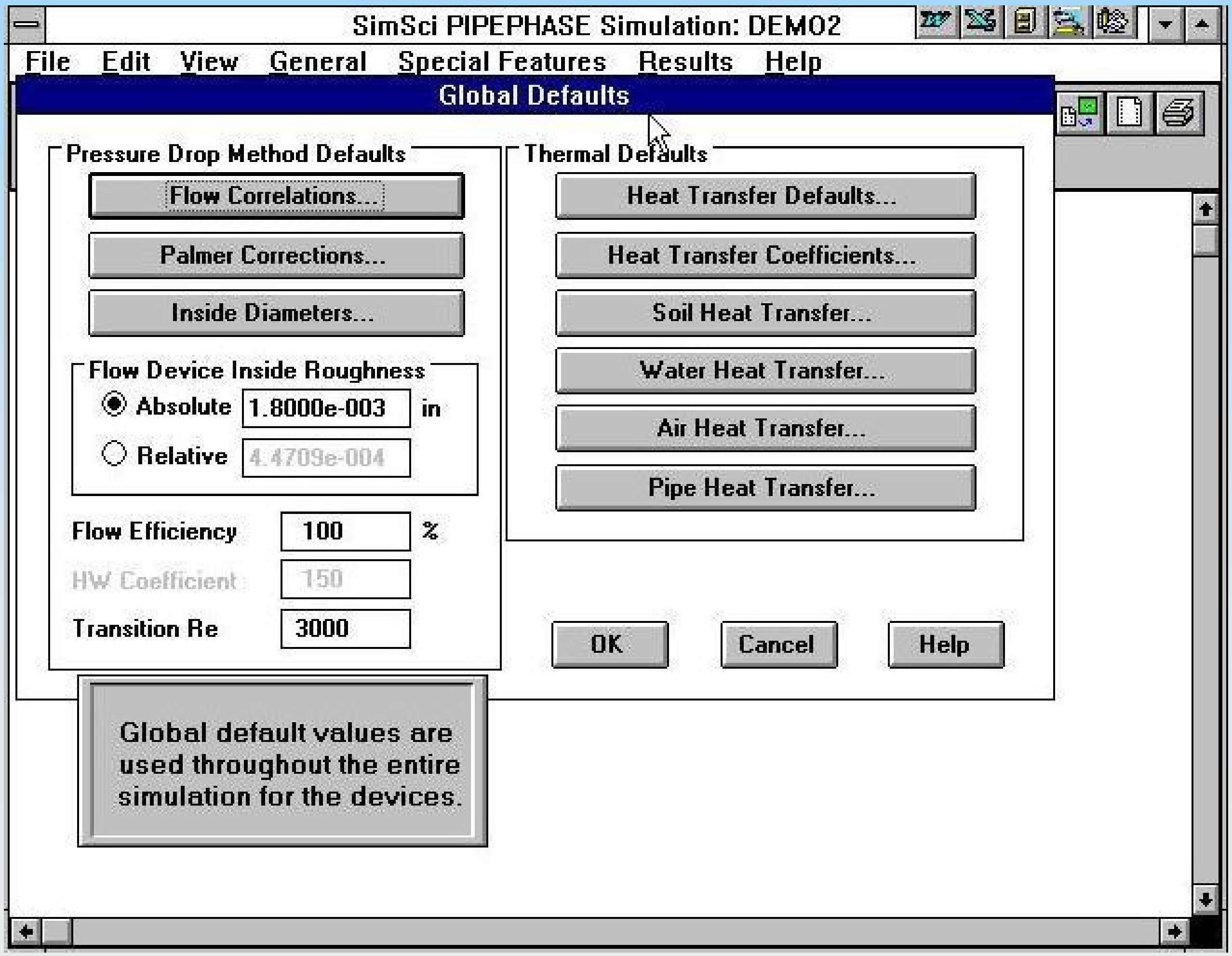

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter Network Methods
The experienced user can set parameters to help convergence - suitable defaults are pre-set for the novice user.

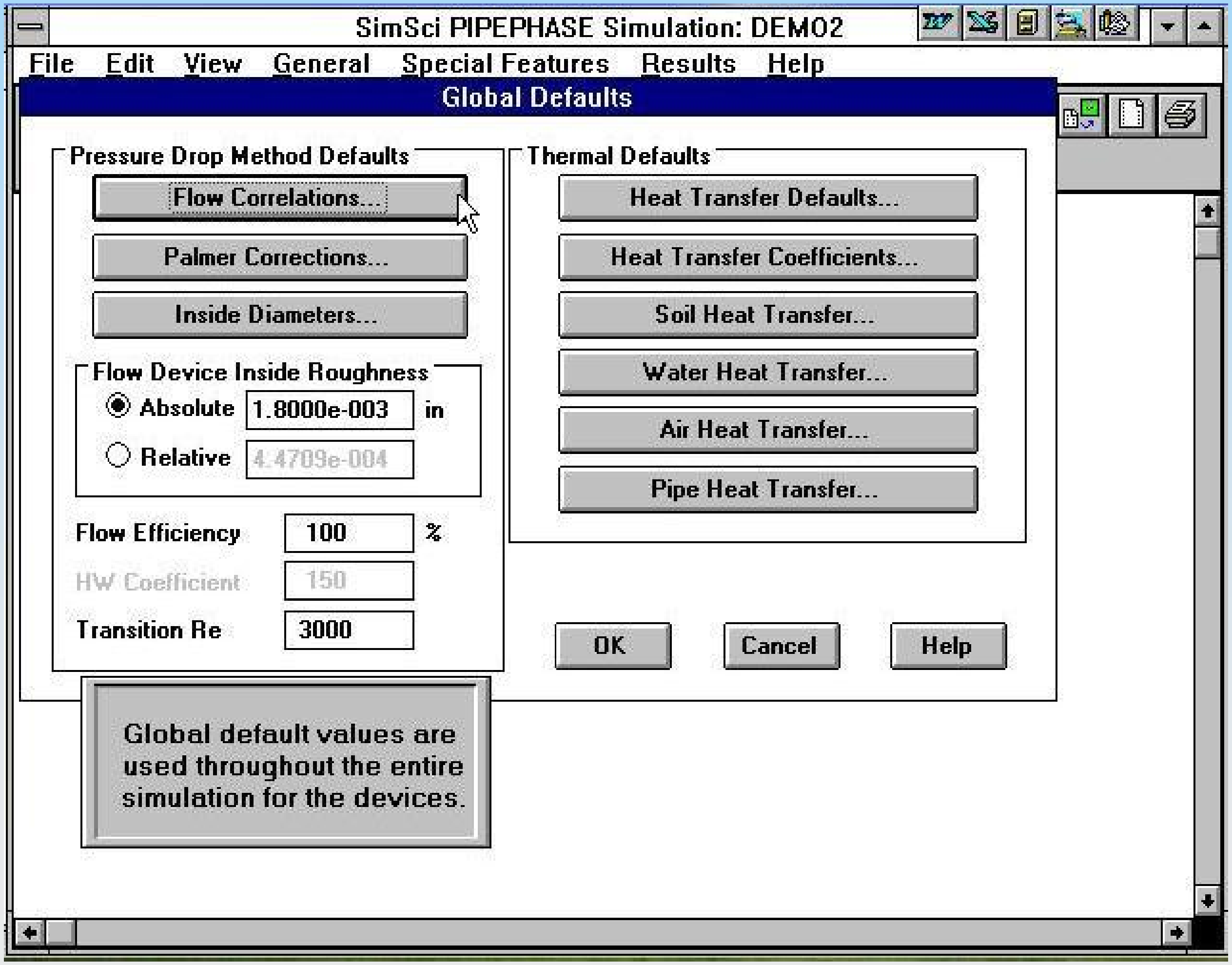

SimSci PIPEPHASE Simulation: DEMO2
Network Methods
Solution Algorithm
PBAL
Enter Solution Tolerances...
PBAL Algorithm
Flow Allocation
Diameter
Flow Loops
No detection
Fluid Properties
Evaluate Once per Link
Maximum Iterations
20
Number of Interval Halvings
3
Slip Angle
5
Deg
Flowrate Damping
0
bbl/day
Pressure Damping
0
psi
No Flow Reversals
Use Small Backward Flow through Regulator
Prevent Below Minimum Well Flowrates
Continuation Steps
Number of Preliminary Steps
1
The experienced user can set parameters to help convergence - suitable defaults are pre-set for the novice user.
Use Blasius Approximation
Broadening of Critical Flow Regime in Chokes
Exponential
PVT Acceleration Options...
OK
Cancel

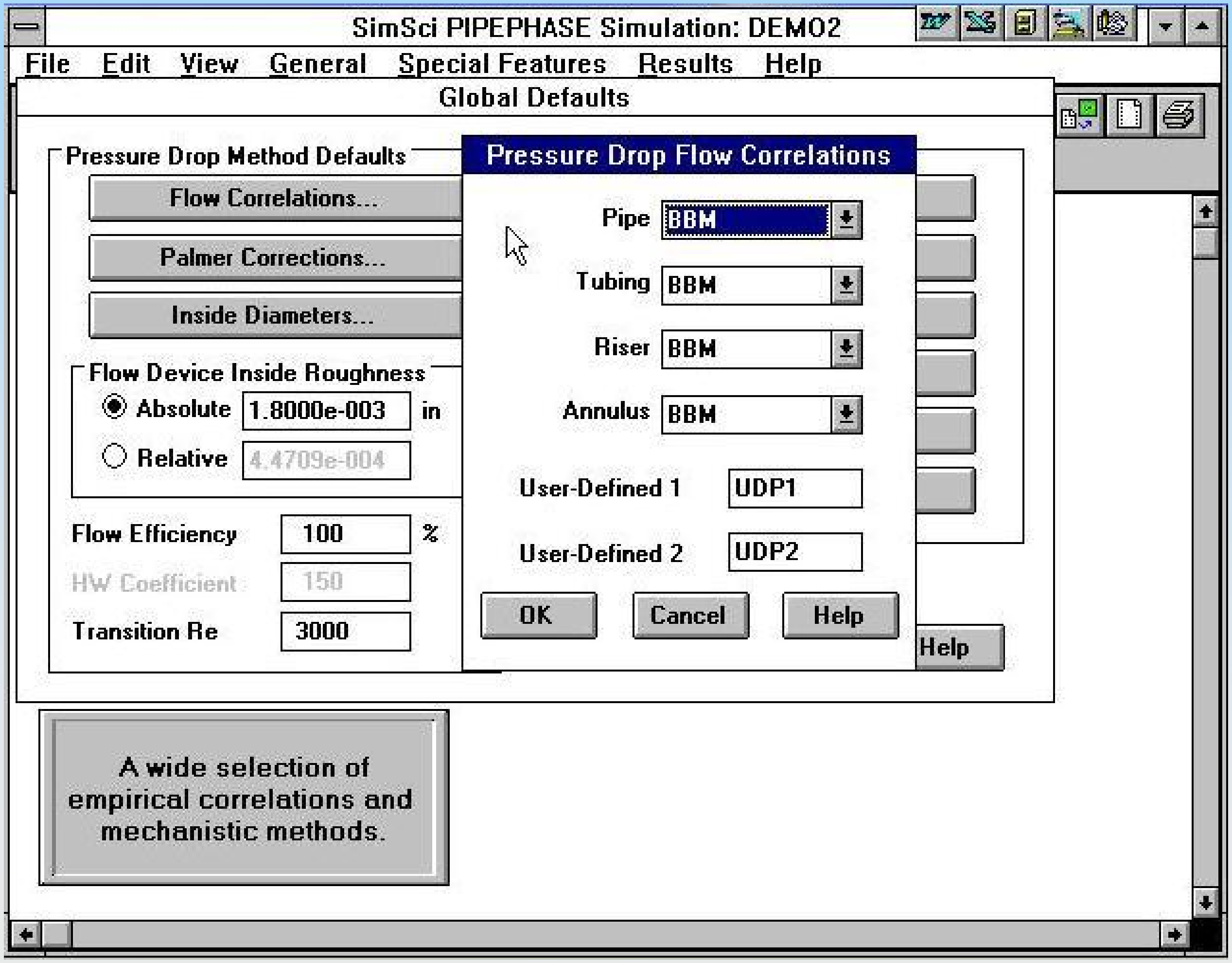

SimSci PIPEPHASE Simulation: DEMO2
Network Methods
Solution Algorithm PBAL
Enter Solution Tolerances...
PBAL Algorithm
Flow Allocation Diameter
Flow Loops No detection
Fluid Properties Evaluate Once per Link
Maximum Iterations 20
Number of Interval Halvings 3
Slip Angle 5 Deg
Flowrate Damping 0 bbl/day
Pressure Damping 0 psi
No Flow Reversals
Use Small Backward Flow through Regulator
Prevent Below Minimum Well Flowrates
Continuation Steps
Number of Preliminary Steps 1
The experienced user can set parameters to help convergence - suitable defaults are pre-set for the novice user.
Use Blasius Approximation
Broadening of Critical Flow Regime in Chokes Exponential
PVT Acceleration Options...
OK
Cancel
Help

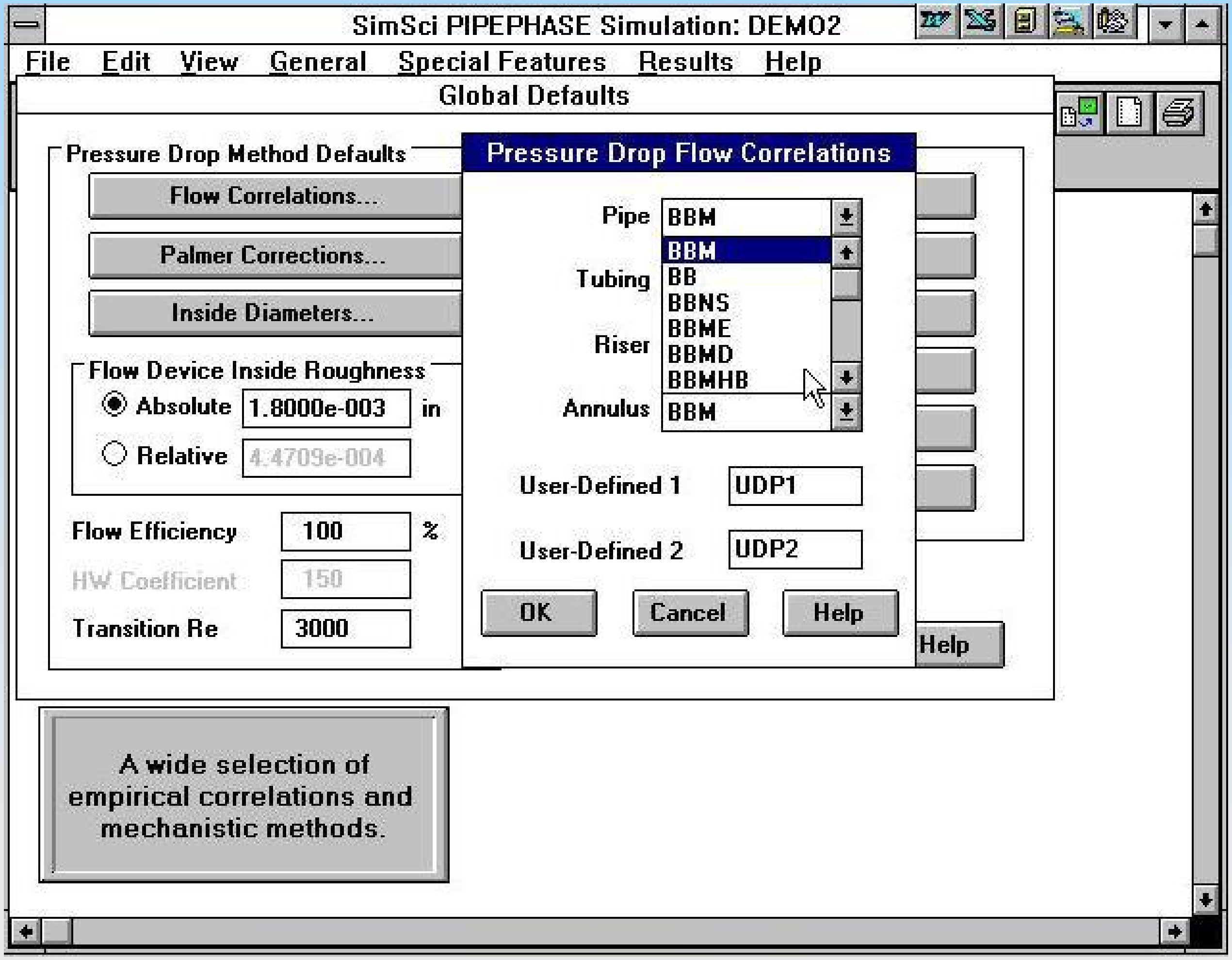

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter Network Methods
Global default values are used throughout the entire simulation for the devices.

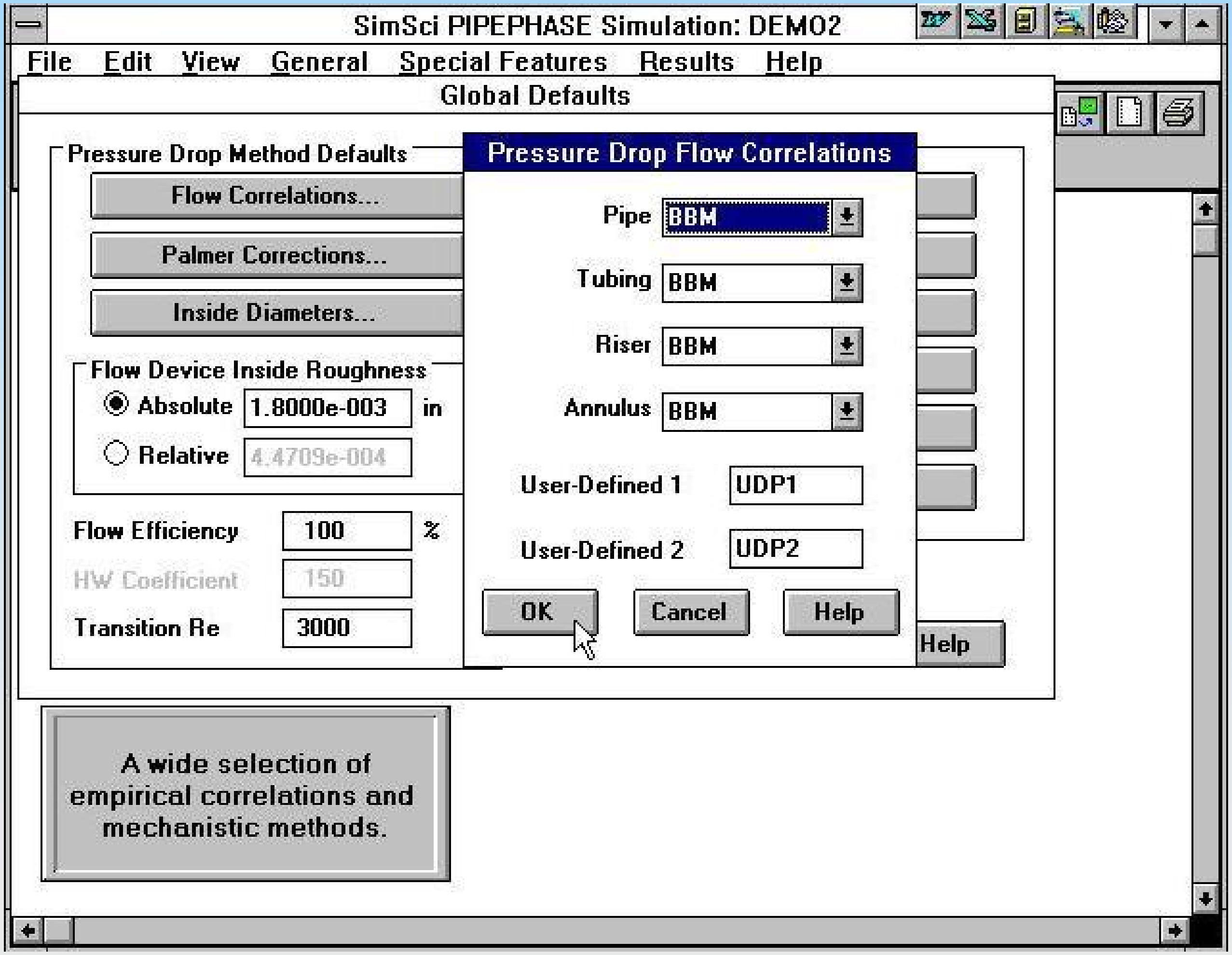

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter Global Defaults
Global default values are used throughout the entire simulation for the devices.


SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute
1.8000e-003
in
Relative
4.4709e-004
Flow Efficiency
100
%
HW Coefficient
150
Transition Re
3000
Thermal Defaults
Heat Transfer Defaults...
Heat Transfer Coefficients...
Soil Heat Transfer...
Water Heat Transfer...
Air Heat Transfer...
Pipe Heat Transfer...
OK
Cancel
Help
Global default values are used throughout the entire simulation for the devices.

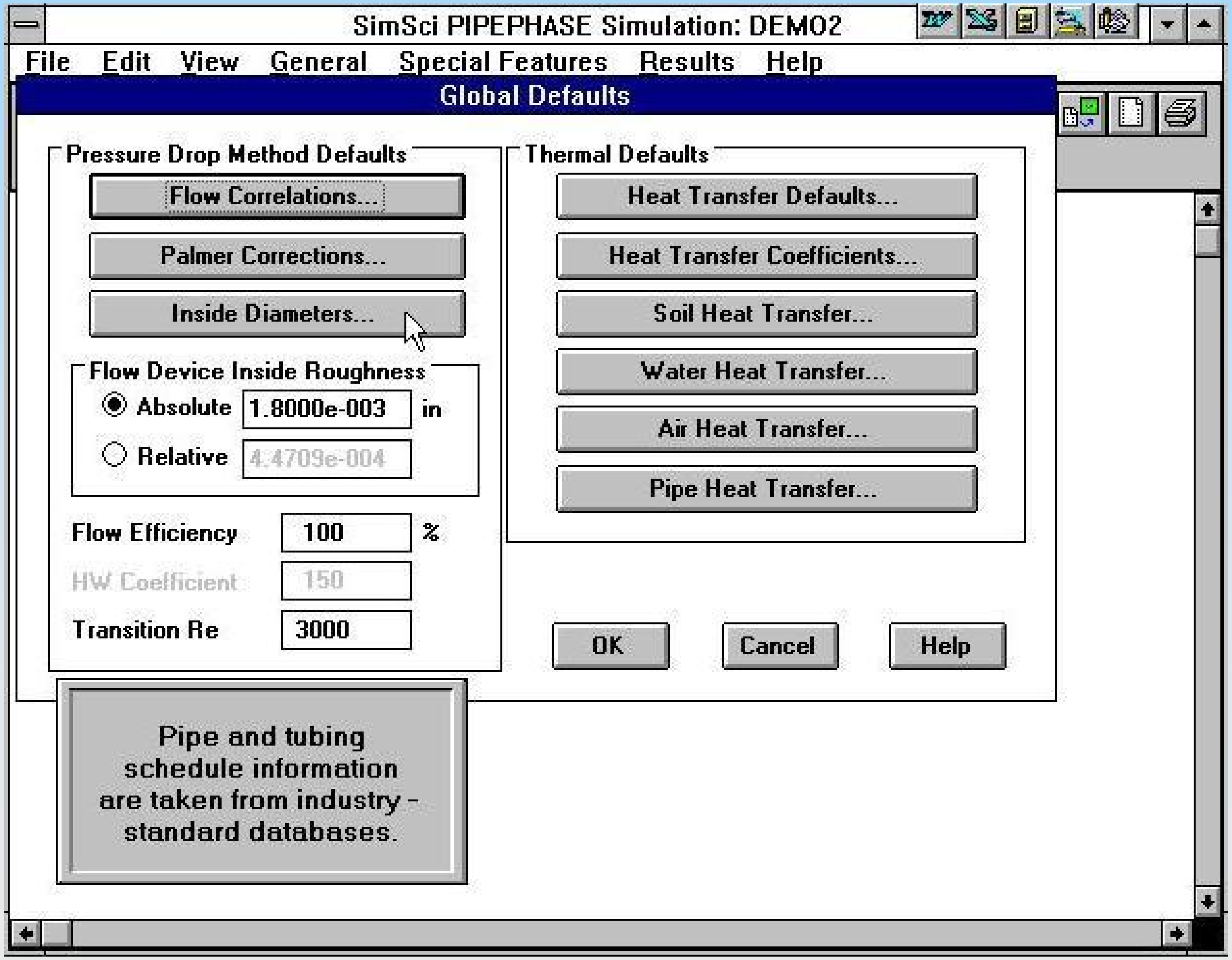

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Thermal Defaults
Heat Transfer Defaults...
Heat Transfer Coefficients...
Soil Heat Transfer...
Water Heat Transfer...
Air Heat Transfer...
Pipe Heat Transfer...
OK
Cancel
Help
Global default values are used throughout the entire simulation for the devices.

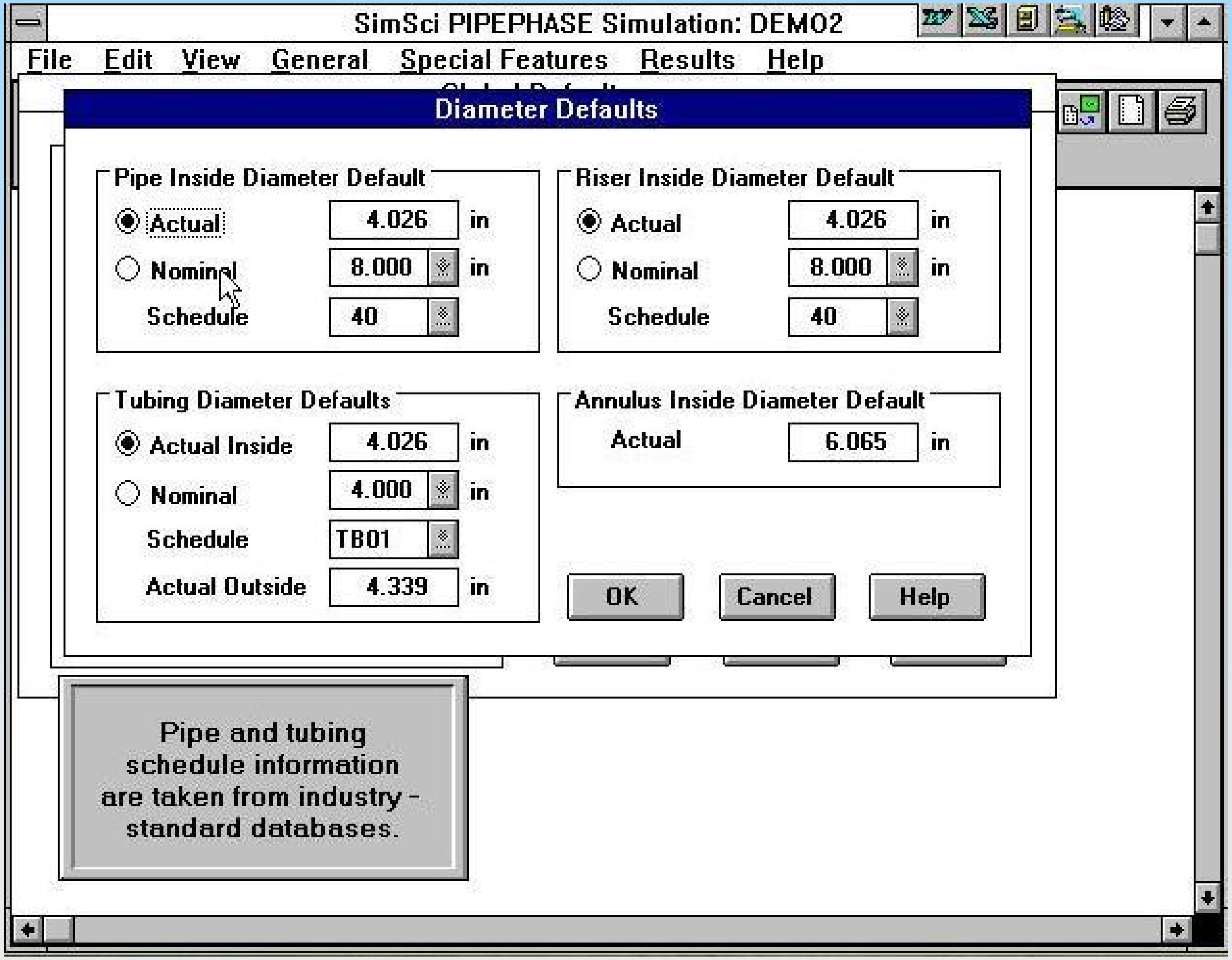

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Pressure Drop Flow Correlations
Pipe BBM
Tubing BBM
Riser BBM
Annulus BBM
User-Defined 1 UDP1
User-Defined 2 UDP2
OK
Cancel
Help
Help
A wide selection of empirical correlations and mechanistic methods.

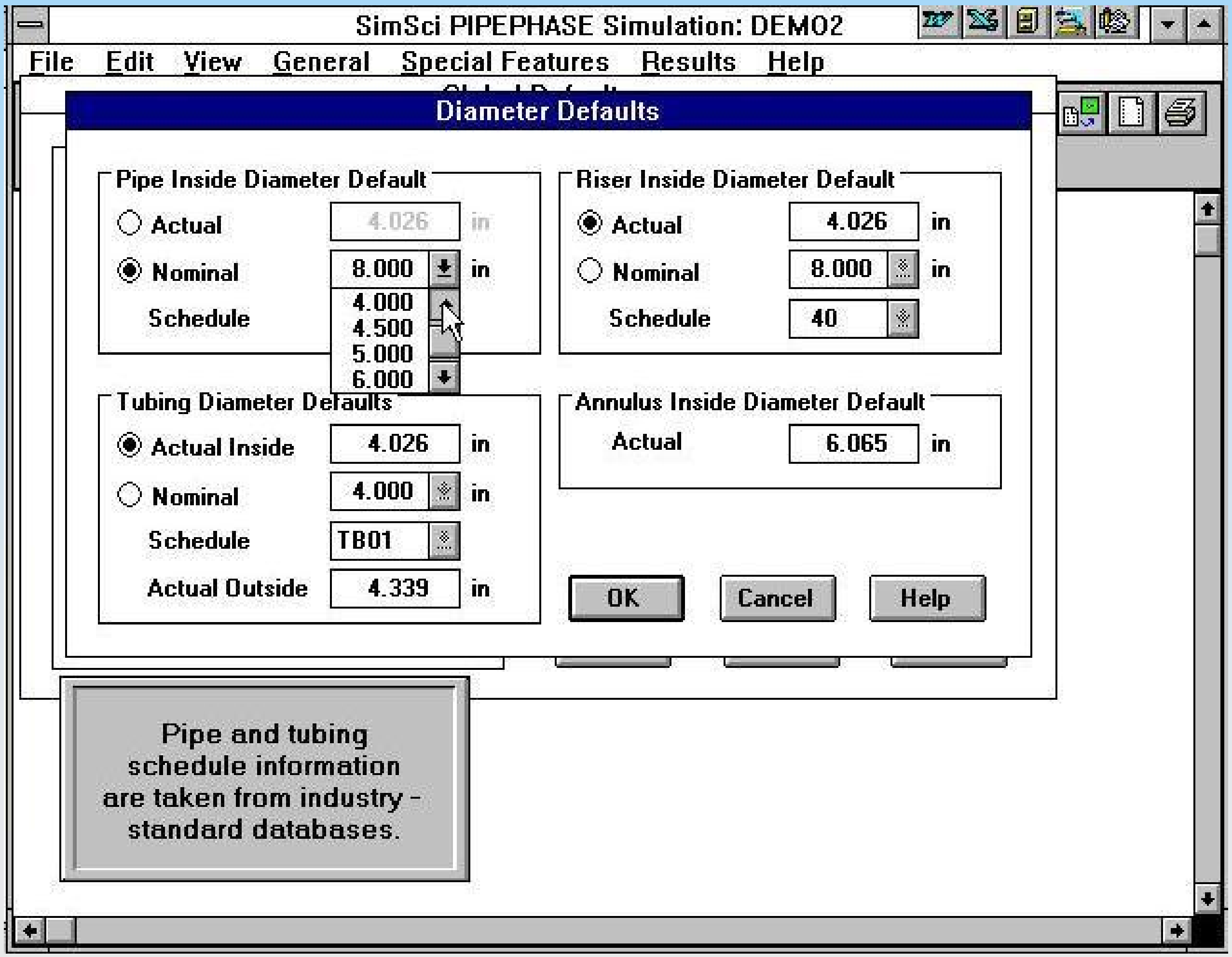

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Pressure Drop Flow Correlations
Pipe BBM
Tubing
Riser
Annulus BBM
BBM
BB
BBNS
BBME
BBMD
BBMHB
User-Defined 1 UDP1
User-Defined 2 UDP2
OK
Cancel
Help
Help
A wide selection of empirical correlations and mechanistic methods.

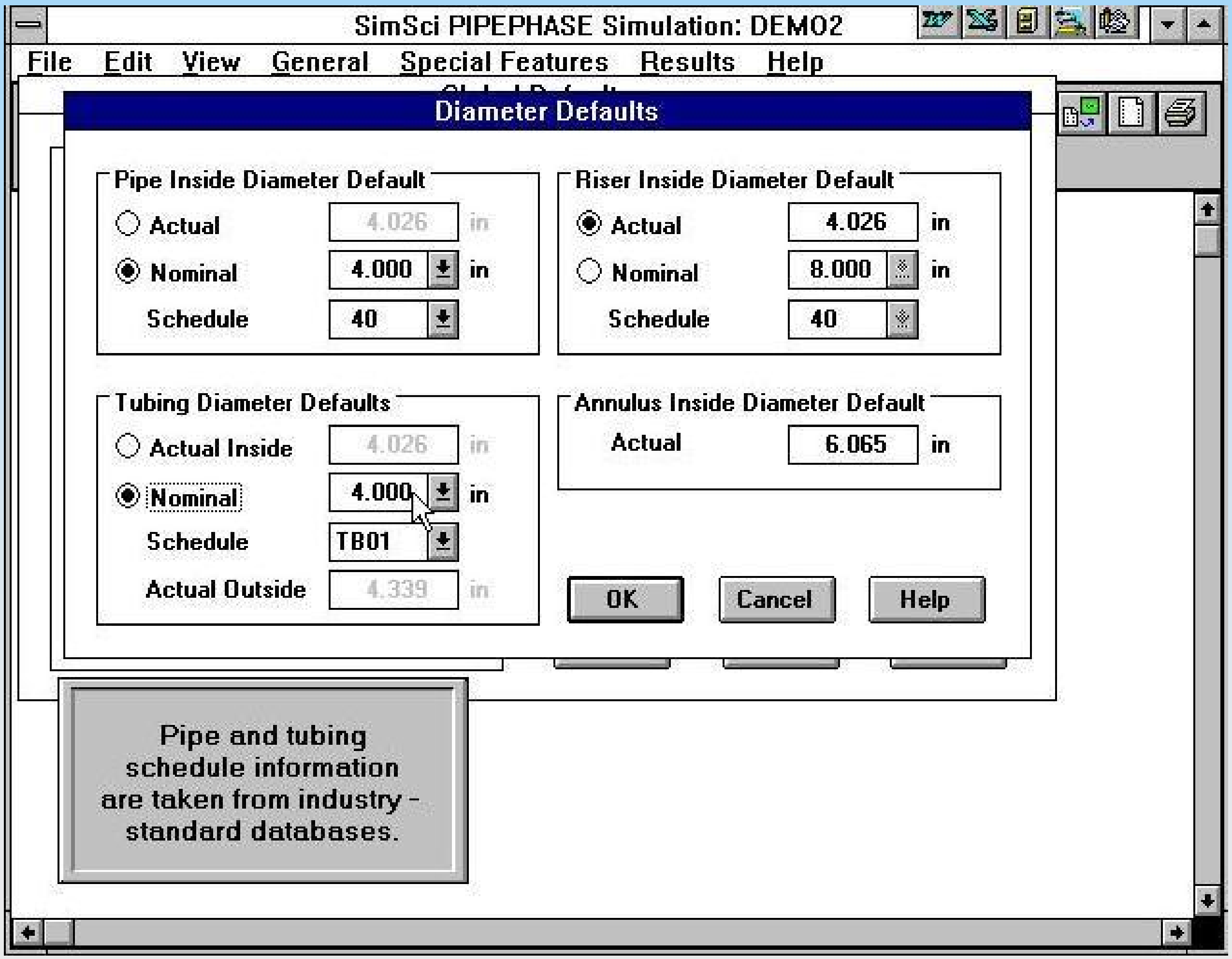


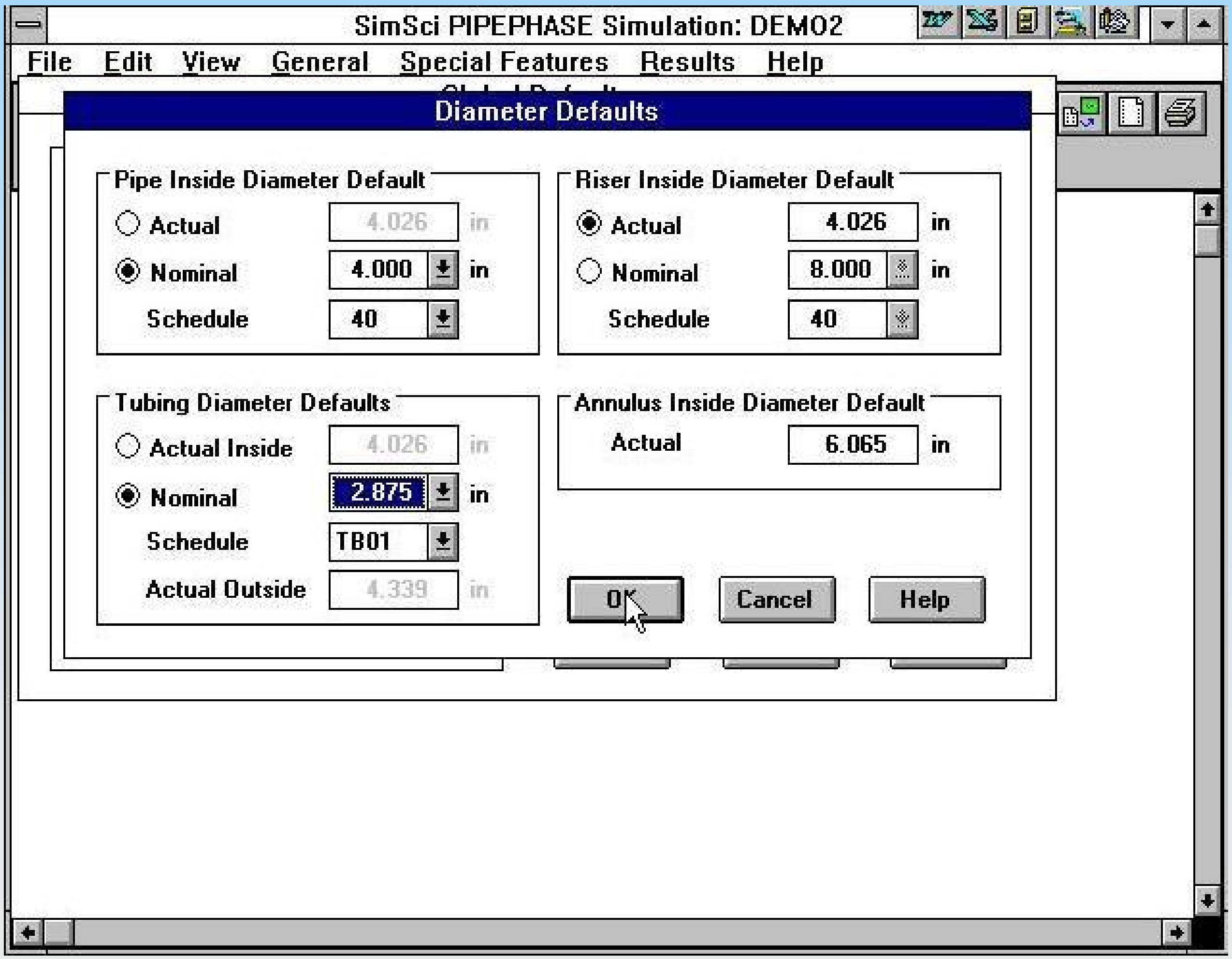
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Pressure Drop Flow Correlations
Pipe BBM
Tubing BBM
Riser BBM
Annulus BBM
User-Defined 1 UDP1
User-Defined 2 UDP2
OK
Cancel
Help
Help
A wide selection of empirical correlations and mechanistic methods.


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Thermal Defaults
Heat Transfer Defaults...
Heat Transfer Coefficients...
Soil Heat Transfer...
Water Heat Transfer...
Air Heat Transfer...
Pipe Heat Transfer...
OK
Cancel
Help
Pipe and tubing schedule information are taken from industry - standard databases.

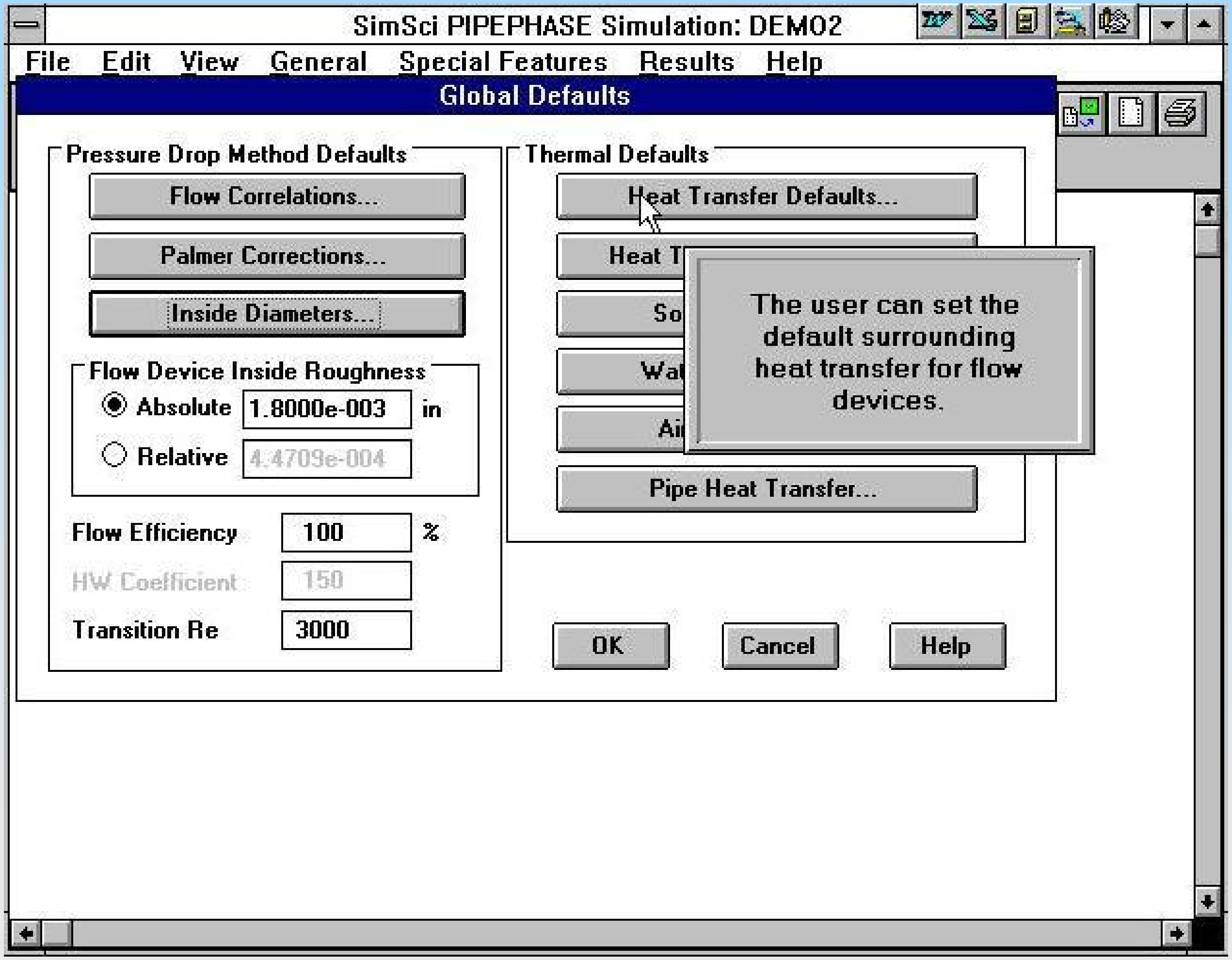

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Diameter Defaults
Pipe Inside Diameter Default
Actual 4.026 in
Nominal 8.000 in
Schedule 40
Riser Inside Diameter Default
Actual 4.026 in
Nominal 8.000 in
Schedule 40
Tubing Diameter Defaults
Actual Inside 4.026 in
Nominal 4.000 in
Schedule TB01
Actual Outside 4.339 in
Annulus Inside Diameter Default
Actual 6.065 in
OK
Cancel
Help
Pipe and tubing schedule information are taken from industry - standard databases.

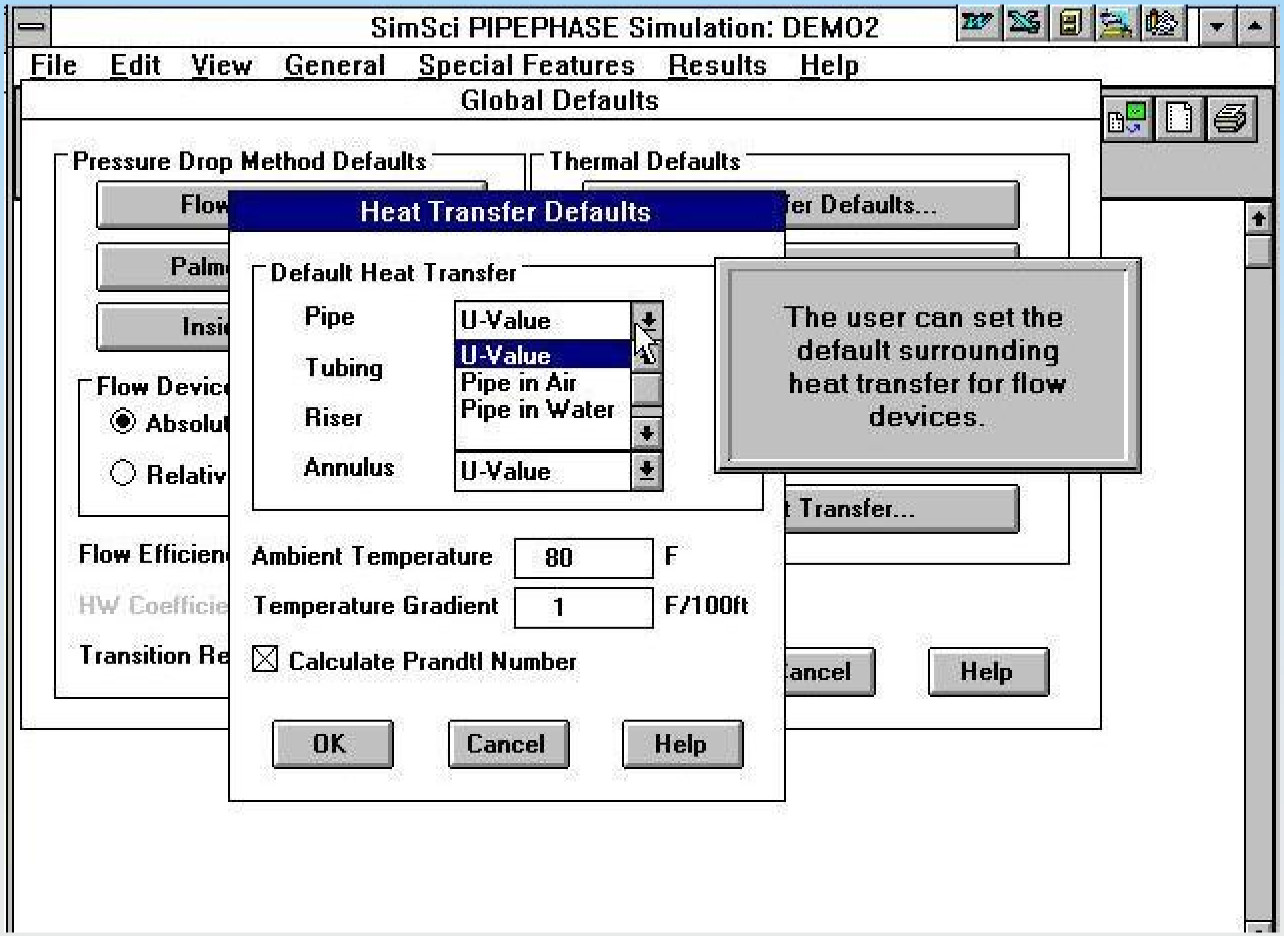

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Diameter Defaults
Pipe Inside Diameter Default
Actual 4.026 in
Nominal 8.000 in
Schedule
4.000
4.500
5.000
6.000
Riser Inside Diameter Default
Actual 4.026 in
Nominal 8.000 in
Schedule 40
Tubing Diameter Defaults
Actual Inside 4.026 in
Nominal 4.000 in
Schedule TB01
Actual Outside 4.339 in
Annulus Inside Diameter Default
Actual 6.065 in
OK
Cancel
Help
Pipe and tubing schedule information are taken from industry - standard databases.

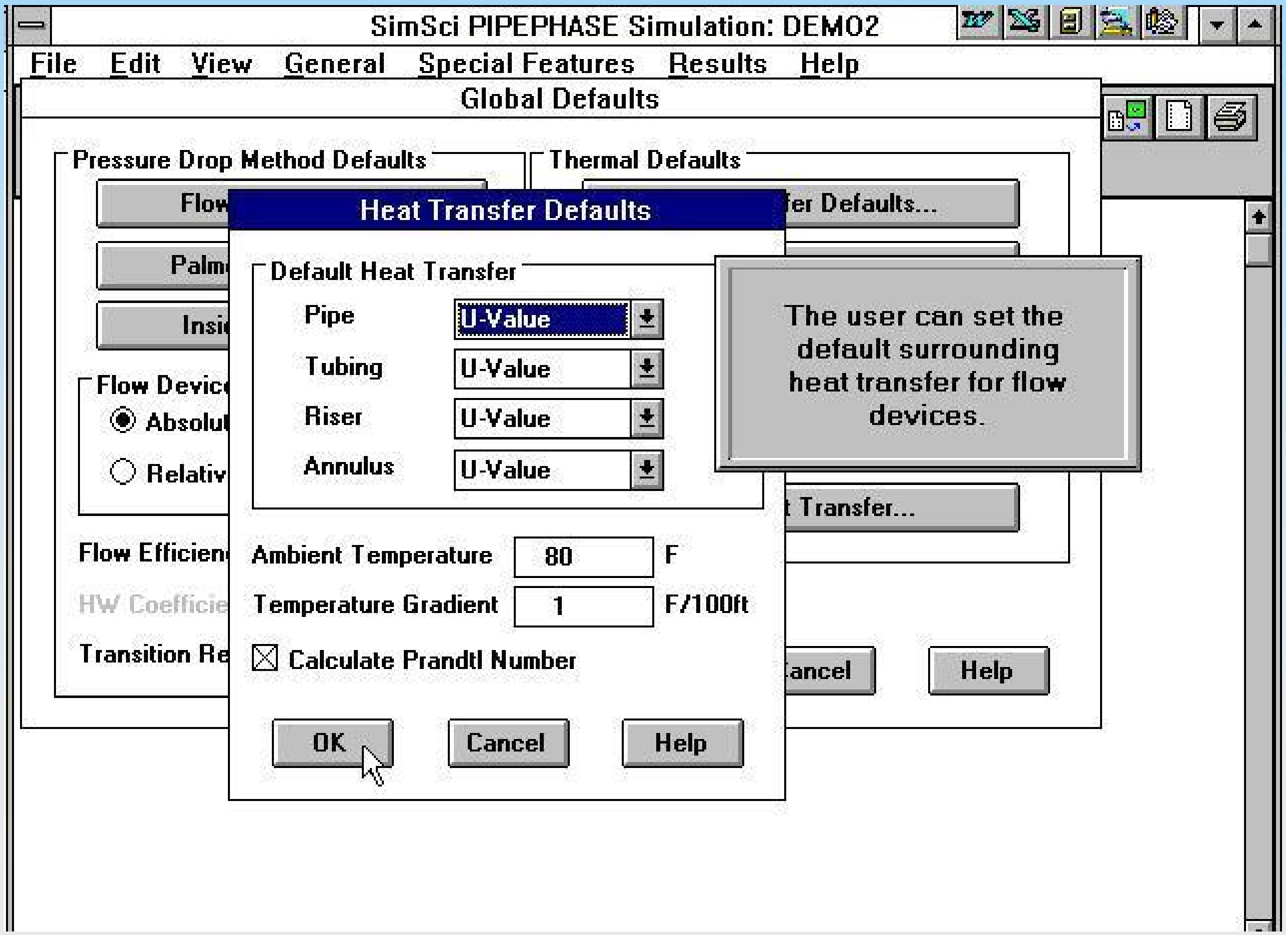

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Diameter Defaults
Pipe Inside Diameter Default
Actual 4.026 in
Nominal 4.000 in
Schedule 40
Riser Inside Diameter Default
Actual 4.026 in
Nominal 8.000 in
Schedule 40
Tubing Diameter Defaults
Actual Inside 4.026 in
Nominal 4.000 in
Schedule TB01
Actual Outside 4.339 in
Annulus Inside Diameter Default
Actual 6.065 in
OK
Cancel
Help
Pipe and tubing schedule information are taken from industry - standard databases.

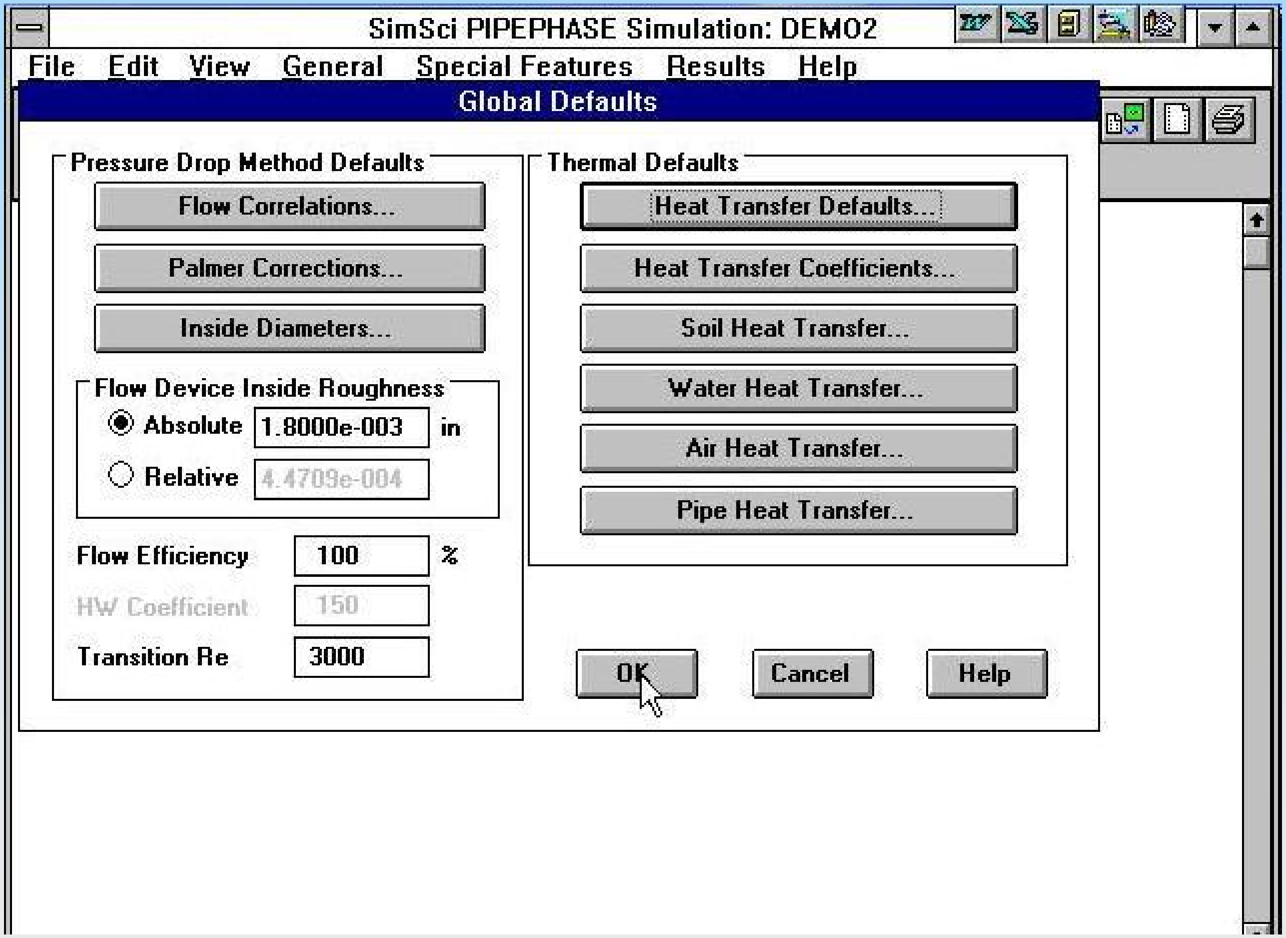


SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Diameter Defaults
Pipe Inside Diameter Default
Actual
4.026
in
Nominal
4.000
in
Schedule
40
Riser Inside Diameter Default
Actual
4.026
in
Nominal
8.000
in
Schedule
40
Tubing Diameter Defaults
Actual Inside
4.026
in
Nominal
2.875
in
Schedule
TB01
Actual Outside
4.339
in
Annulus Inside Diameter Default
Actual
6.065
in
OK
Cancel
Help

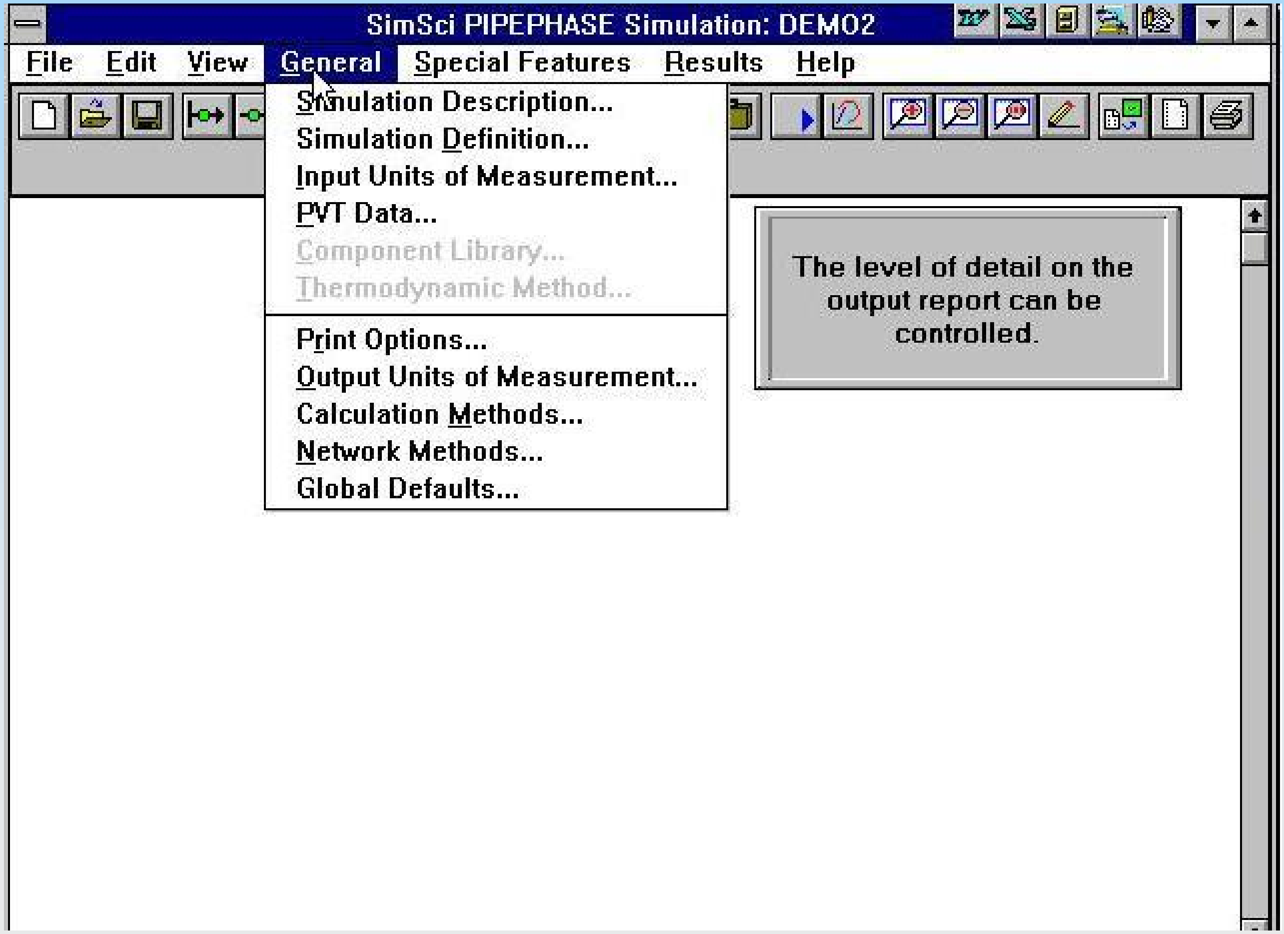

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Thermal Defaults
Heat Transfer Defaults...
Pipe Heat Transfer...
The user can set the default surrounding heat transfer for flow devices.
OK
Cancel
Help

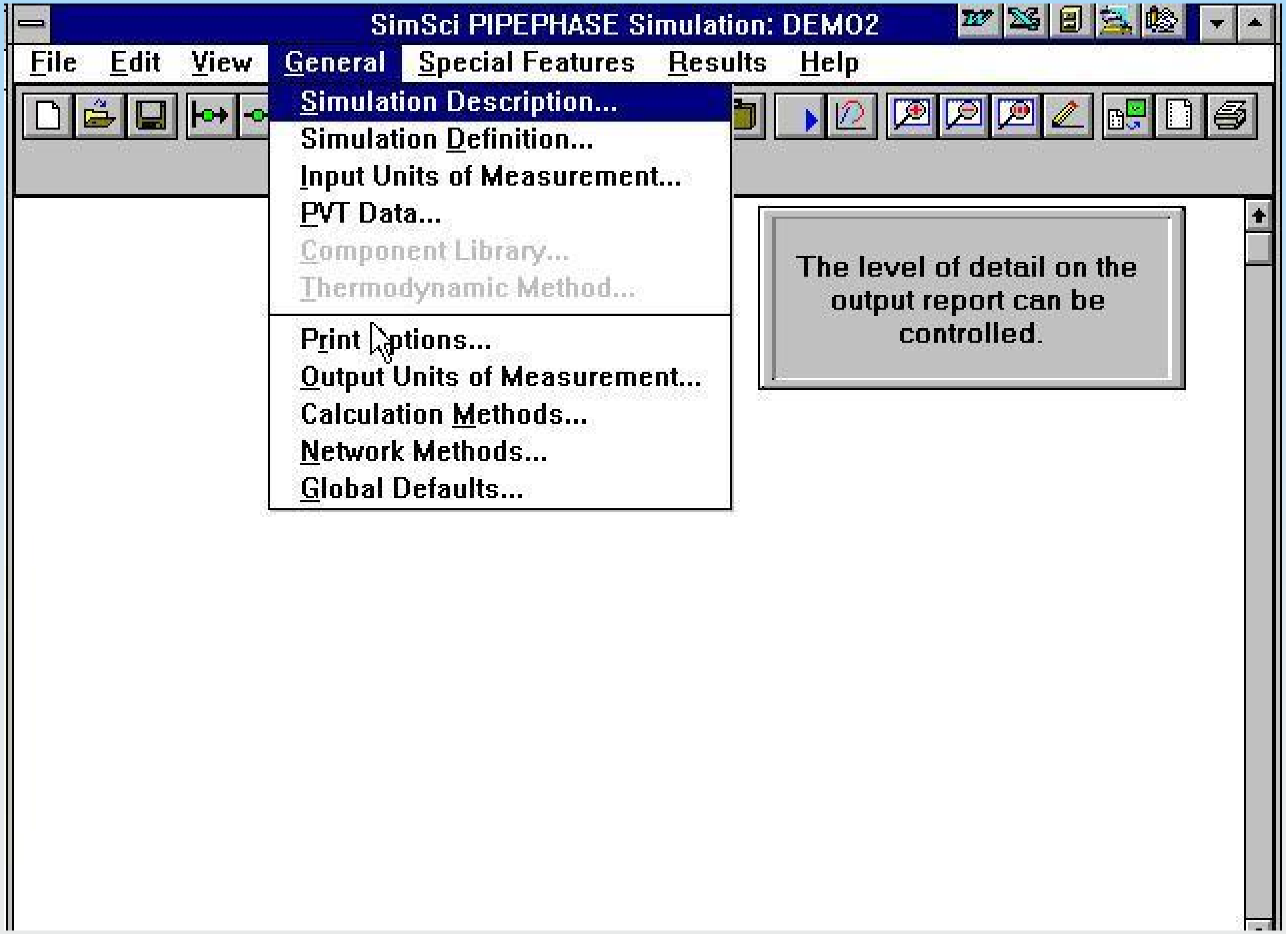

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Thermal Defaults
Heat Transfer Defaults
Default Heat Transfer
Pipe
Tubing
Riser
Annulus
U-Value
U-Value
Pipe in Air
Pipe in Water
U-Value
The user can set the default surrounding heat transfer for flow devices.
Ambient Temperature
80
F
Temperature Gradient
1
F/100ft
Calculate Prandtl Number
OK
Cancel
Help
Help

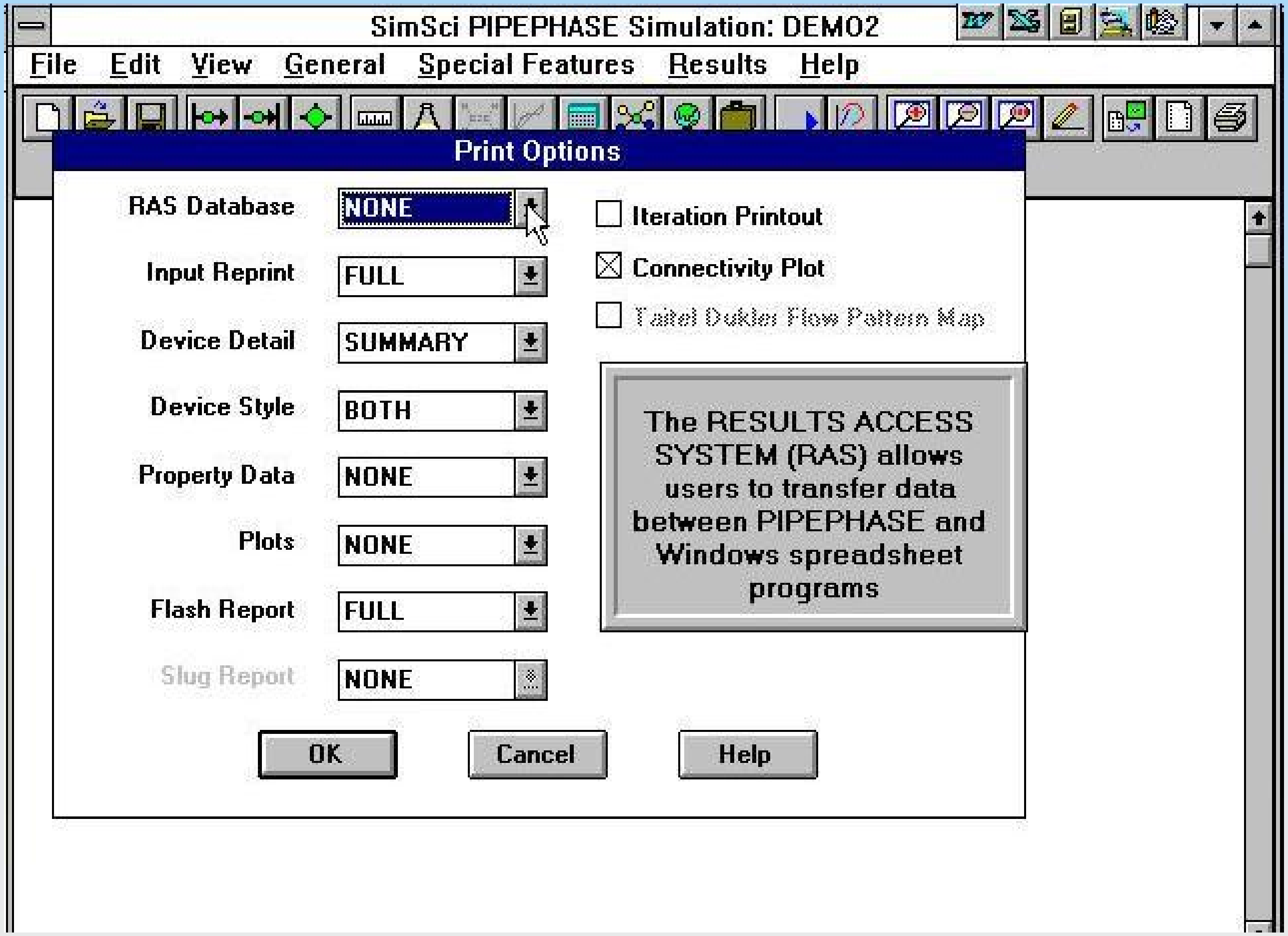

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Thermal Defaults
Heat Transfer Defaults
Default Heat Transfer
Pipe U-Value
Tubing U-Value
Riser U-Value
Annulus U-Value
Ambient Temperature 80 F
Temperature Gradient 1 F/100ft
Calculate Prandtl Number
OK
Cancel
Help
The user can set the default surrounding heat transfer for flow devices.

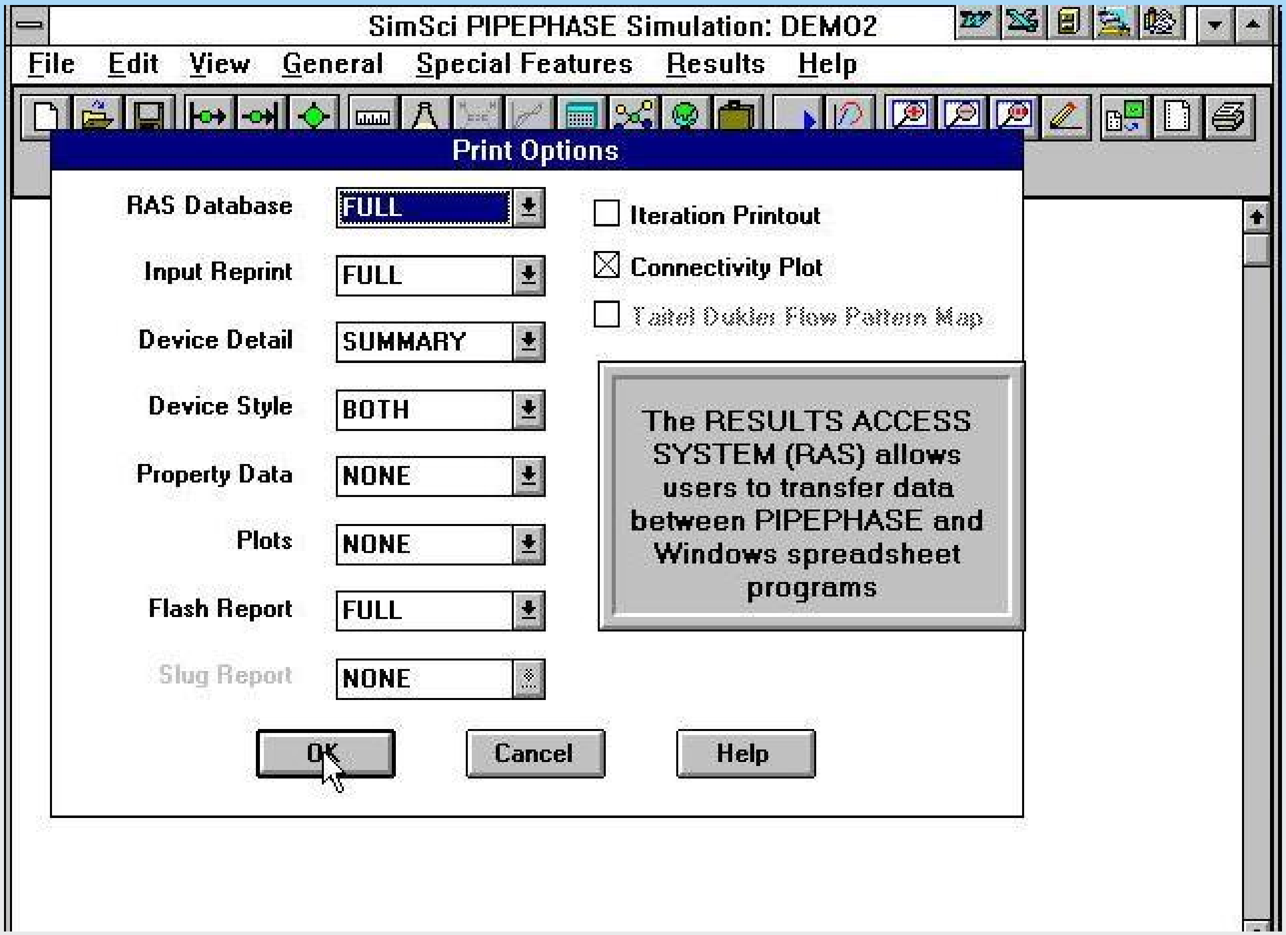


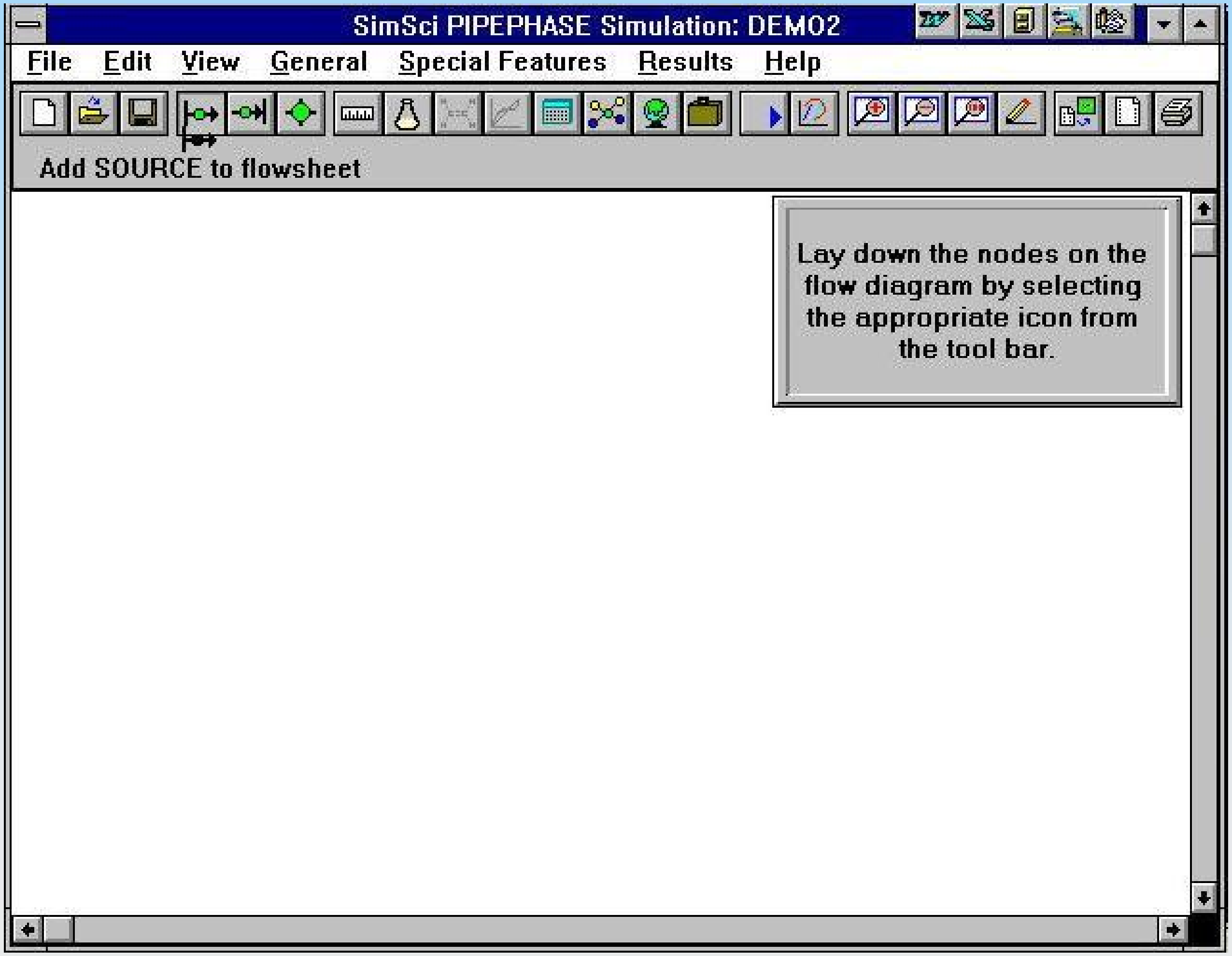
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Global Defaults
Pressure Drop Method Defaults
Flow Correlations...
Palmer Corrections...
Inside Diameters...
Flow Device Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Flow Efficiency 100 %
HW Coefficient 150
Transition Re 3000
Thermal Defaults
Heat Transfer Defaults...
Heat Transfer Coefficients...
Soil Heat Transfer...
Water Heat Transfer...
Air Heat Transfer...
Pipe Heat Transfer...
OK
Cancel
Help

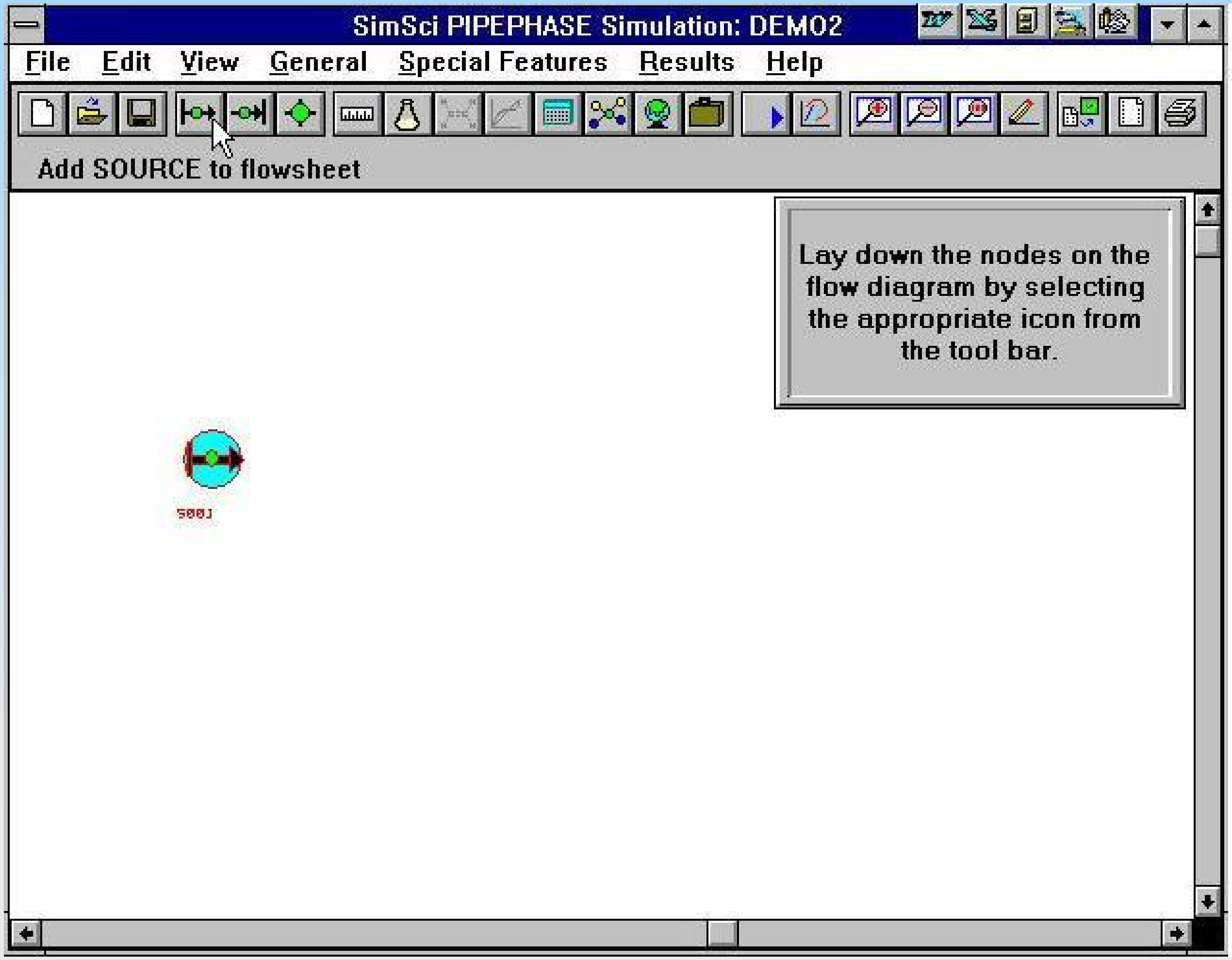

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Simulation Description...
Simulation Definition...
Input Units of Measurement...
PVT Data...
Component Library...
Thermodynamic Method...
Print Options...
Output Units of Measurement...
Calculation Methods...
Network Methods...
Global Defaults...
The level of detail on the output report can be controlled.

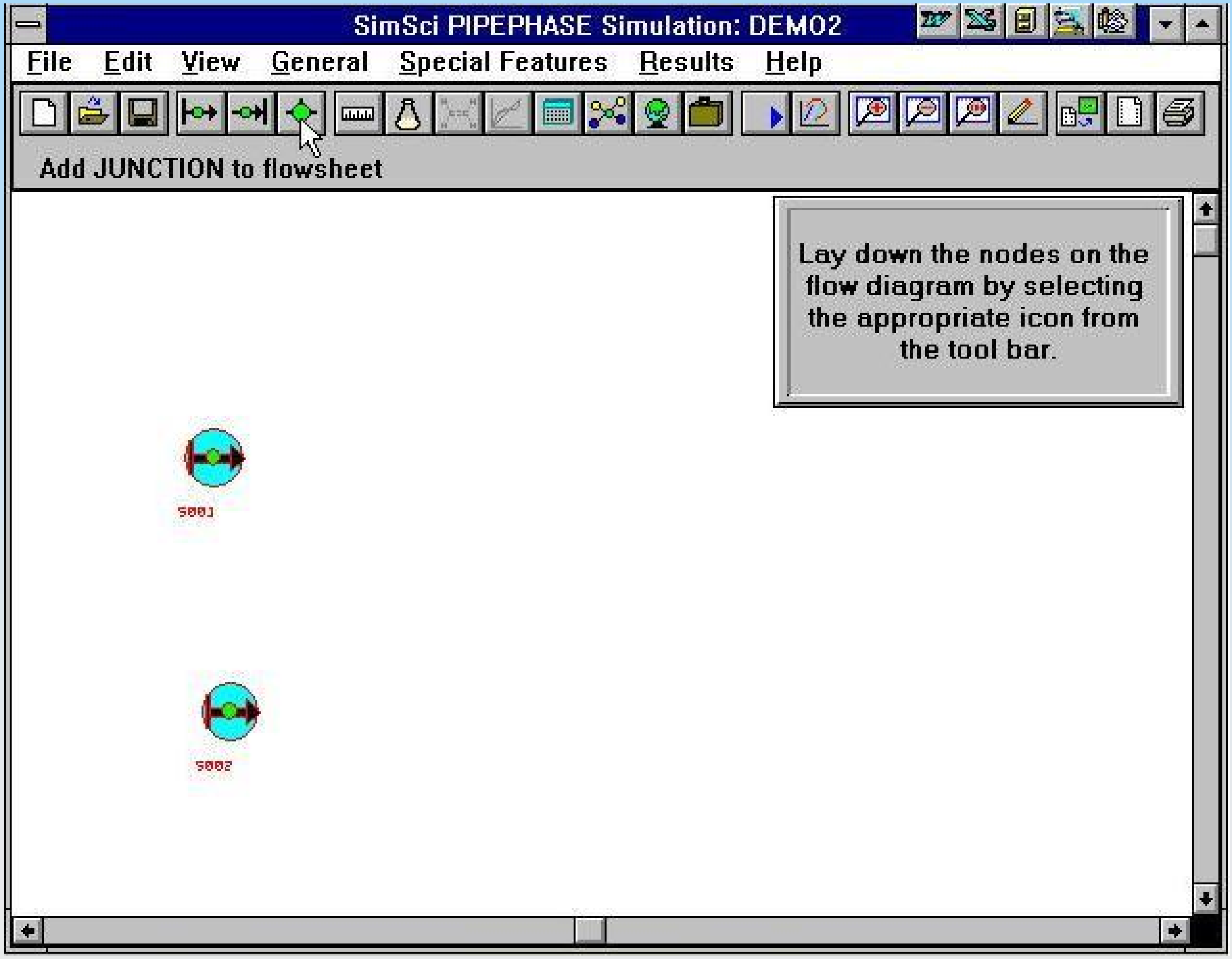

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Simulation Description...
Simulation Definition...
Input Units of Measurement...
PVT Data...
Component Library...
Thermodynamic Method...
Print Options...
Output Units of Measurement...
Calculation Methods...
Network Methods...
Global Defaults...
The level of detail on the output report can be controlled.

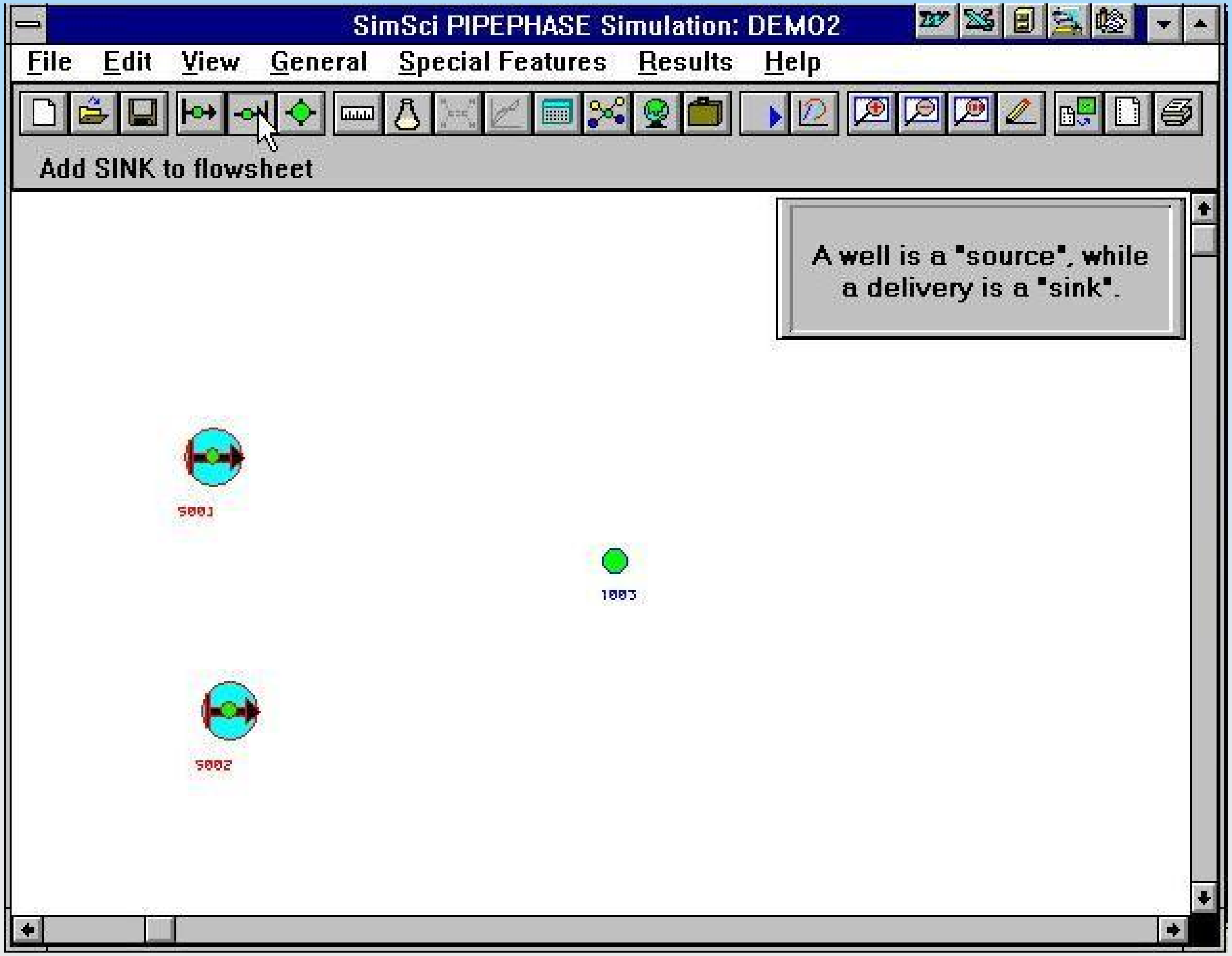

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Print Options
RAS Database
NONE
Input Reprint
FULL
Device Detail
SUMMARY
Device Style
BOTH
Property Data
NONE
Plots
NONE
Flash Report
FULL
Slug Report
NONE
Iteration Printout
Connectivity Plot
Taitel Dukler Flow Pattern Map
The RESULTS ACCESS SYSTEM (RAS) allows users to transfer data between PIPEPHASE and Windows spreadsheet programs
OK
Cancel
Help

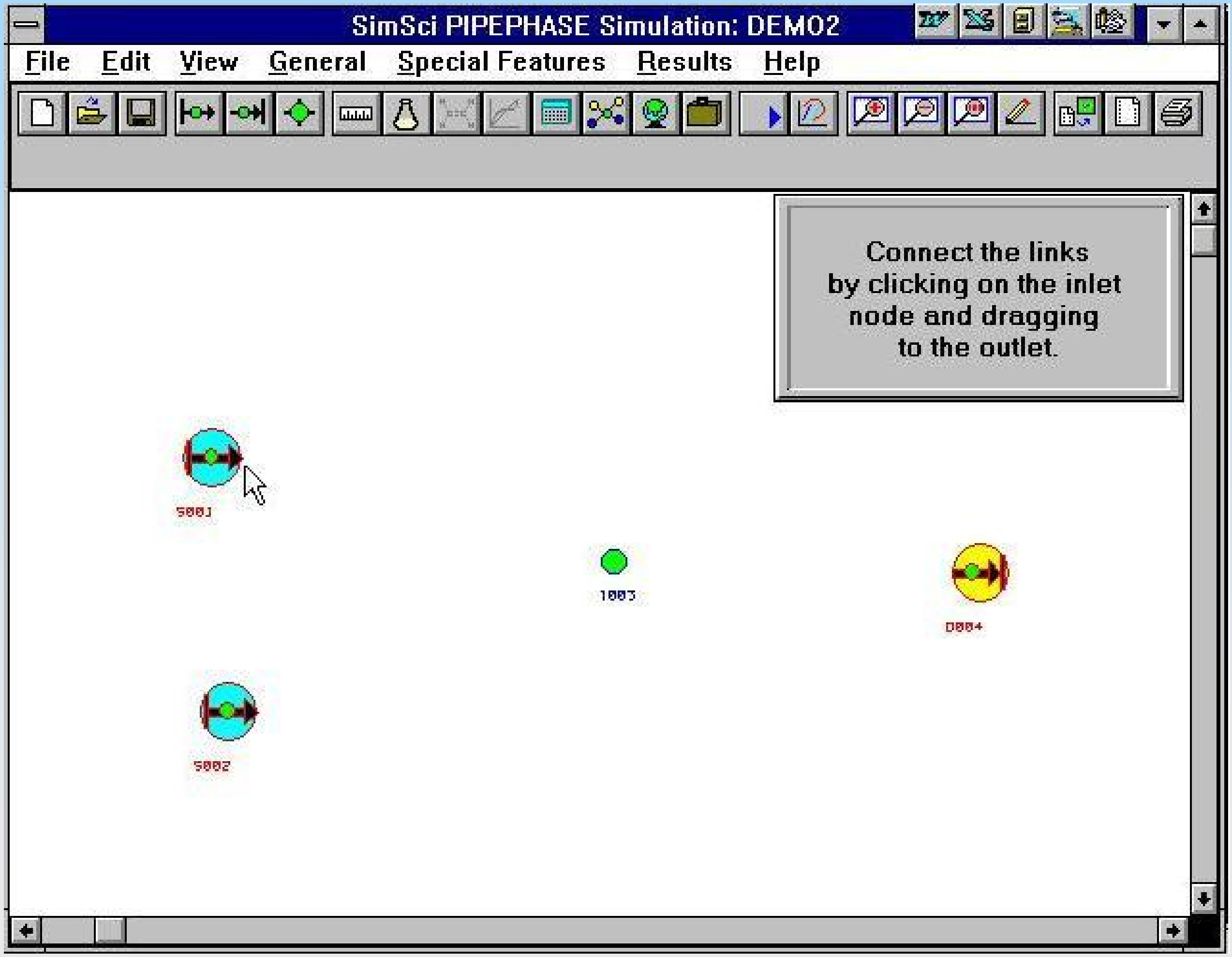

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Print Options
RAS Database FULL
Input Reprint FULL
Device Detail SUMMARY
Device Style BOTH
Property Data NONE
Plots NONE
Flash Report FULL
Slug Report NONE
Iteration Printout
Connectivity Plot
Taitel Dukler Flow Pattern Map
The RESULTS ACCESS SYSTEM (RAS) allows users to transfer data between PIPEPHASE and Windows spreadsheet programs
OK
Cancel
Help

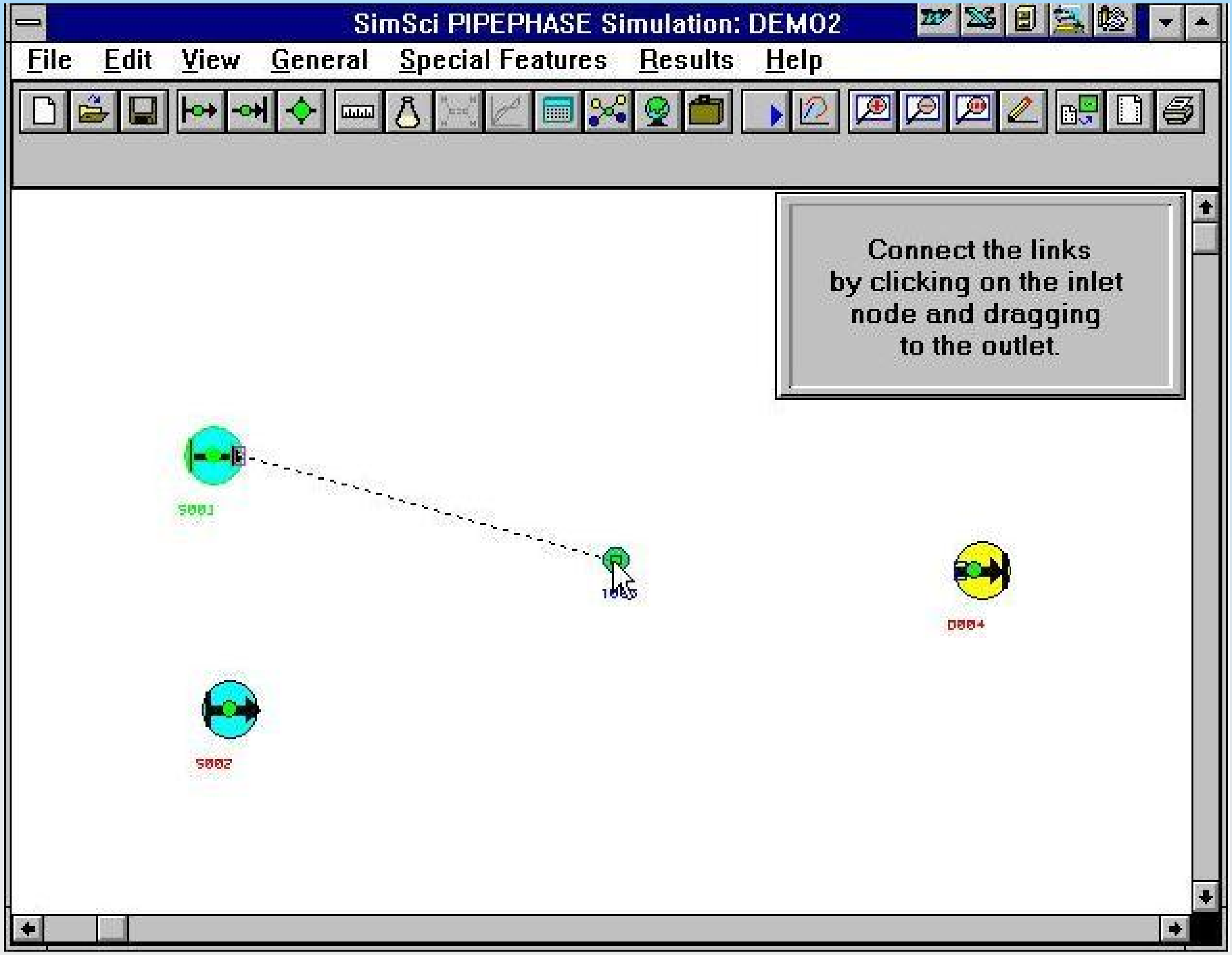

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Add SOURCE to flowsheet
Lay down the nodes on the flow diagram by selecting the appropriate icon from the tool bar.

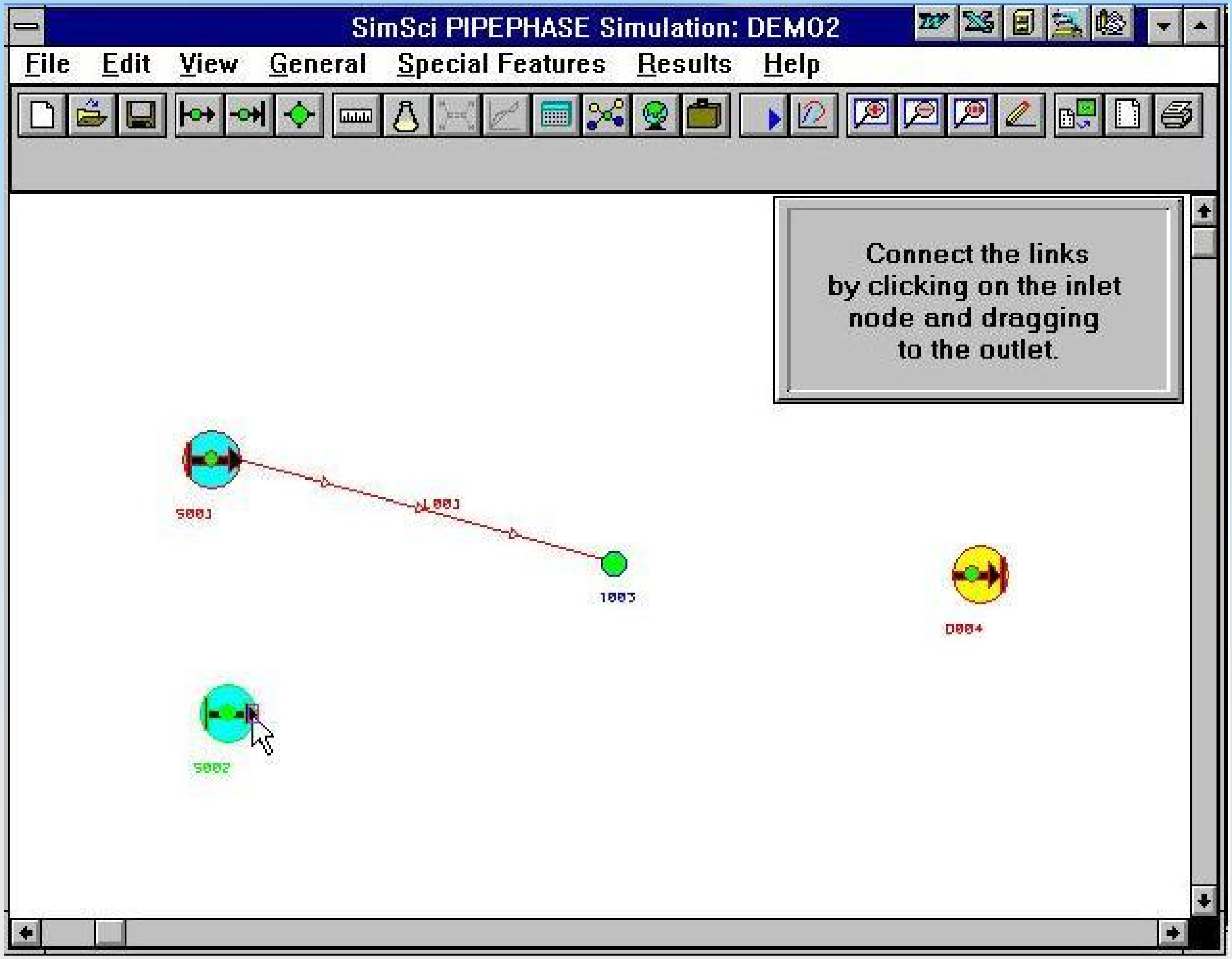

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Add SOURCE to flowsheet
Lay down the nodes on the flow diagram by selecting the appropriate icon from the tool bar.

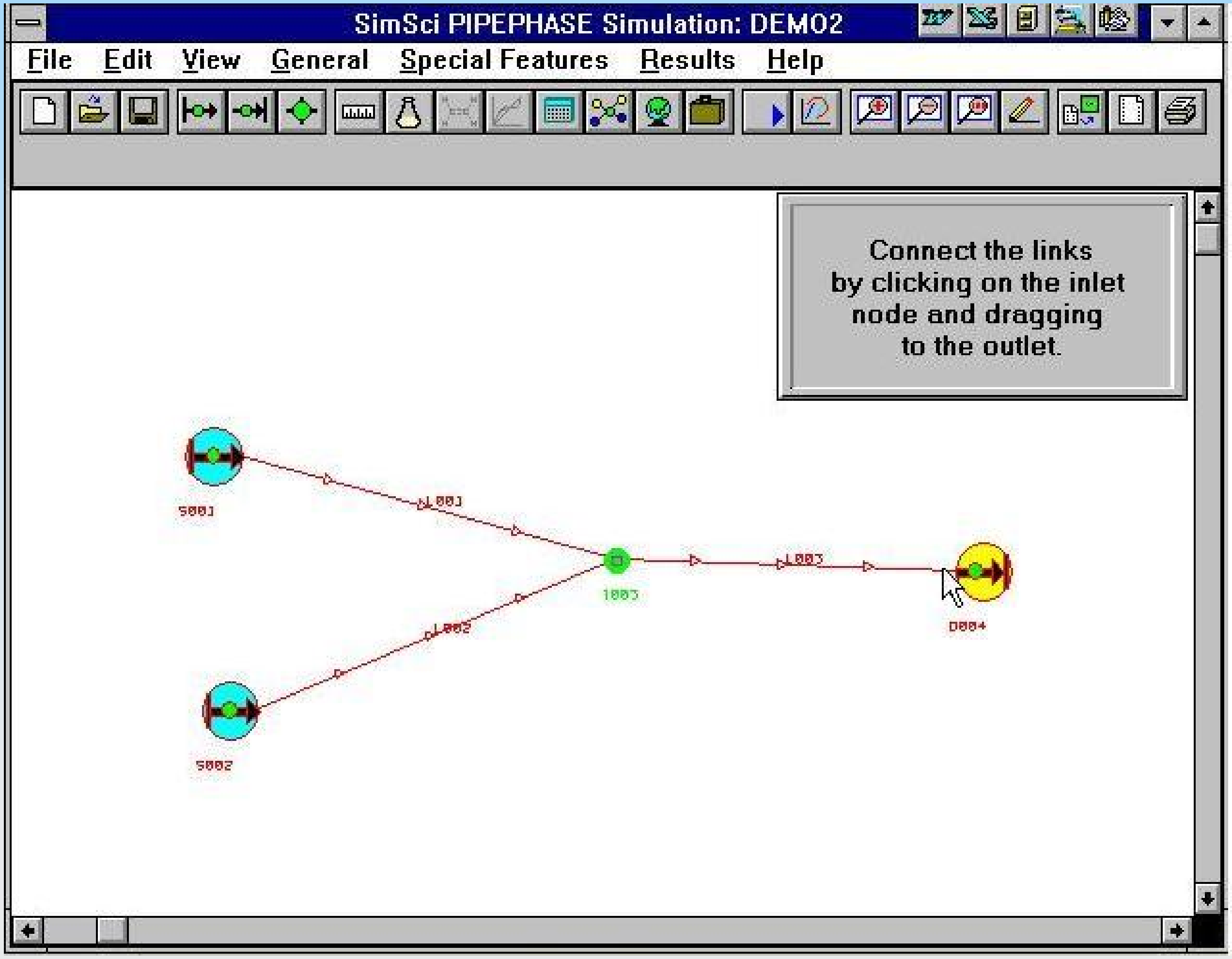

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Add JUNCTION to flowsheet
Lay down the nodes on the flow diagram by selecting the appropriate icon from the tool bar.
S001
S002


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Add SINK to flowsheet
A well is a "source", while a delivery is a "sink".
S001
1003
S002

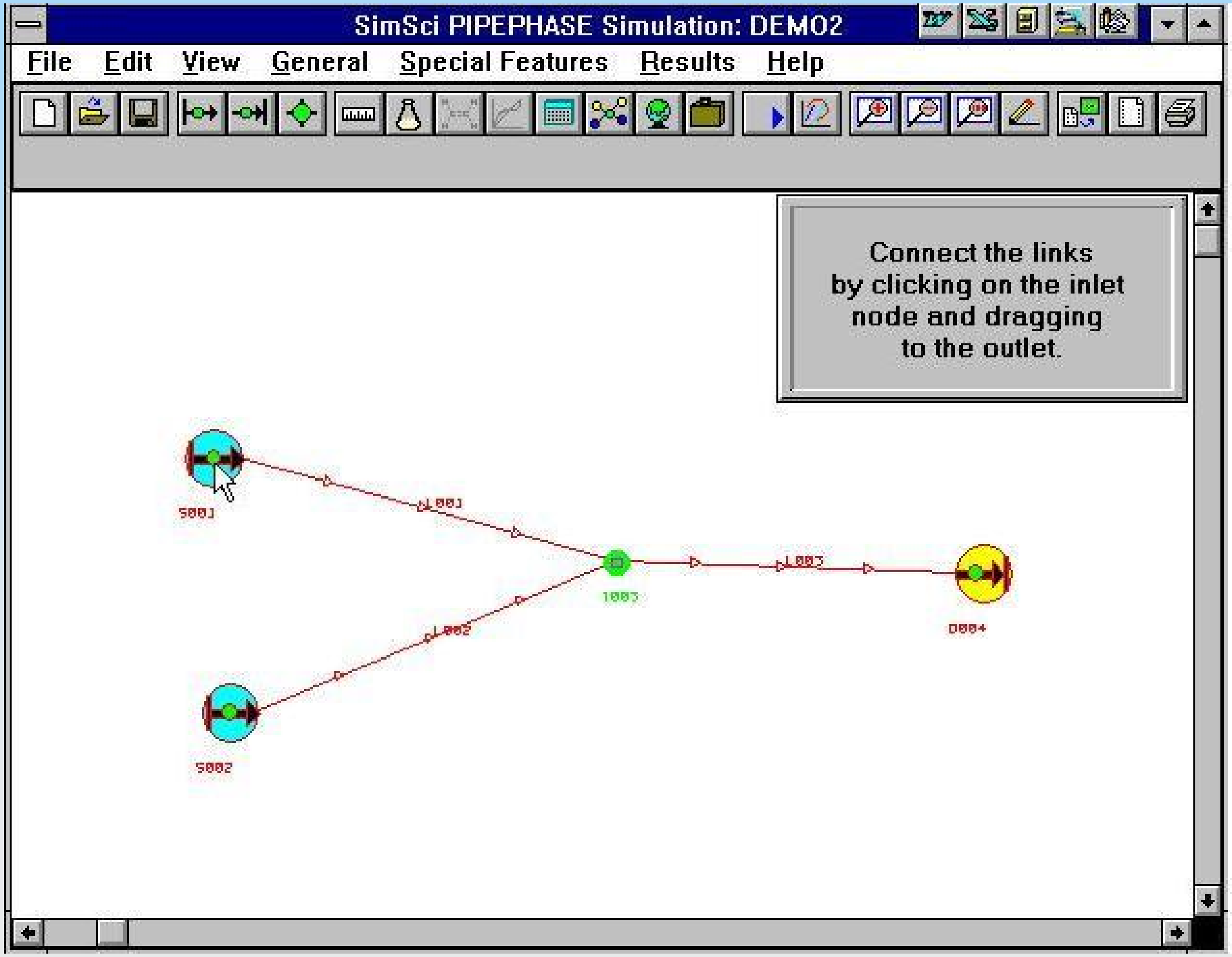

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Connect the links
by clicking on the inlet
node and dragging
to the outlet.
1003

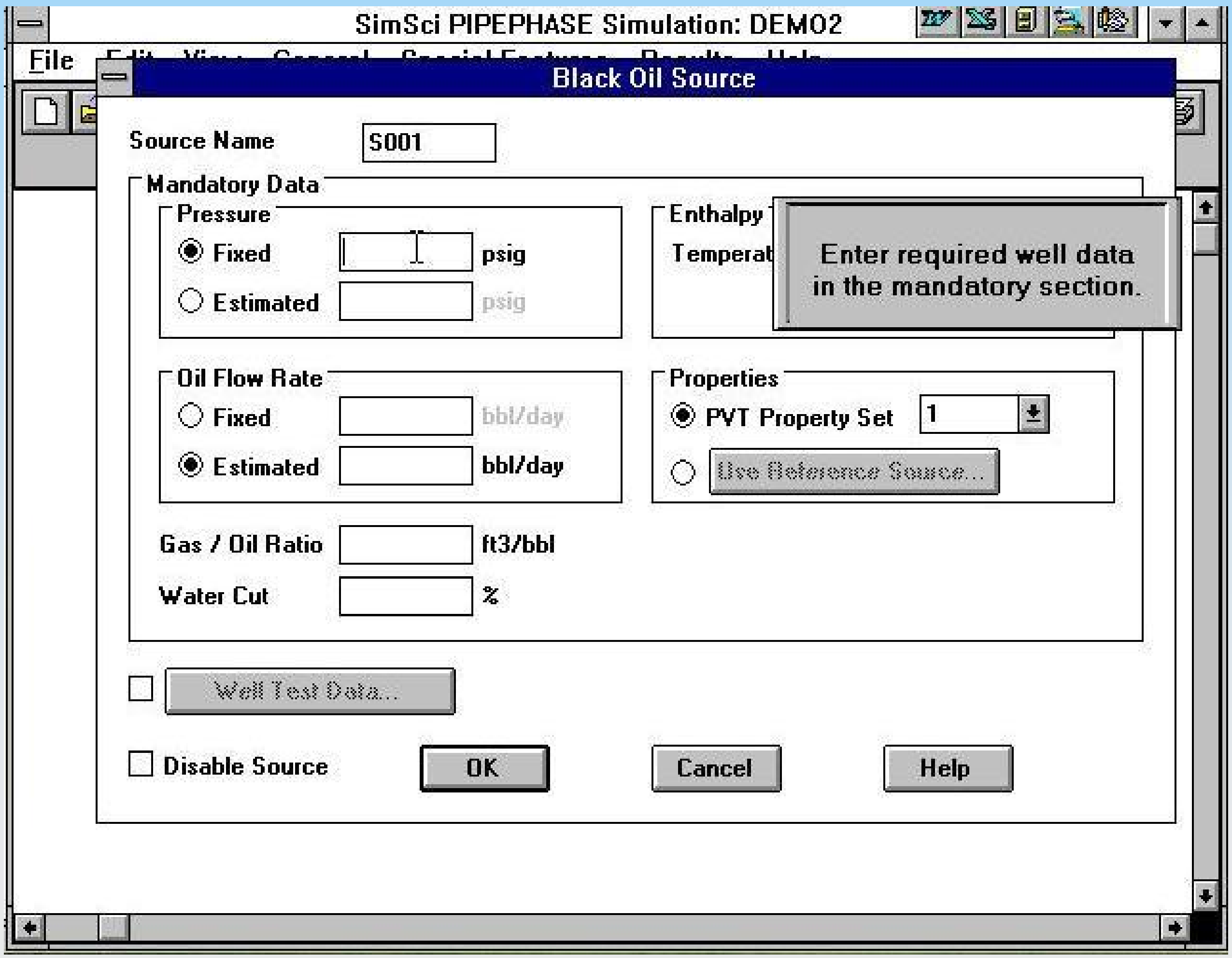

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Connect the links
by clicking on the inlet
node and dragging
to the outlet.
S001
D004
S002

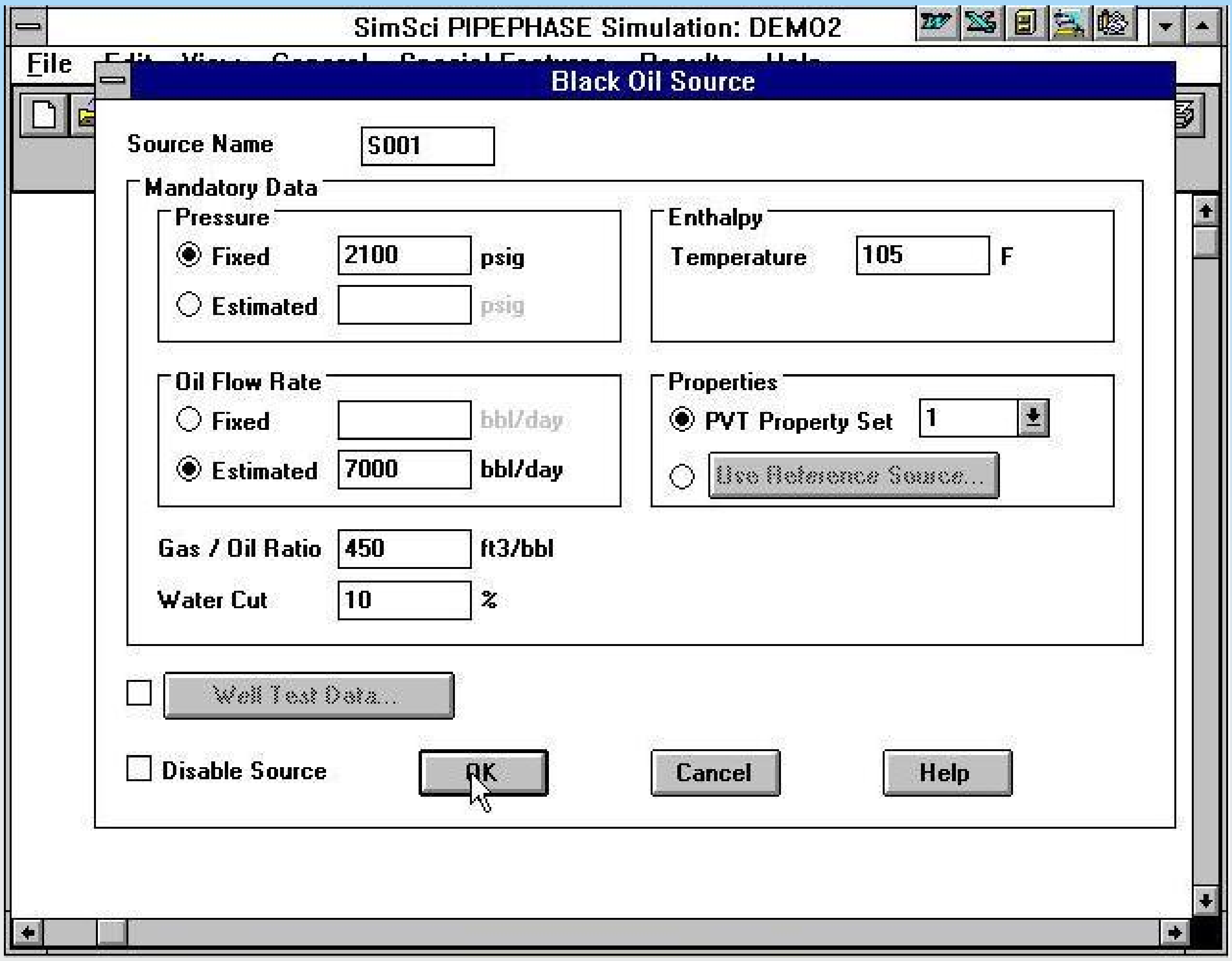

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Connect the links by clicking on the inlet node and dragging to the outlet.
S001
L001
J003
D004
S002



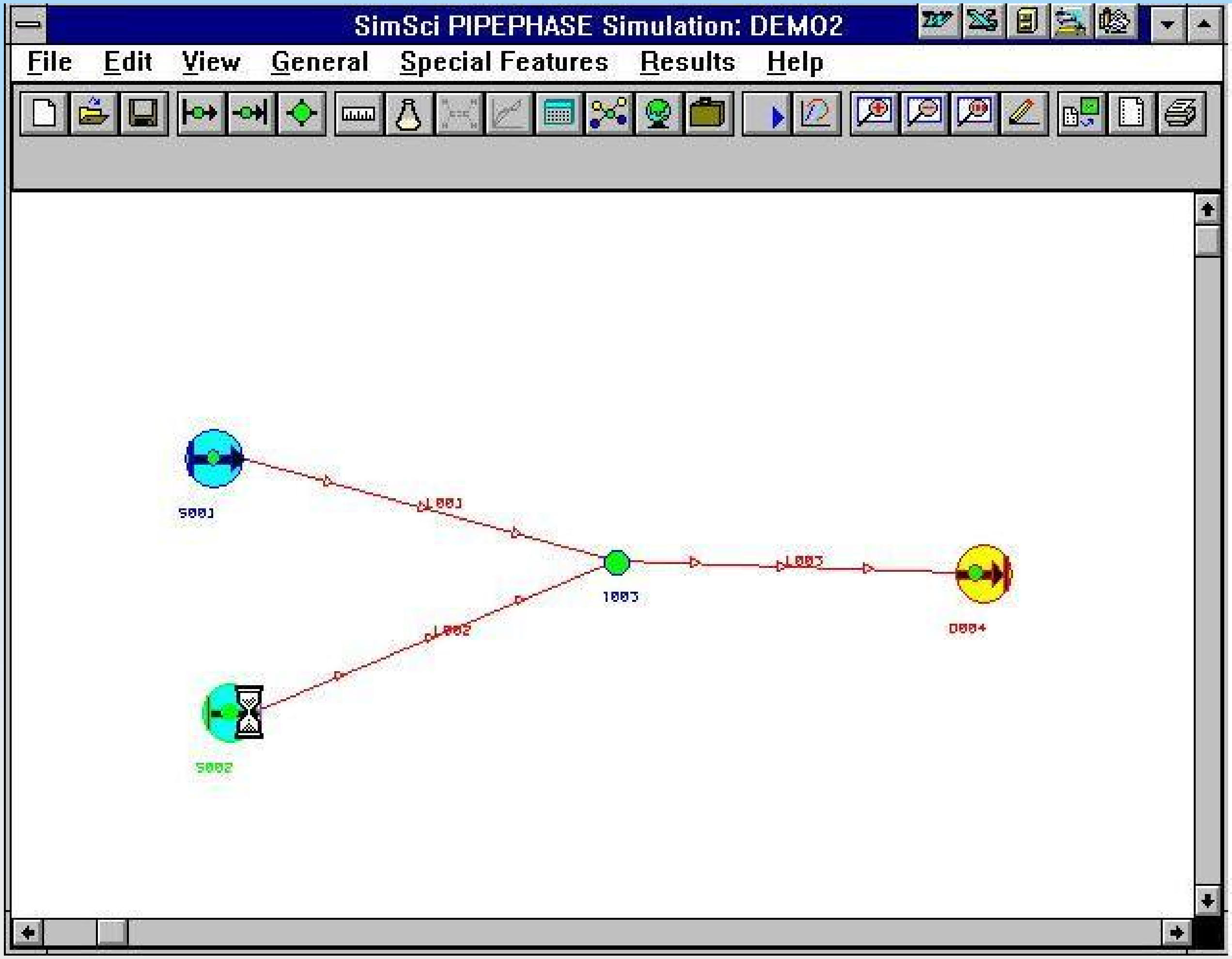
SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Connect the links by clicking on the inlet node and dragging to the outlet.

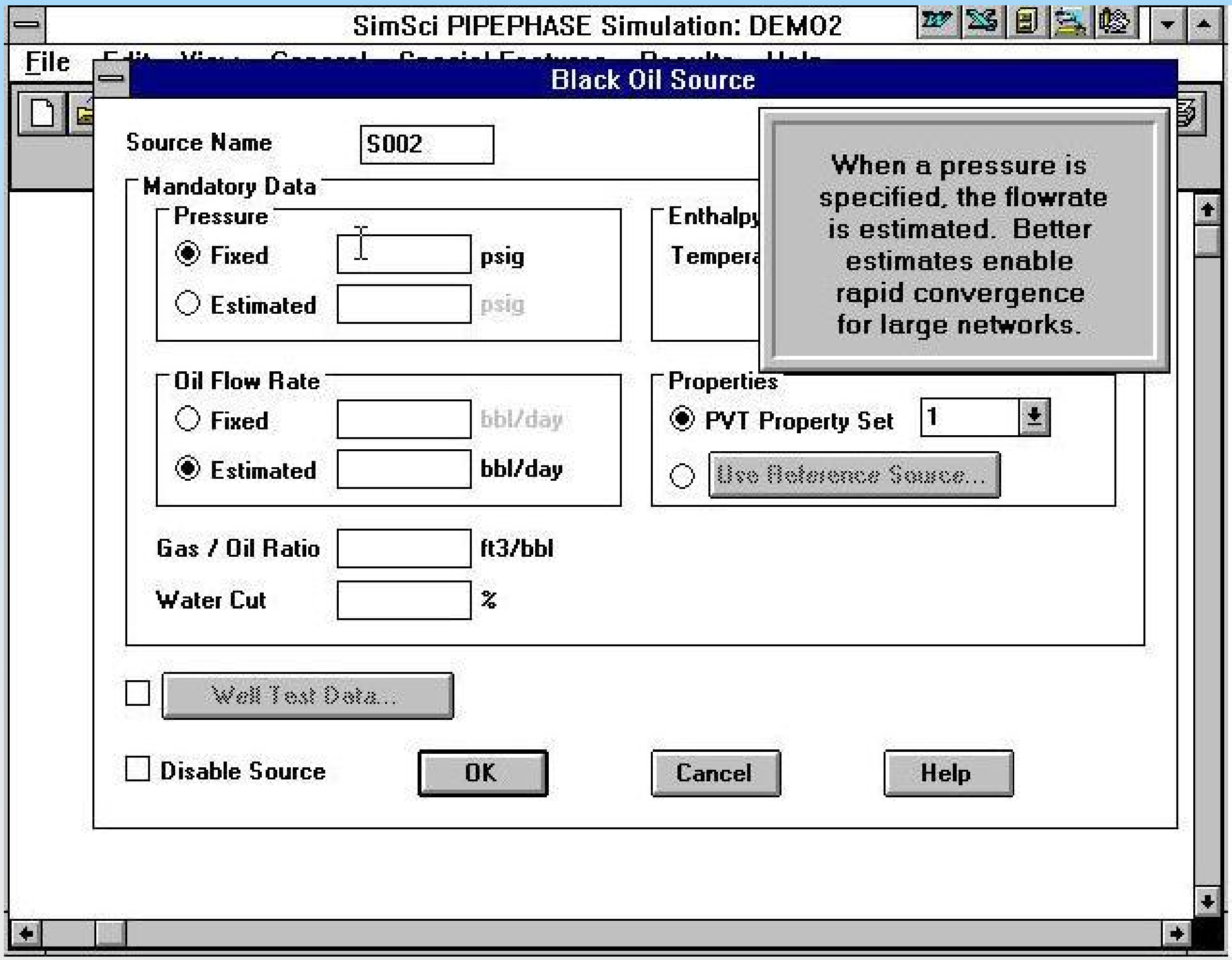

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Connect the links
by clicking on the inlet
node and dragging
to the outlet.

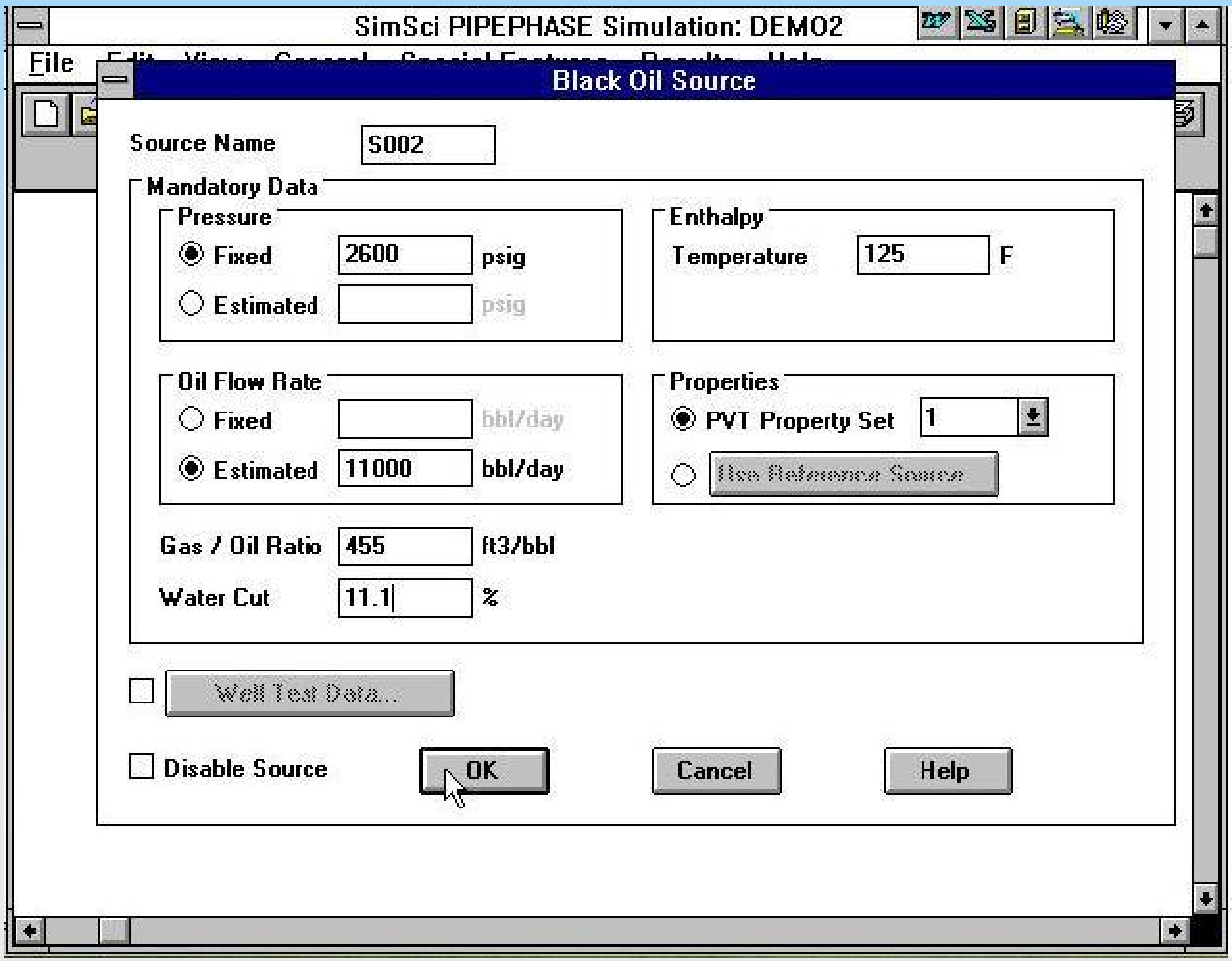

SimSci PIPEPHASE Simulation: DEMO2
File
Black Oil Source
Source Name
S001
Mandatory Data
Pressure
Fixed
psig
Estimated
psig
Enthalpy
Temperat
Enter required well data
in the mandatory section.
Oil Flow Rate
Fixed
bbl/day
Estimated
bbl/day
Properties
PVT Property Set
1
Use Reference Source...
Gas / Oil Ratio
ft3/bbl
Water Cut
%
Well Test Data...
Disable Source
OK
Cancel
Help

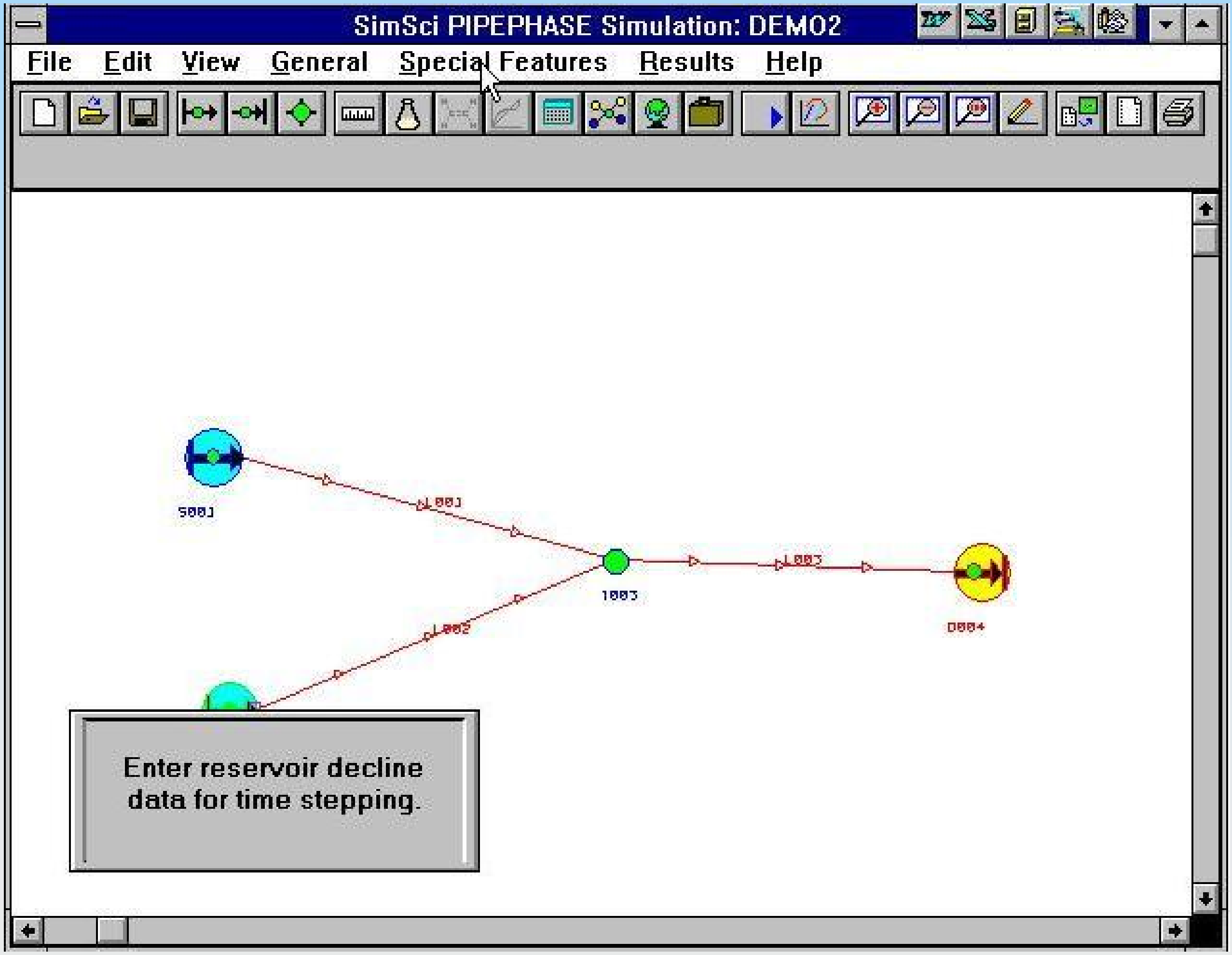


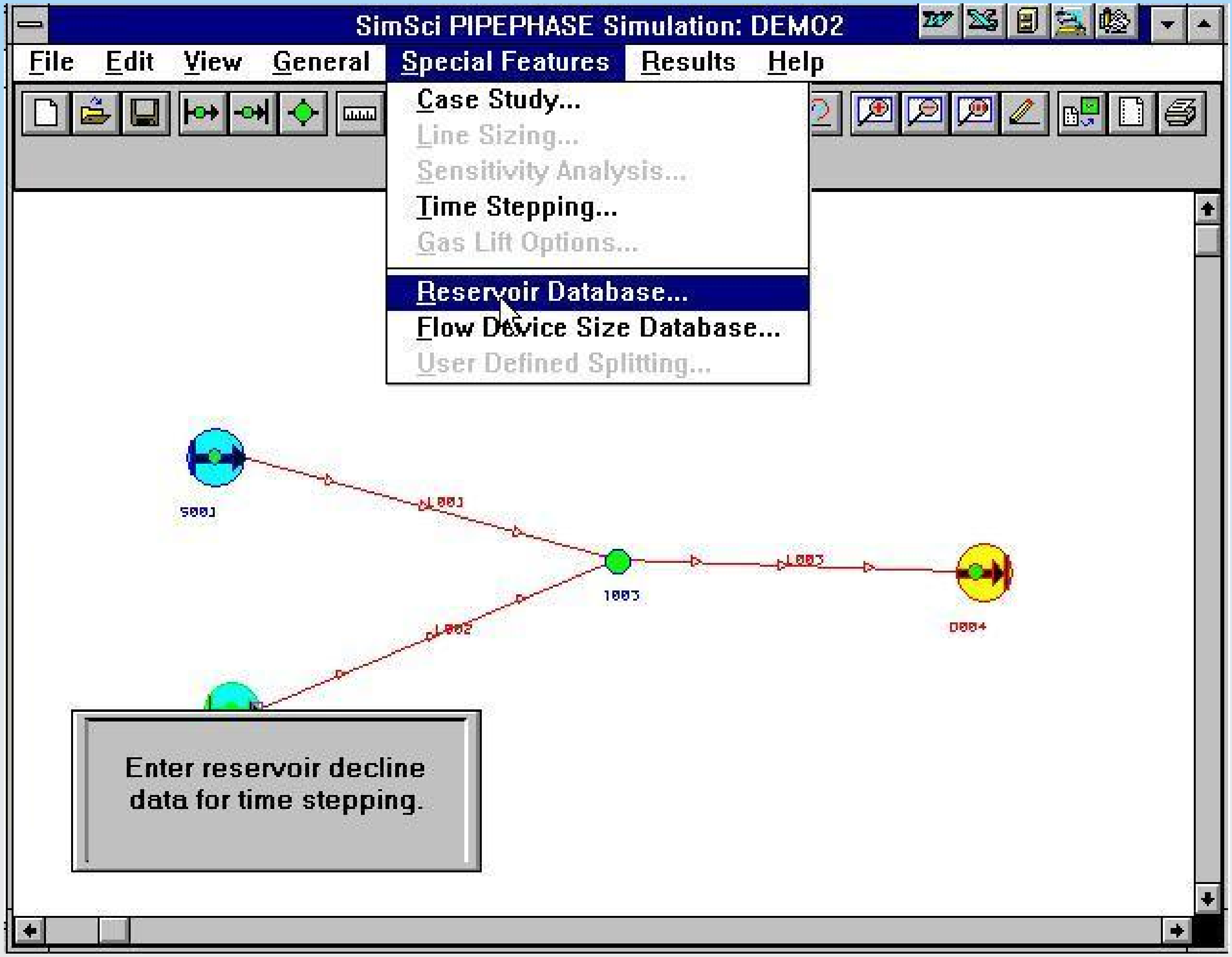
SimSci PIPEPHASE Simulation: DEMO2
File
Black Oil Source
Source Name
S001
Mandatory Data
Pressure
Fixed
2100
psig
Estimated
psig
Enthalpy
Temperature
105
F
Oil Flow Rate
Fixed
bbl/day
Estimated
7000
bbl/day
Properties
PVT Property Set
1
Use Reference Source...
Gas / Oil Ratio
450
ft3/bbl
Water Cut
10
%
Well Test Data...
Disable Source
OK
Cancel
Help

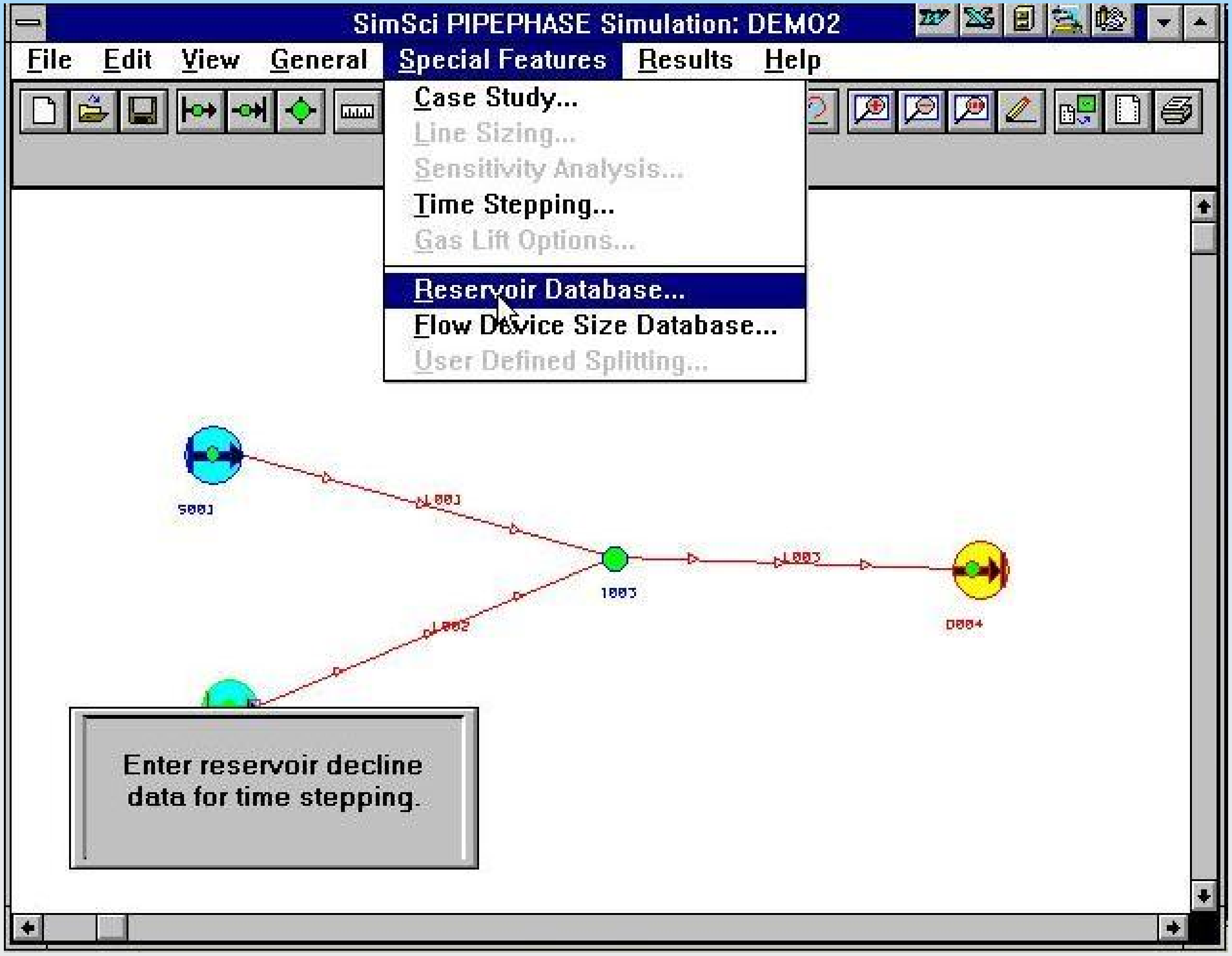

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
L001
S001
L003
1003
D004
L002
S002

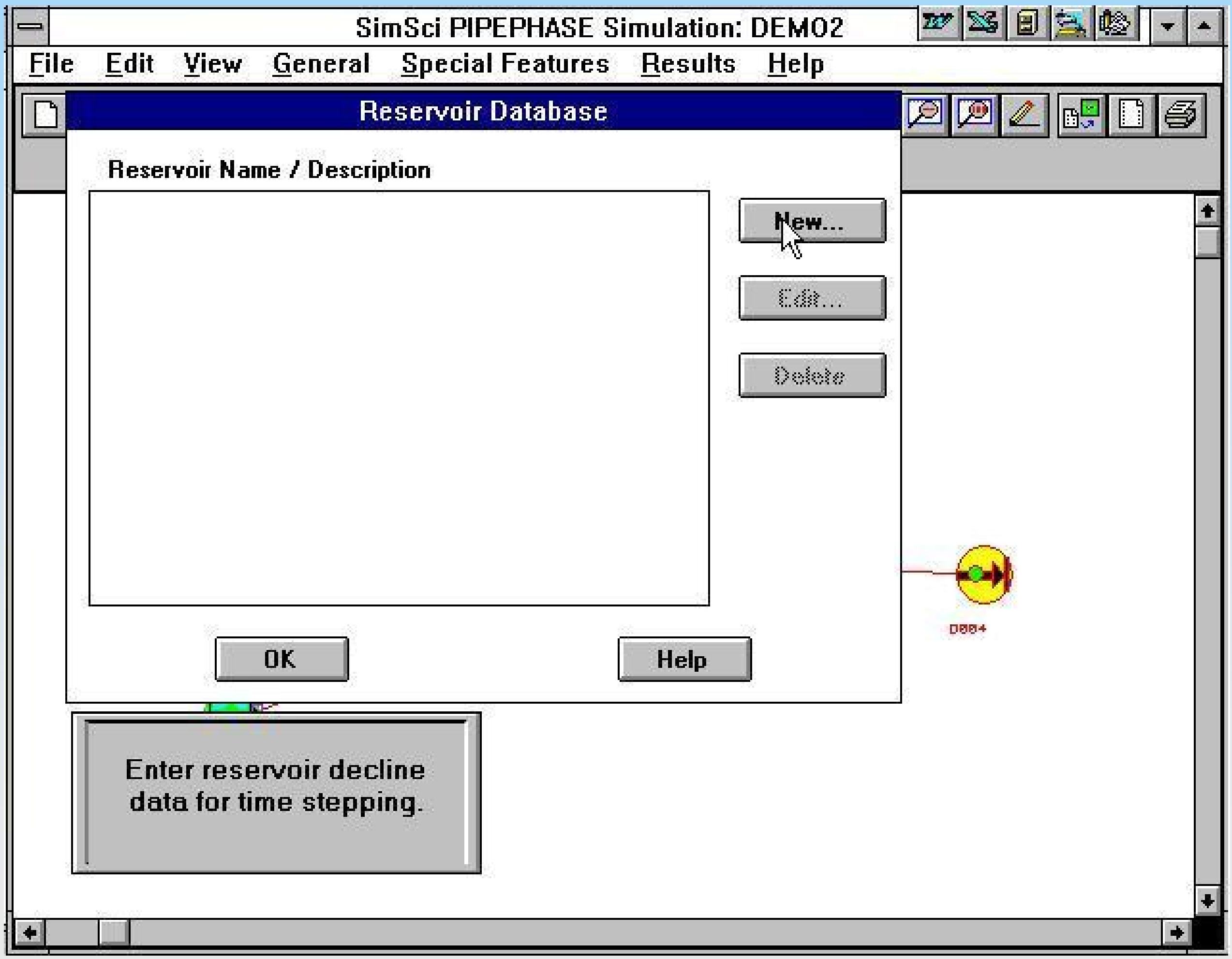

SimSci PIPEPHASE Simulation: DEMO2
File
Black Oil Source
Source Name
S002
Mandatory Data
Pressure
Fixed
psig
Estimated
psig
Enthalpy
Oil Flow Rate
Fixed
bbl/day
Estimated
bbl/day
Properties
PVT Property Set
1
Use Reference Source...
Gas / Oil Ratio
ft3/bbl
Water Cut
%
Well Test Data...
Disable Source
OK
Cancel
Help
When a pressure is specified, the flowrate is estimated. Better estimates enable rapid convergence for large networks.

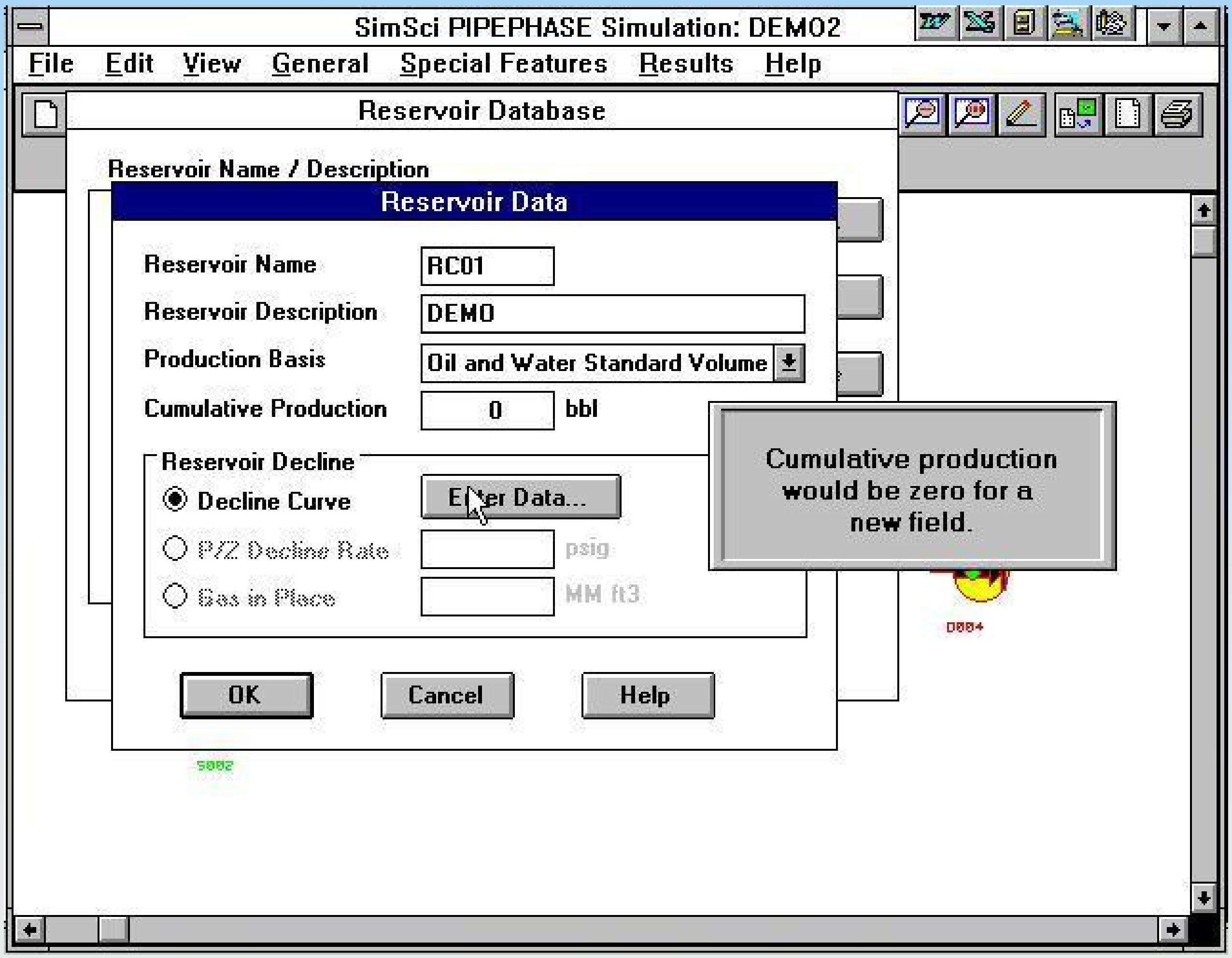

SimSci PIPEPHASE Simulation: DEMO2
File
Black Oil Source
Source Name
S002
Mandatory Data
Pressure
Fixed
2600
psig
Estimated
psig
Enthalpy
Temperature
125
F
Oil Flow Rate
Fixed
bbl/day
Estimated
11000
bbl/day
Properties
PVT Property Set
1
Use Reference Source
Gas / Oil Ratio
455
ft3/bbl
Water Cut
11.1
%
Well Test Data...
Disable Source
OK
Cancel
Help

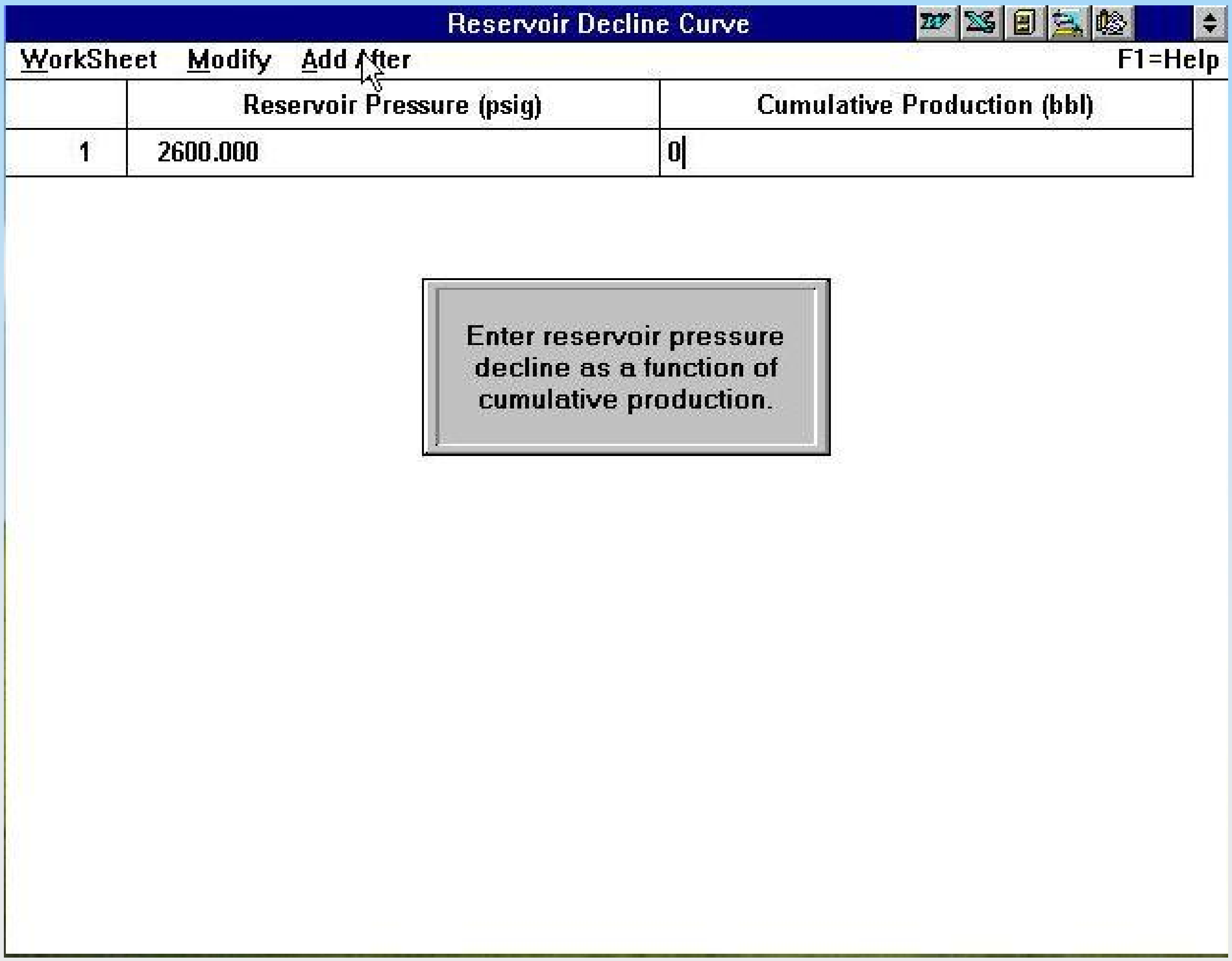

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Enter reservoir decline data for time stepping.

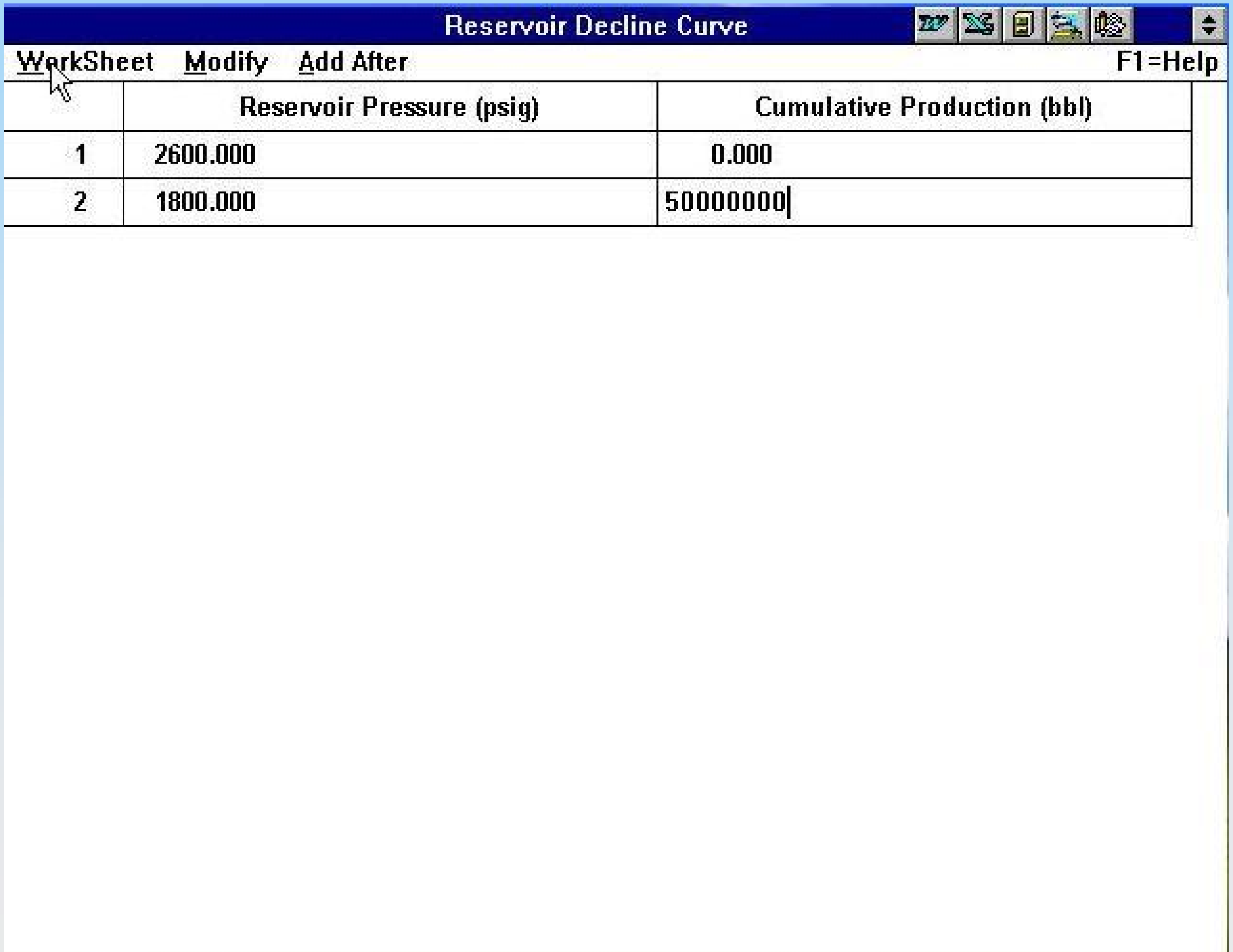

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Case Study...
Line Sizing...
Sensitivity Analysis...
Time Stepping...
Gas Lift Options...
Reservoir Database...
Flow Device Size Database...
User Defined Splitting...
Enter reservoir decline data for time stepping.


SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Case Study...
Line Sizing...
Sensitivity Analysis...
Time Stepping...
Gas Lift Options...
Reservoir Database...
Flow Device Size Database...
User Defined Splitting...
Enter reservoir decline data for time stepping.

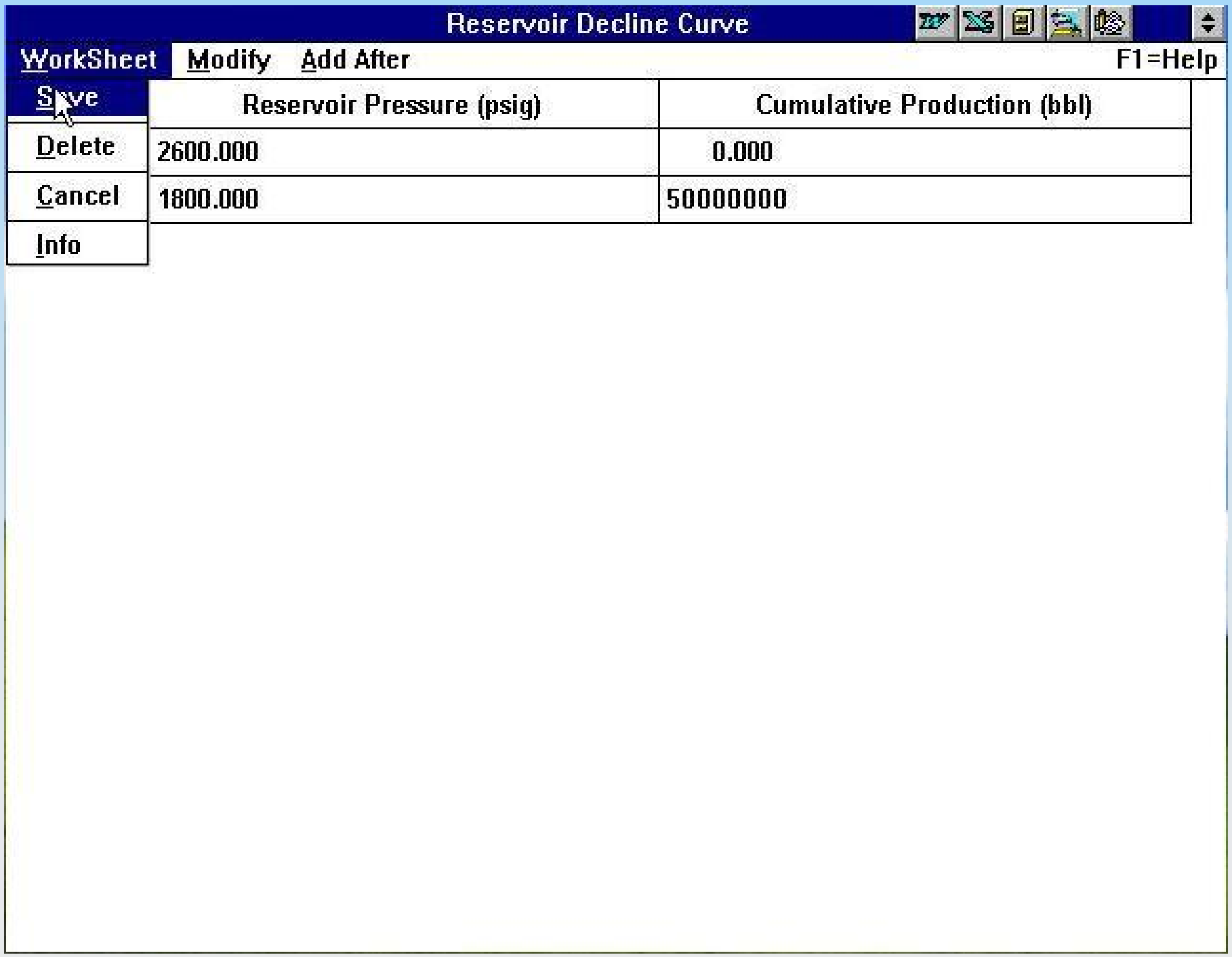

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Reservoir Database
Reservoir Name / Description
New...
Edit...
Delete
OK
Help
D004
Enter reservoir decline data for time stepping.

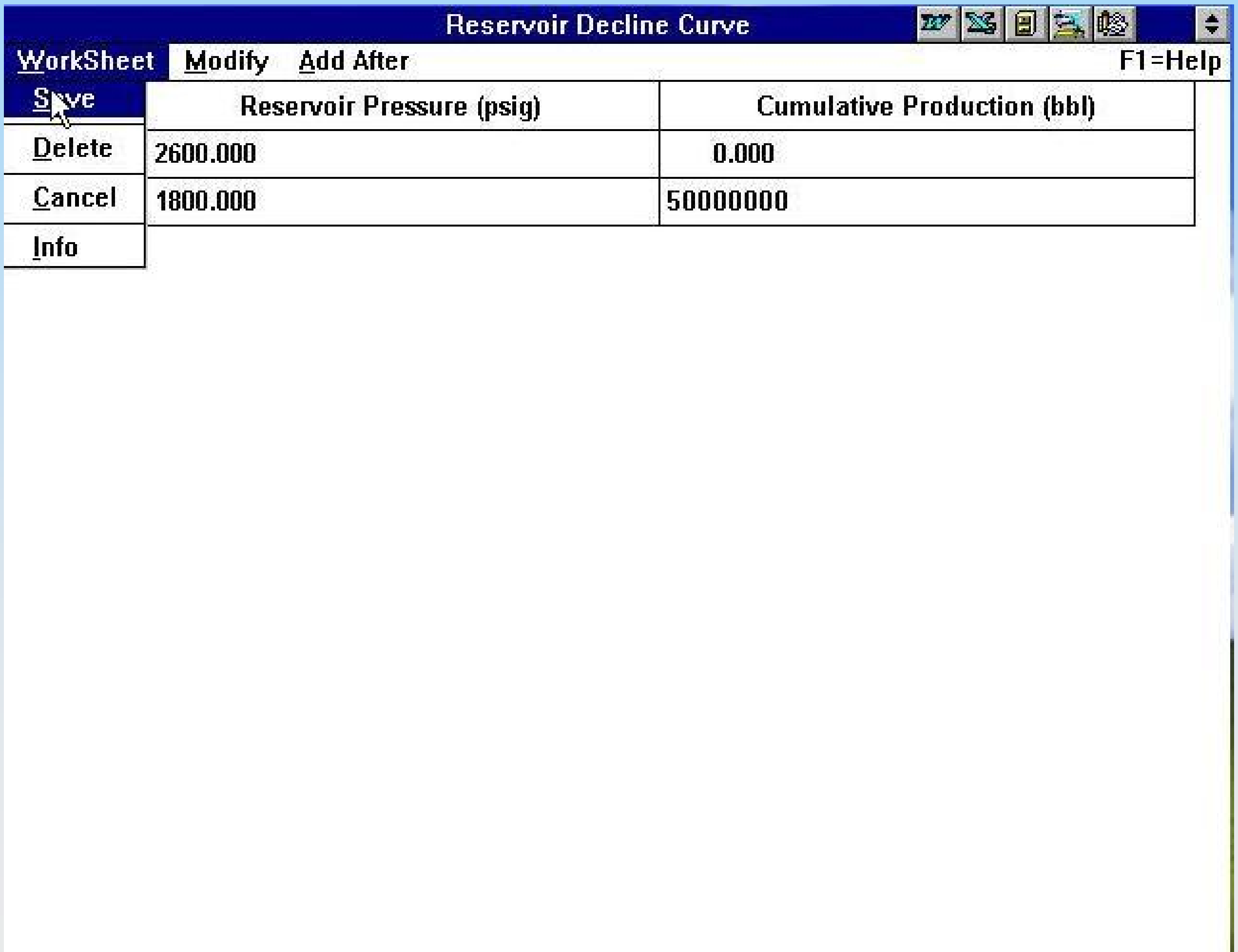

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Reservoir Database
Reservoir Name / Description
Reservoir Data
Reservoir Name
RC01
Reservoir Description
DEMO
Production Basis
Oil and Water Standard Volume
Cumulative Production
0
bbl
Reservoir Decline
Decline Curve
Enter Data...
P/Z Decline Rate
psig
Gas in Place
MM ft3
OK
Cancel
Help
Cumulative production would be zero for a new field.

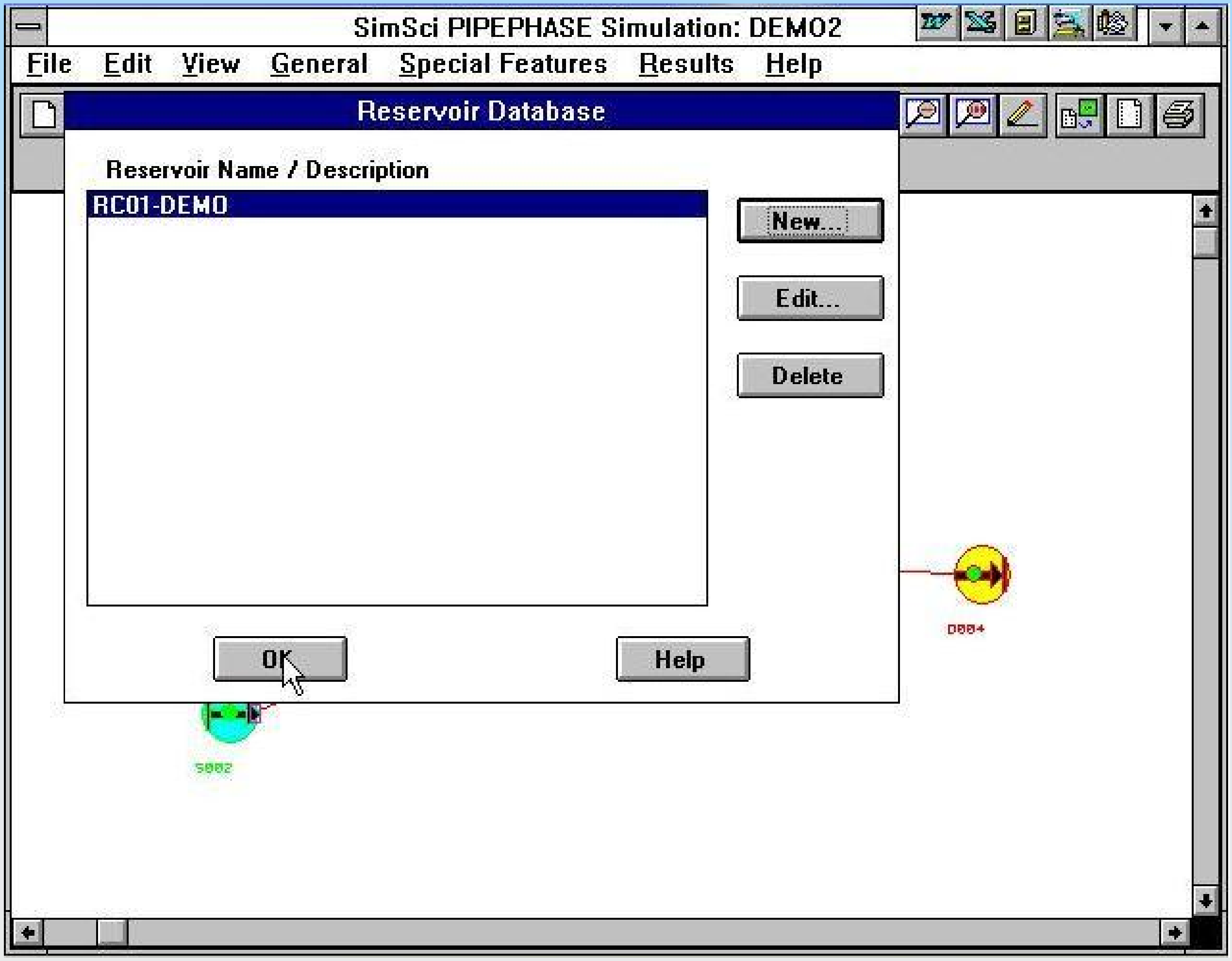

Reservoir Decline Curve
WorkSheet
Modify
Add After
F1=Help
Reservoir Pressure (psig)
Cumulative Production (bbl)
1
2600.000
0
Enter reservoir pressure decline as a function of cumulative production.

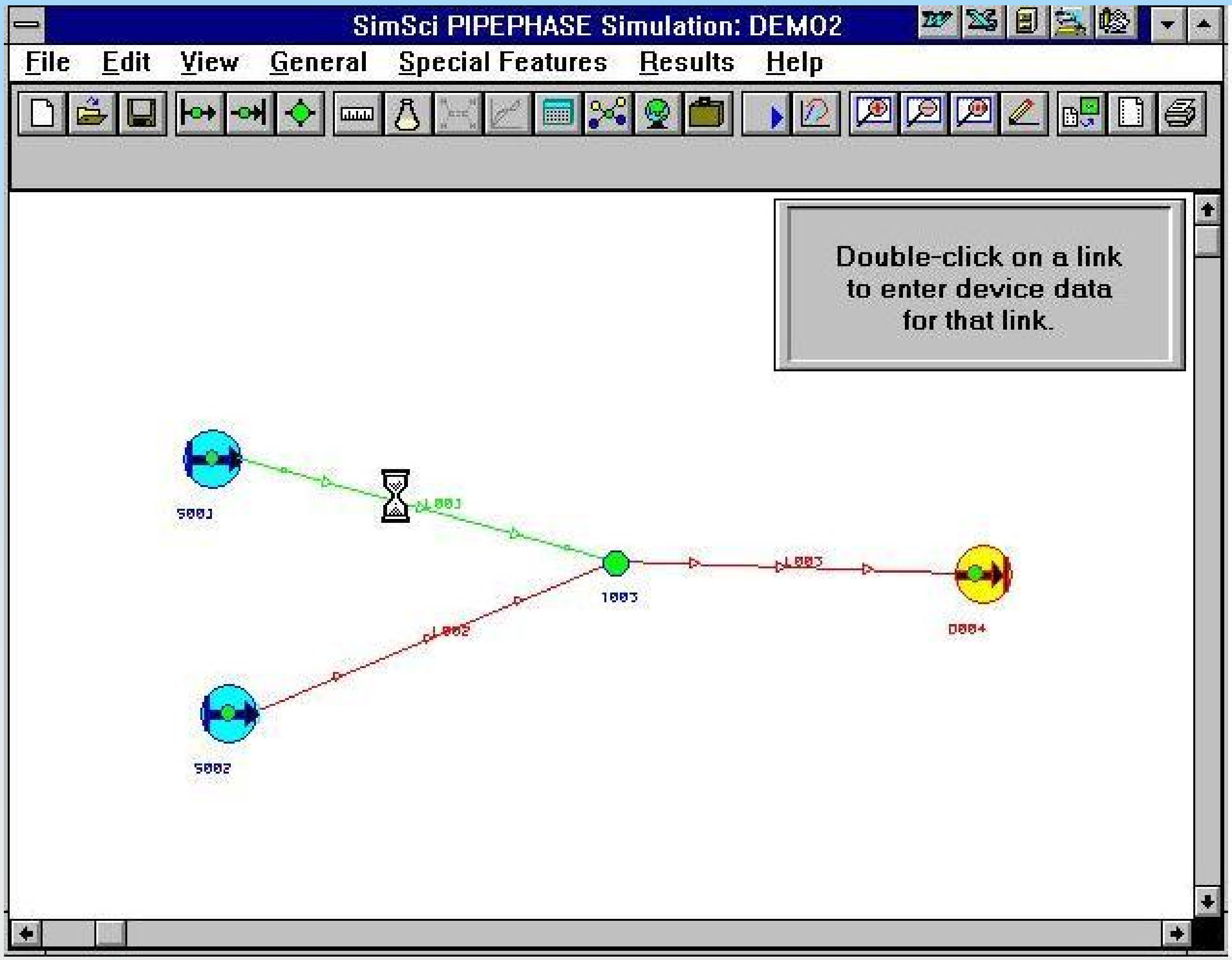


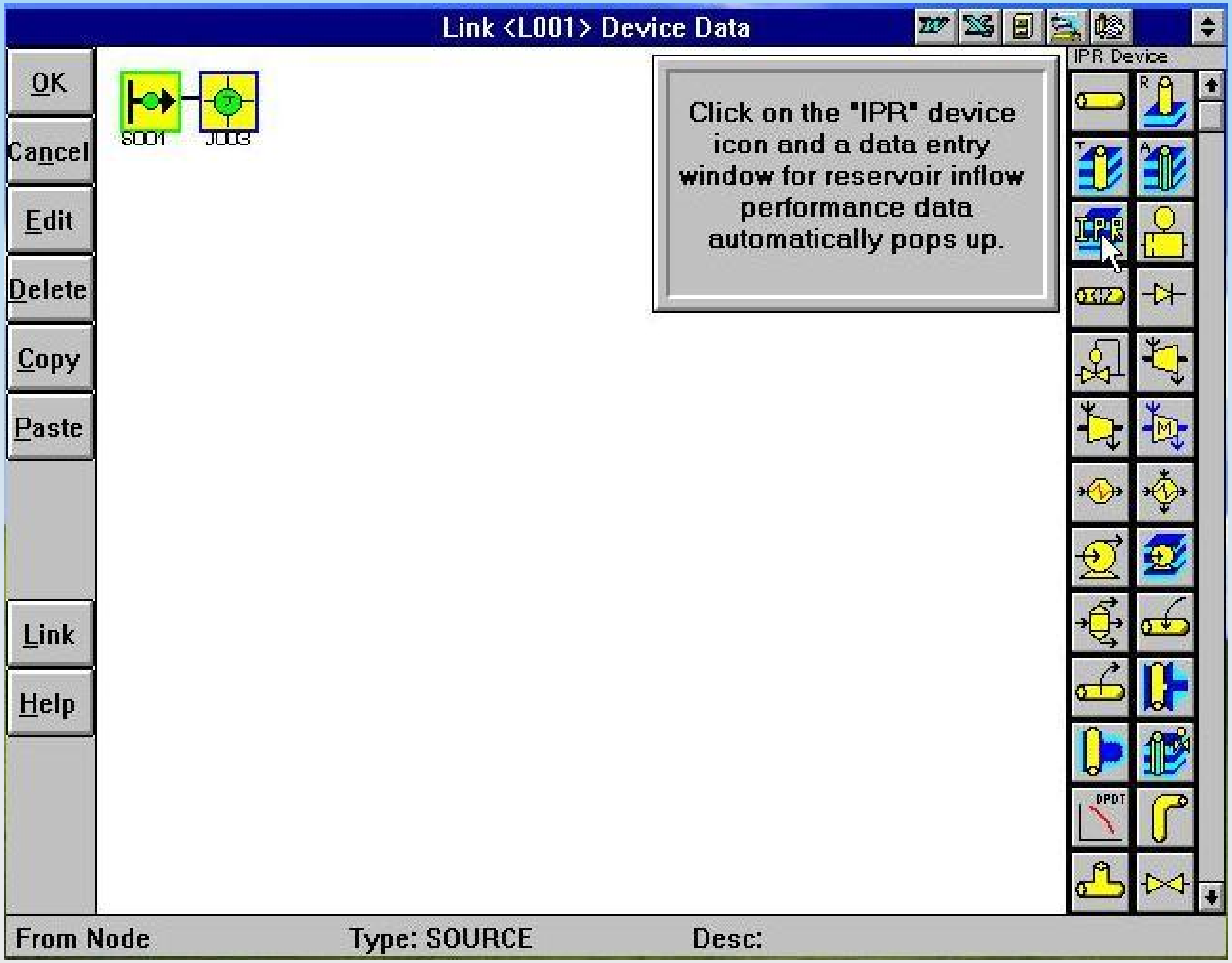
	Reservoir Pressure (psig)	Cumulative Production (bbl)
1	2600.000	0.000
2	1800.000	50000000

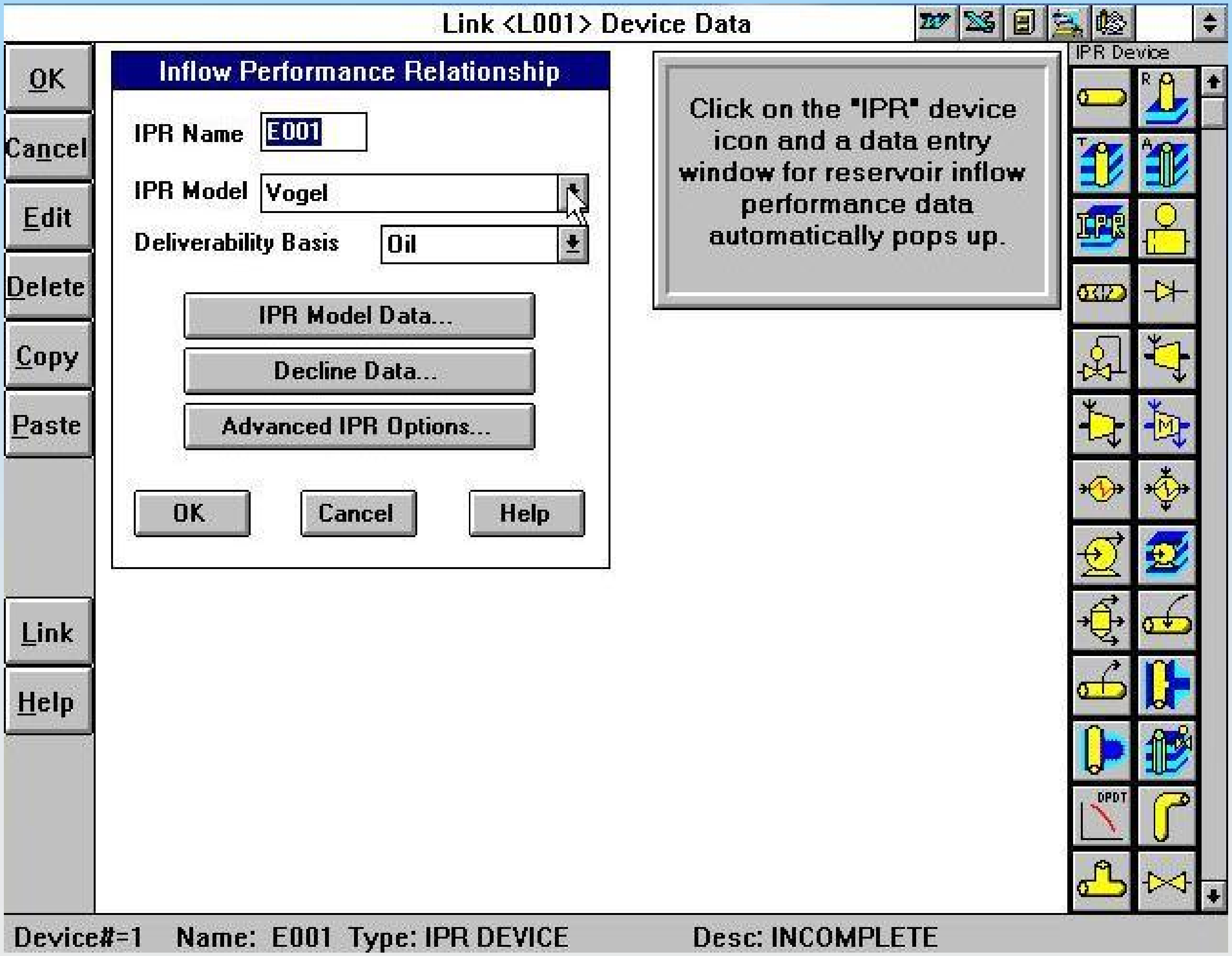

Reservoir Decline Curve
WorkSheet
Modify
Add After
F1=Help
Save
Delete
Cancel
Info
Reservoir Pressure (psig)
Cumulative Production (bbl)
2600.000
0.000
1800.000
50000000

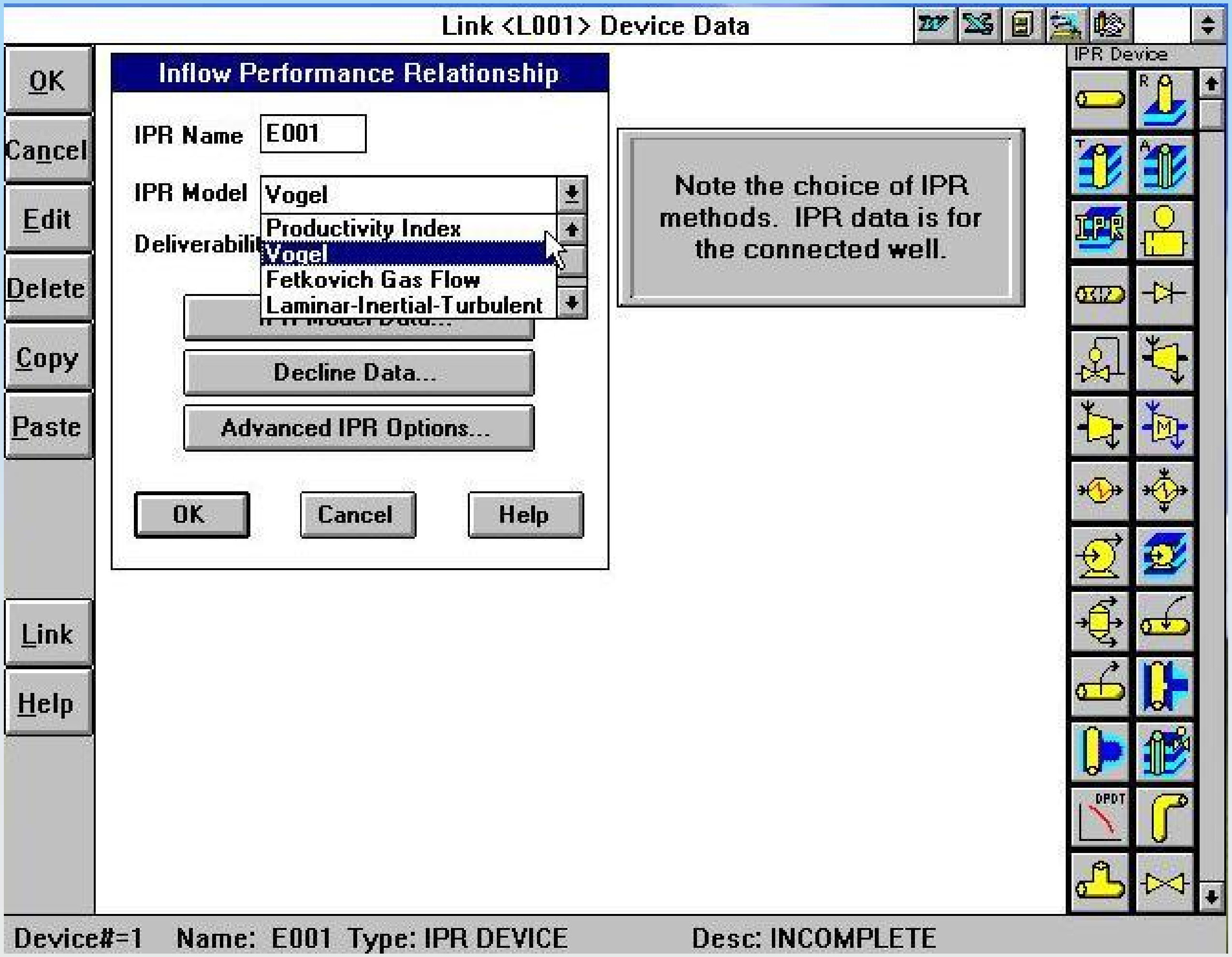

Reservoir Decline Curve
WorkSheet
Modify
Add After
F1=Help
Save
Delete
Cancel
Info
Reservoir Pressure (psig)
Cumulative Production (bbl)
2600.000
0.000
1800.000
50000000

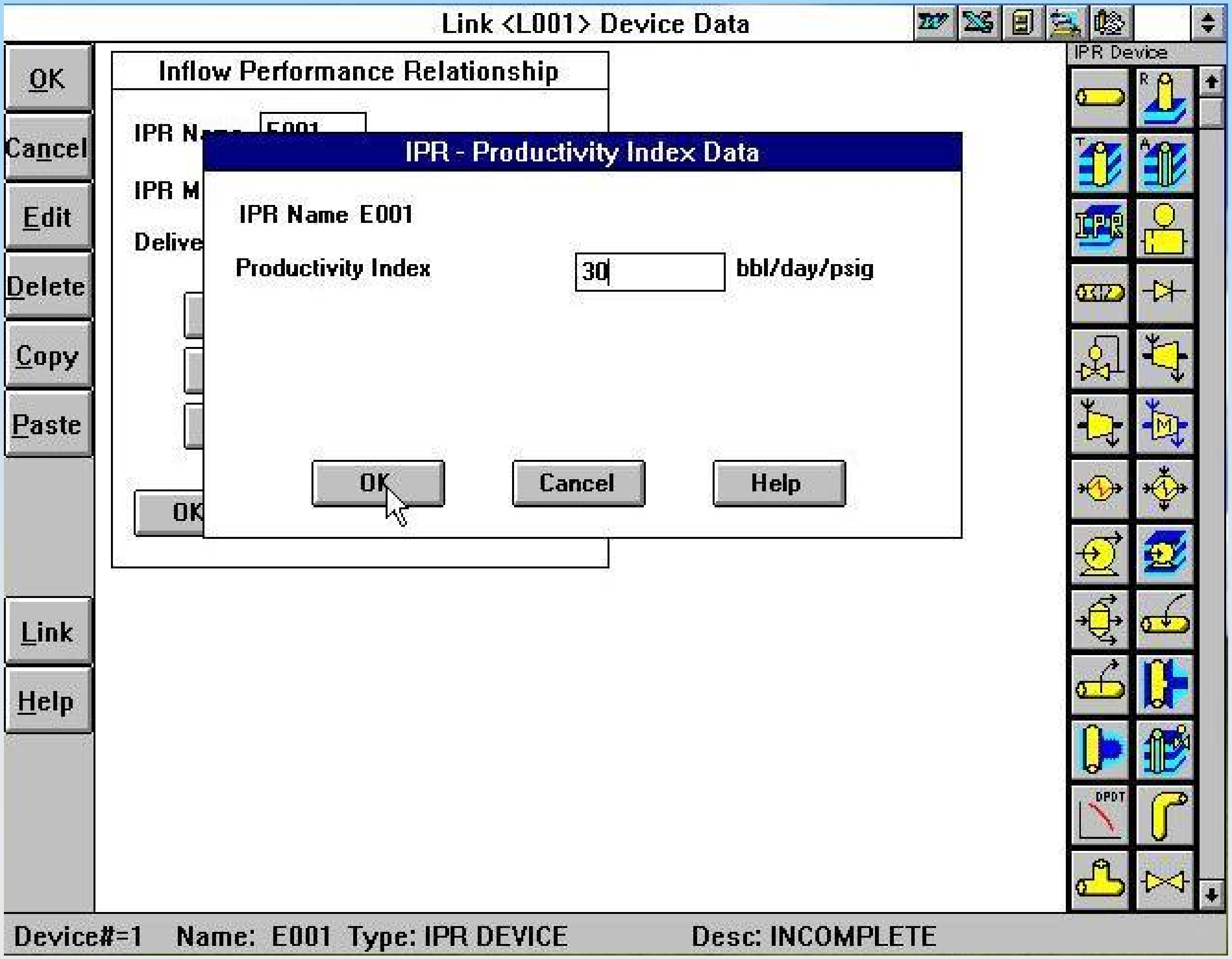

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Reservoir Database
Reservoir Name / Description
RC01-DEMO
New...
Edit...
Delete
OK
Help


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Double-click on a link
to enter device data
for that link.
S001
L001
1003
L003
D004
L002
S002

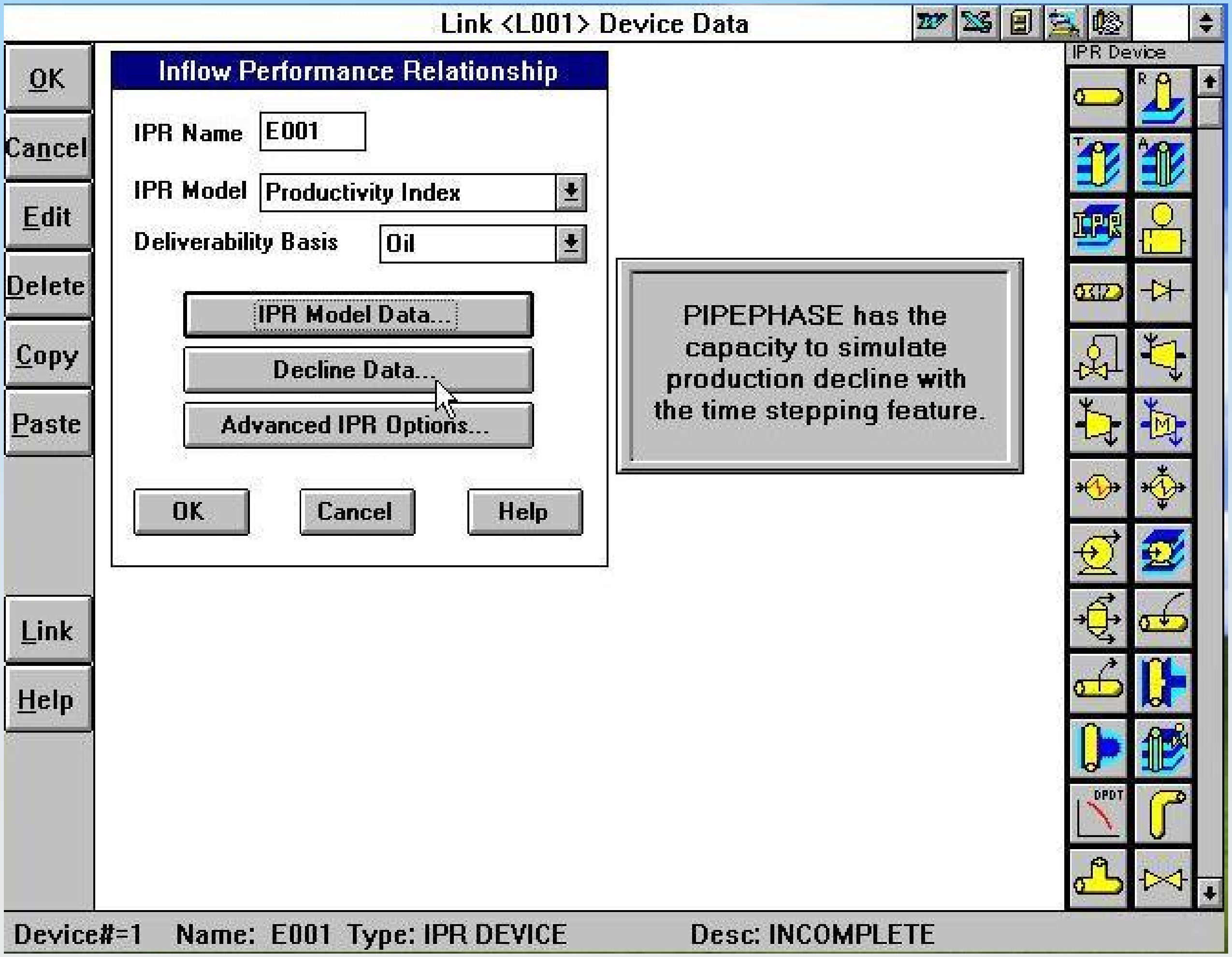

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S001
J003
IPR Device
Click on the "IPR" device icon and a data entry window for reservoir inflow performance data automatically pops up.
From Node
Type: SOURCE
Desc:

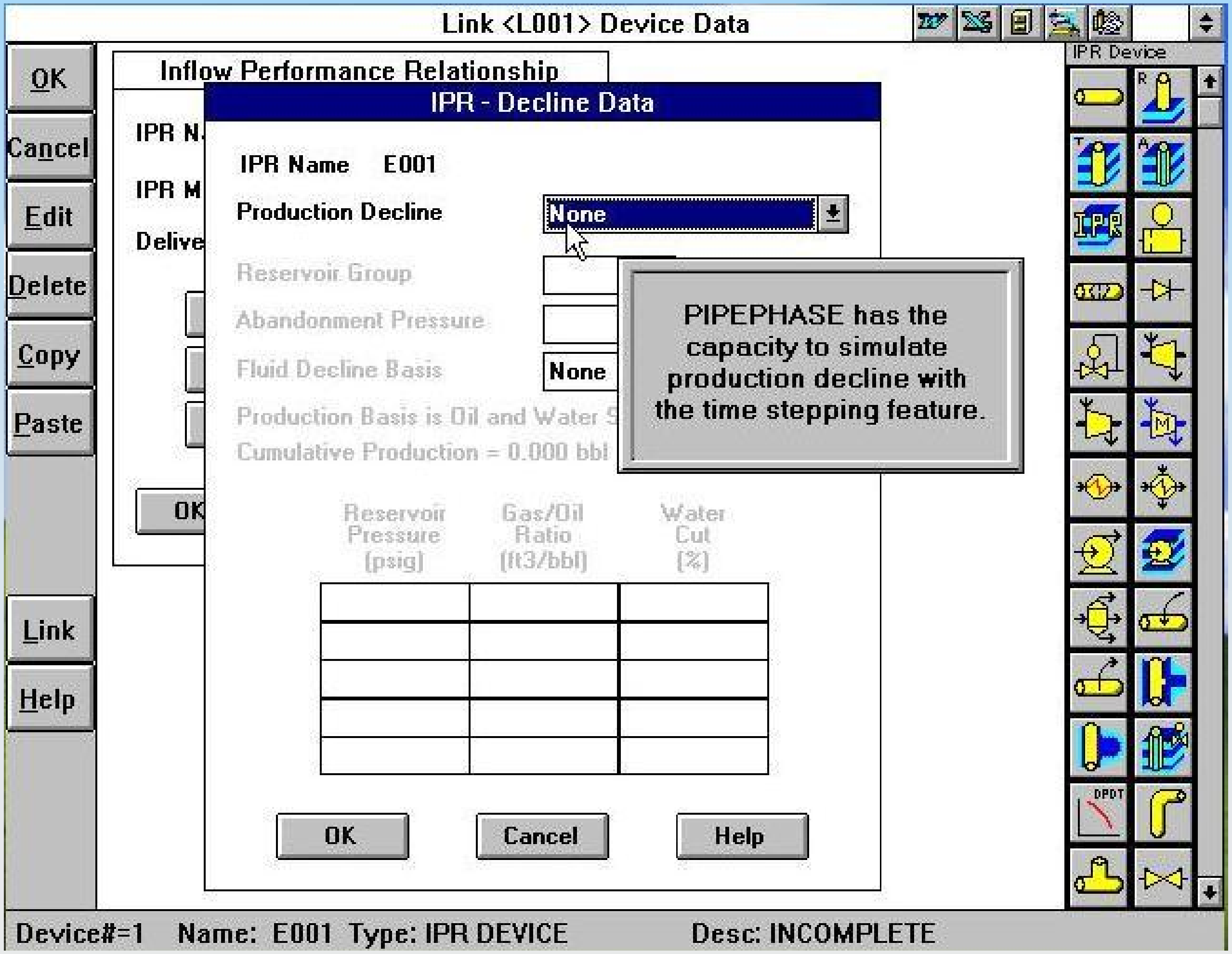

Link <L001> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name E001
IPR Model Vogel
Deliverability Basis Oil
IPR Model Data...
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
Click on the "IPR" device icon and a data entry window for reservoir inflow performance data automatically pops up.
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

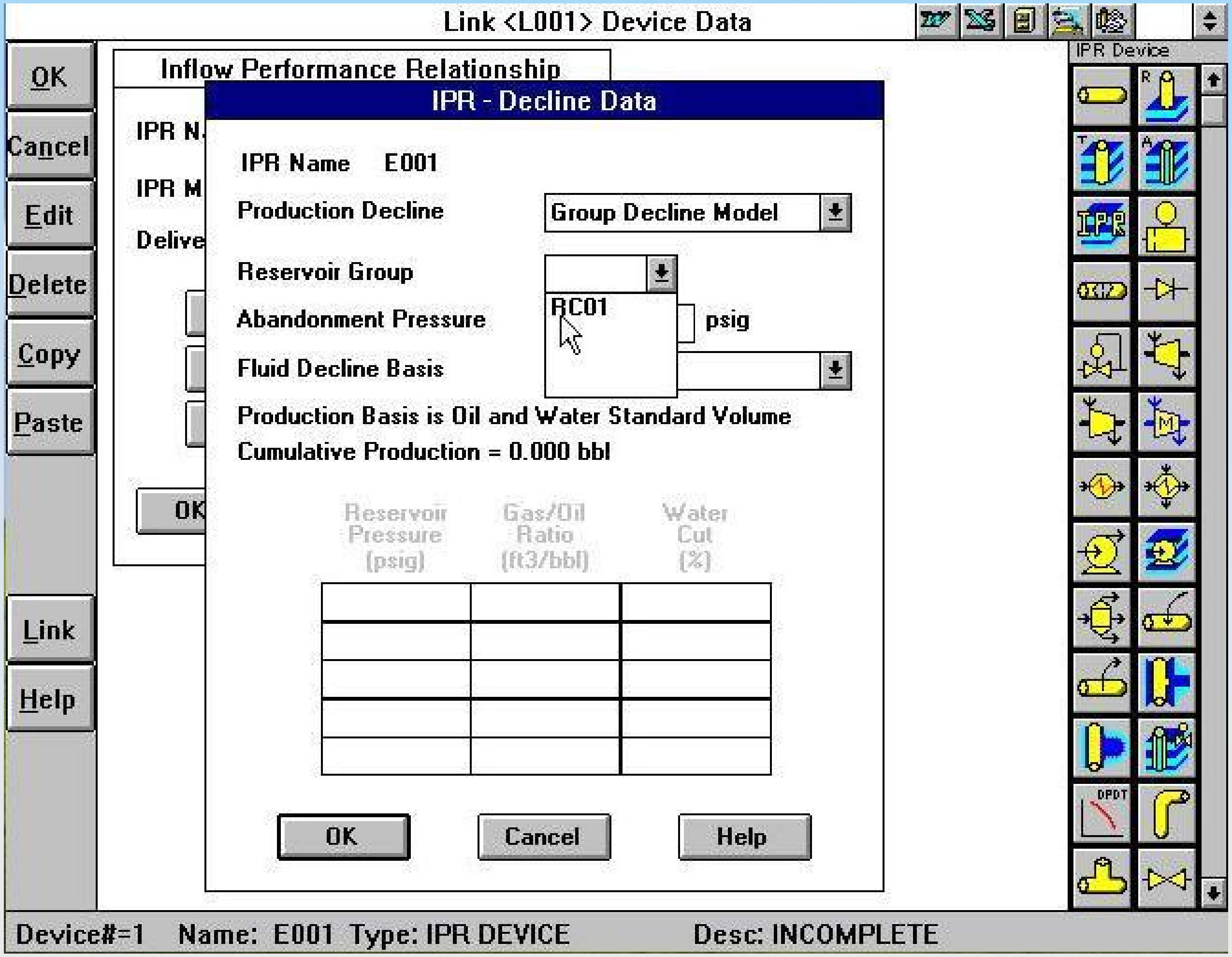

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
E001
IPR Model
Vogel
Deliverabilit
Productivity Index
Vogel
Fetkovich Gas Flow
Laminar-Inertial-Turbulent
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
Note the choice of IPR methods. IPR data is for the connected well.
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

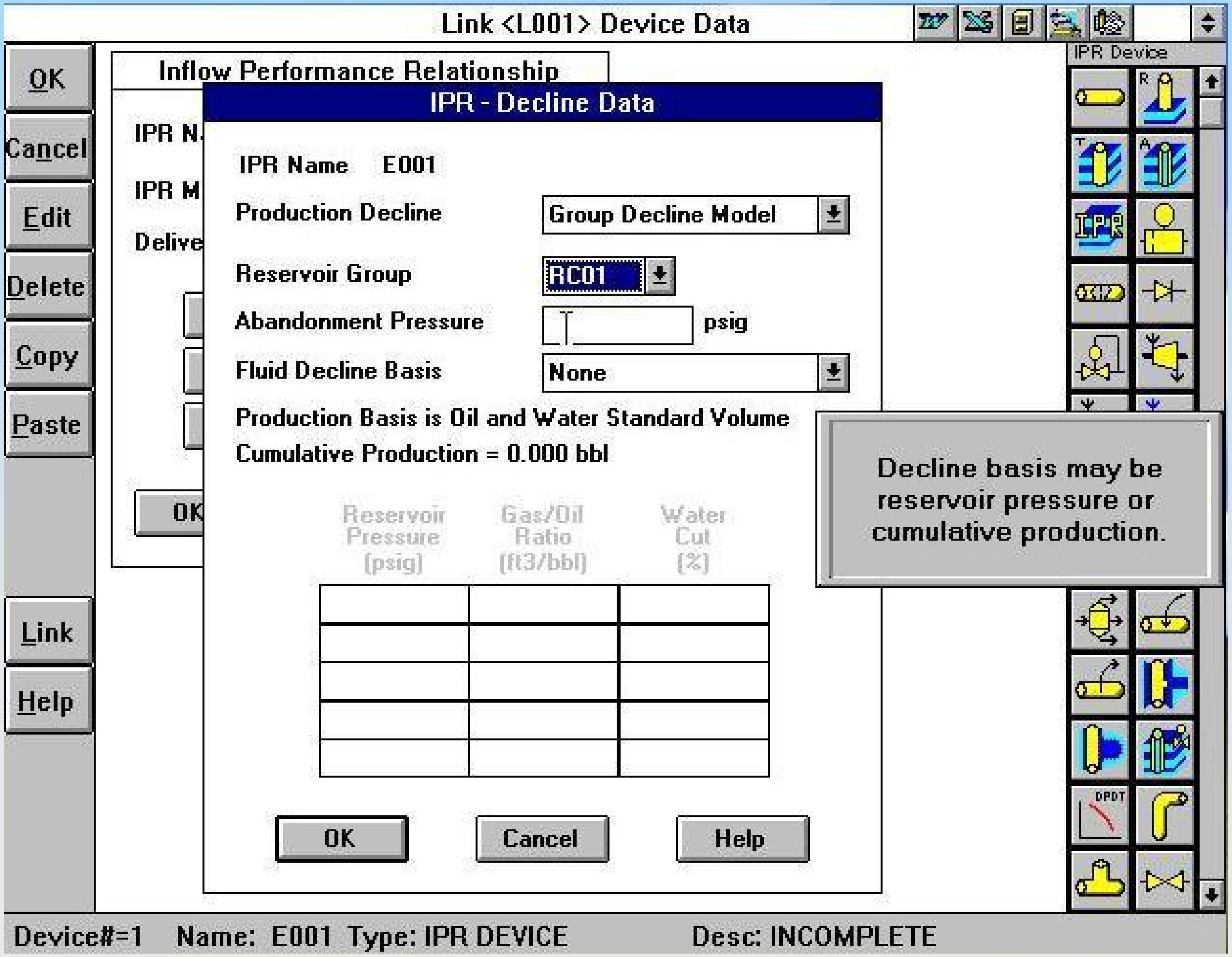


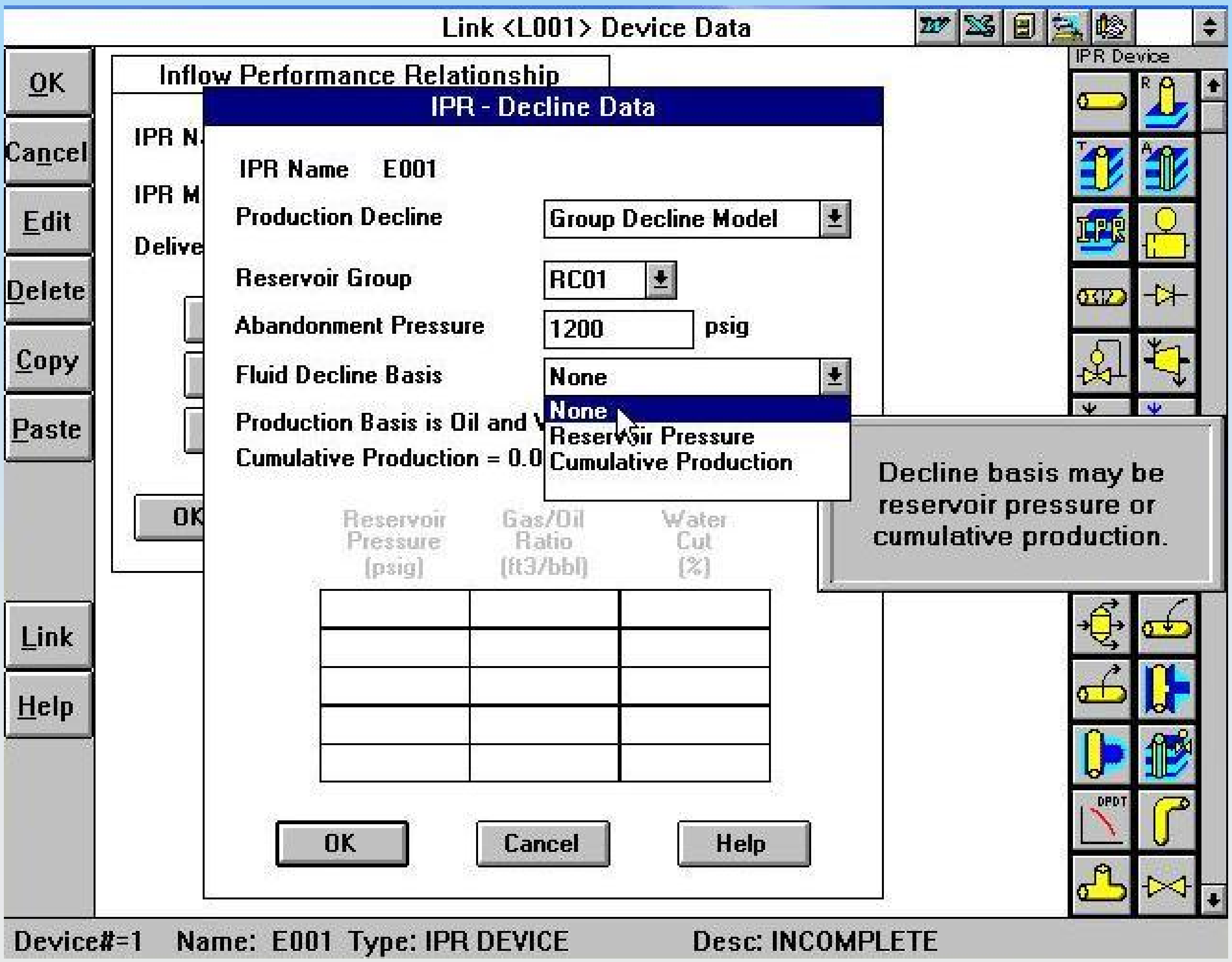
Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
IPR M
Delive
OK
IPR - Productivity Index Data
IPR Name E001
Productivity Index
30
bbl/day/psig
OK
Cancel
Help
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE
Desc: INCOMPLETE

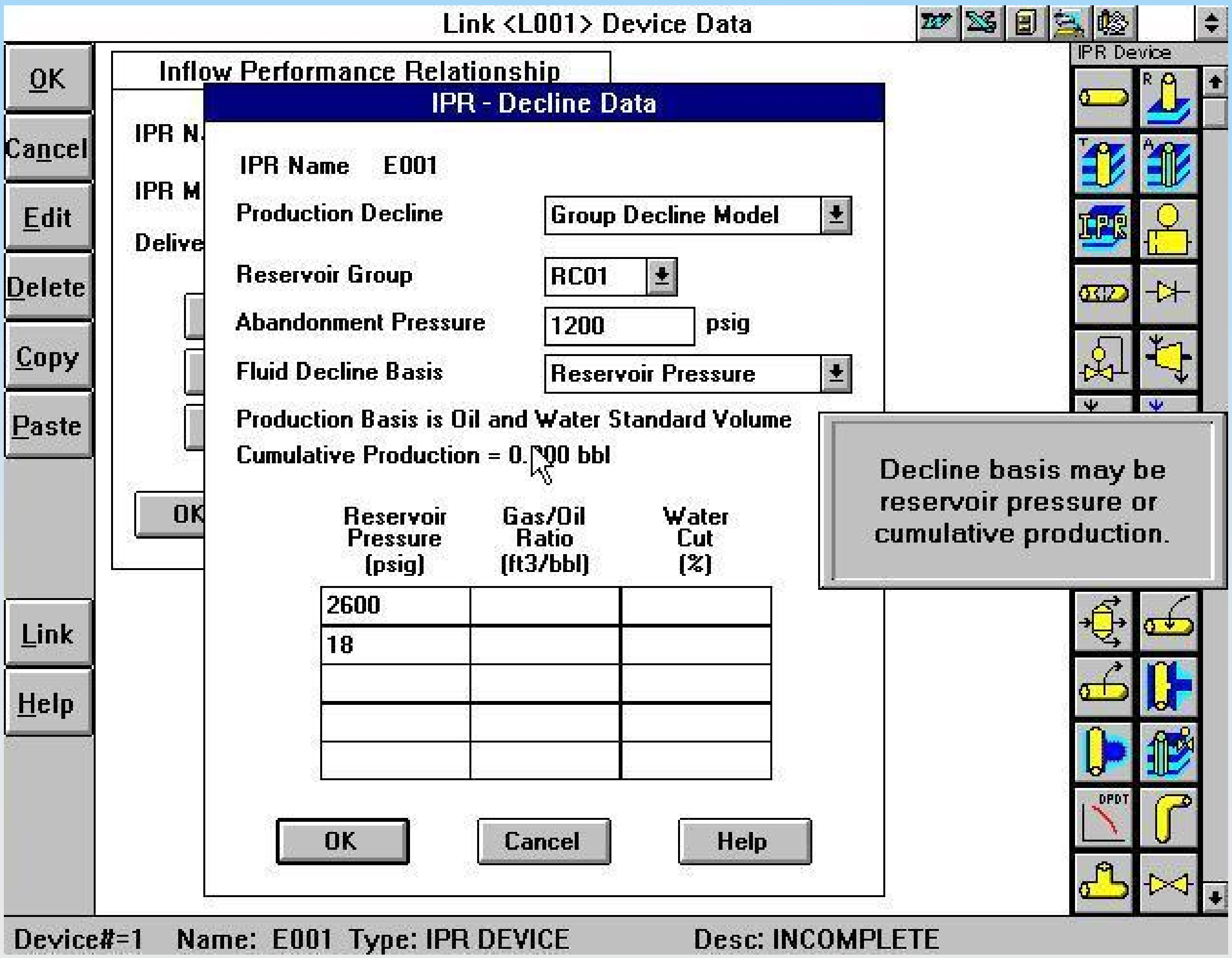

Link <L001> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name E001
IPR Model Productivity Index
Deliverability Basis Oil
IPR Model Data...
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
PIPEPHASE has the capacity to simulate production decline with the time stepping feature.
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

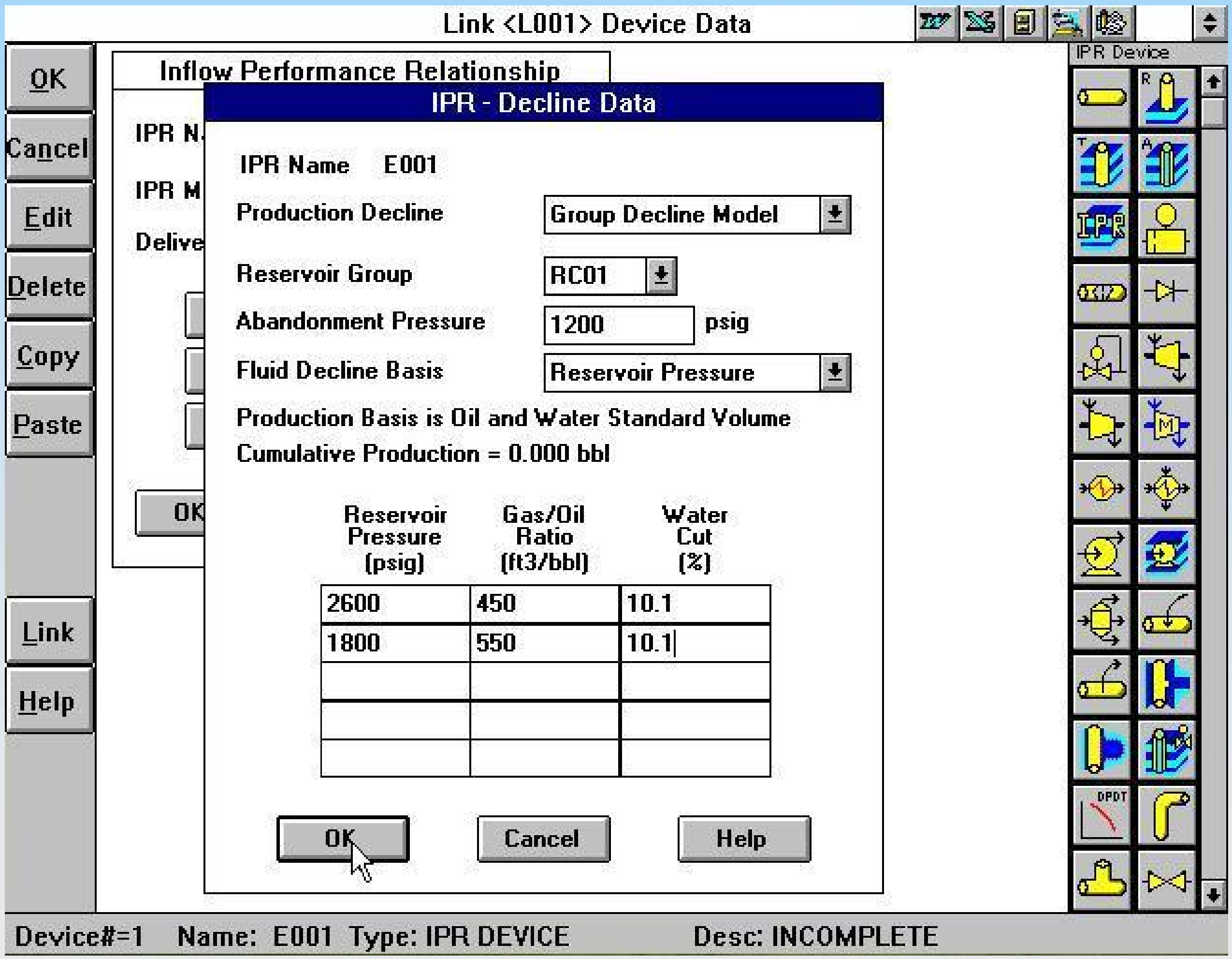

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR - Decline Data
IPR Name E001
Production Decline
None
Reservoir Group
Abandonment Pressure
Fluid Decline Basis
None
Production Basis is Oil and Water S
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
PIPEPHASE has the capacity to simulate production decline with the time stepping feature.
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

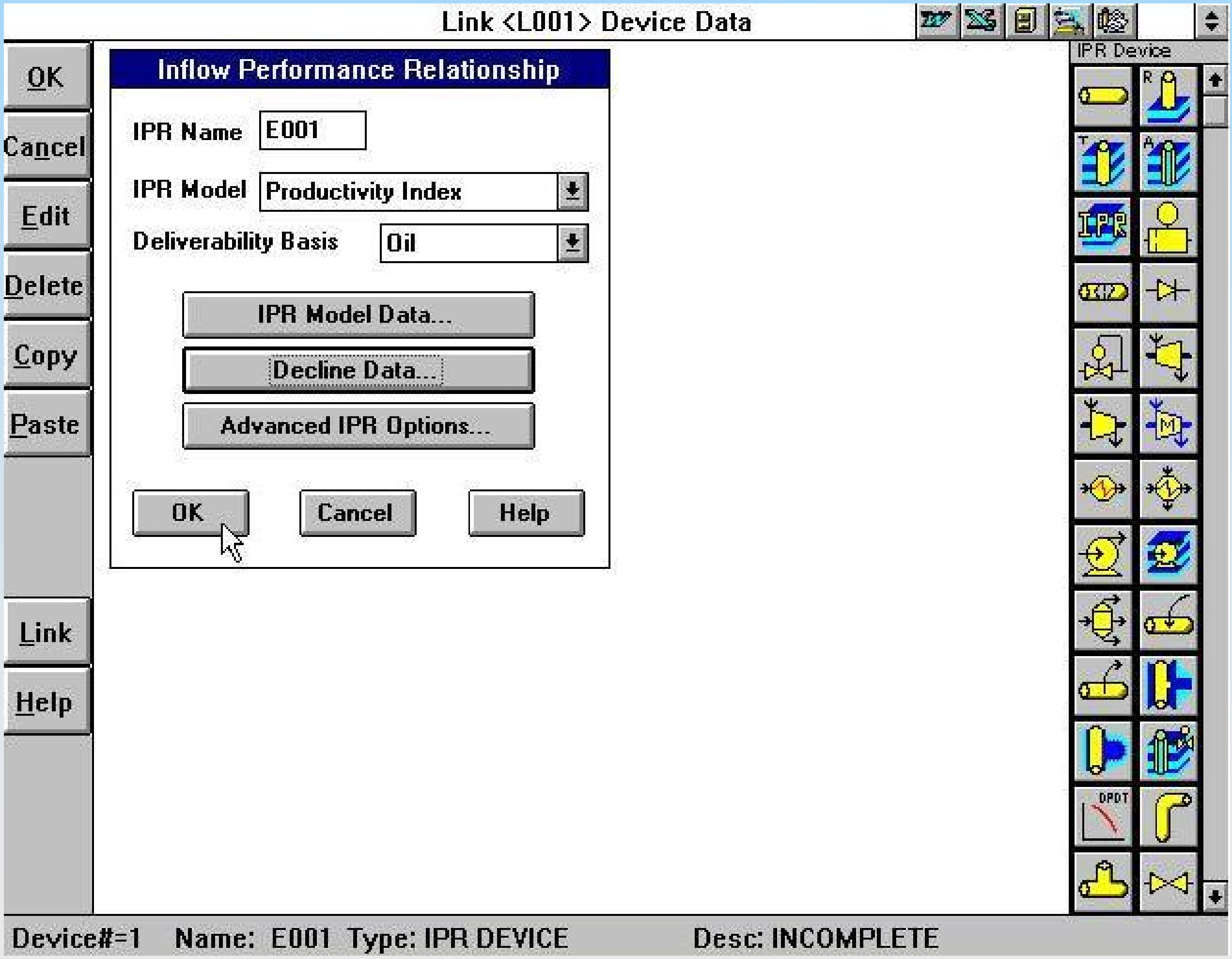

Link <L001> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR N
IPR M
Delive
OK
IPR - Decline Data
IPR Name E001
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
psig
Fluid Decline Basis
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

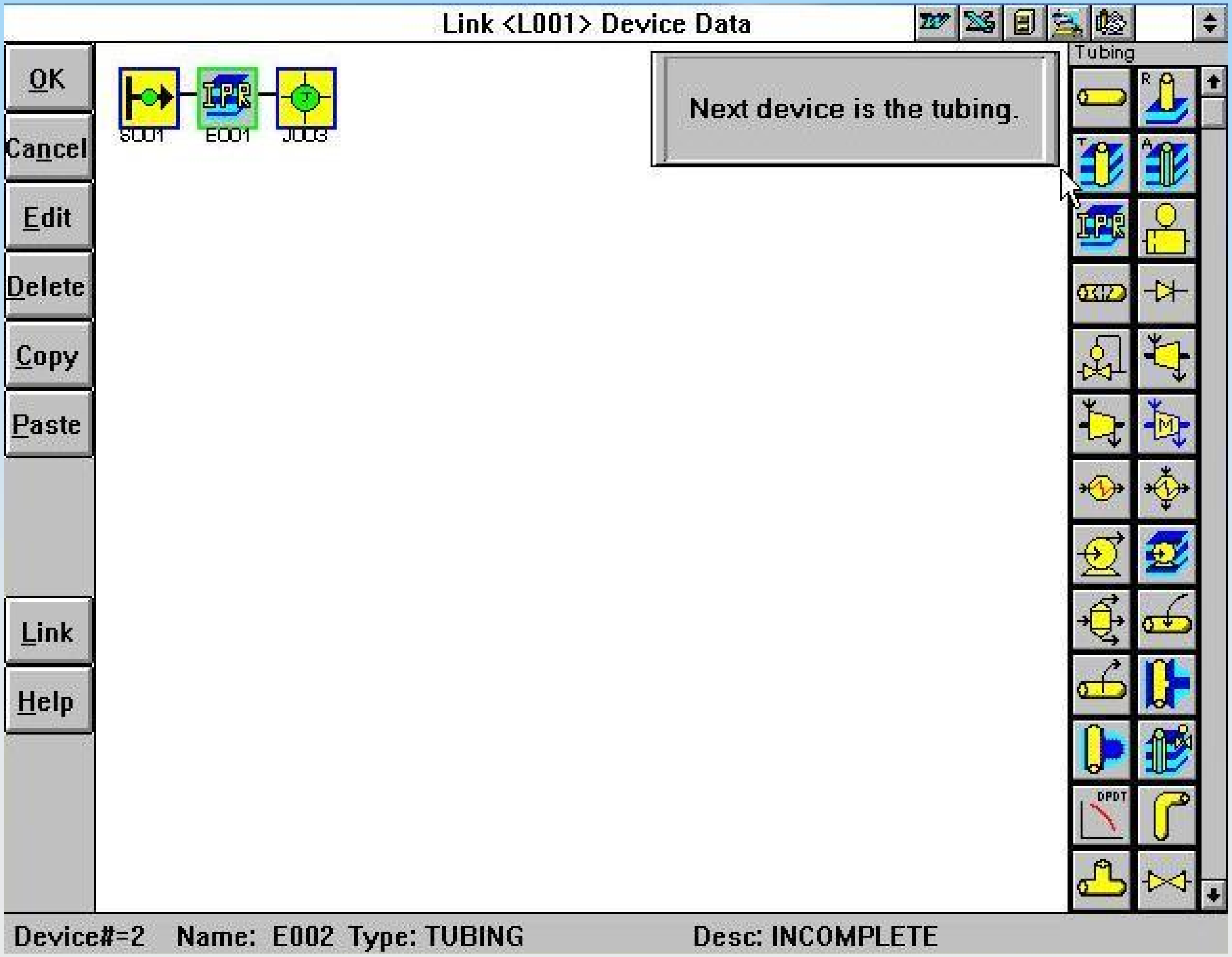

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR - Decline Data
IPR Name E001
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
psig
Fluid Decline Basis
None
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
Decline basis may be reservoir pressure or cumulative production.
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

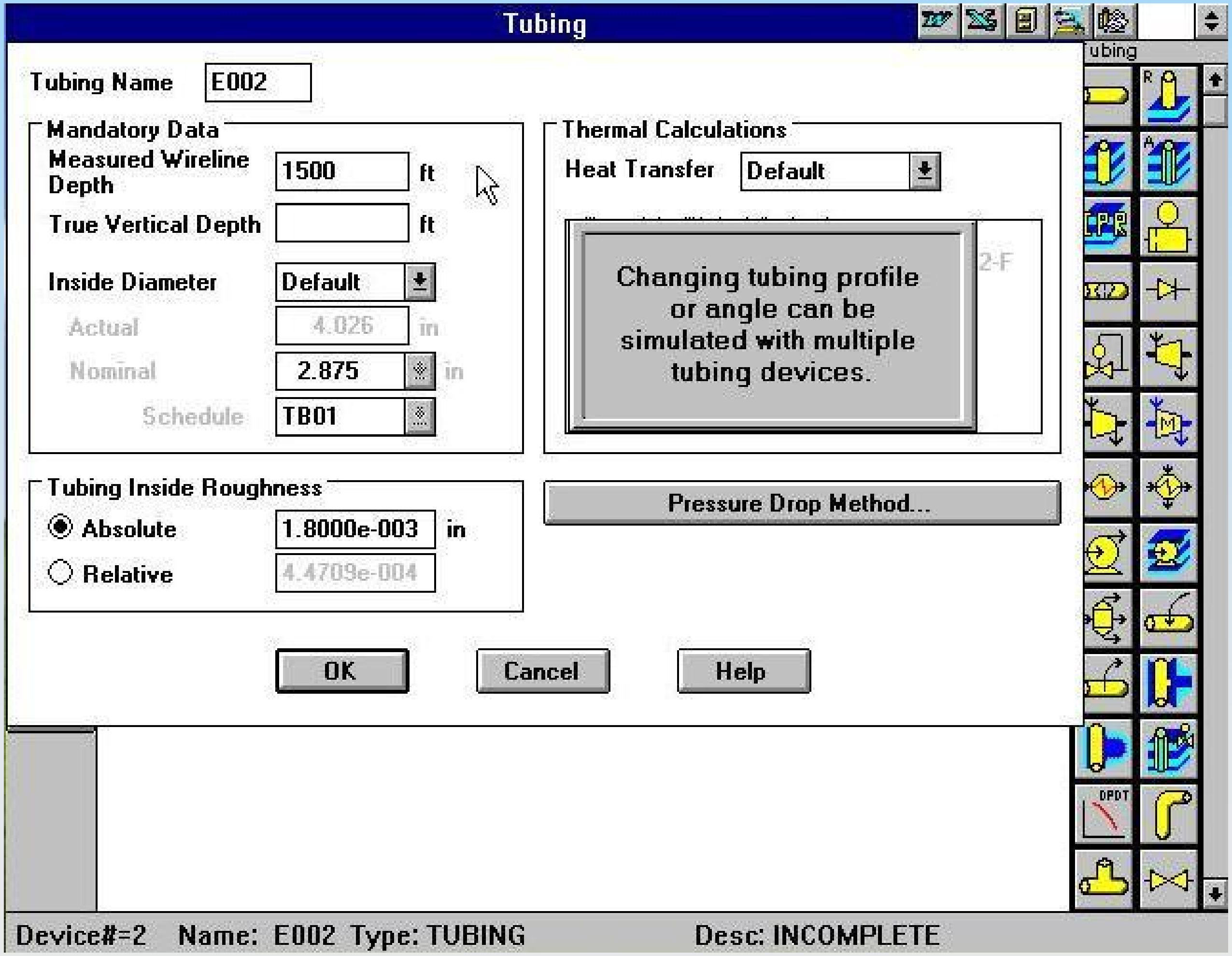

Link <L001> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR - Decline Data
IPR Name E001
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
1200
psig
Fluid Decline Basis
None
None
Reservoir Pressure
Cumulative Production
Cumulative Production = 0.0
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
Decline basis may be reservoir pressure or cumulative production.
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

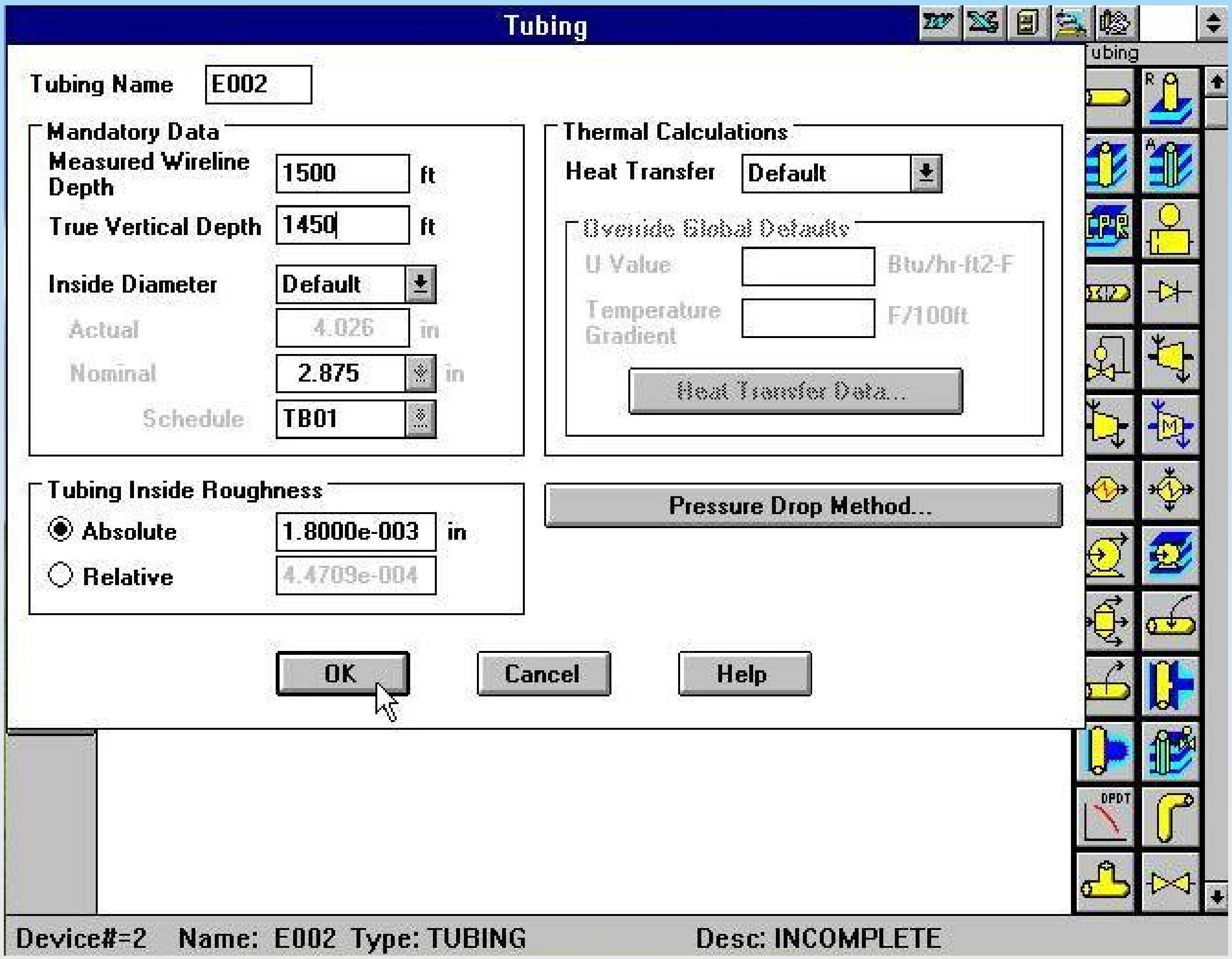

Link <L001> Device Data
Inflow Performance Relationship
IPR - Decline Data
IPR Name E001
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
1200
psig
Fluid Decline Basis
Reservoir Pressure
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
2600
18
OK
Cancel
Help
Decline basis may be reservoir pressure or cumulative production.
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

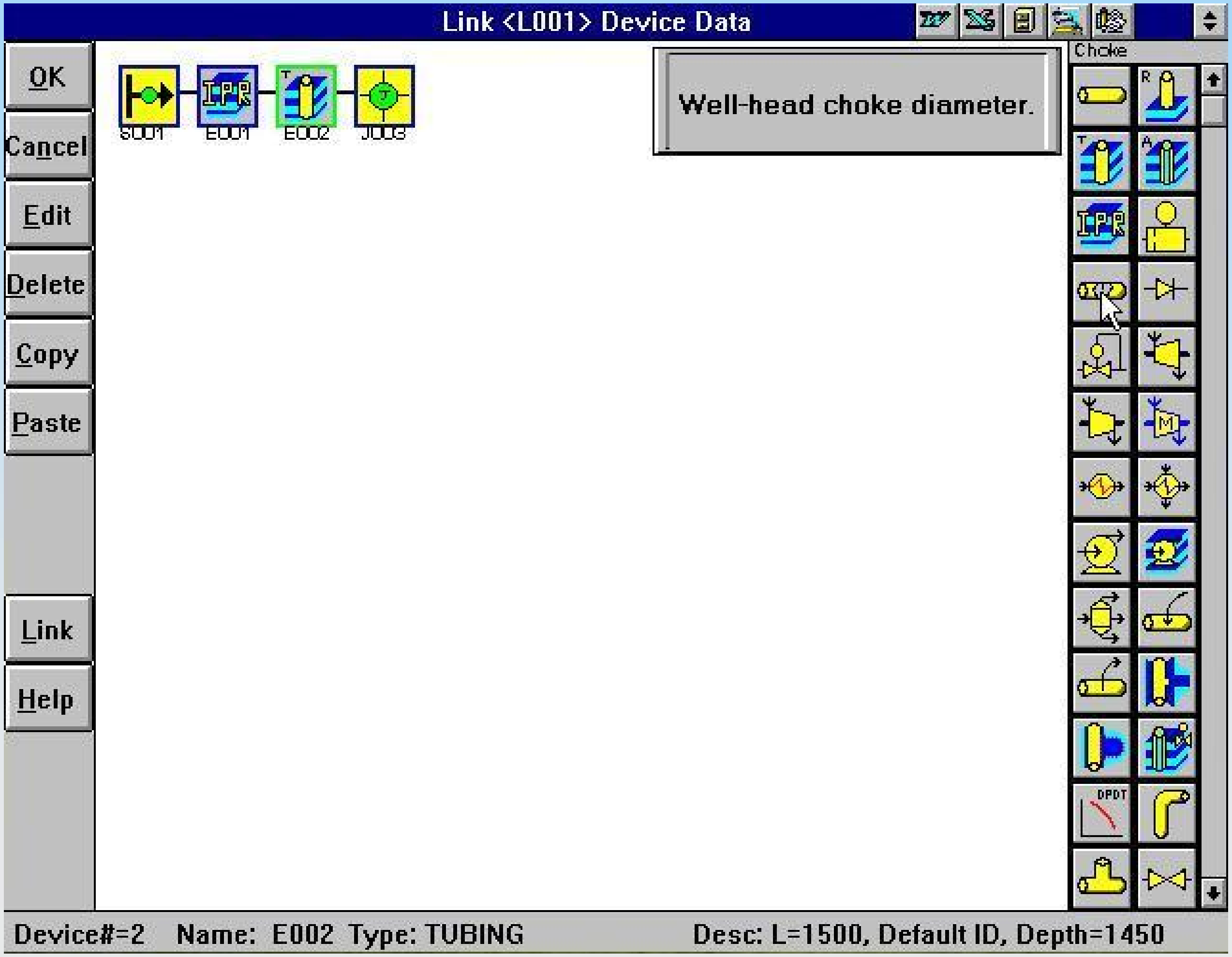

Link <L001> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR N
IPR M
Delive
OK
IPR - Decline Data
IPR Name E001
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
1200
psig
Fluid Decline Basis
Reservoir Pressure
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
2600 450 10.1
1800 550 10.1
OK
Cancel
Help
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

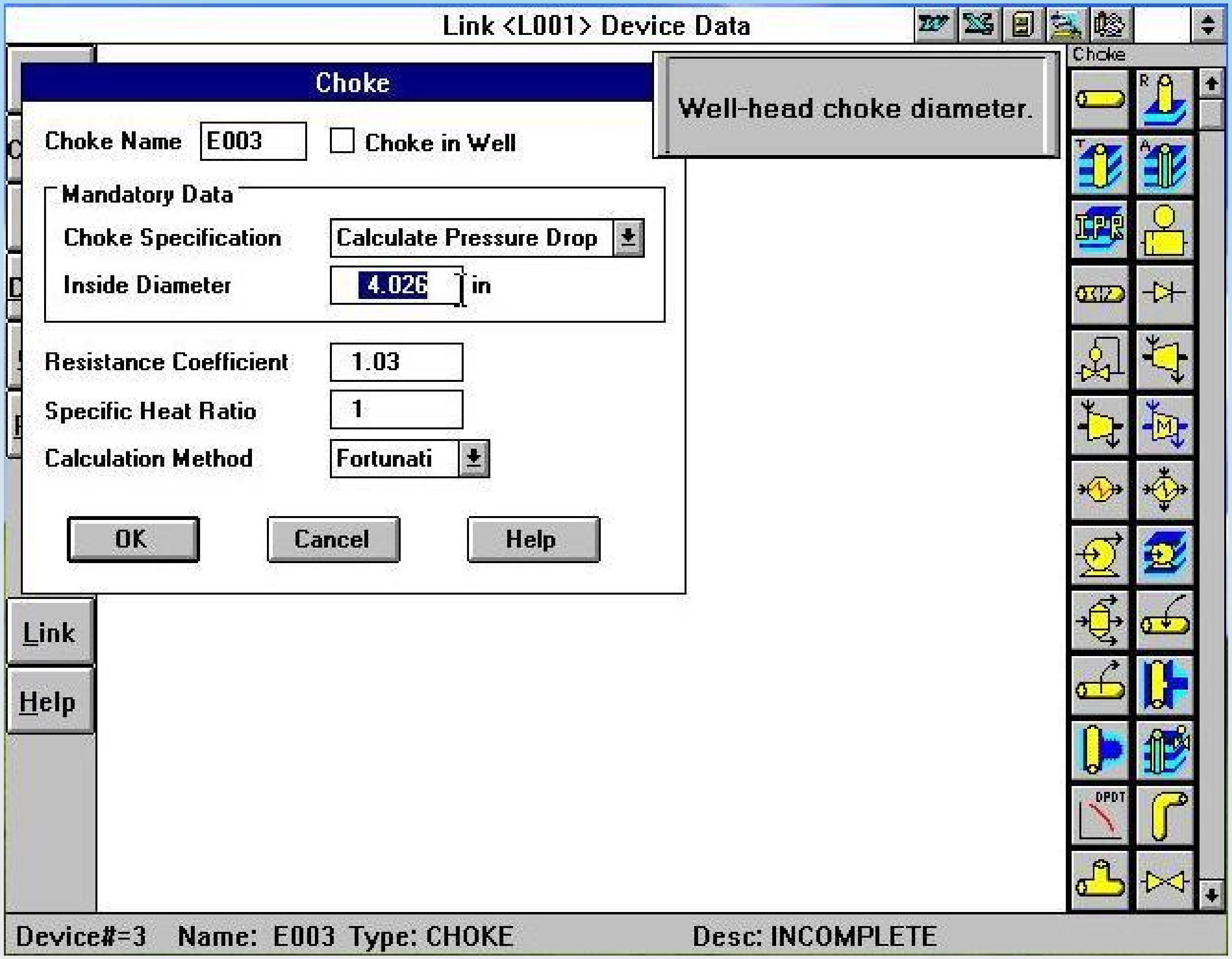

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
E001
IPR Model
Productivity Index
Deliverability Basis
Oil
IPR Model Data...
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
IPR Device
Device#=1 Name: E001 Type: IPR DEVICE Desc: INCOMPLETE

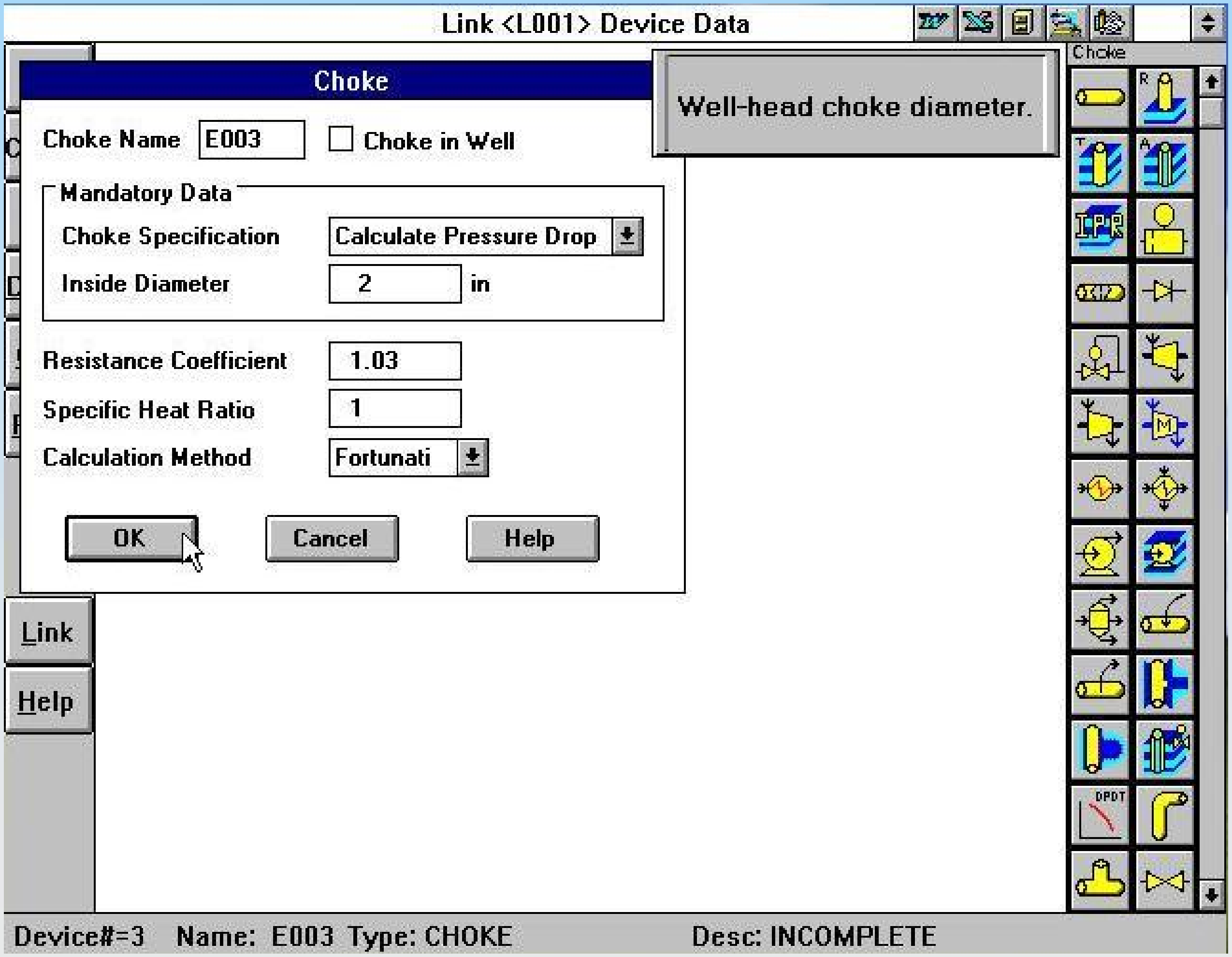

Link <L001> Device Data
Tubing
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S001
E001
J003
Next device is the tubing.
Device#=2 Name: E002 Type: TUBING
Desc: INCOMPLETE

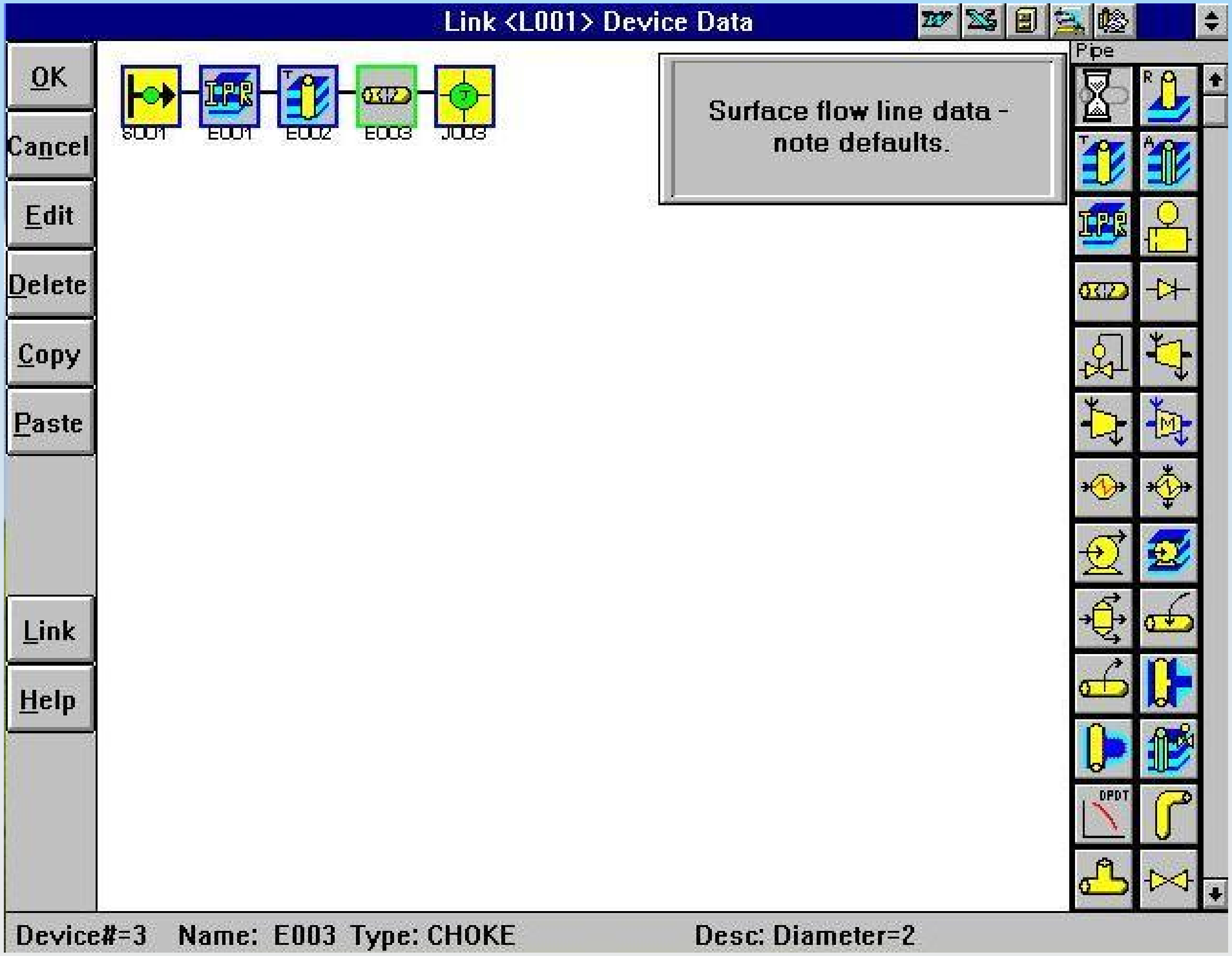

Tubing
Tubing Name E002
Mandatory Data
Measured Wireline Depth 1500 ft
True Vertical Depth ft
Inside Diameter Default
Actual 4.026 in
Nominal 2.875 in
Schedule TB01
Thermal Calculations
Heat Transfer Default
Changing tubing profile or angle can be simulated with multiple tubing devices.
Tubing Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Pressure Drop Method...
OK
Cancel
Help
Device#=2 Name: E002 Type: TUBING Desc: INCOMPLETE


Tubing
Tubing Name E002
Mandatory Data
Measured Wireline Depth 1500 ft
True Vertical Depth 1450 ft
Inside Diameter Default
Actual 4.026 in
Nominal 2.875 in
Schedule TB01
Thermal Calculations
Heat Transfer Default
Override Global Defaults
U Value Btu/hr-ft2-F
Temperature Gradient F/100ft
Heat Transfer Data...
Tubing Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Pressure Drop Method...
OK
Cancel
Help
Device#=2 Name: E002 Type: TUBING
Desc: INCOMPLETE

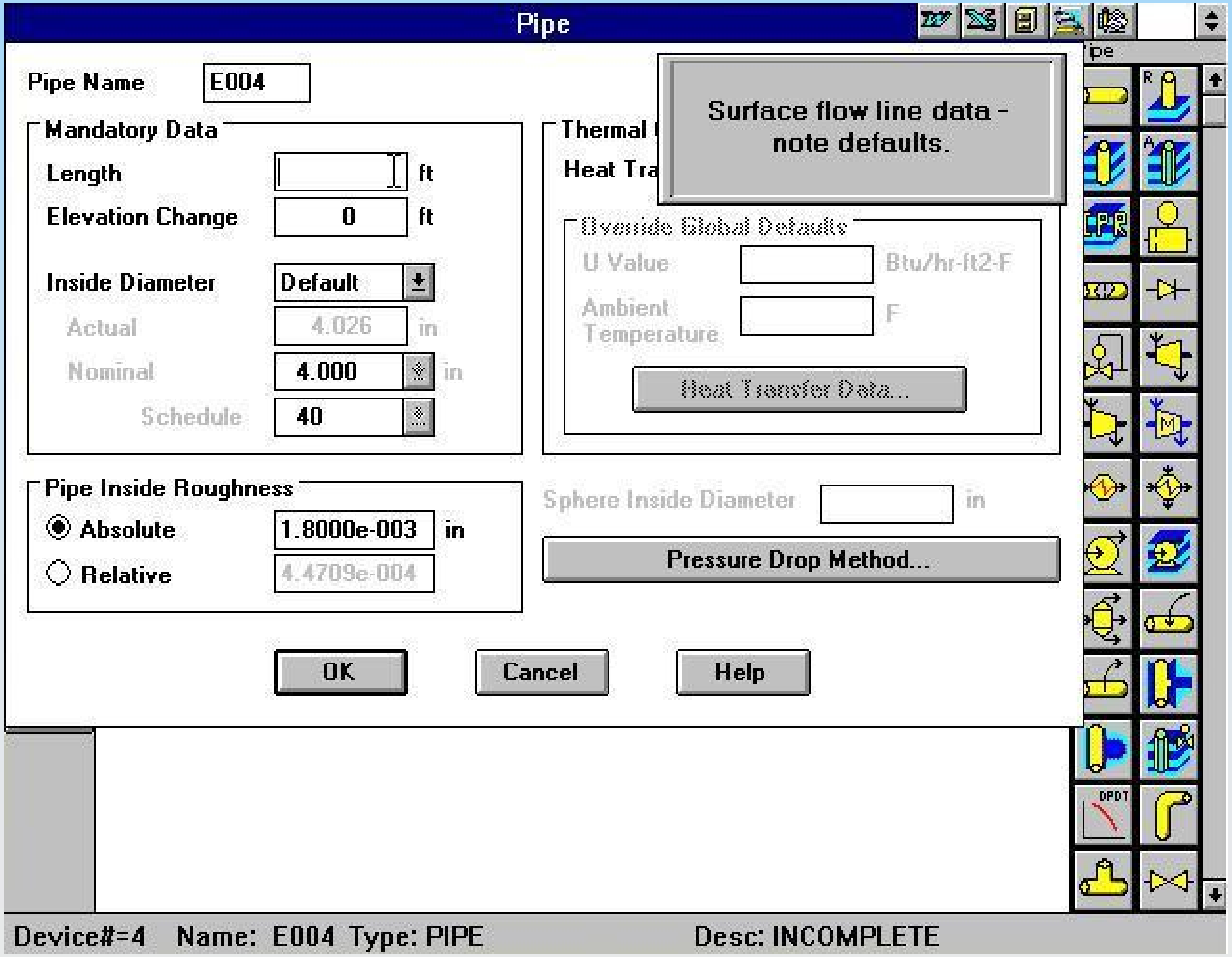

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S001
E001
E002
J003
Well-head choke diameter.
Choke
Device#=2 Name: E002 Type: TUBING
Desc: L=1500, Default ID, Depth=1450

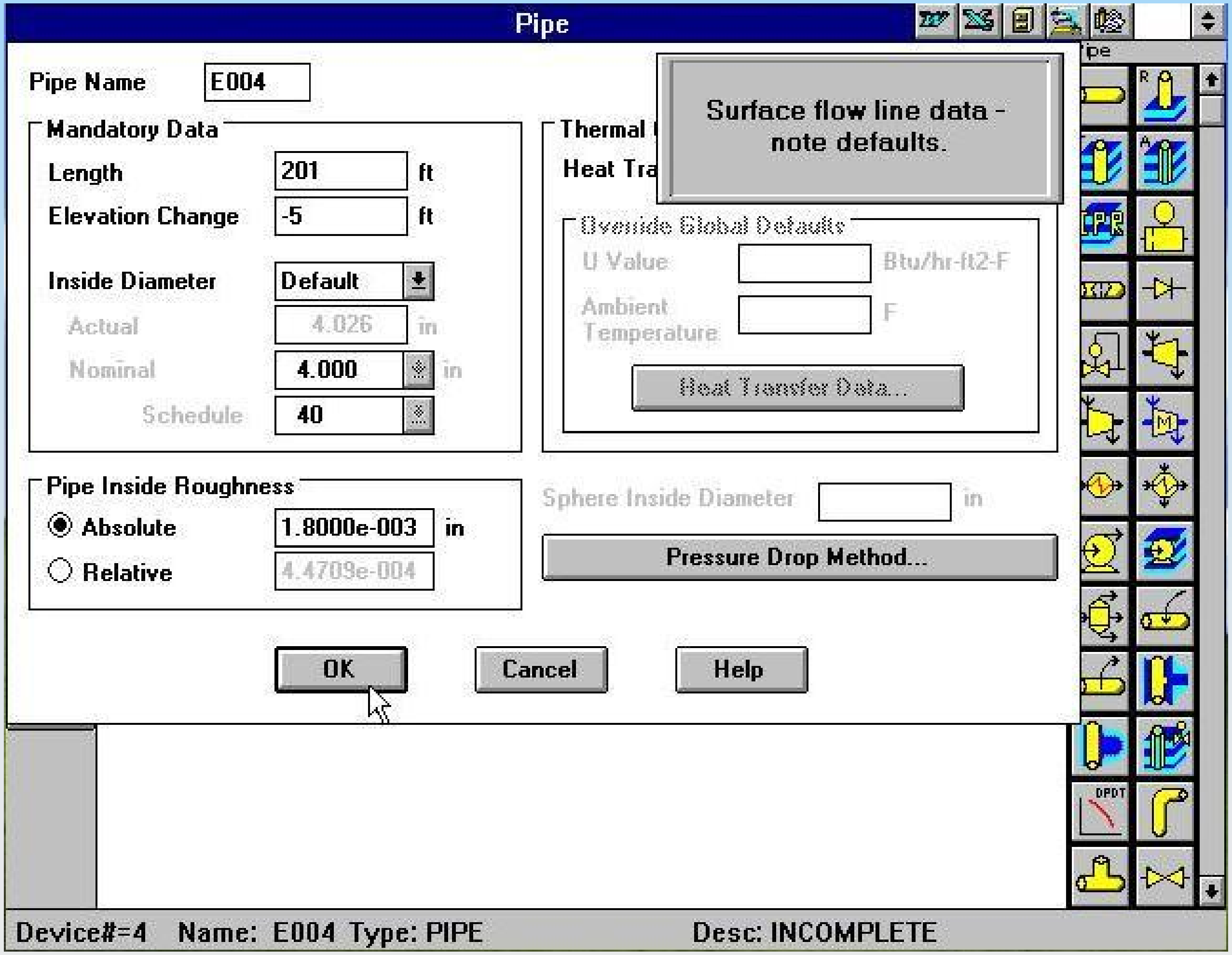

Link <L001> Device Data
Choke
Choke
Well-head choke diameter.
Choke Name
E003
Choke in Well
Mandatory Data
Choke Specification
Calculate Pressure Drop
Inside Diameter
4.026
in
Resistance Coefficient
1.03
Specific Heat Ratio
1
Calculation Method
Fortunati
OK
Cancel
Help
Link
Help
Device#=3 Name: E003 Type: CHOKE
Desc: INCOMPLETE

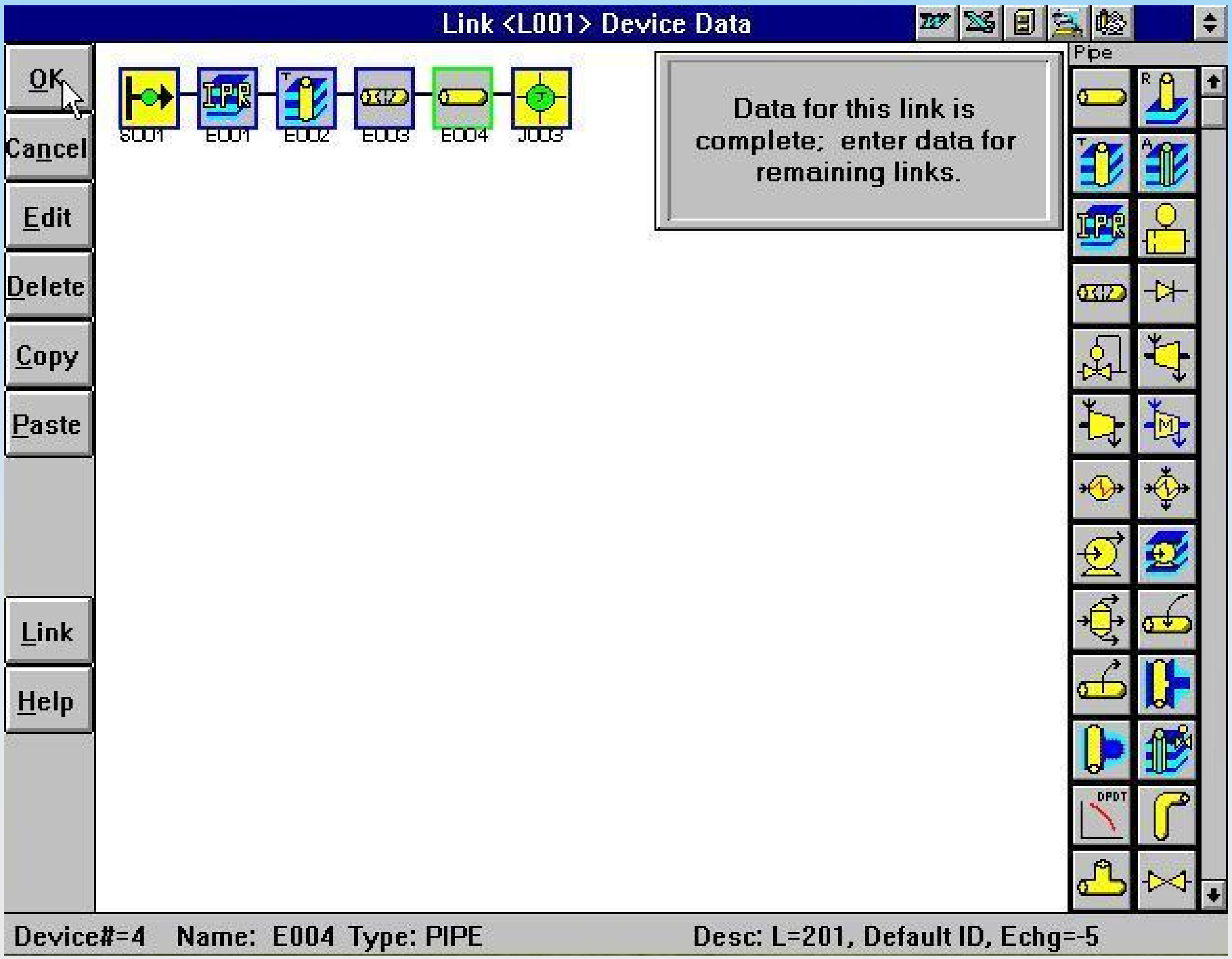

Link <L001> Device Data
Choke
Choke
Well-head choke diameter.
Choke Name
E003
Choke in Well
Mandatory Data
Choke Specification
Calculate Pressure Drop
Inside Diameter
2
in
Resistance Coefficient
1.03
Specific Heat Ratio
1
Calculation Method
Fortunati
OK
Cancel
Help
Link
Help
Device#=3 Name: E003 Type: CHOKE Desc: INCOMPLETE

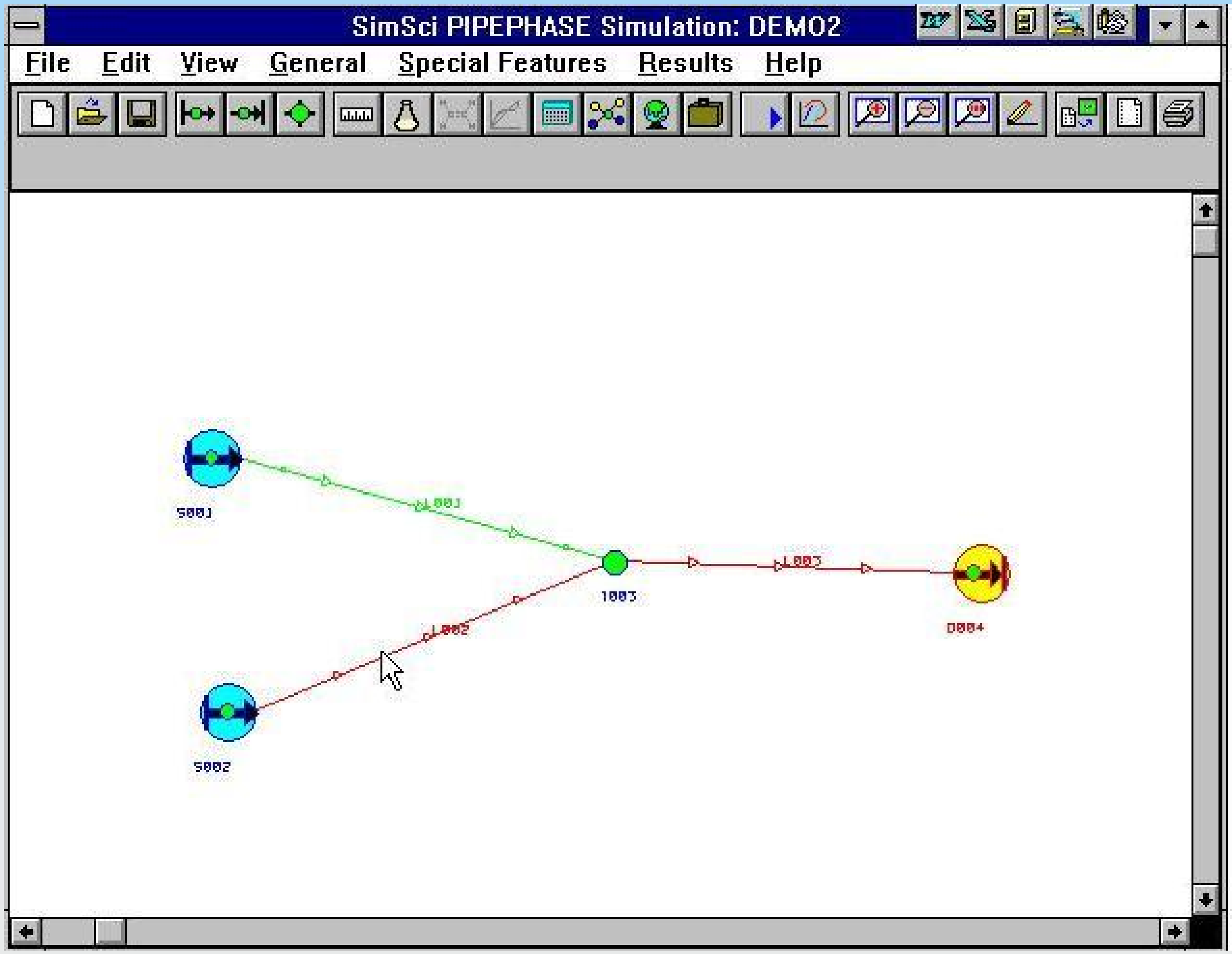


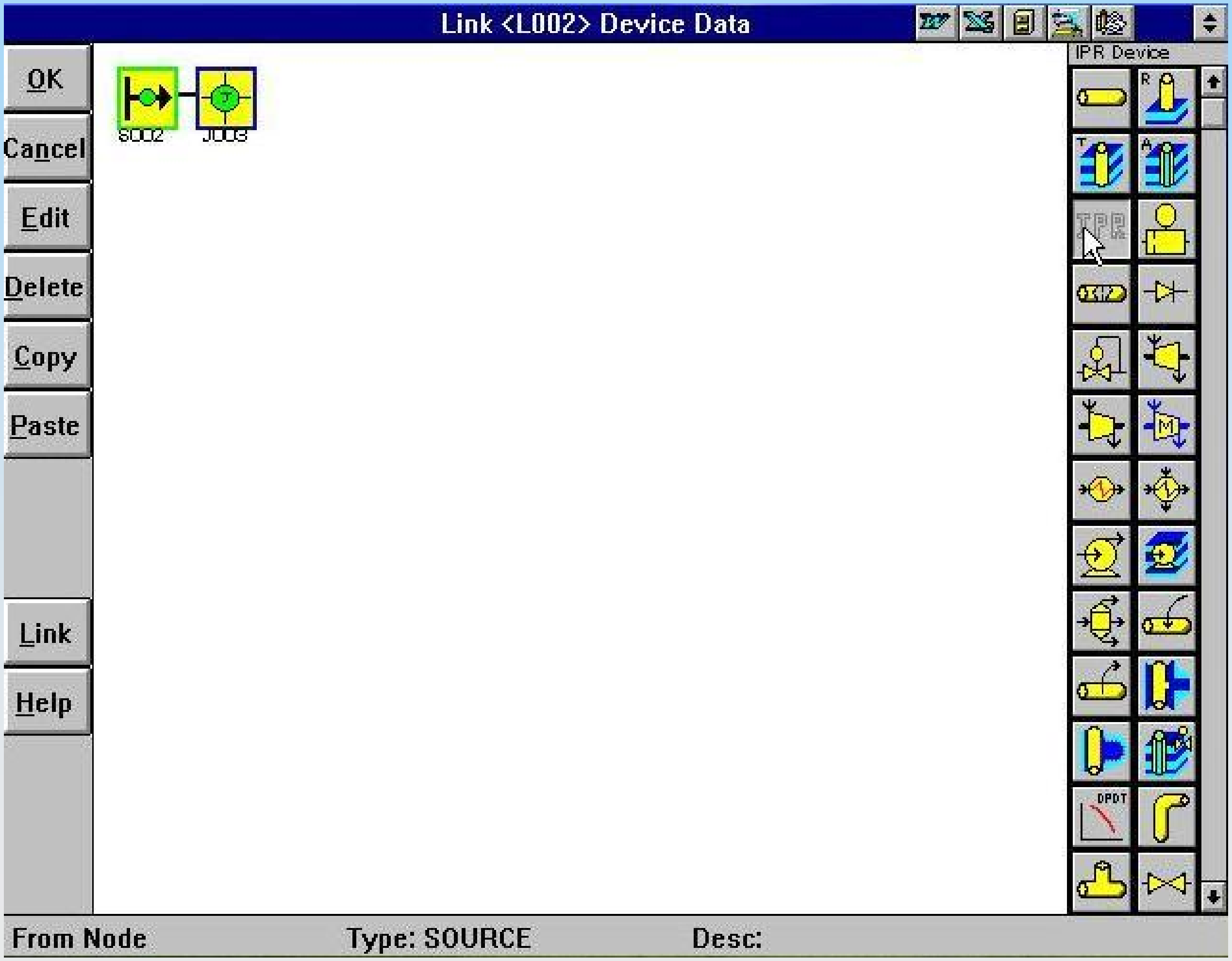
Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Pipe
Surface flow line data - note defaults.
Device#=3 Name: E003 Type: CHOKE
Desc: Diameter=2

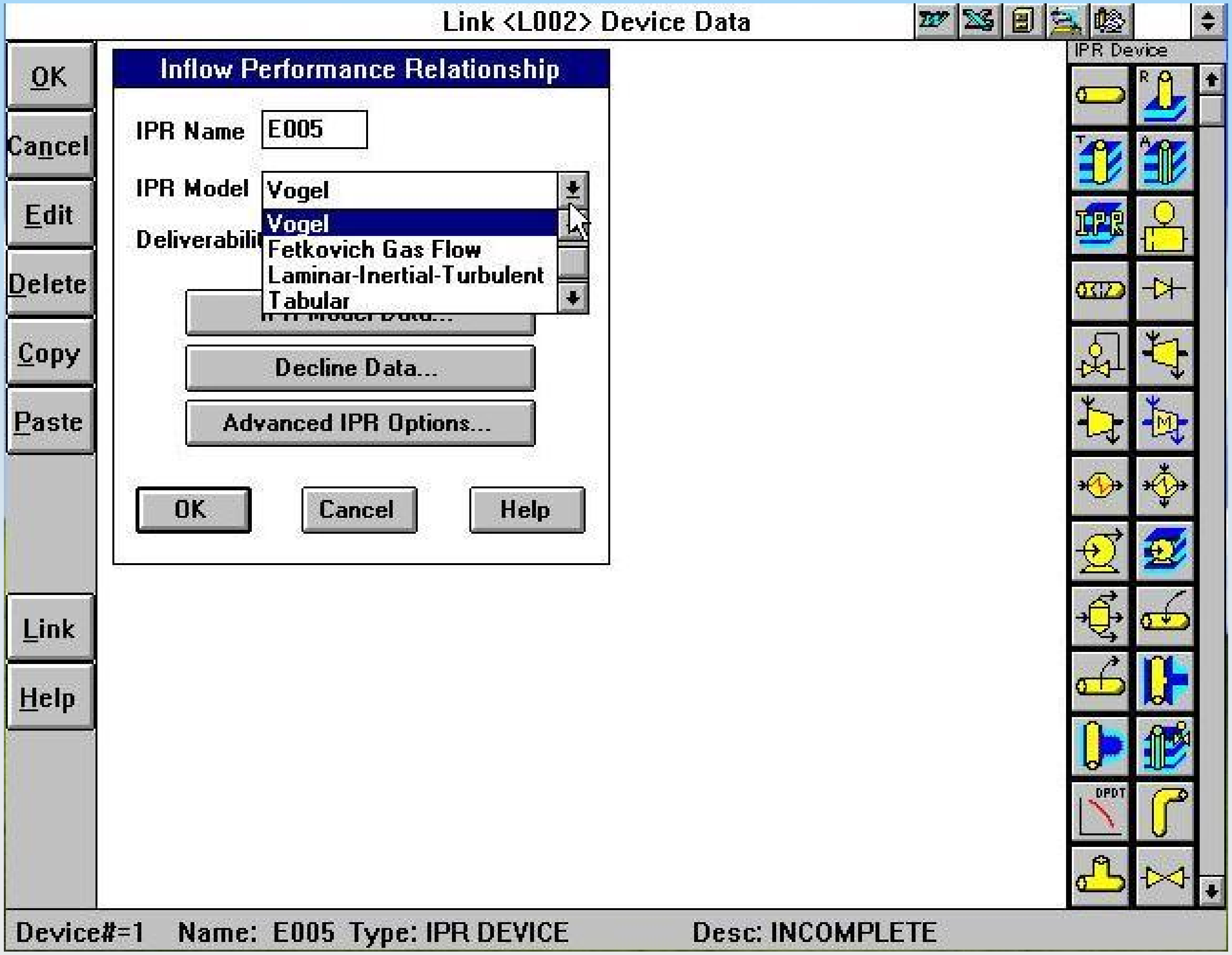

Pipe
Pipe Name
E004
Mandatory Data
Length
ft
Elevation Change
0
ft
Inside Diameter
Default
Actual
4.026
in
Nominal
4.000
in
Schedule
40
Pipe Inside Roughness
Absolute
1.8000e-003
in
Relative
4.4709e-004
Thermal
Heat Tra
Surface flow line data - note defaults.
Override Global Defaults
U Value
Btu/hr-ft2-F
Ambient Temperature
F
Heat Transfer Data...
Sphere Inside Diameter
in
Pressure Drop Method...
OK
Cancel
Help
Device#=4 Name: E004 Type: PIPE
Desc: INCOMPLETE


Pipe
Pipe Name E004
Mandatory Data
Length 201 ft
Elevation Change -5 ft
Inside Diameter Default
Actual 4.026 in
Nominal 4.000 in
Schedule 40
Pipe Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Thermal
Heat Tra
Surface flow line data - note defaults.
Override Global Defaults
U Value Btu/hr-ft2-F
Ambient Temperature F
Heat Transfer Data...
Sphere Inside Diameter in
Pressure Drop Method...
OK
Cancel
Help
Device#=4 Name: E004 Type: PIPE Desc: INCOMPLETE

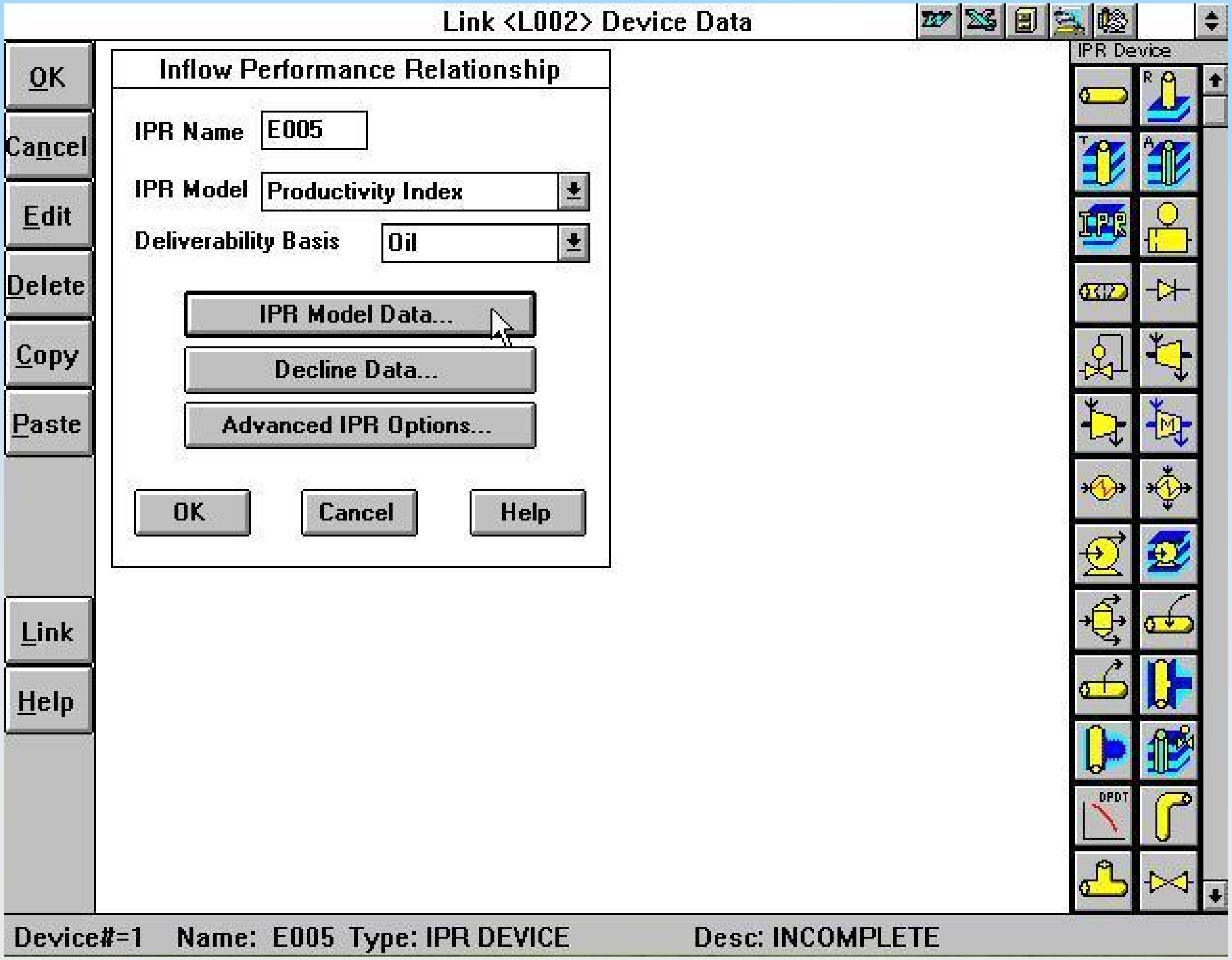

Link <L001> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S001
E001
E002
E003
E004
J003
Data for this link is complete; enter data for remaining links.
Pipe
DPDT
Device#=4 Name: E004 Type: PIPE
Desc: L=201, Default ID, Echg=-5

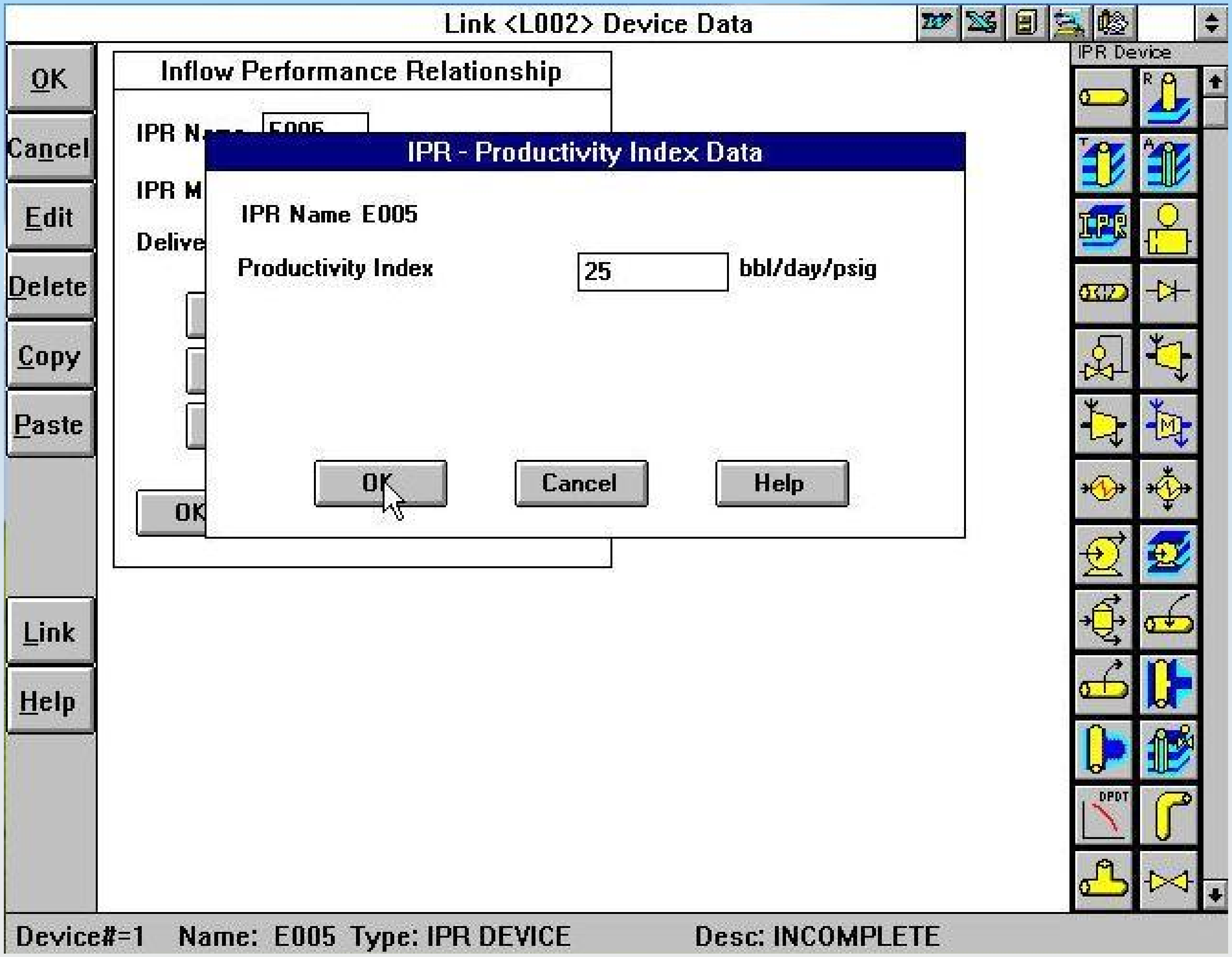

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
S001
L001
1003
L003
D004
L002
S002

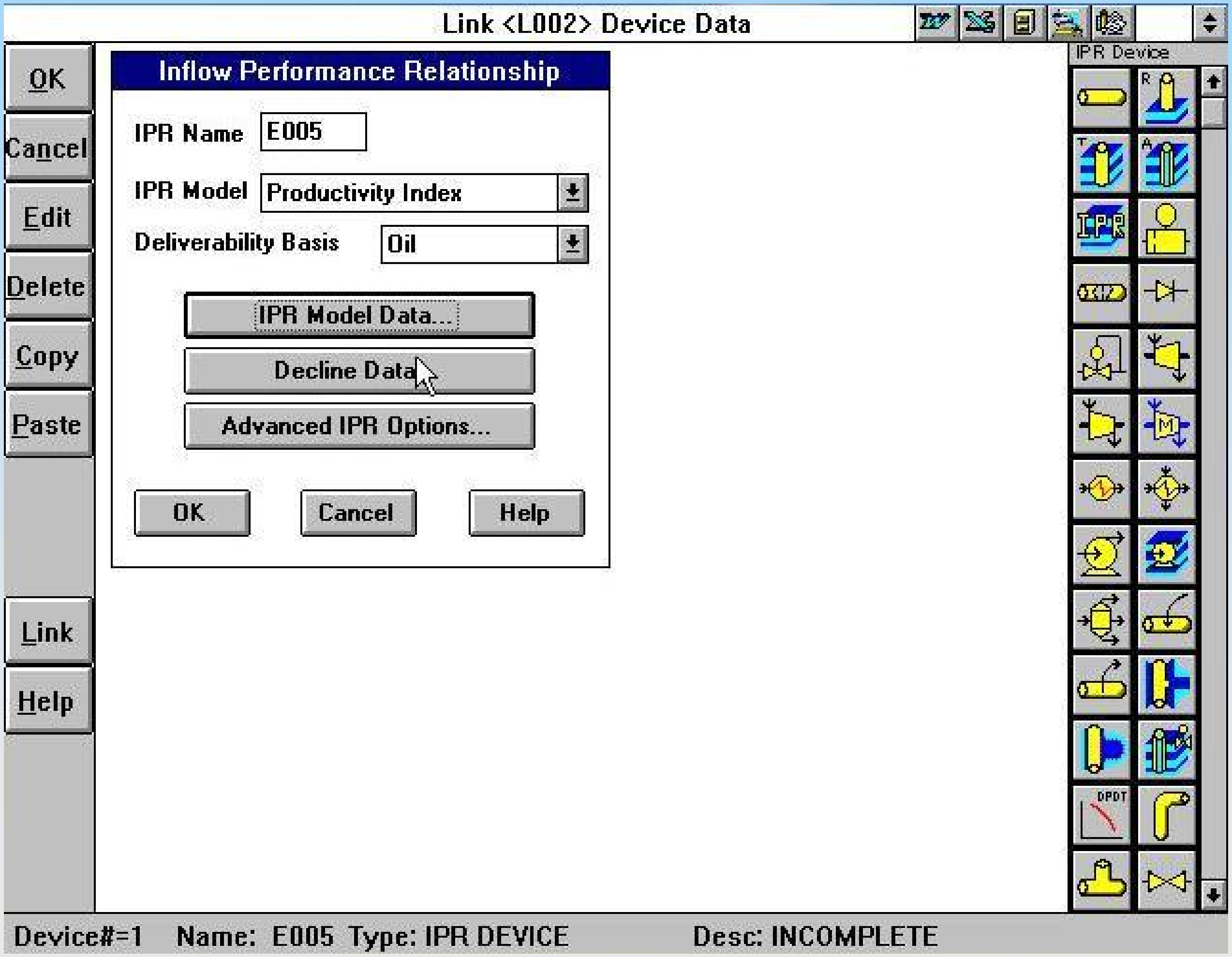

Link <L002> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
IPR Device
From Node
Type: SOURCE
Desc:

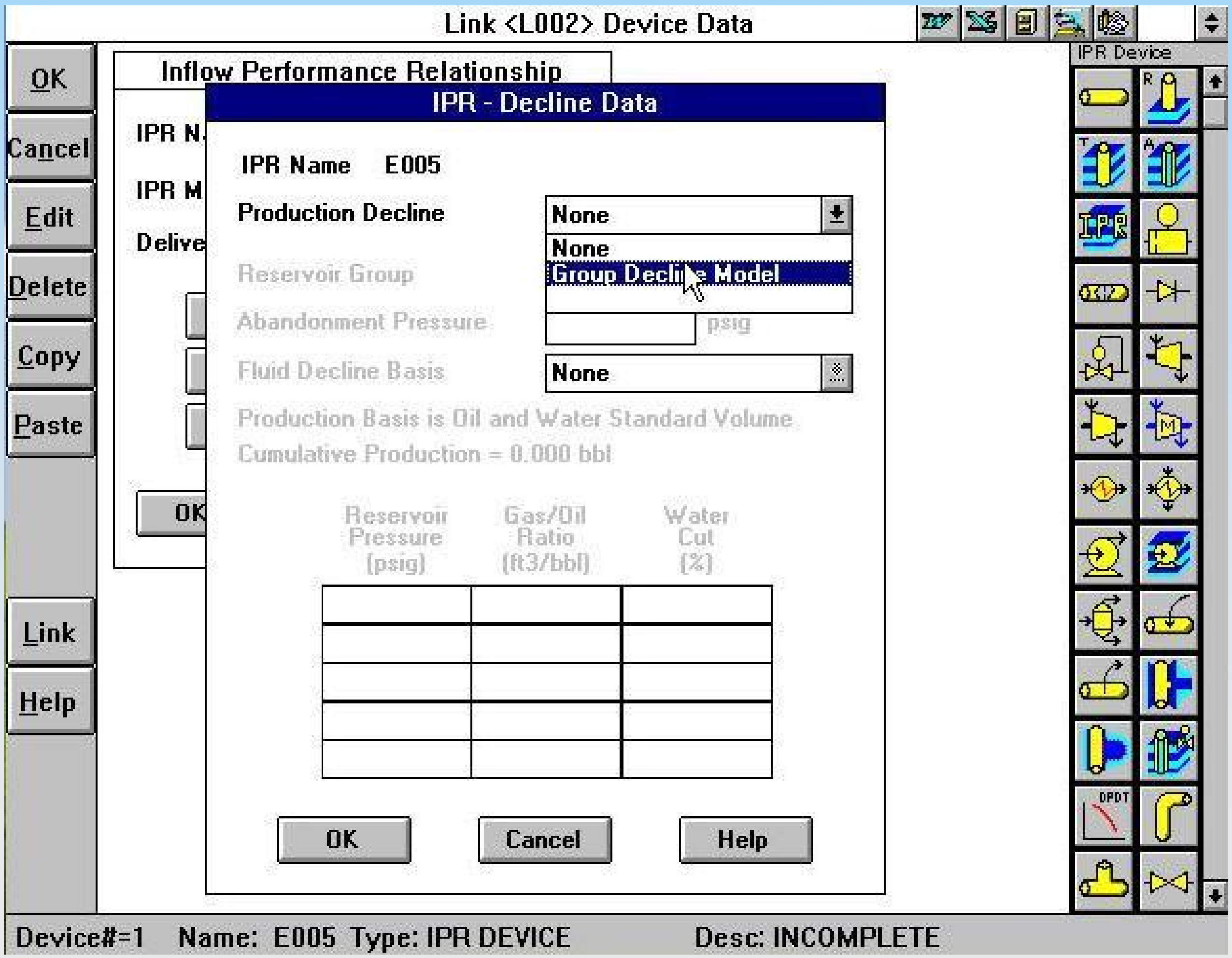


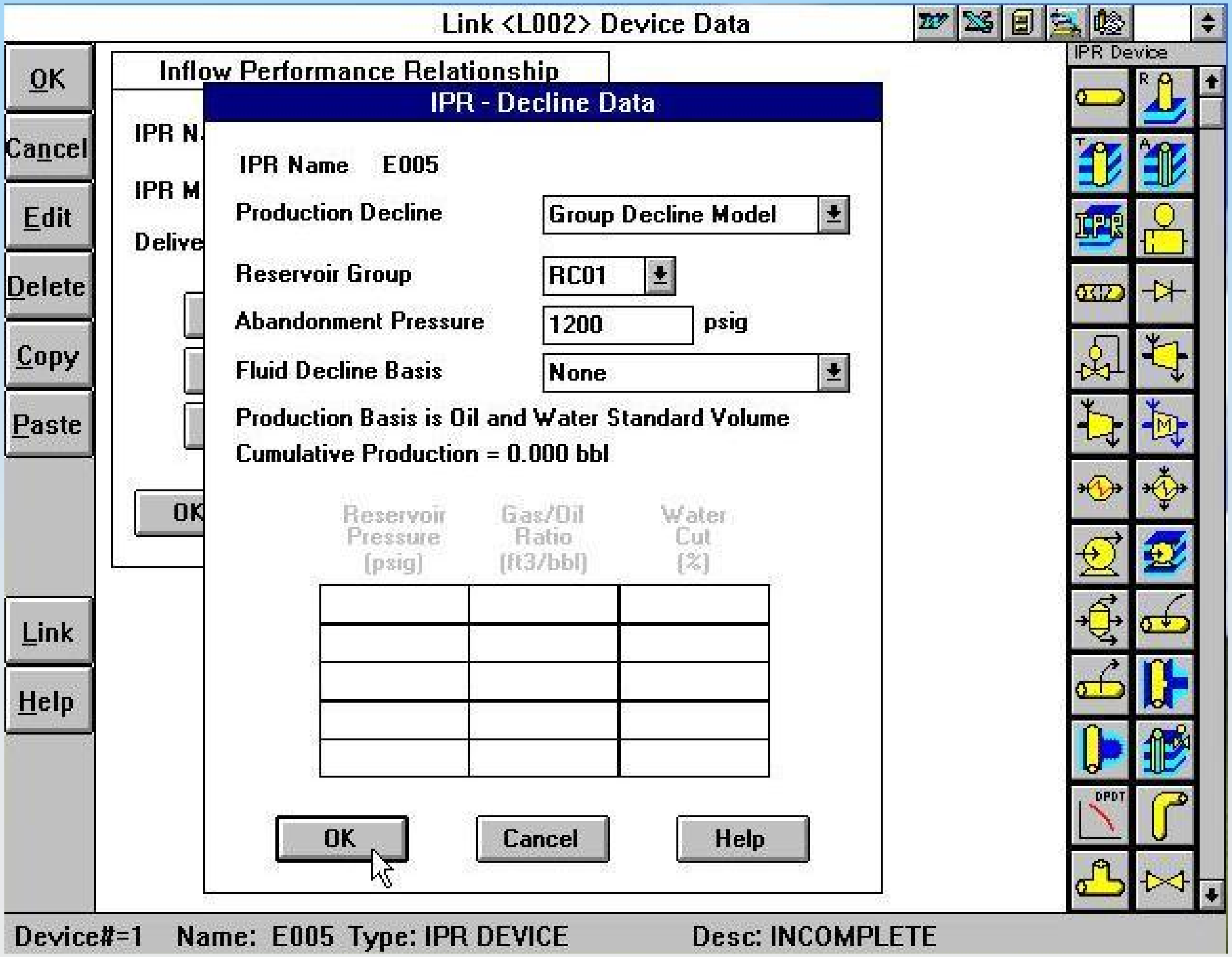
Link <L002> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
E005
IPR Model
Vogel
Vogel
Fetkovich Gas Flow
Laminar-Inertial-Turbulent
Tabular
Deliverabilit
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

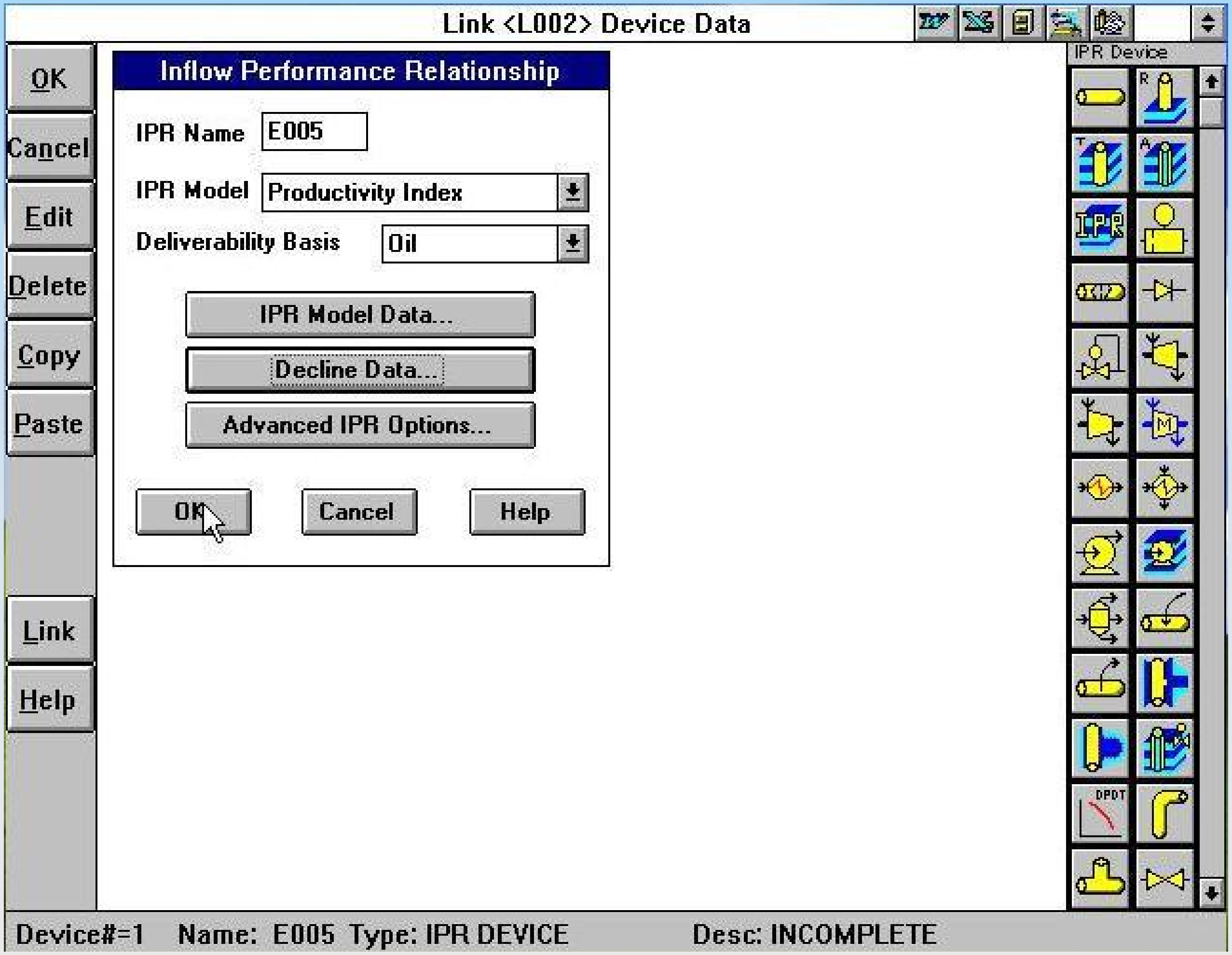

Link <L002> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
E005
IPR Model
Productivity Index
Deliverability Basis
Oil
IPR Model Data...
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

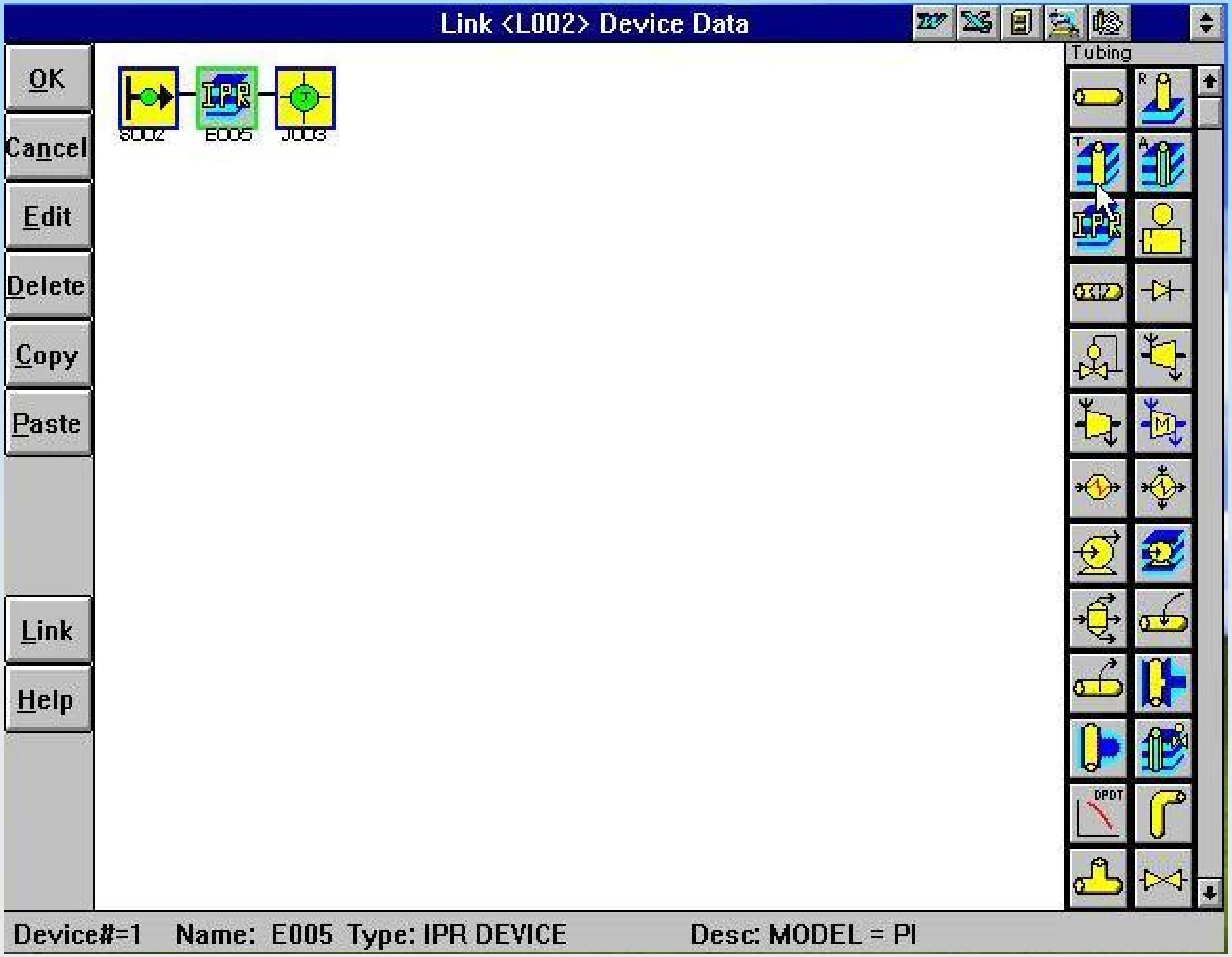

Link <L002> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
IPR M
Delive
OK
IPR - Productivity Index Data
IPR Name E005
Productivity Index
25
bbl/day/psig
OK
Cancel
Help
DPDT
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

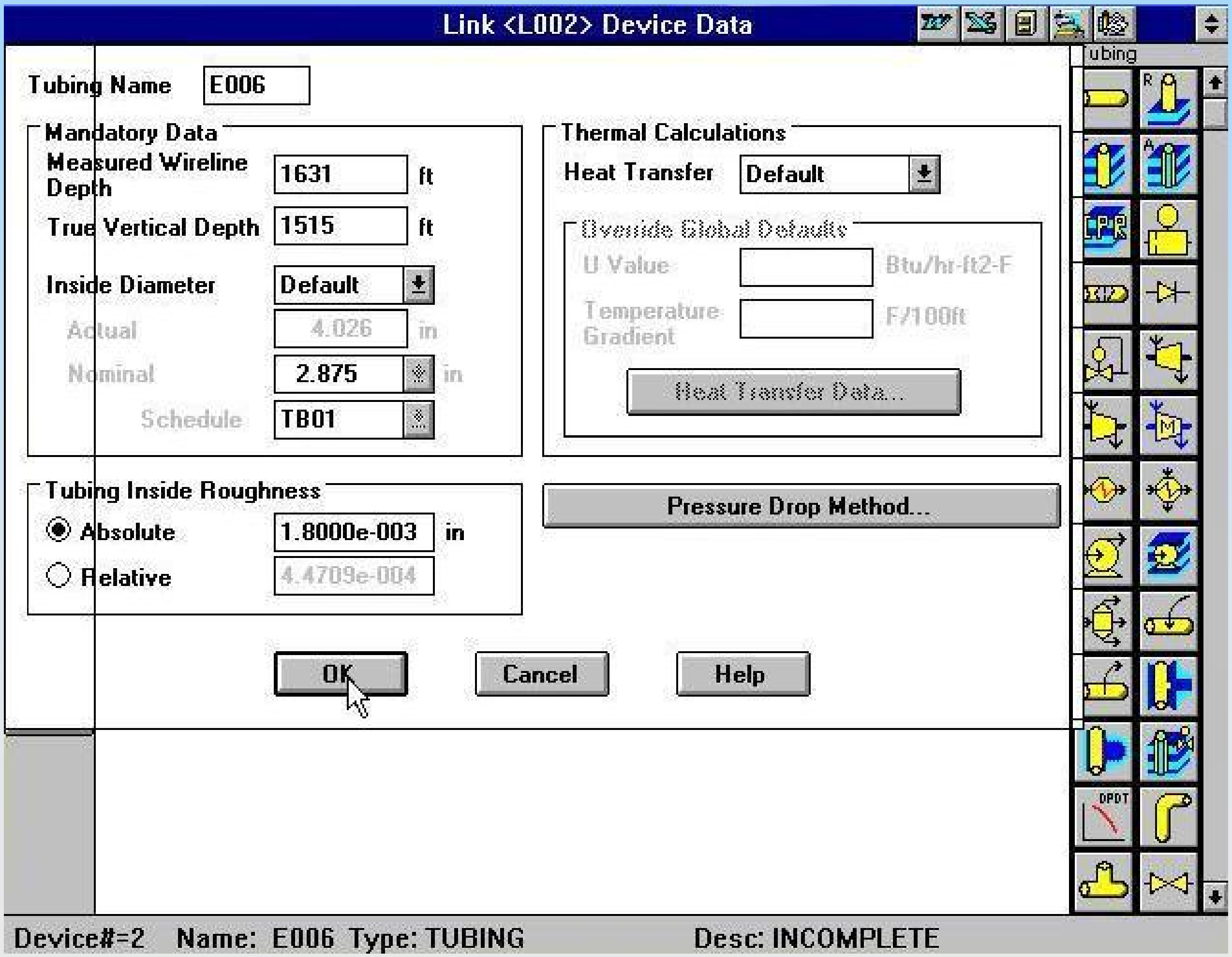

Link <L002> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name
E005
IPR Model
Productivity Index
Deliverability Basis
Oil
IPR Model Data...
Decline Data
Advanced IPR Options...
OK
Cancel
Help
IPR Device
Device#=1 Name: E005 Type: IPR DEVICE
Desc: INCOMPLETE

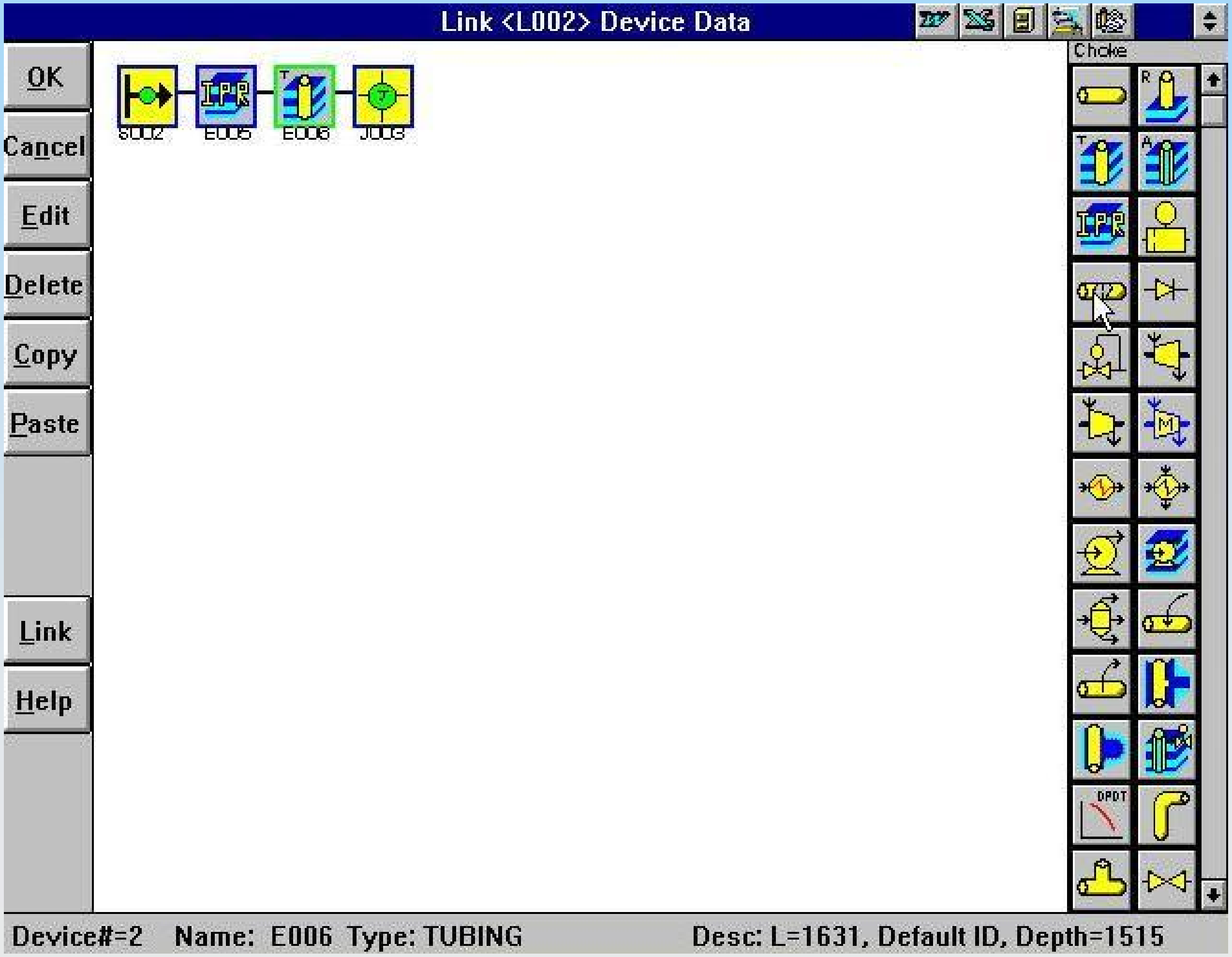

Link <L002> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR - Decline Data
IPR Name E005
Production Decline
None
None
Group Decline Model
Reservoir Group
Abandonment Pressure
psig
Fluid Decline Basis
None
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

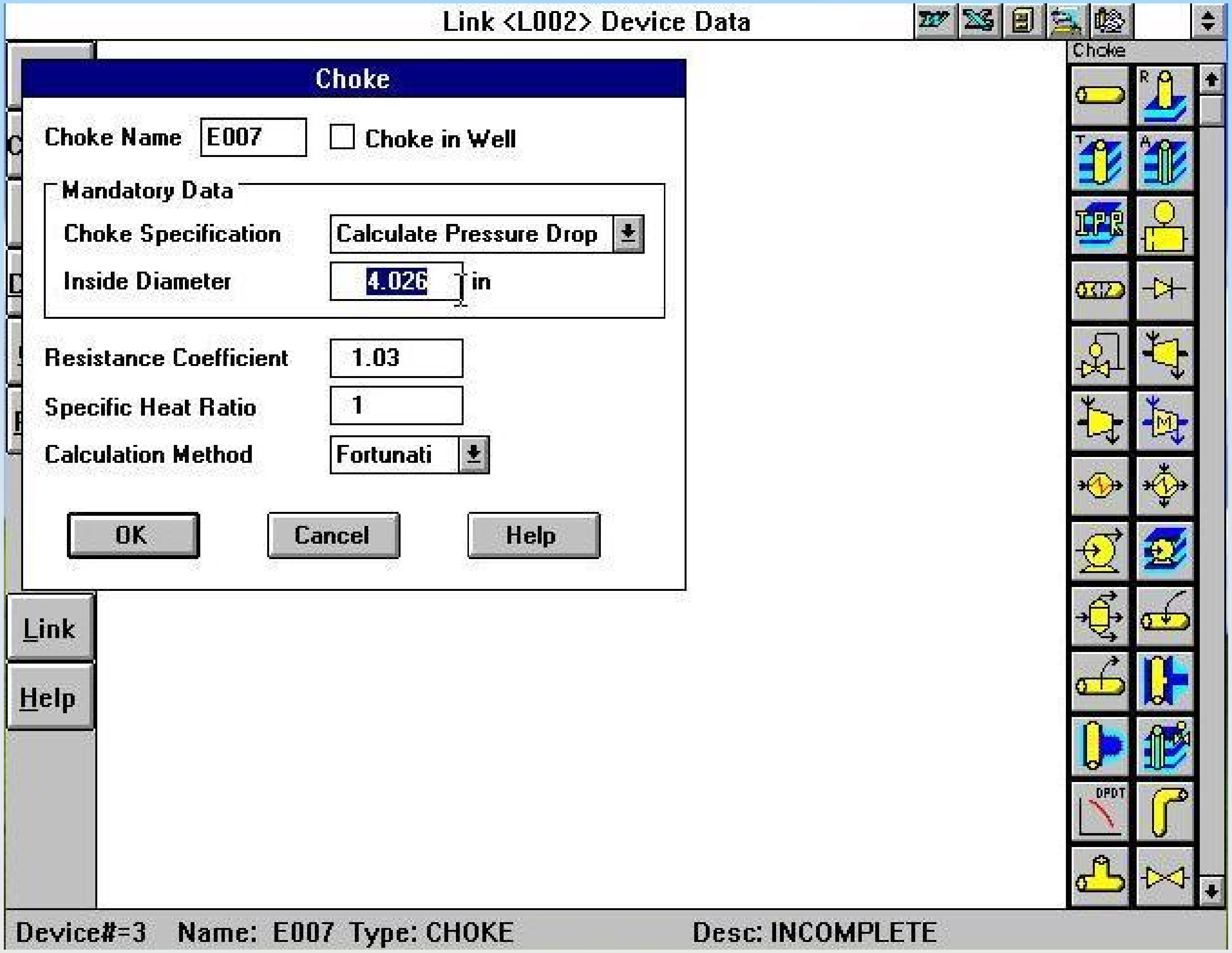

Link <L002> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR - Decline Data
IPR Name E005
Production Decline
Group Decline Model
Reservoir Group
RC01
Abandonment Pressure
1200
psig
Fluid Decline Basis
None
Production Basis is Oil and Water Standard Volume
Cumulative Production = 0.000 bbl
Reservoir Pressure (psig)
Gas/Oil Ratio (ft3/bbl)
Water Cut (%)
OK
Cancel
Help
IPR Device
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

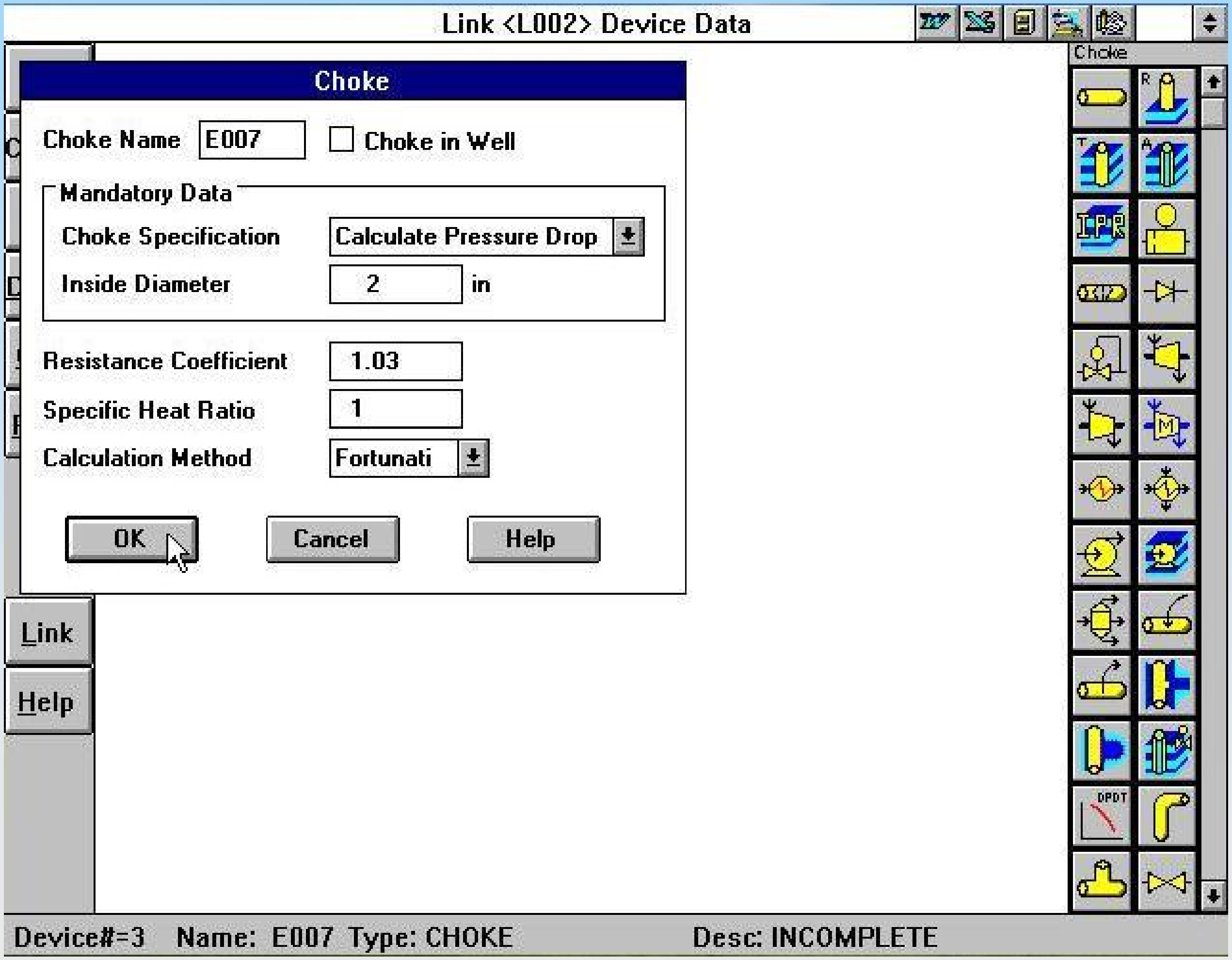

Link <L002> Device Data
IPR Device
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Inflow Performance Relationship
IPR Name E005
IPR Model Productivity Index
Deliverability Basis Oil
IPR Model Data...
Decline Data...
Advanced IPR Options...
OK
Cancel
Help
Device#=1 Name: E005 Type: IPR DEVICE Desc: INCOMPLETE

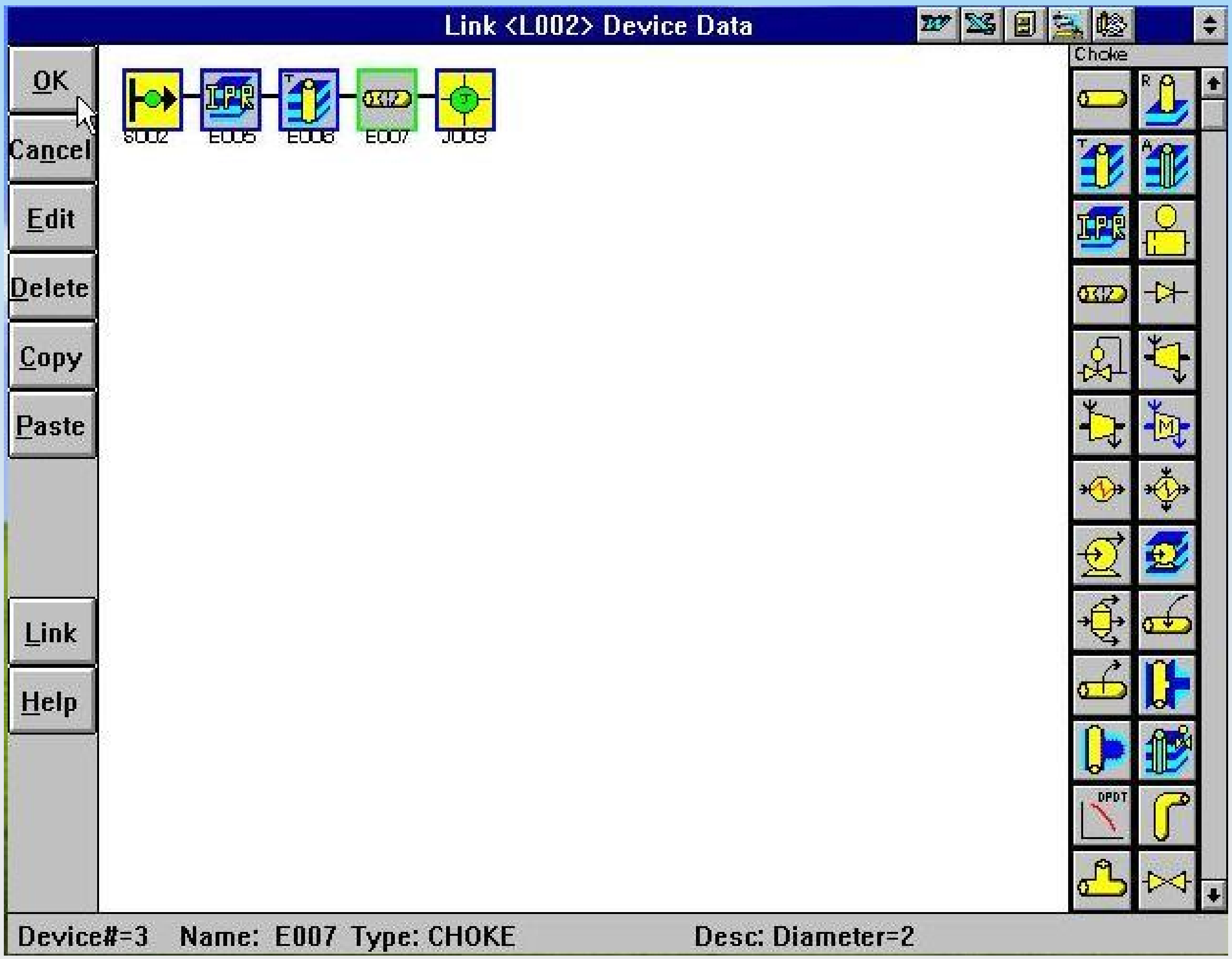

Link <L002> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S002
E005
J003
Tubing
Device#=1 Name: E005 Type: IPR DEVICE Desc: MODEL = PI

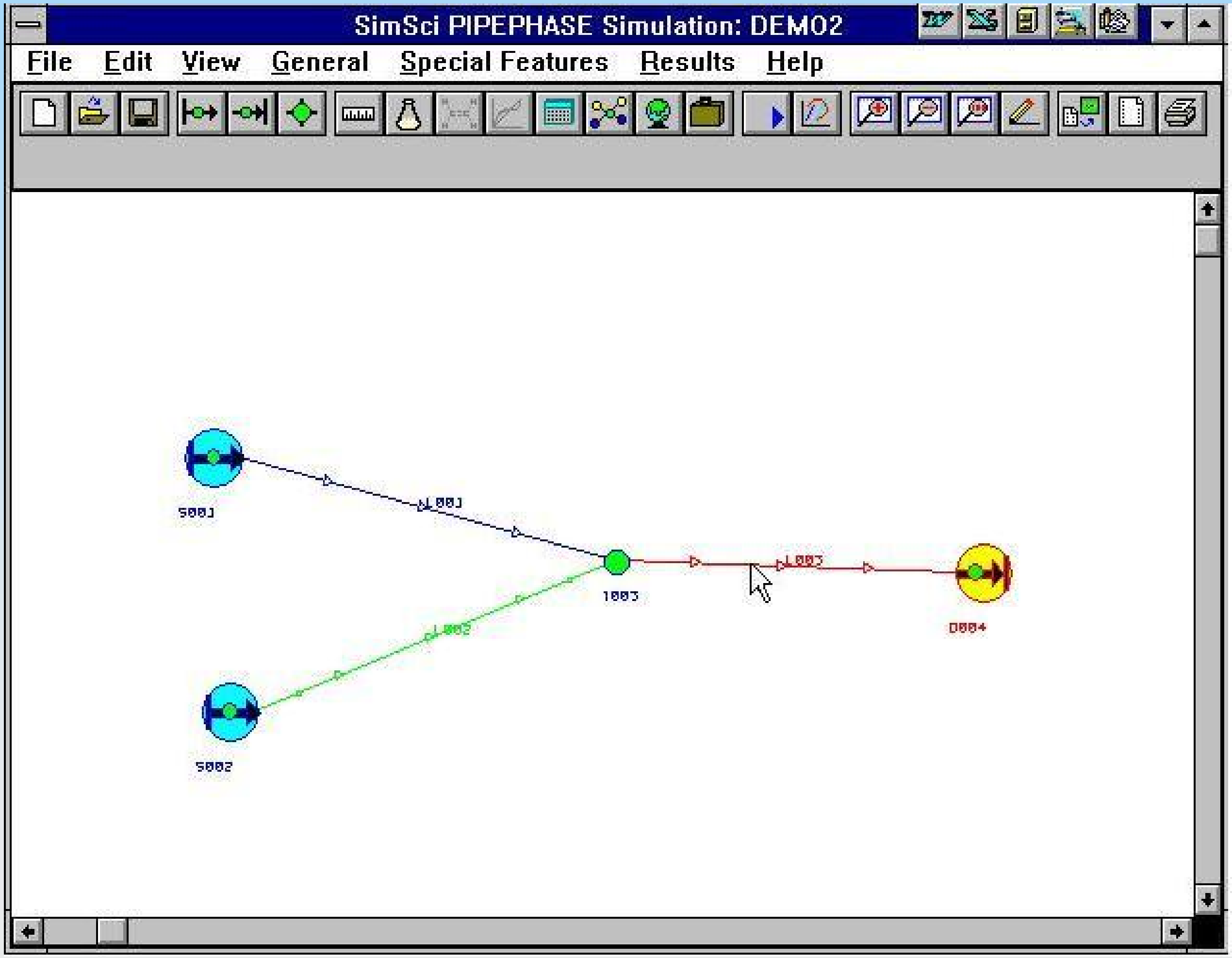

Link <L002> Device Data
Tubing Name E006
Mandatory Data
Measured Wireline Depth 1631 ft
True Vertical Depth 1515 ft
Inside Diameter Default
Actual 4.026 in
Nominal 2.875 in
Schedule TB01
Thermal Calculations
Heat Transfer Default
Override Global Defaults
U Value Btu/hr-ft2-F
Temperature Gradient F/100ft
Heat Transfer Data...
Tubing Inside Roughness
Absolute 1.8000e-003 in
Relative 4.4709e-004
Pressure Drop Method...
OK
Cancel
Help
Device#=2 Name: E006 Type: TUBING Desc: INCOMPLETE


Link <L002> Device Data
Choke
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
Device#=2 Name: E006 Type: TUBING
Desc: L=1631, Default ID, Depth=1515

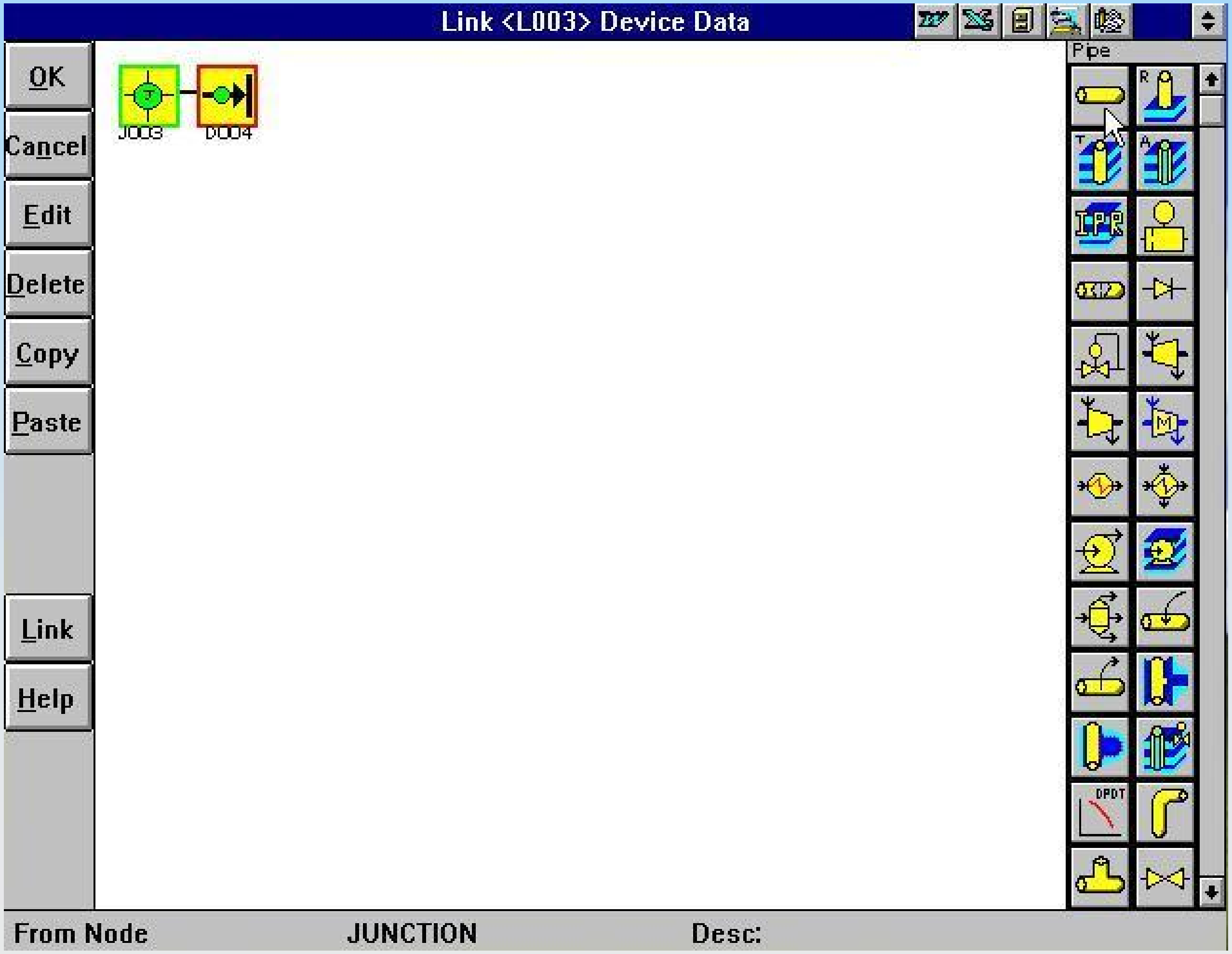

Link <L002> Device Data
Choke
Choke
Choke Name
E007
Choke in Well
Mandatory Data
Choke Specification
Calculate Pressure Drop
Inside Diameter
4.026
in
Resistance Coefficient
1.03
Specific Heat Ratio
1
Calculation Method
Fortunati
OK
Cancel
Help
Link
Help
Device#=3 Name: E007 Type: CHOKE
Desc: INCOMPLETE

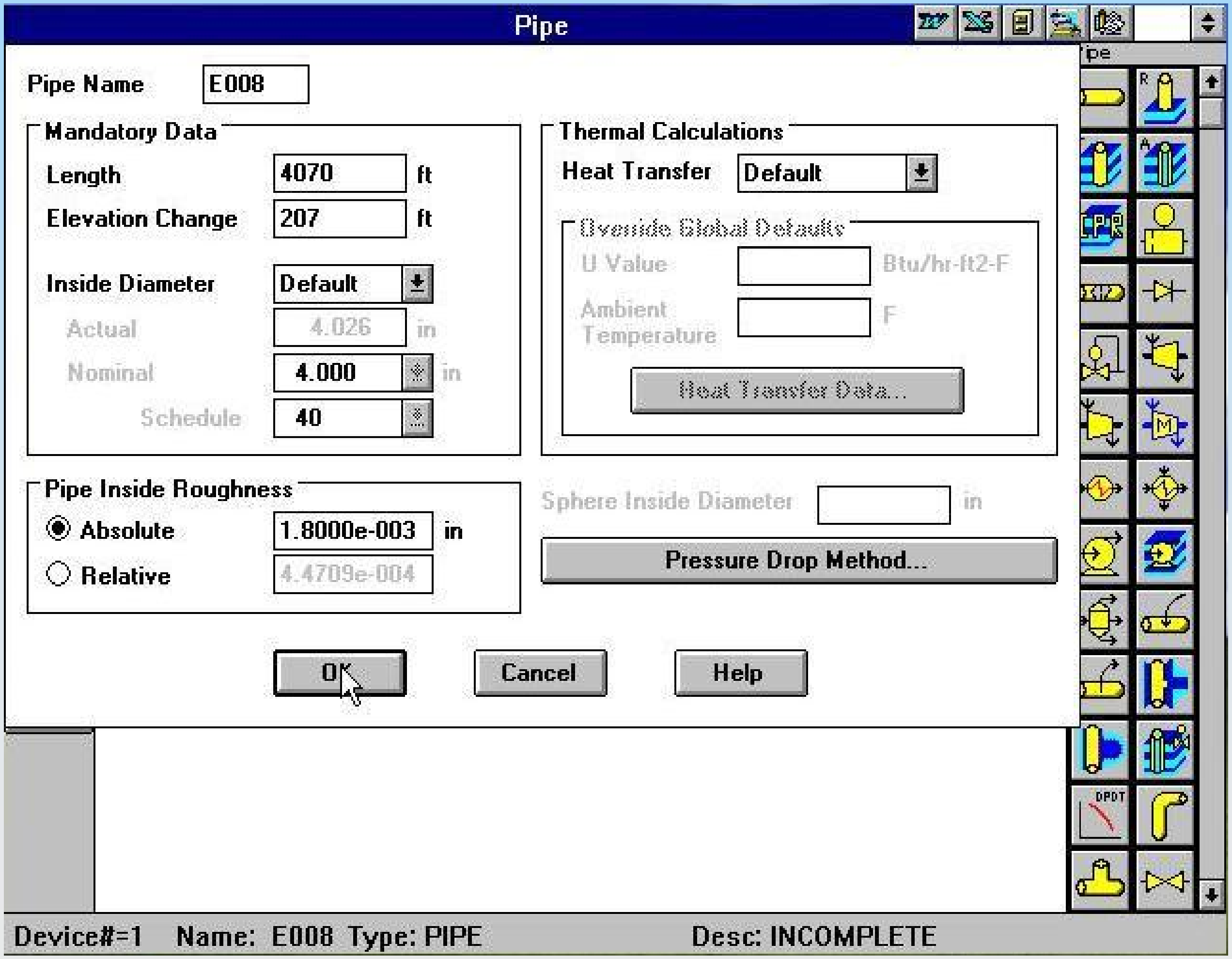

Link <L002> Device Data
Choke
Choke Name
E007
Choke in Well
Mandatory Data
Choke Specification
Calculate Pressure Drop
Inside Diameter
2
in
Resistance Coefficient
1.03
Specific Heat Ratio
1
Calculation Method
Fortunati
OK
Cancel
Help
Link
Help
Device#=3 Name: E007 Type: CHOKE
Desc: INCOMPLETE


Link <L002> Device Data
Choke
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
S002
E005
E006
E007
J003
Device#=3 Name: E007 Type: CHOKE Desc: Diameter=2

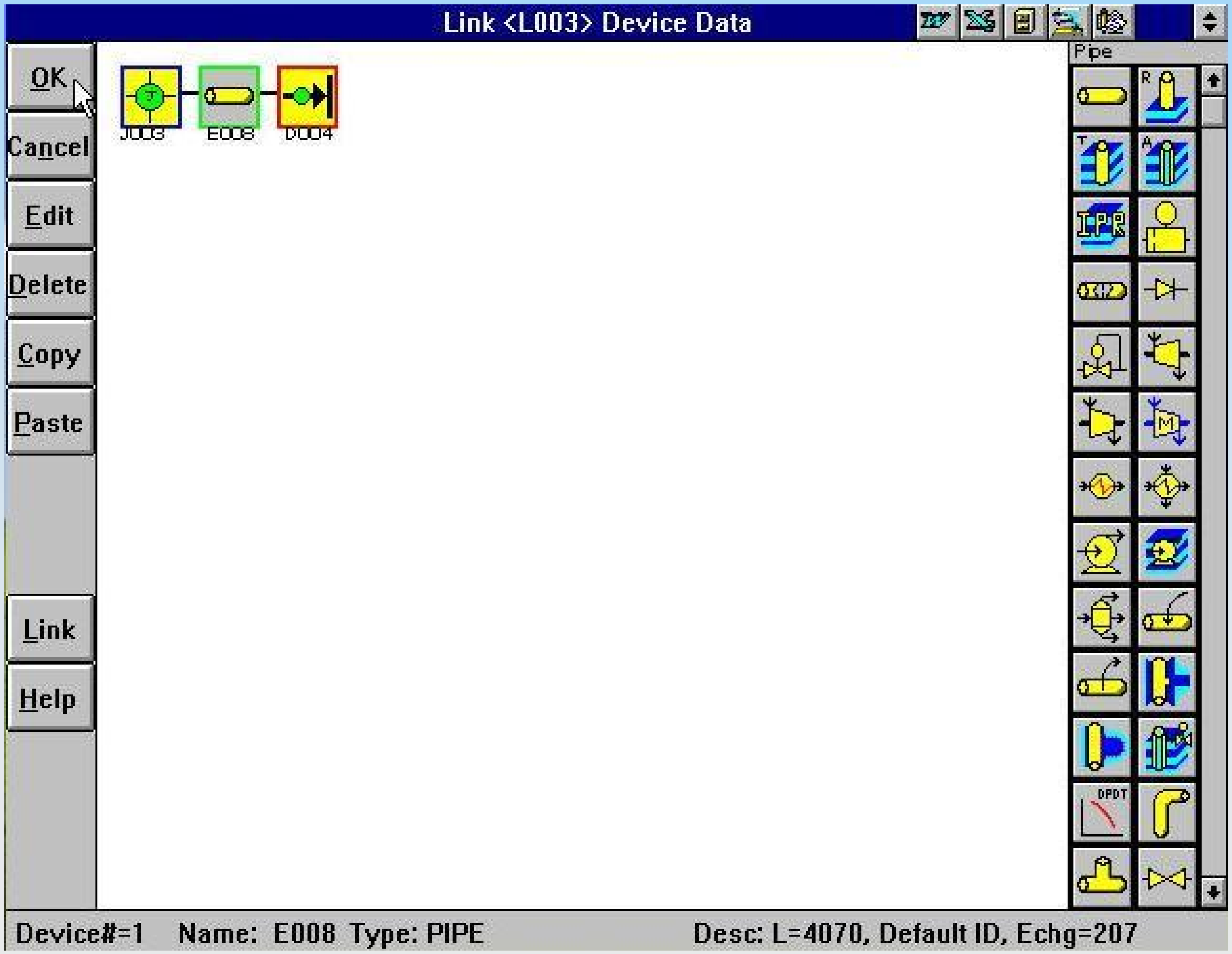


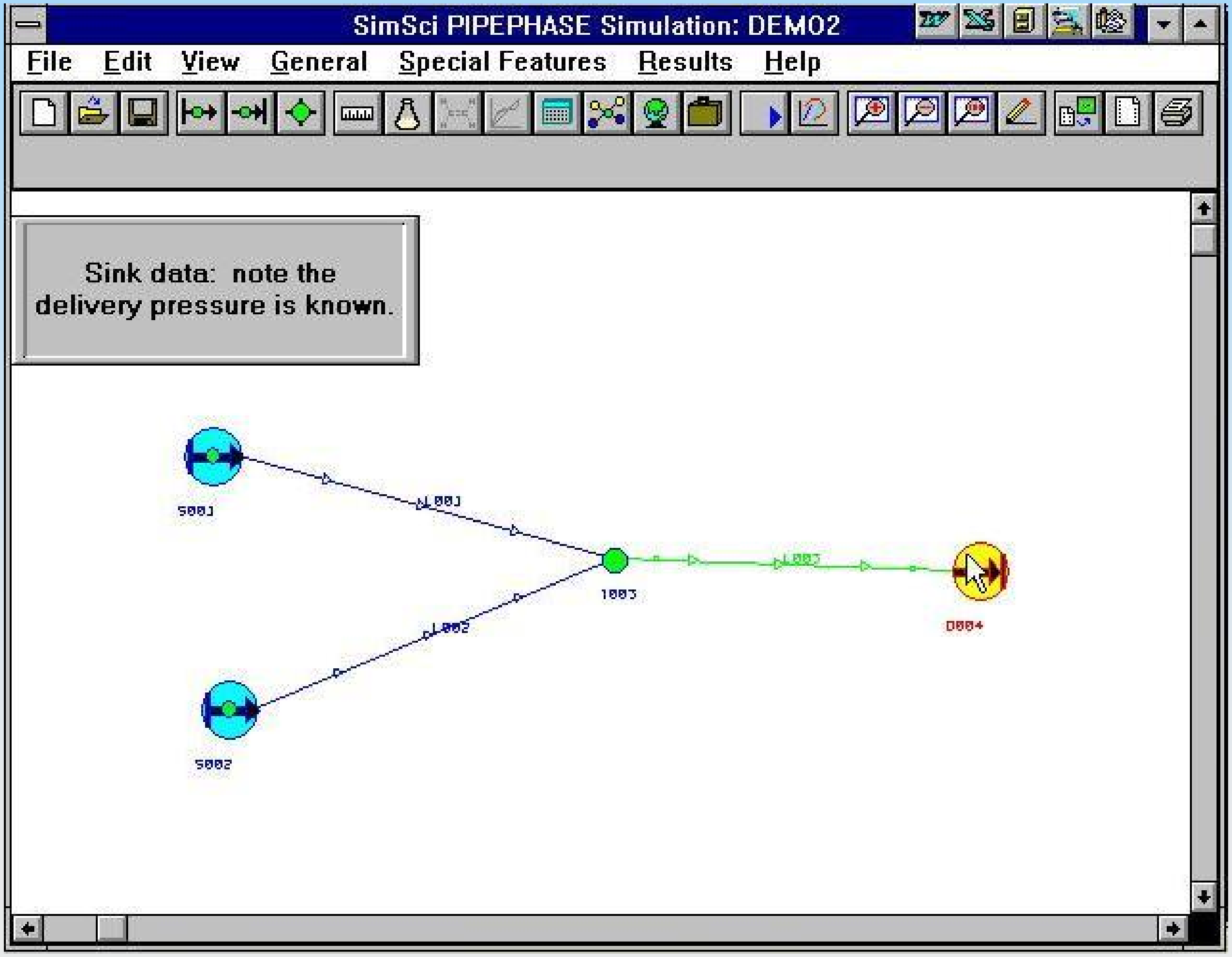
SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
S001
L001
1003
L003
D004
L002
S002


Link <L003> Device Data
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
J003
D004
Pipe
From Node
JUNCTION
Desc:

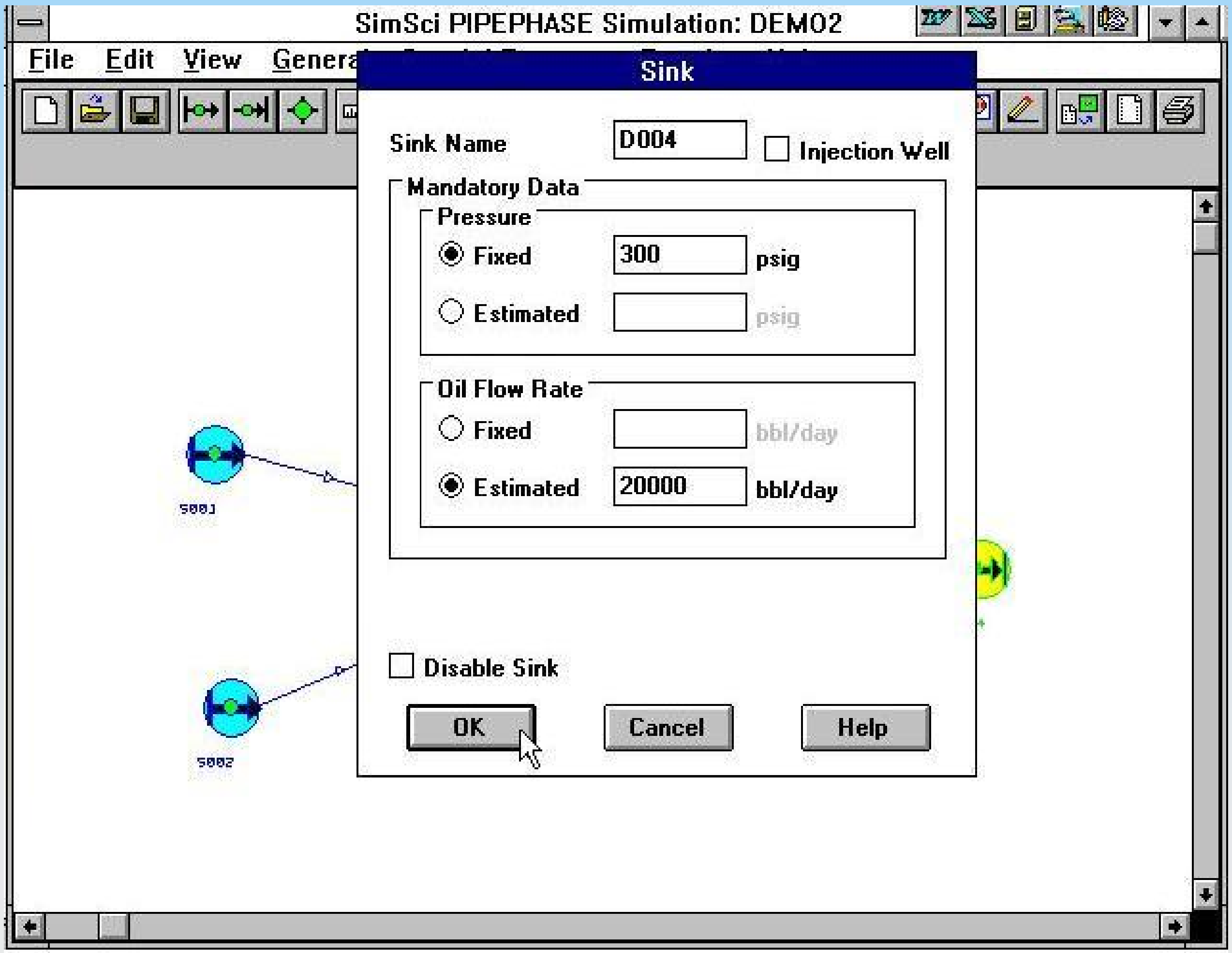


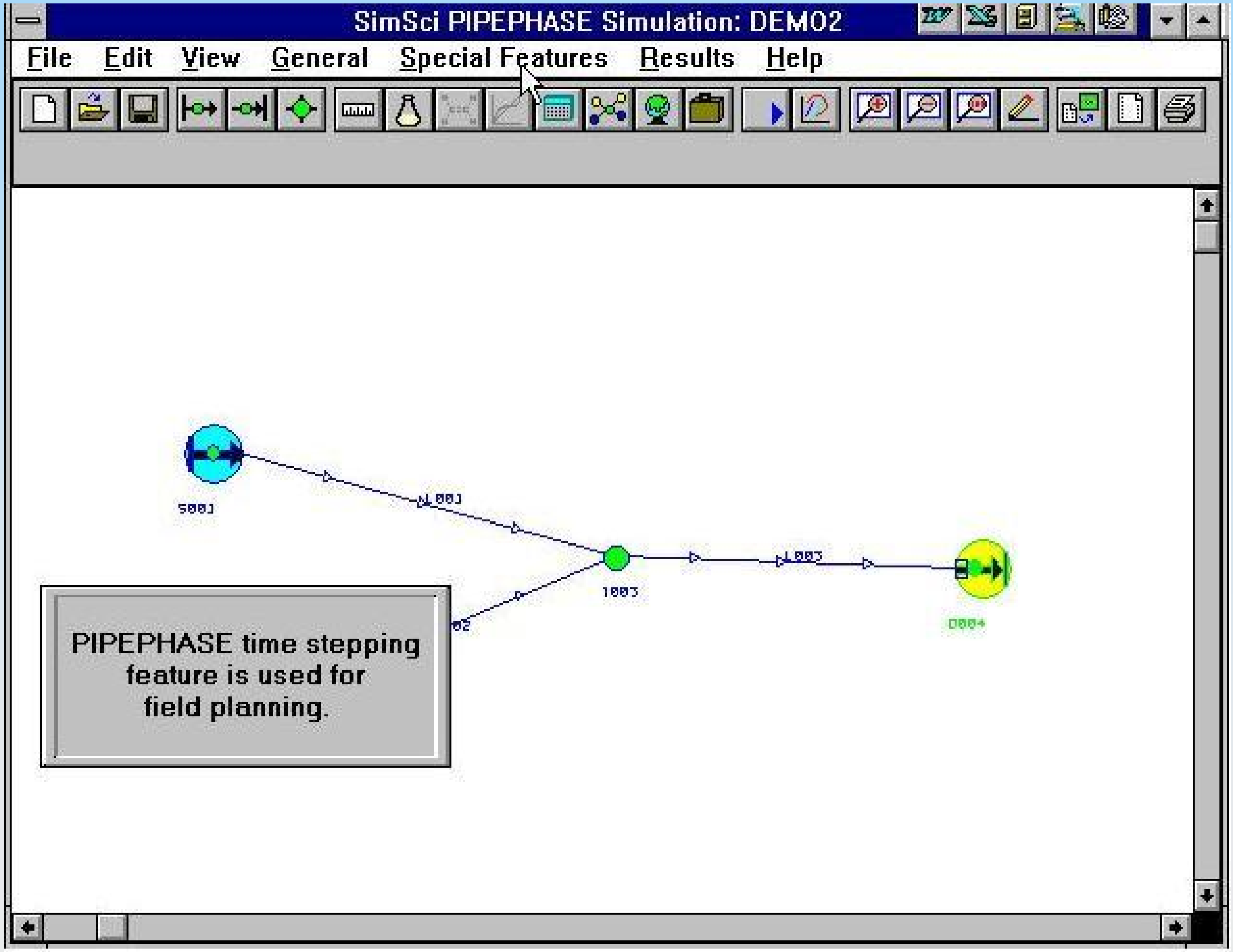
Pipe
Pipe Name
E008
Mandatory Data
Length
4070
ft
Elevation Change
207
ft
Inside Diameter
Default
Actual
4.026
in
Nominal
4.000
in
Schedule
40
Thermal Calculations
Heat Transfer
Default
Override Global Defaults
U Value
Btu/hr-ft2-F
Ambient Temperature
F
Heat Transfer Data...
Pipe Inside Roughness
Absolute
1.8000e-003
in
Relative
4.4709e-004
Sphere Inside Diameter
in
Pressure Drop Method...
OK
Cancel
Help
Device#=1 Name: E008 Type: PIPE
Desc: INCOMPLETE

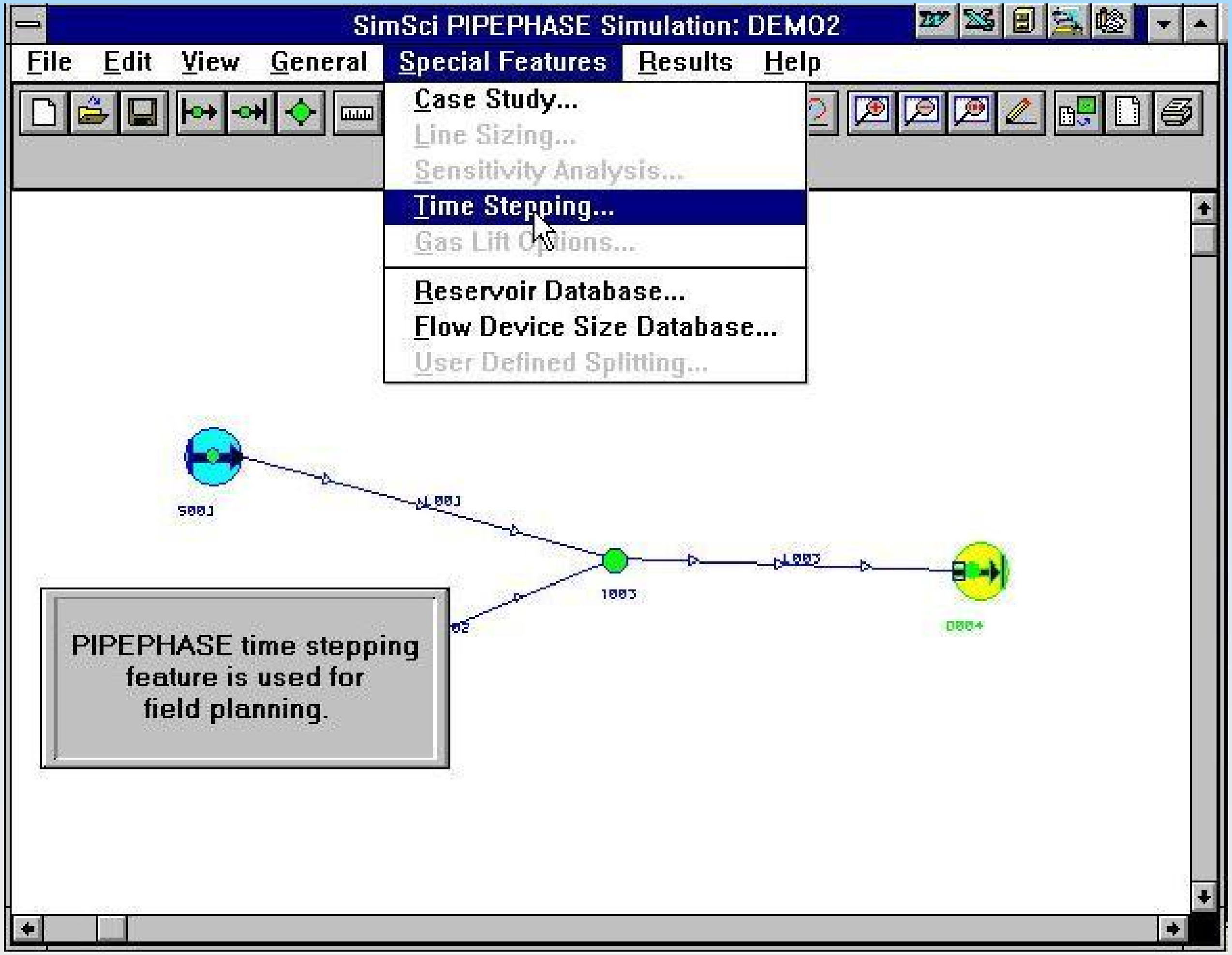

Link <L003> Device Data
Pipe
OK
Cancel
Edit
Delete
Copy
Paste
Link
Help
J003
E008
D004
Device#=1 Name: E008 Type: PIPE
Desc: L=4070, Default ID, Echg=207

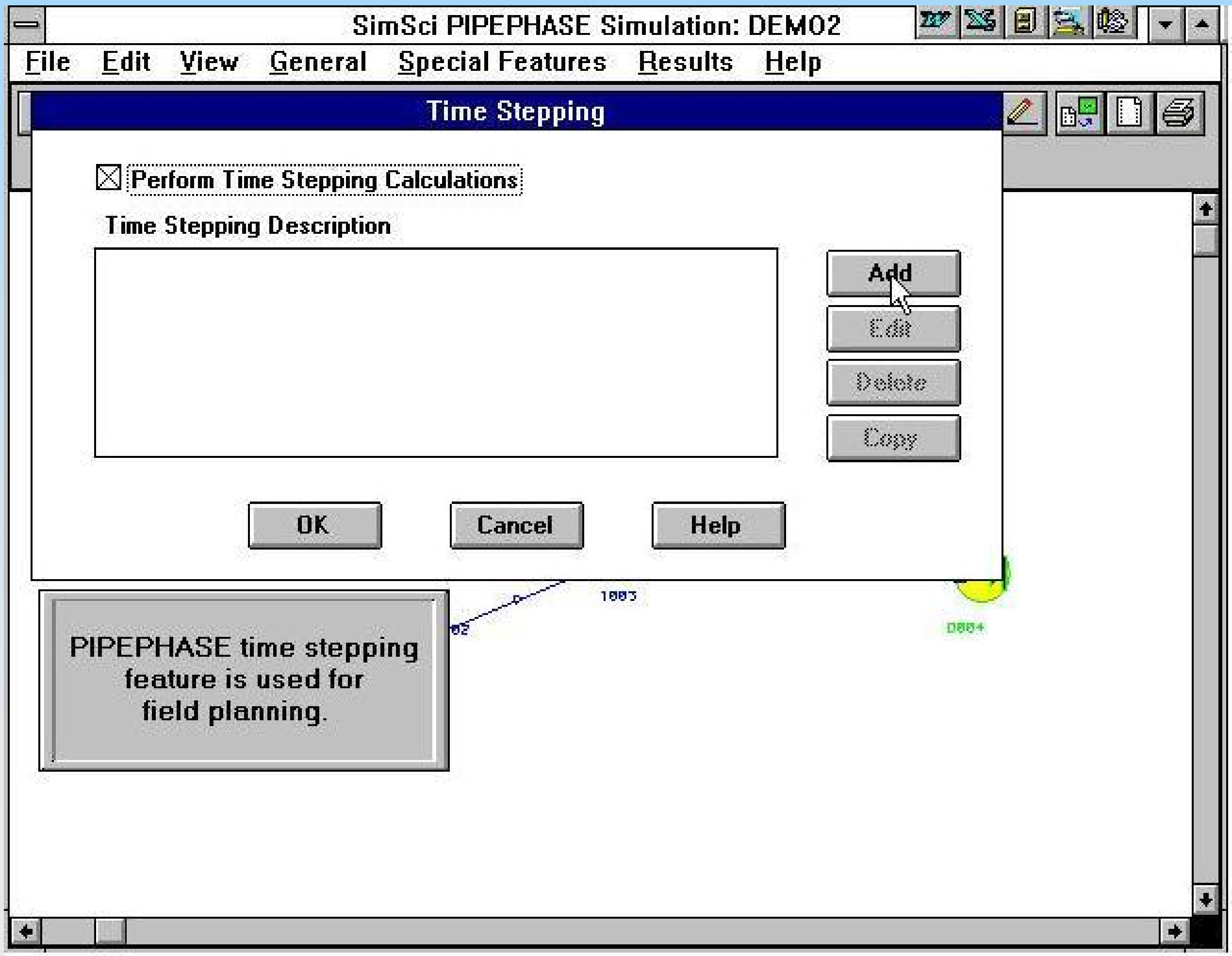


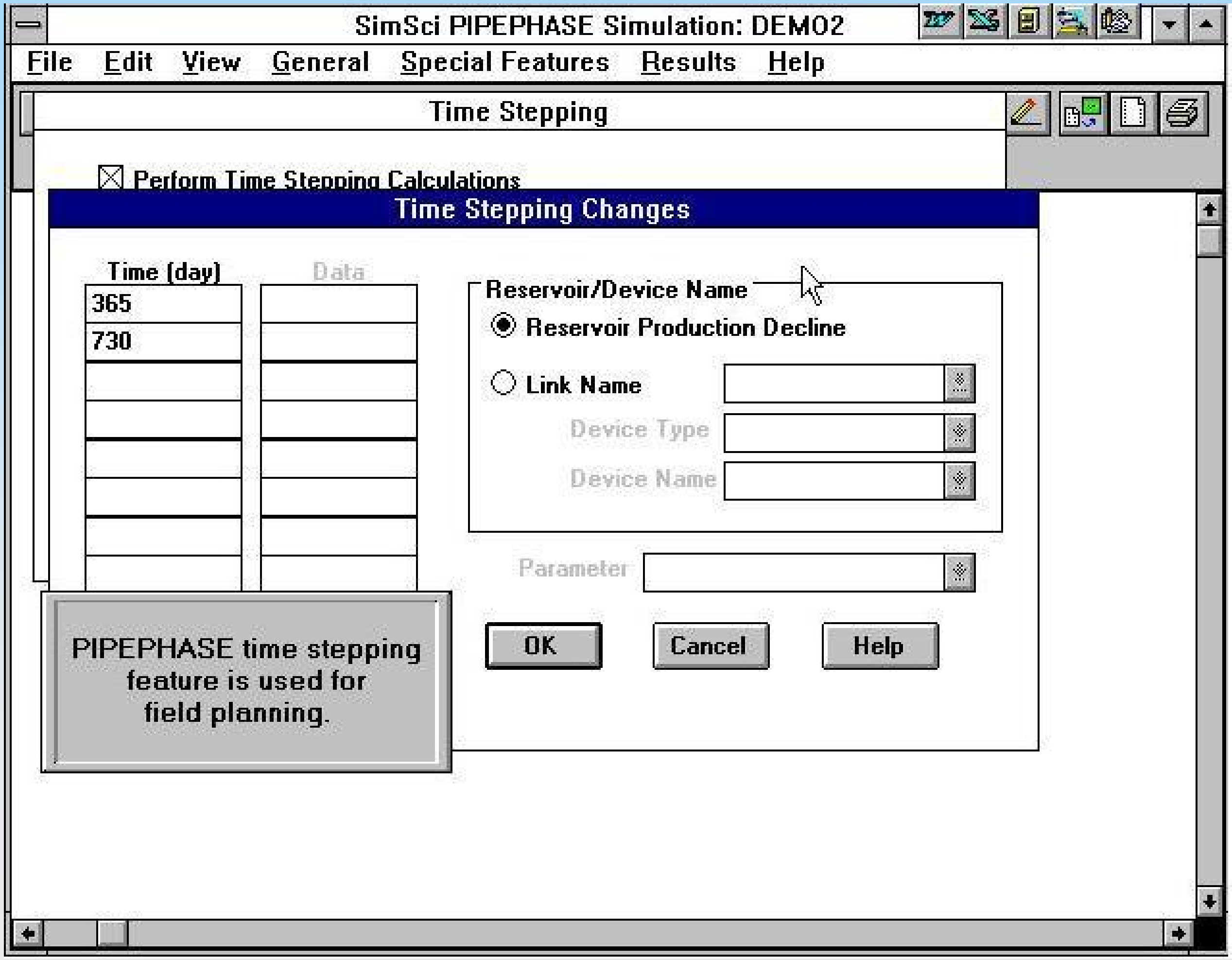
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Sink data: note the delivery pressure is known.
S001
L001
S002
L002
1003
L003
D004

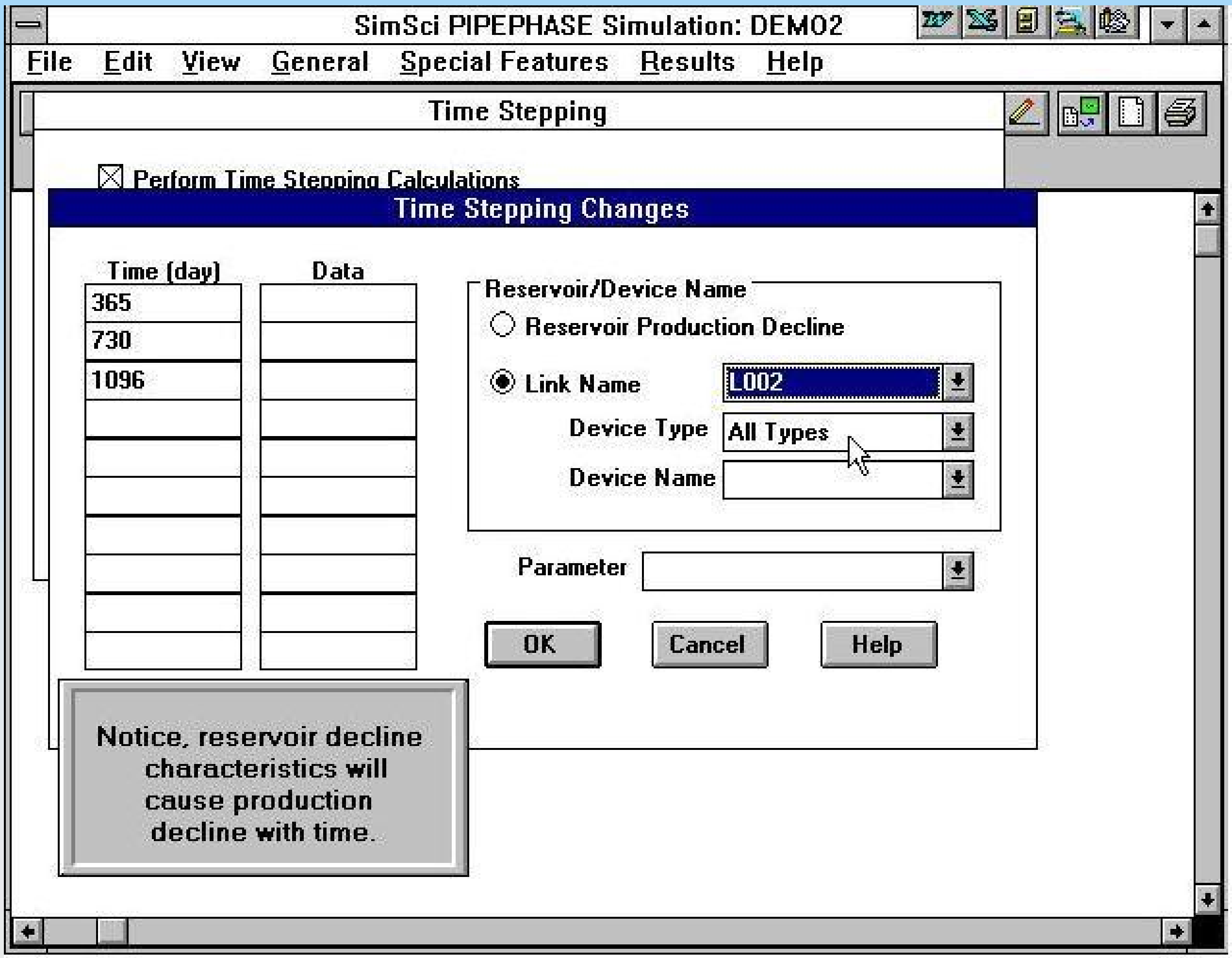

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
Sink
Sink Name
D004
Injection Well
Mandatory Data
Pressure
Fixed
300
psig
Estimated
psig
Oil Flow Rate
Fixed
bbl/day
Estimated
20000
bbl/day
Disable Sink
OK
Cancel
Help
S001
S002

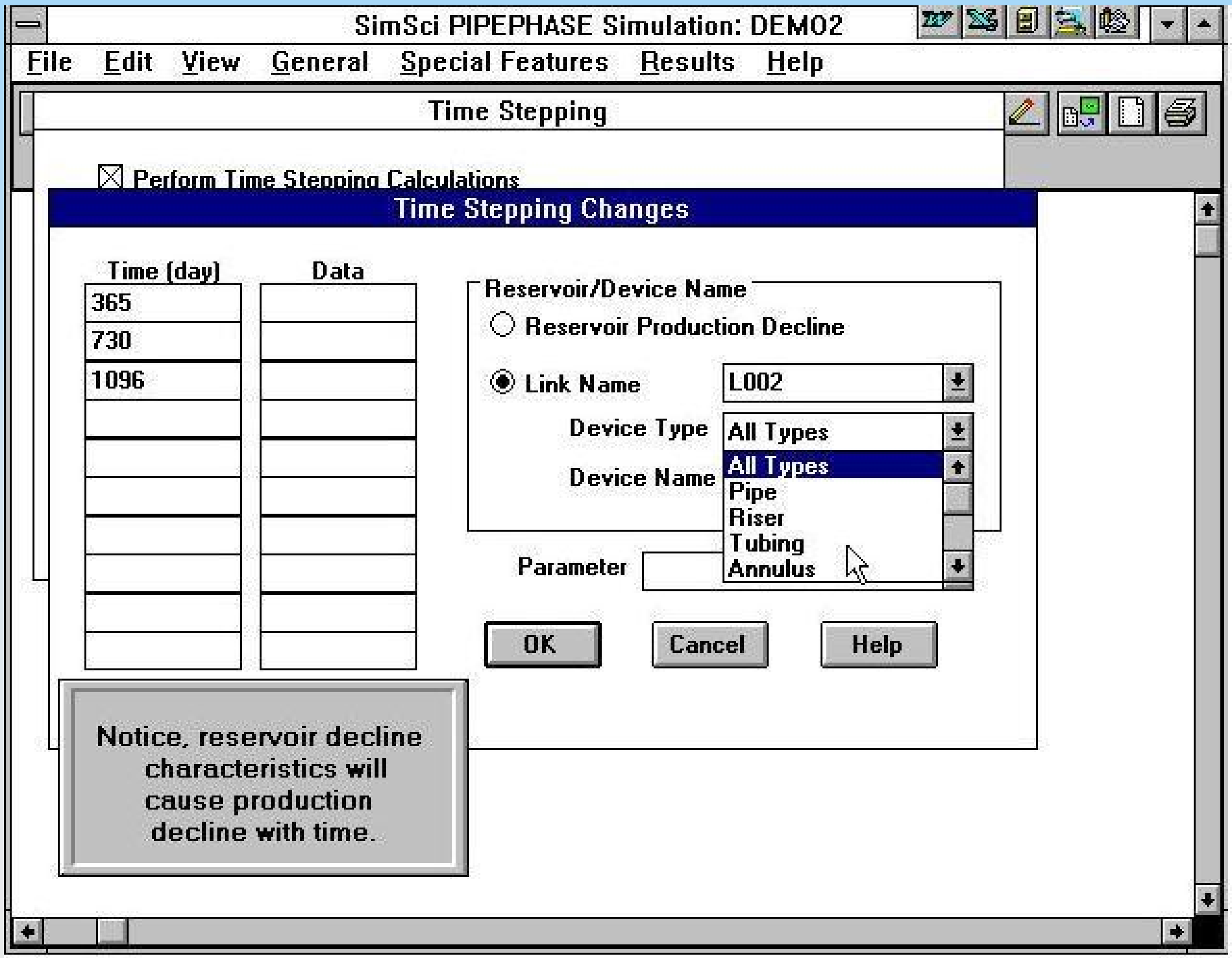

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
PIPEPHASE time stepping feature is used for field planning.

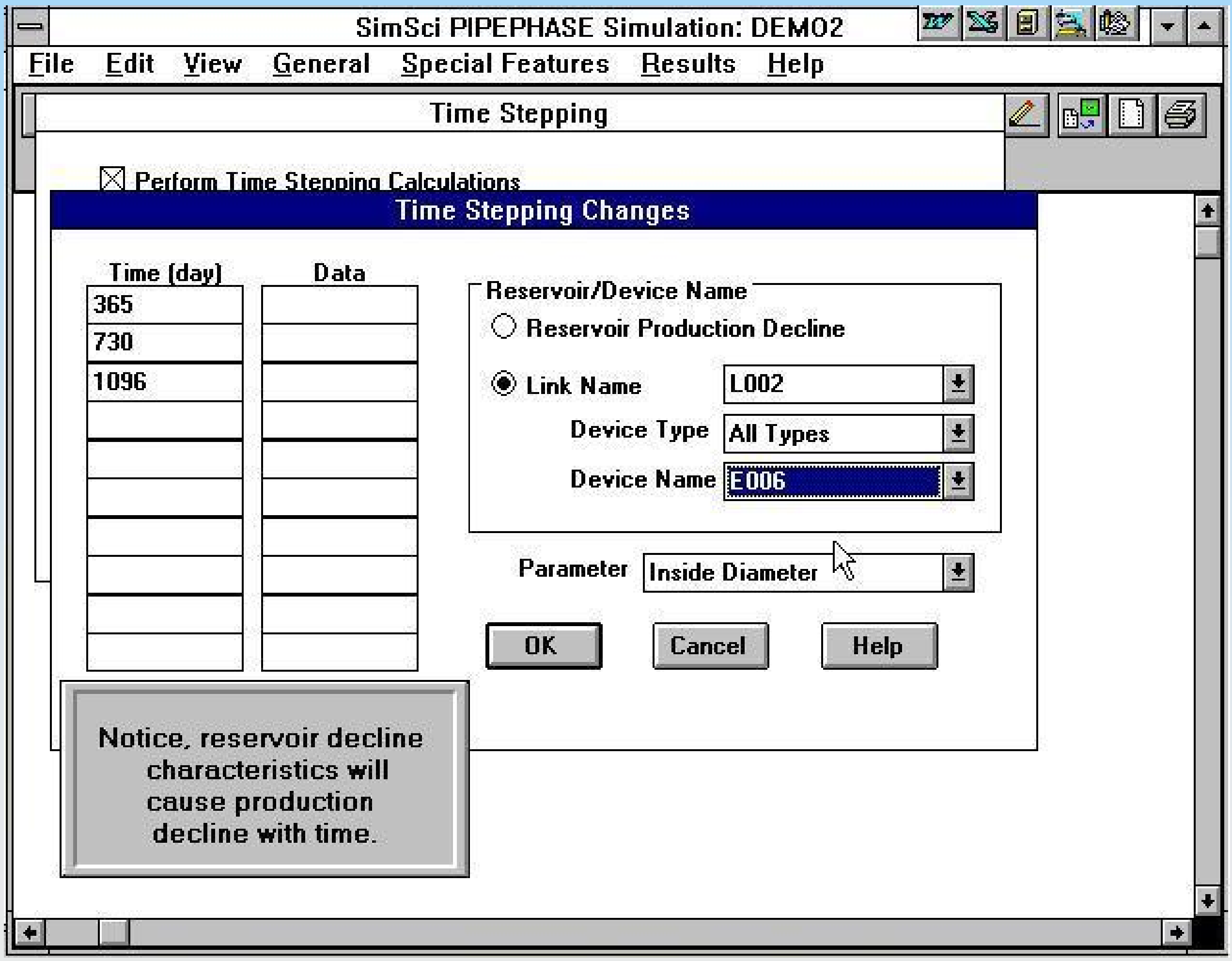

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Case Study...
Line Sizing...
Sensitivity Analysis...
Time Stepping...
Gas Lift Options...
Reservoir Database...
Flow Device Size Database...
User Defined Splitting...
PIPEPHASE time stepping feature is used for field planning.

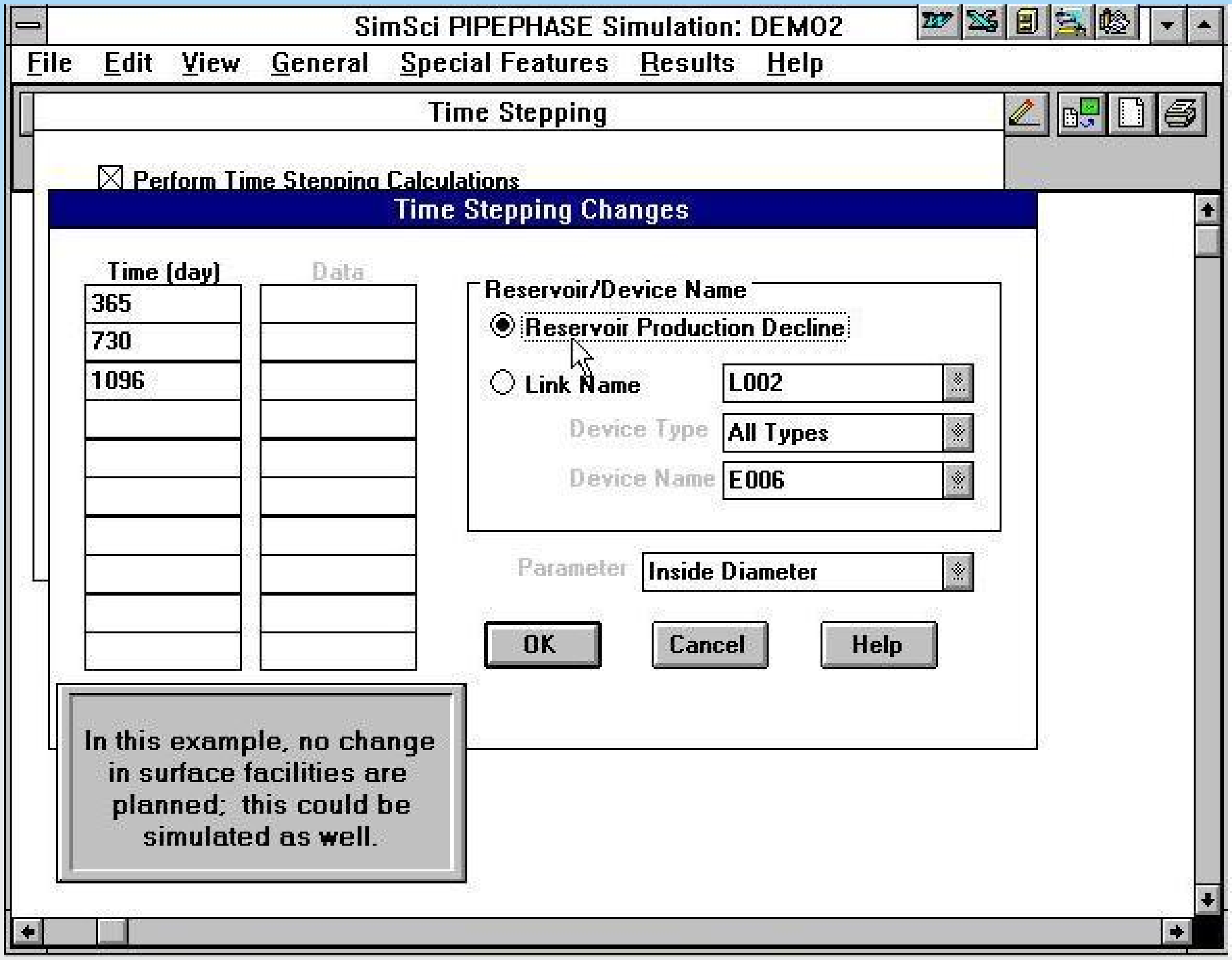

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Description
Add
Edit
Delete
Copy
OK
Cancel
Help
PIPEPHASE time stepping feature is used for field planning.


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
Reservoir/Device Name
Reservoir Production Decline
Link Name
Device Type
Device Name
Parameter
OK
Cancel
Help
PIPEPHASE time stepping feature is used for field planning.

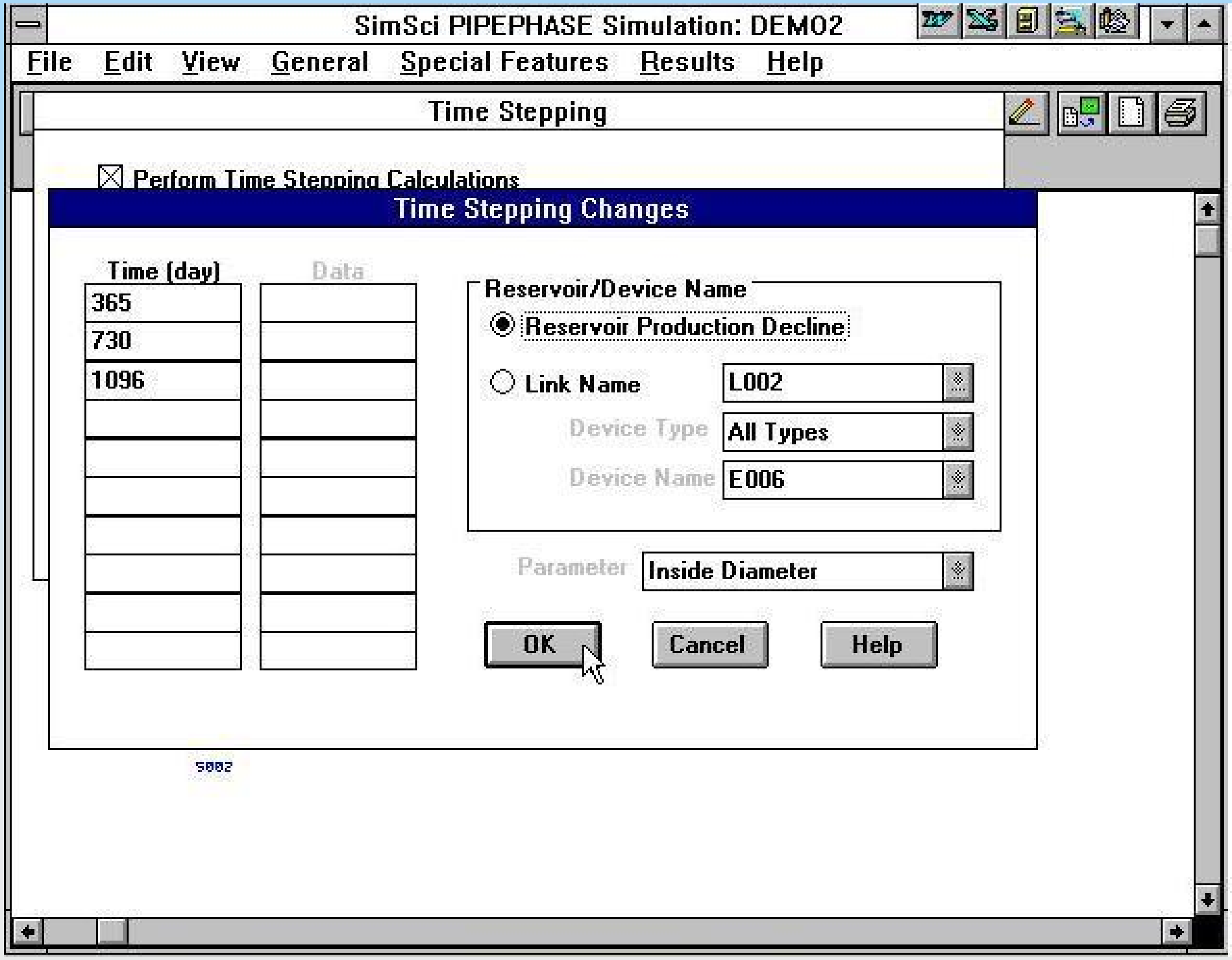

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
1096
Reservoir/Device Name
Reservoir Production Decline
Link Name
L002
Device Type
All Types
Device Name
Parameter
OK
Cancel
Help
Notice, reservoir decline characteristics will cause production decline with time.

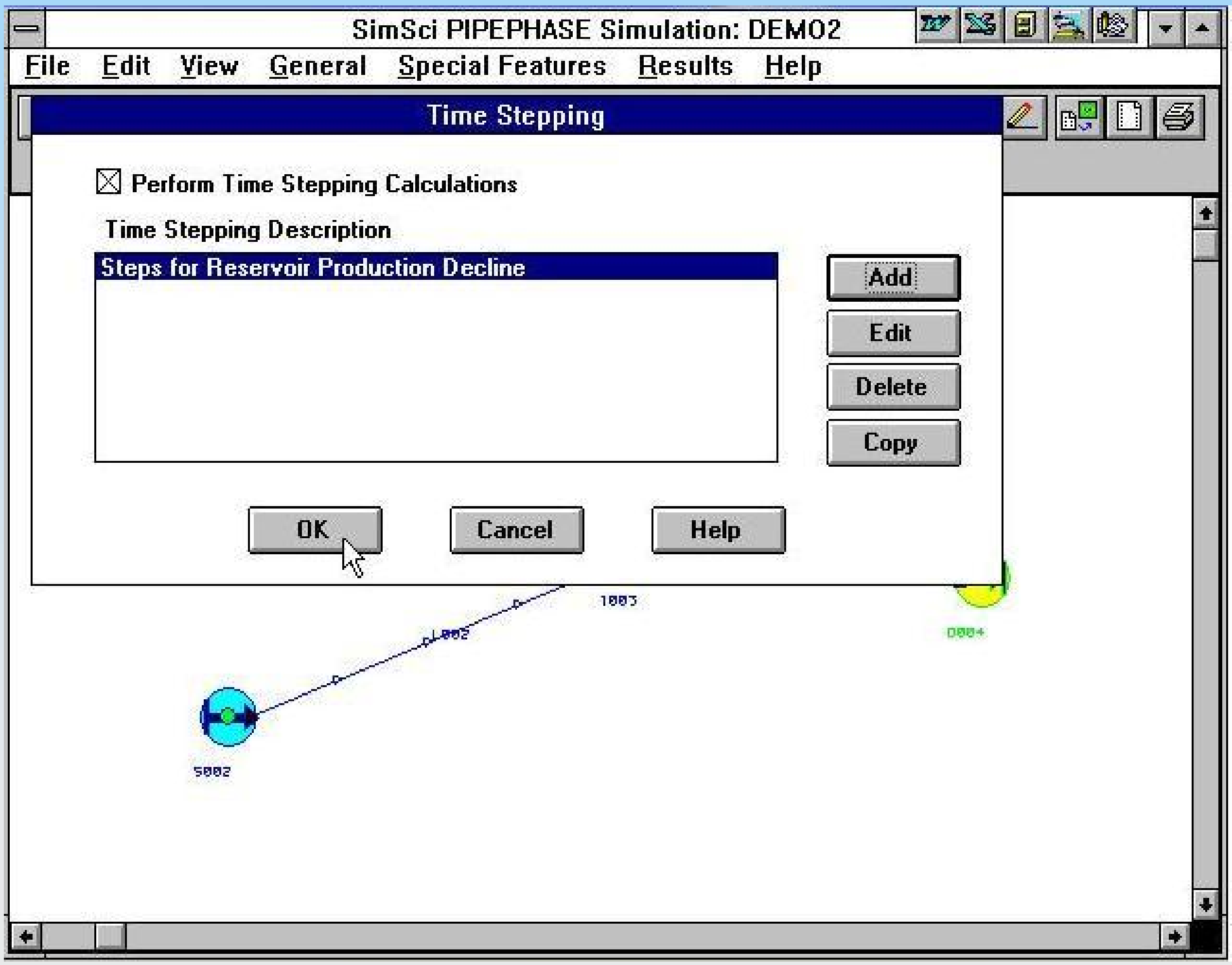

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
1096
Reservoir/Device Name
Reservoir Production Decline
Link Name
L002
Device Type
All Types
Device Name
All Types
Pipe
Riser
Tubing
Annulus
Parameter
OK
Cancel
Help
Notice, reservoir decline characteristics will cause production decline with time.


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
1096
Reservoir/Device Name
Reservoir Production Decline
Link Name
L002
Device Type
All Types
Device Name
E006
Parameter
Inside Diameter
OK
Cancel
Help
Notice, reservoir decline characteristics will cause production decline with time.

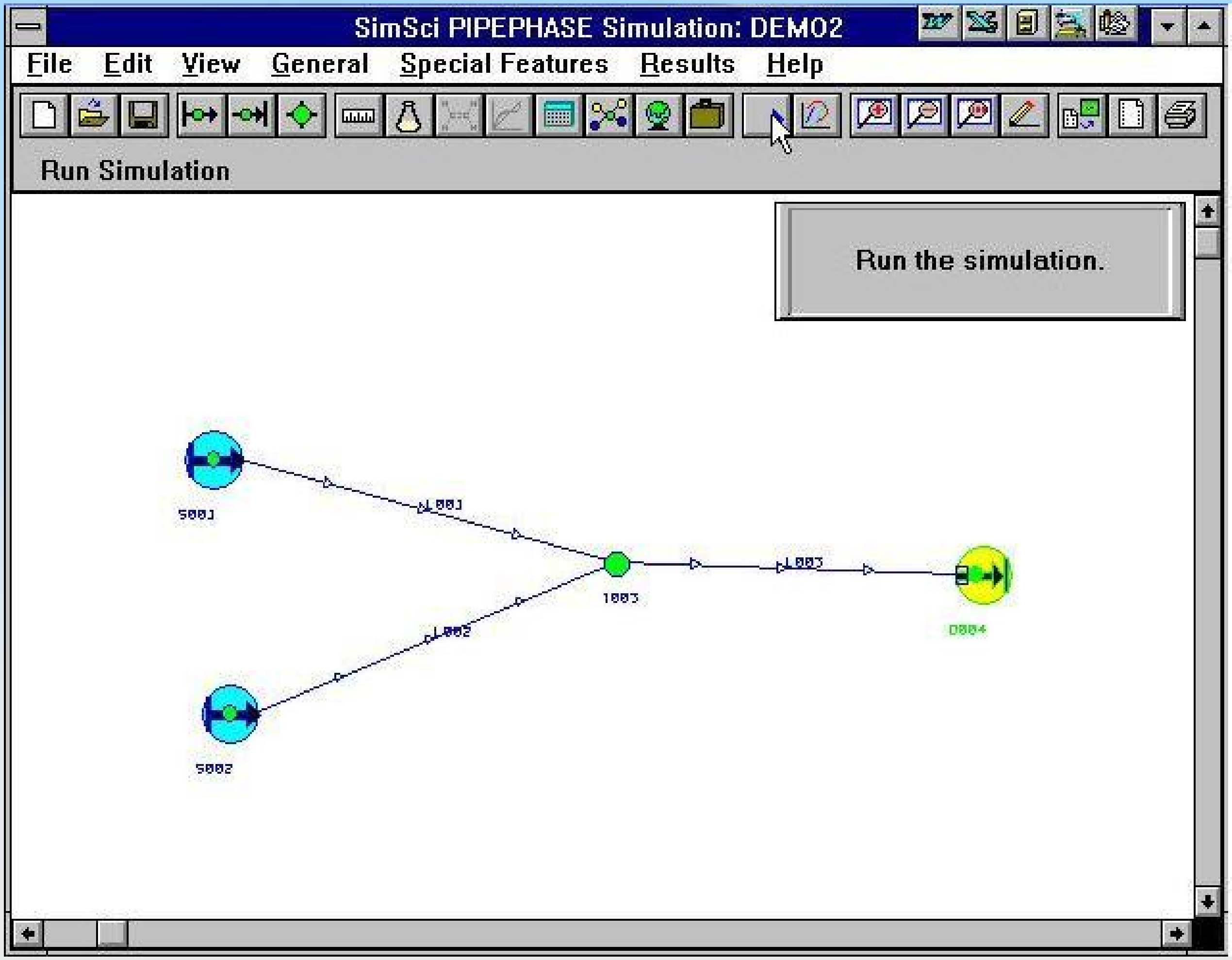


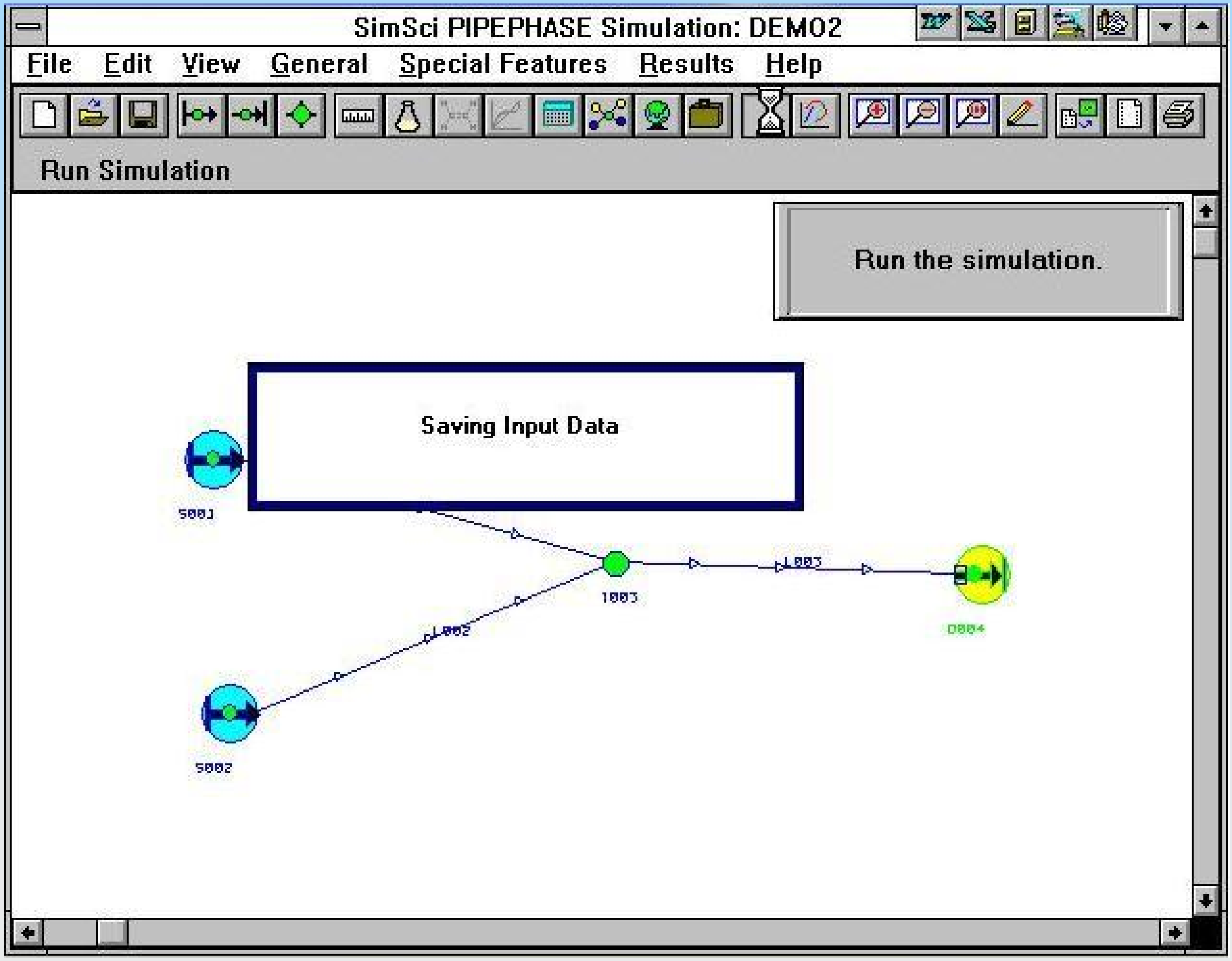
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
1096
Reservoir/Device Name
Reservoir Production Decline
Link Name
L002
Device Type
All Types
Device Name
E006
Parameter
Inside Diameter
OK
Cancel
Help
In this example, no change in surface facilities are planned; this could be simulated as well.

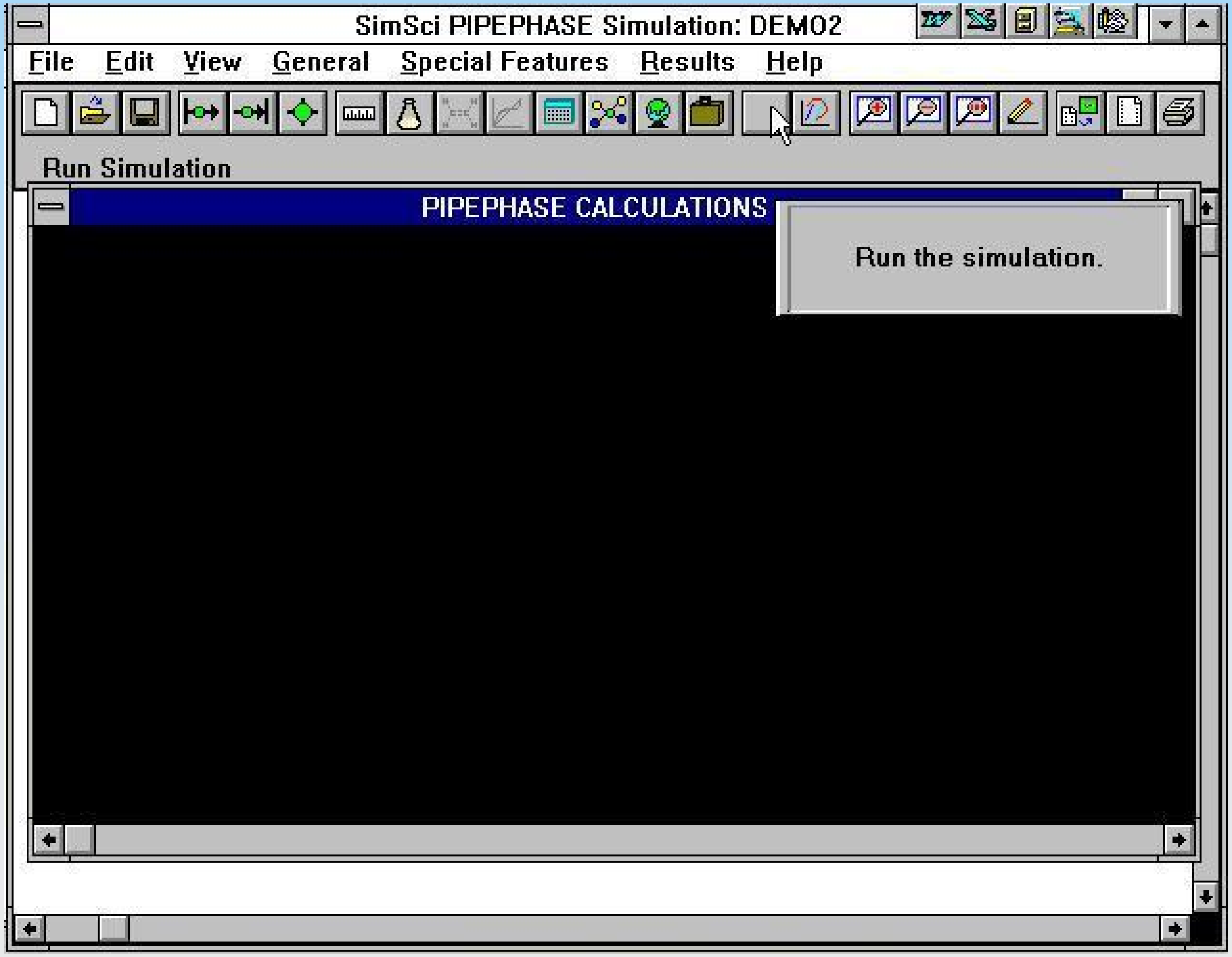

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Changes
Time (day)
Data
365
730
1096
Reservoir/Device Name
Reservoir Production Decline
Link Name
L002
Device Type
All Types
Device Name
E006
Parameter
Inside Diameter
OK
Cancel
Help

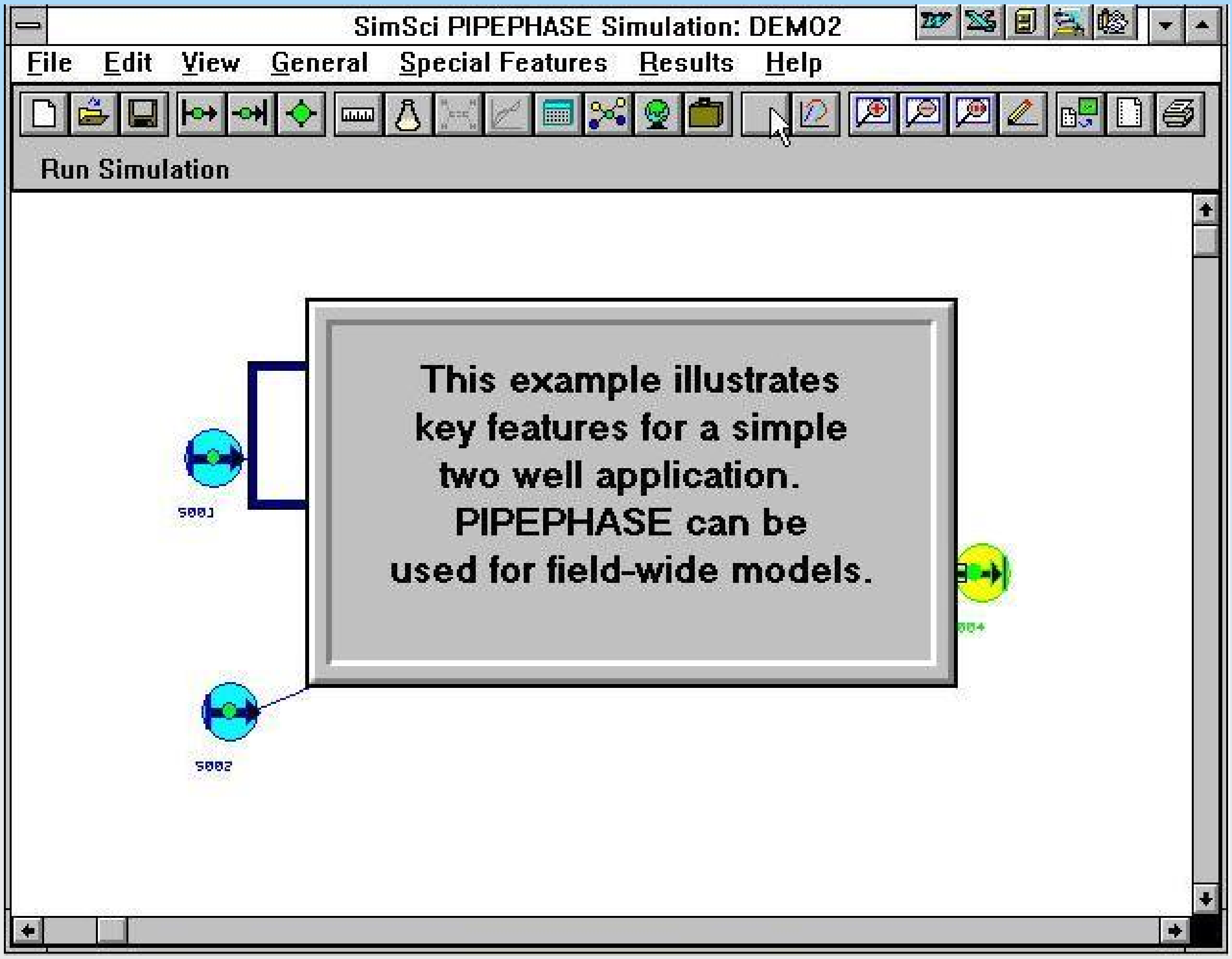


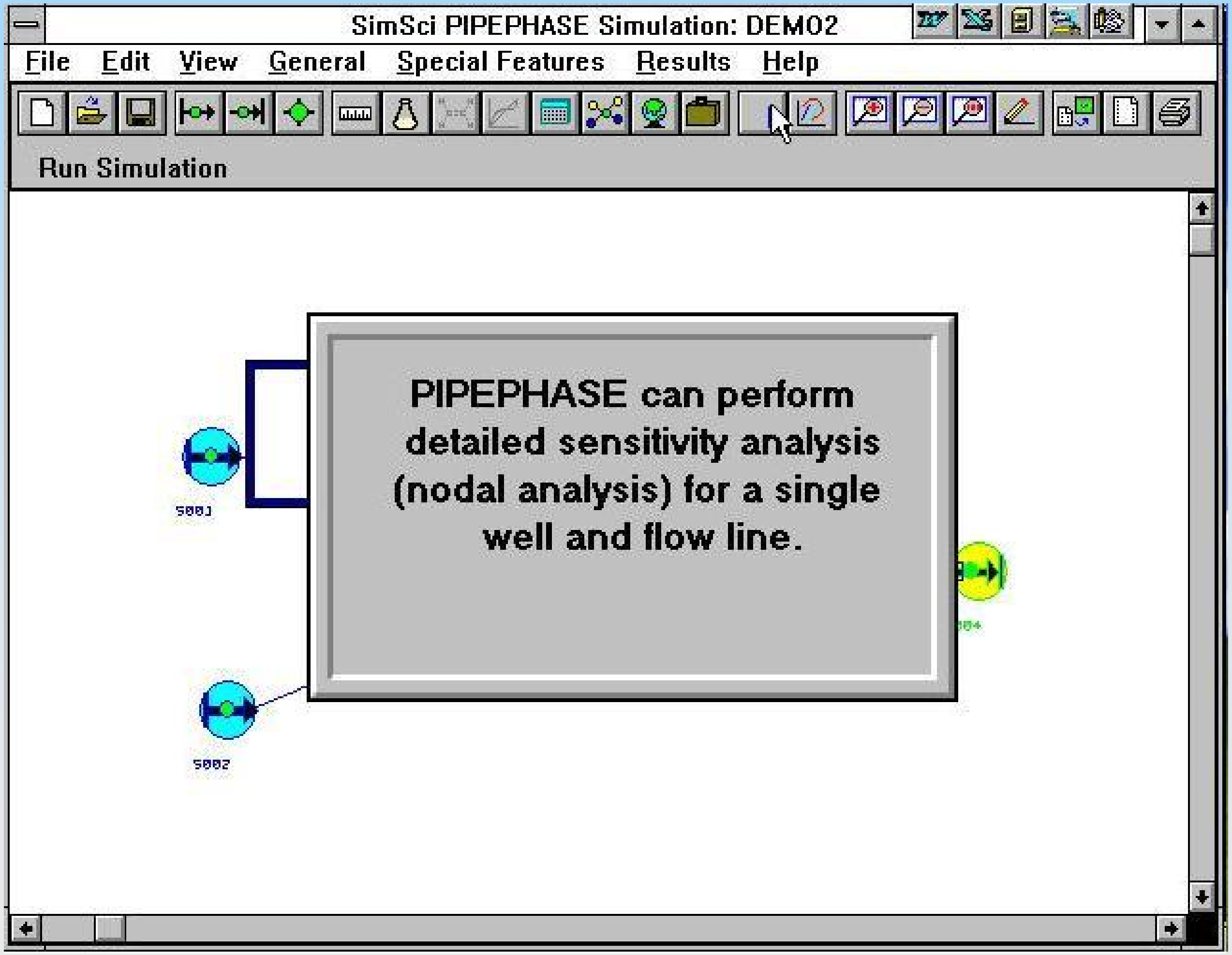
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Time Stepping
Perform Time Stepping Calculations
Time Stepping Description
Steps for Reservoir Production Decline
Add
Edit
Delete
Copy
OK
Cancel
Help

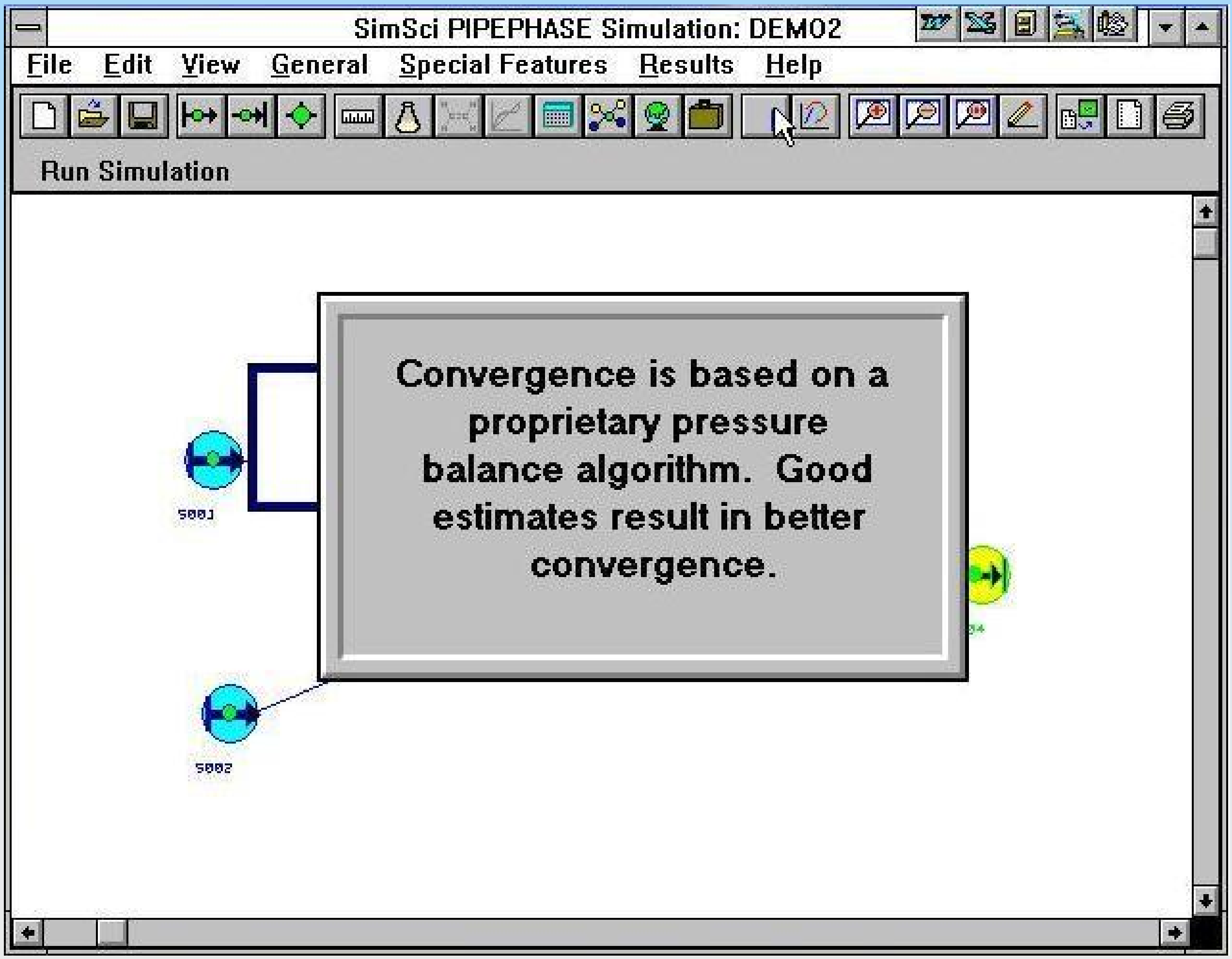

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
Run the simulation.
S001
L001
L002
L003
S002
J003
D004

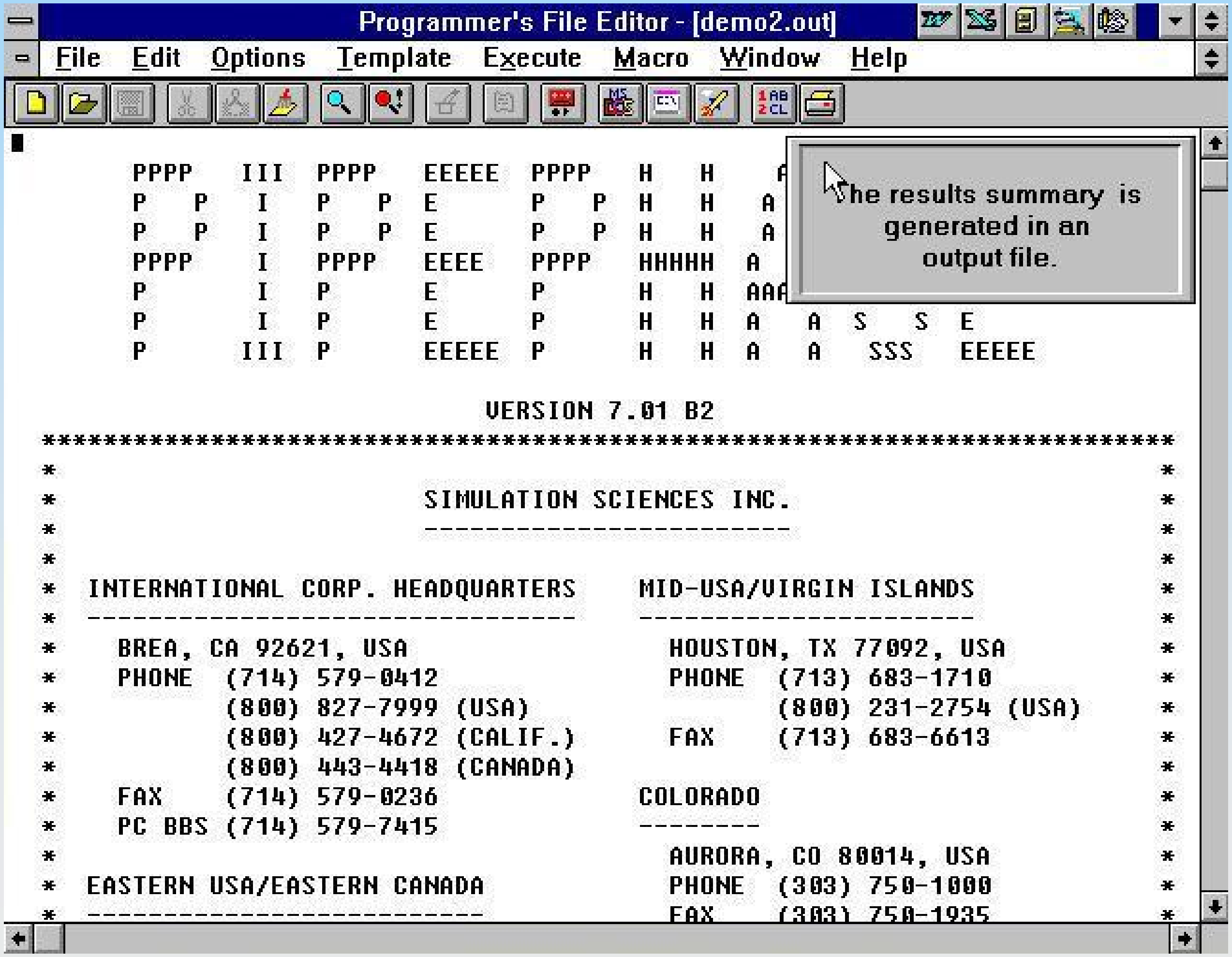

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
Run the simulation.
Saving Input Data
S001
S002
1003
L003
L002
D004


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
PIPEPHASE CALCULATIONS
Run the simulation.


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
This example illustrates key features for a simple two well application. PIPEPHASE can be used for field-wide models.


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
PIPEPHASE can perform detailed sensitivity analysis (nodal analysis) for a single well and flow line.
S001
S002


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Simulation
Convergence is based on a proprietary pressure balance algorithm. Good estimates result in better convergence.


Programmer's File Editor - [demo2.out]
File Edit Options Template Execute Macro Window Help
The results summary is generated in an output file.
VERSION 7.01 B2
SIMULATION SCIENCES INC.
INTERNATIONAL CORP. HEADQUARTERS
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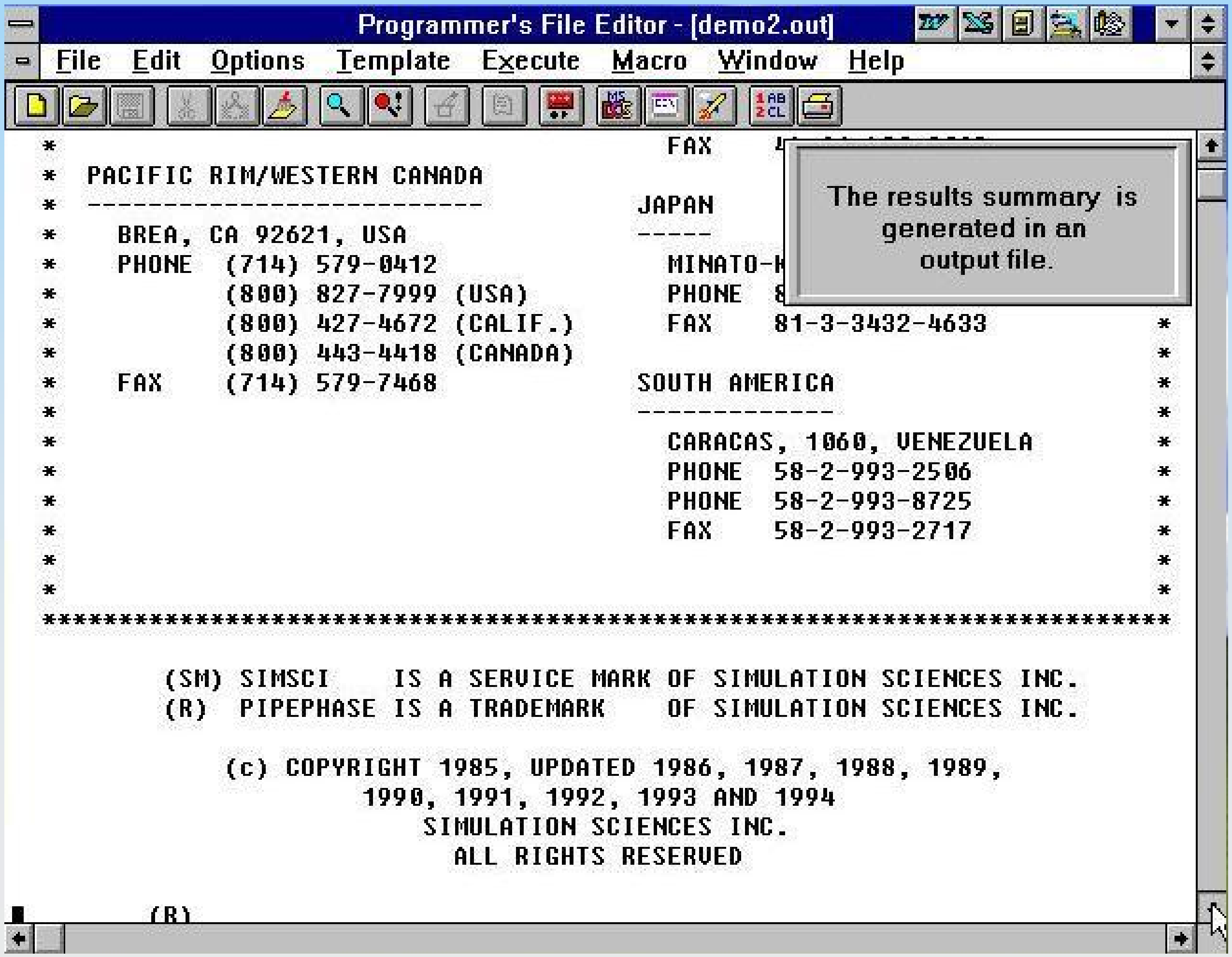
(800) 827-7999 (USA)
(800) 427-4672 (CALIF.)
(800) 443-4418 (CANADA)
FAX (714) 579-0236
PC BBS (714) 579-7415
EASTERN USA/EASTERN CANADA
MID-USA/VIRGIN ISLANDS
HOUSTON, TX 77092, USA
PHONE (713) 683-1710
(800) 231-2754 (USA)
FAX (713) 683-6613
COLORADO
AURORA, CO 80014, USA
PHONE (303) 750-1000
FAX (303) 750-1935


Programmer's File Editor - [demo2.out]
File Edit Options Template Execute Macro Window Help
FAX
PACIFIC RIM/WESTERN CANADA
BREA, CA 92621, USA
PHONE (714) 579-0412
(800) 827-7999 (USA)
(800) 427-4672 (CALIF.)
(800) 443-4418 (CANADA)
FAX (714) 579-7468
JAPAN
PHONE
FAX 81-3-3432-4633
SOUTH AMERICA
CARACAS, 1060, VENEZUELA
PHONE 58-2-993-2506
PHONE 58-2-993-8725
FAX 58-2-993-2717
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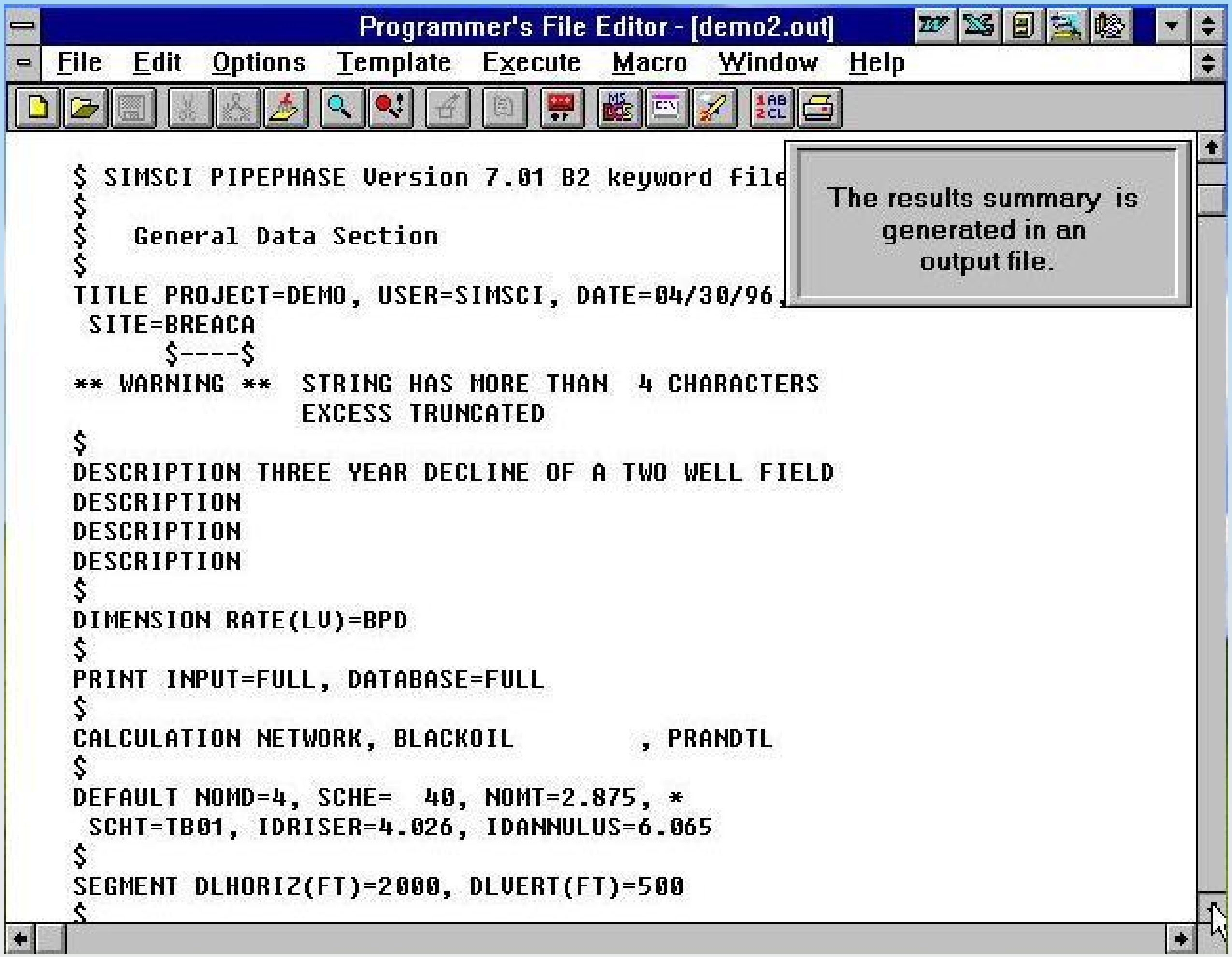
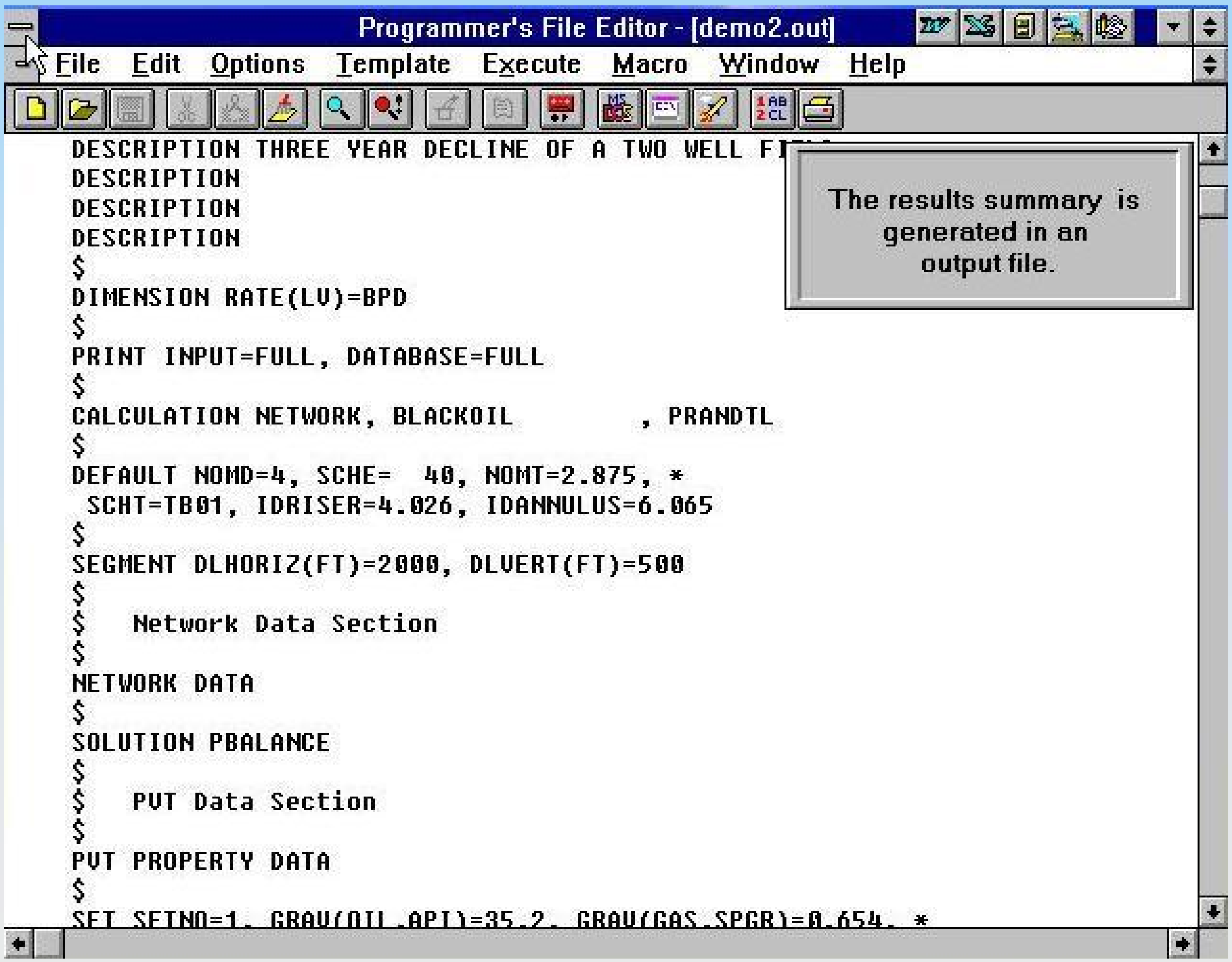
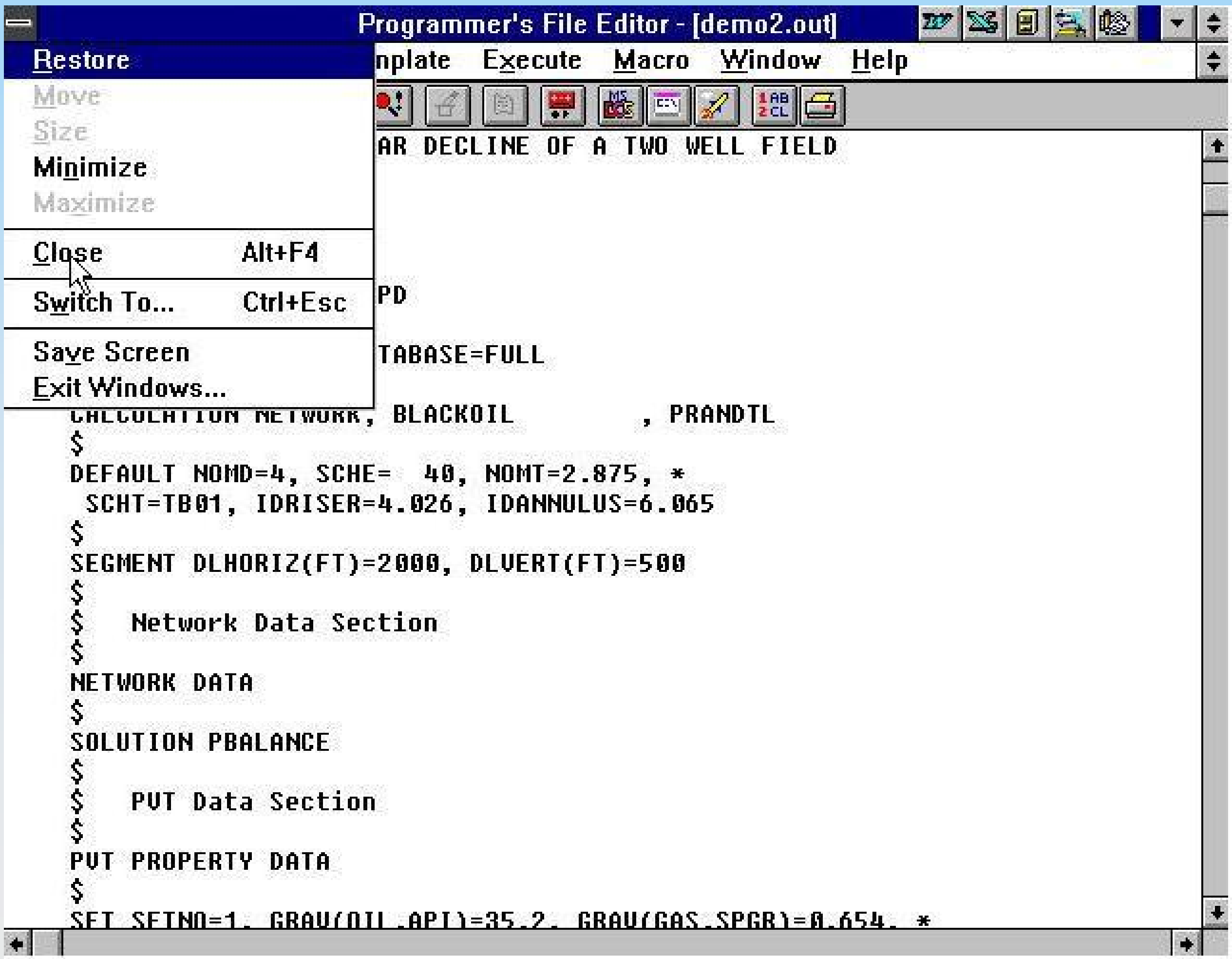
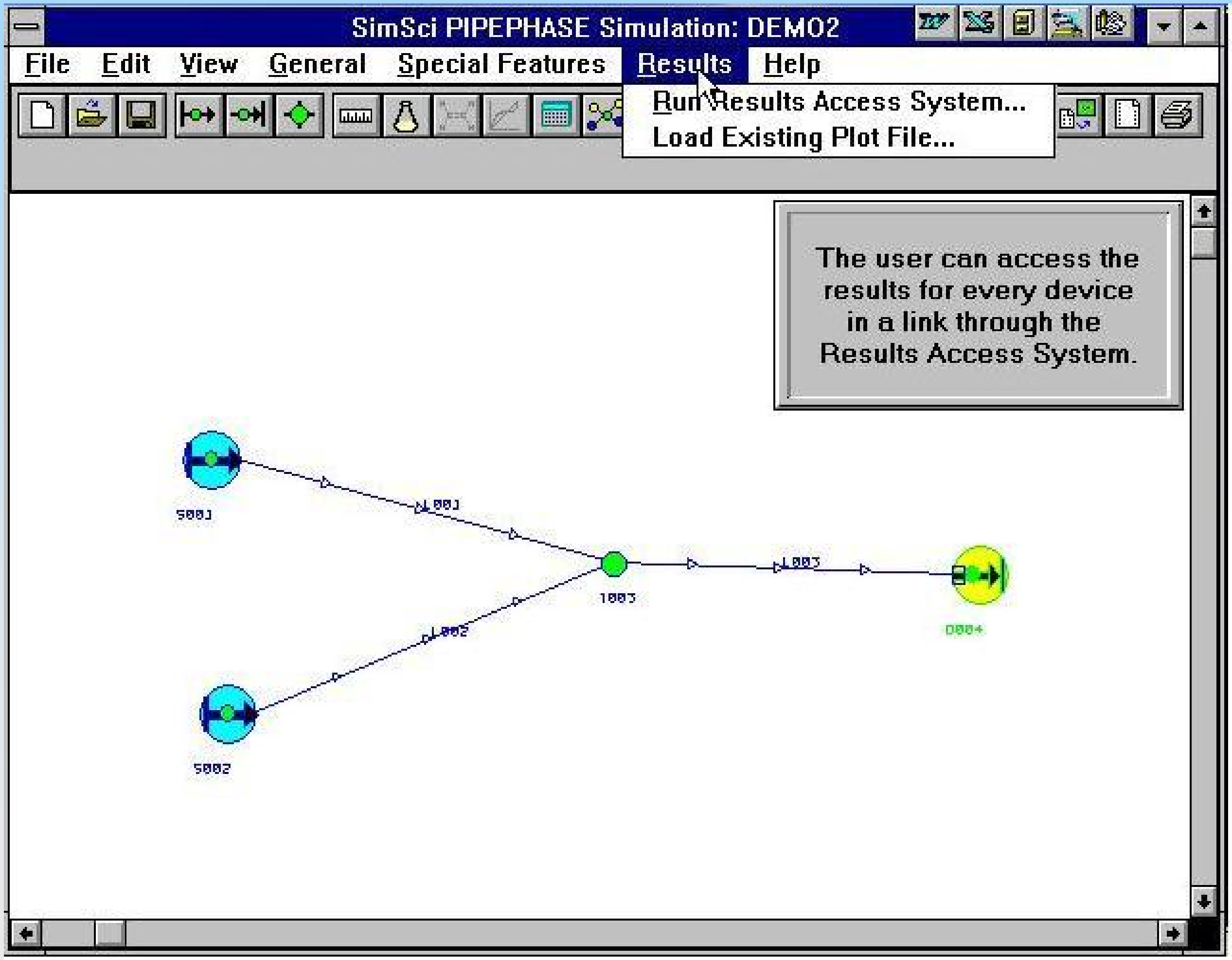
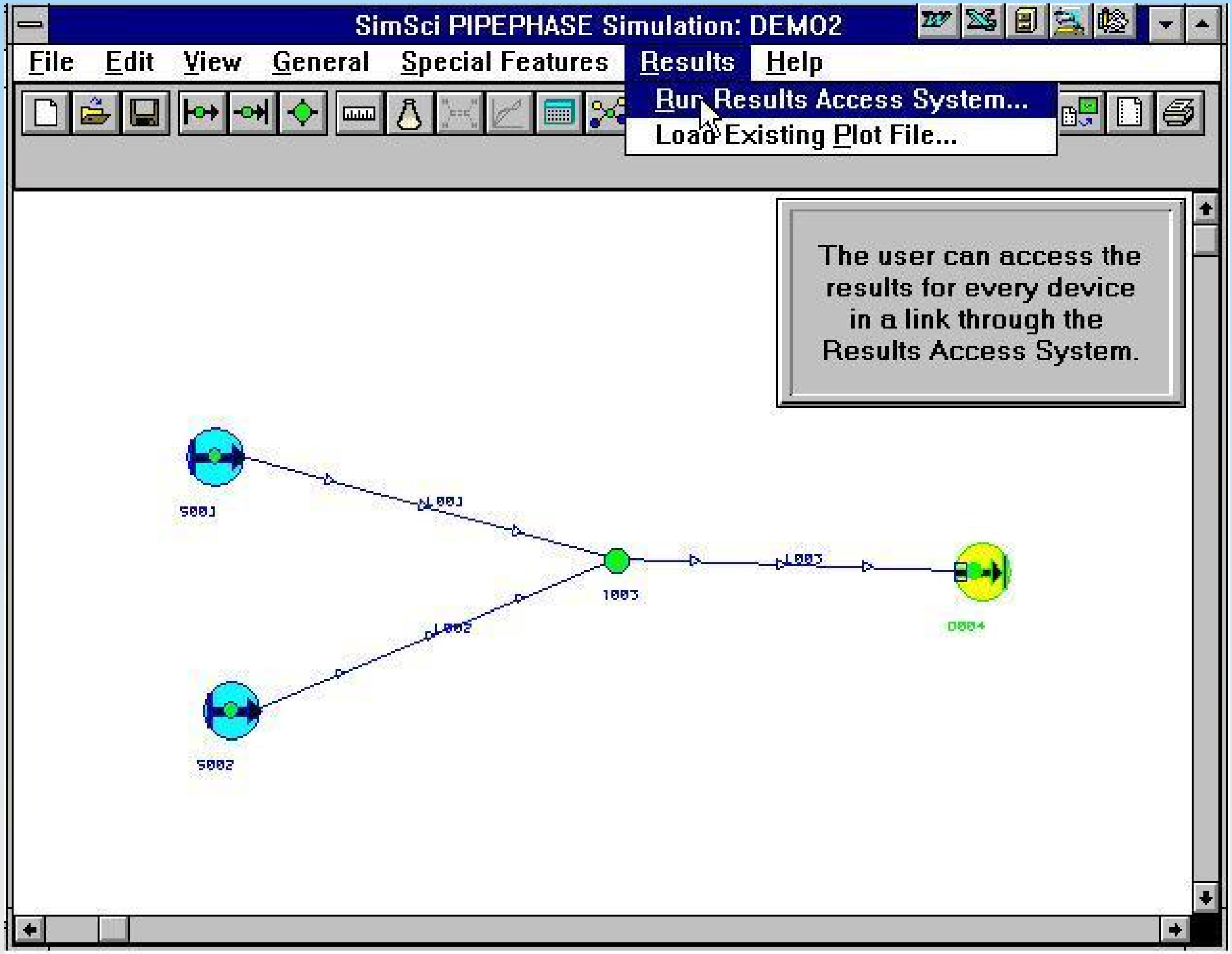
ALL RIGHTS RESERVED
The results summary is generated in an output file.

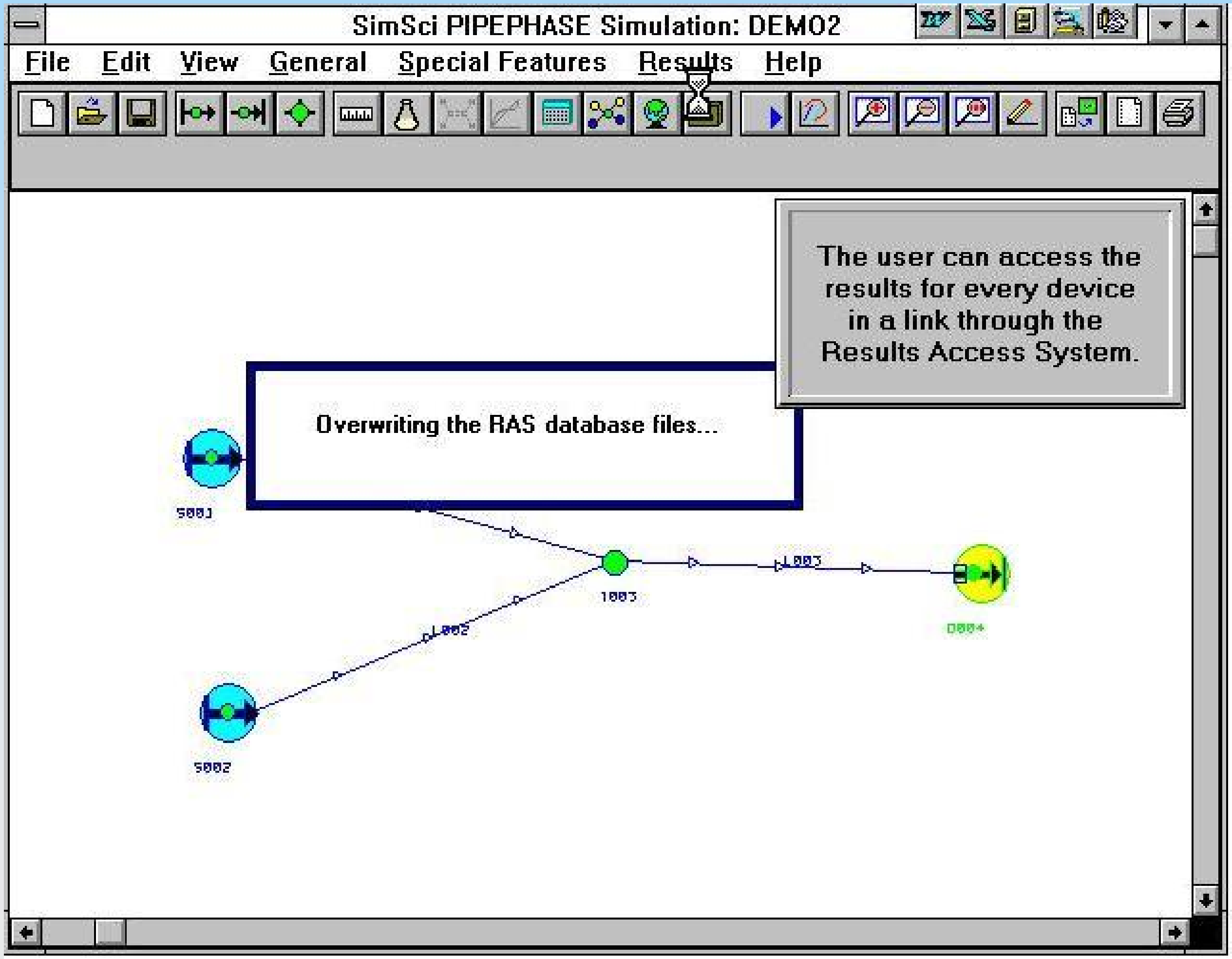

Programmer's File Editor - [demo2.out]
File Edit Options Template Execute Macro Window Help
$ SIMSCI PIPEPHASE Version 7.01 B2 keyword file
$
$ General Data Section
$
TITLE PROJECT=DEMO, USER=SIMSCI, DATE=04/30/96,
SITE=BREACA
$----$
** WARNING ** STRING HAS MORE THAN 4 CHARACTERS
EXCESS TRUNCATED
$
DESCRIPTION THREE YEAR DECLINE OF A TWO WELL FIELD
DESCRIPTION
DESCRIPTION
DESCRIPTION
$
DIMENSION RATE(LV)=BPD
$
PRINT INPUT=FULL, DATABASE=FULL
$
CALCULATION NETWORK, BLACKOIL , PRANDTL
$
DEFAULT NOMD=4, SCHE= 40, NOMT=2.875, *
SCHT=TB01, IDRISER=4.026, IDANNULUS=6.065
$
SEGMENT DLHORIZ(FT)=2000, DLVERT(FT)=500
$
The results summary is generated in an output file.

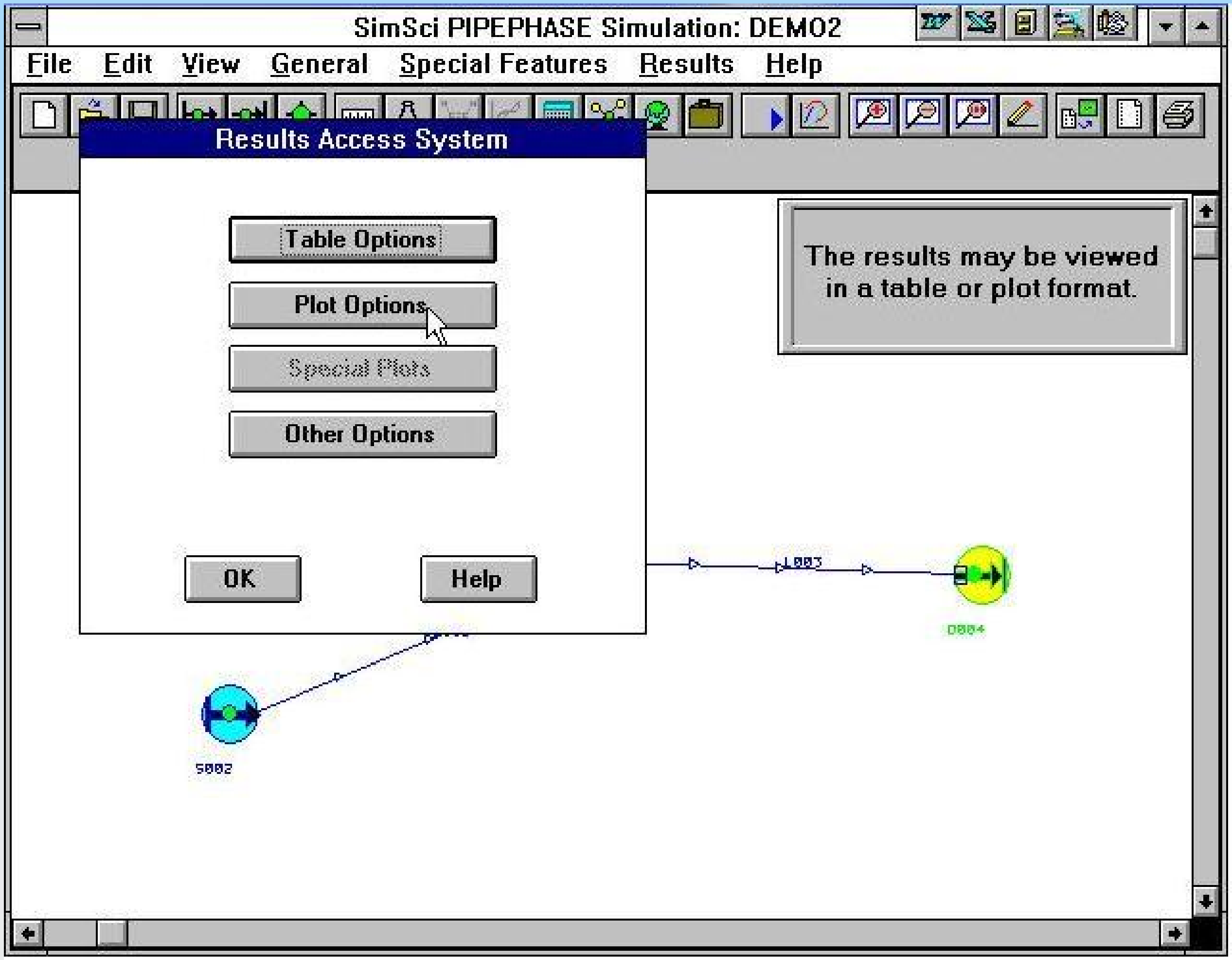

Programmer's File Editor - [demo2.out]
File Edit Options Template Execute Macro Window Help
DESCRIPTION THREE YEAR DECLINE OF A TWO WELL
DESCRIPTION
DESCRIPTION
DESCRIPTION
$
DIMENSION RATE(LV)=BPD
$
PRINT INPUT=FULL, DATABASE=FULL
$
CALCULATION NETWORK, BLACKOIL , PRANDTL
$
DEFAULT NOMD=4, SCHE= 40, NOMT=2.875, *
SCHT=TB01, IDRISER=4.026, IDANNULUS=6.065
$
SEGMENT DLHORIZ(FT)=2000, DLVERT(FT)=500
$
$ Network Data Section
$
NETWORK DATA
$
SOLUTION PBALANCE
$
$ PVT Data Section
$
PVT PROPERTY DATA
$
SET SETNO=1, GRAV(OIL,API)=35.2, GRAV(GAS,SPGR)=0.654, *
The results summary is generated in an output file.

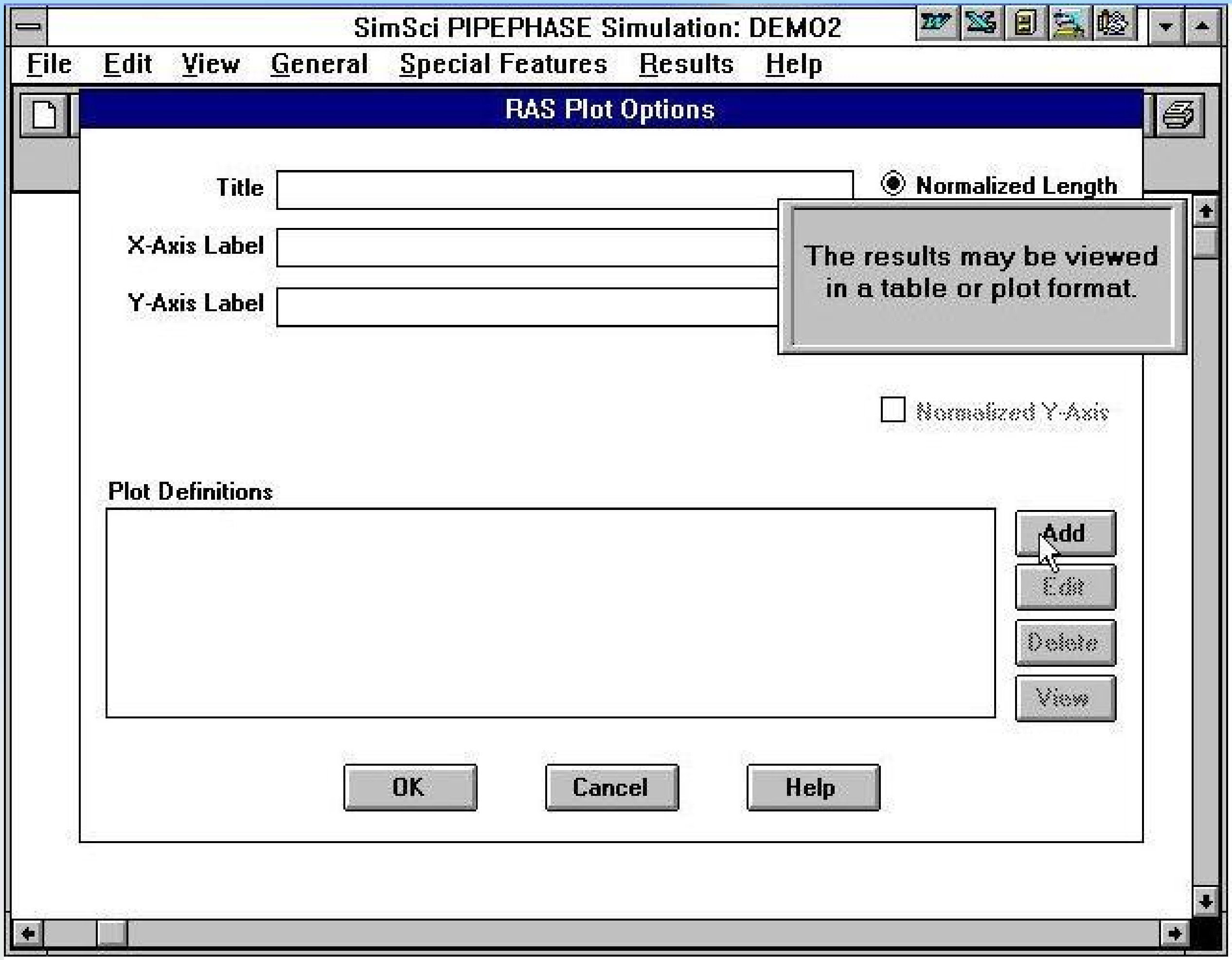

Programmer's File Editor - [demo2.out]
Restore
Move
Size
Minimize
Maximize
Close Alt+F4
Switch To... Ctrl+Esc
Save Screen
Exit Windows...
nplate Execute Macro Window Help
AR DECLINE OF A TWO WELL FIELD
PD
TABASE=FULL
, BLACKOIL , PRANDTL
$
DEFAULT NOMD=4, SCHE= 40, NOMT=2.875, *
SCHT=TB01, IDRISER=4.026, IDANNULUS=6.065
$
SEGMENT DLHORIZ(FT)=2000, DLVERT(FT)=500
$
$ Network Data Section
$
NETWORK DATA
$
SOLUTION PBALANCE
$
$ PVT Data Section
$
PVT PROPERTY DATA
$

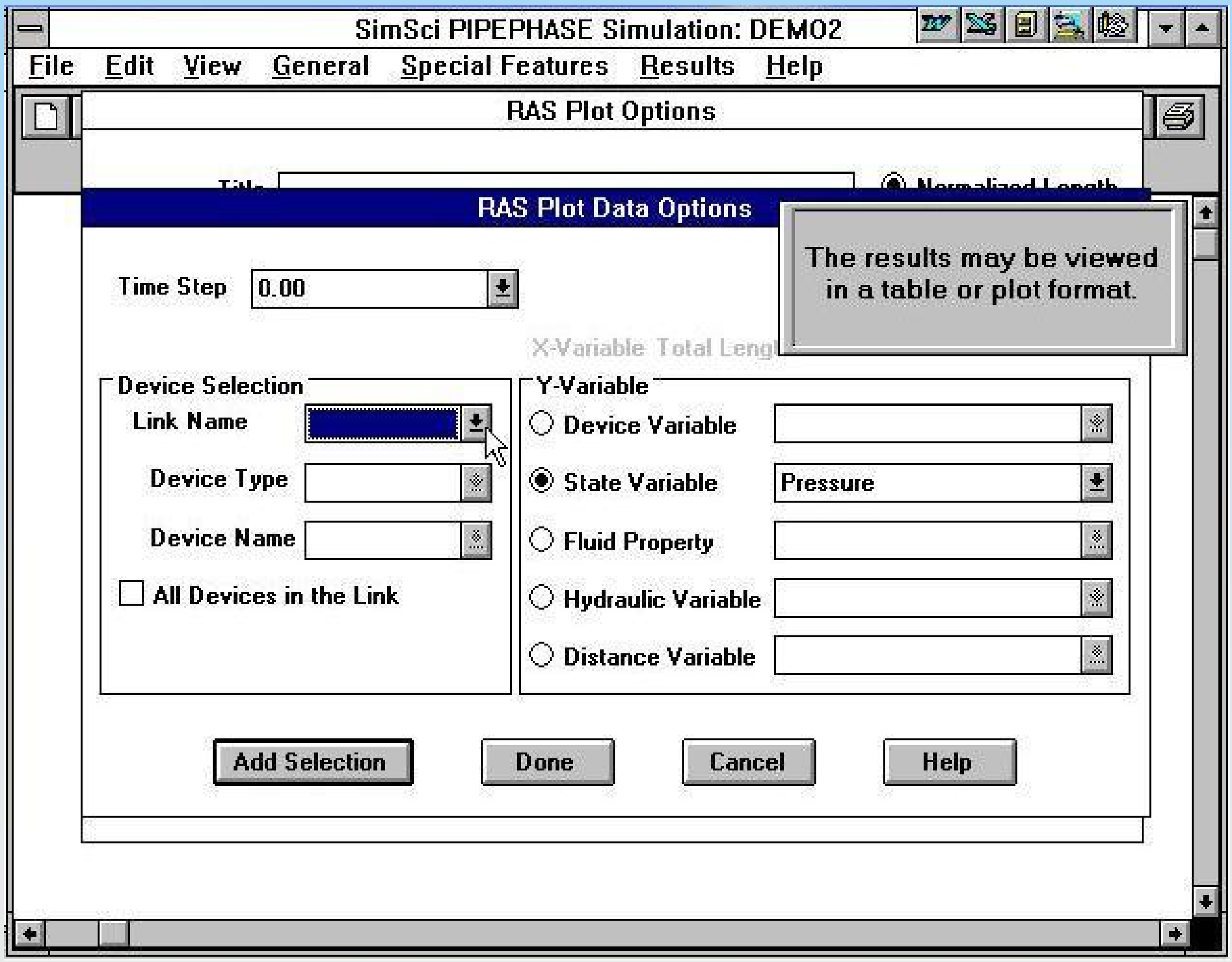

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Run Results Access System...
Load Existing Plot File...
The user can access the results for every device in a link through the Results Access System.
S001
L001
1003
L003
D004
L002
S002


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Run Results Access System...
Load Existing Plot File...
The user can access the results for every device in a link through the Results Access System.

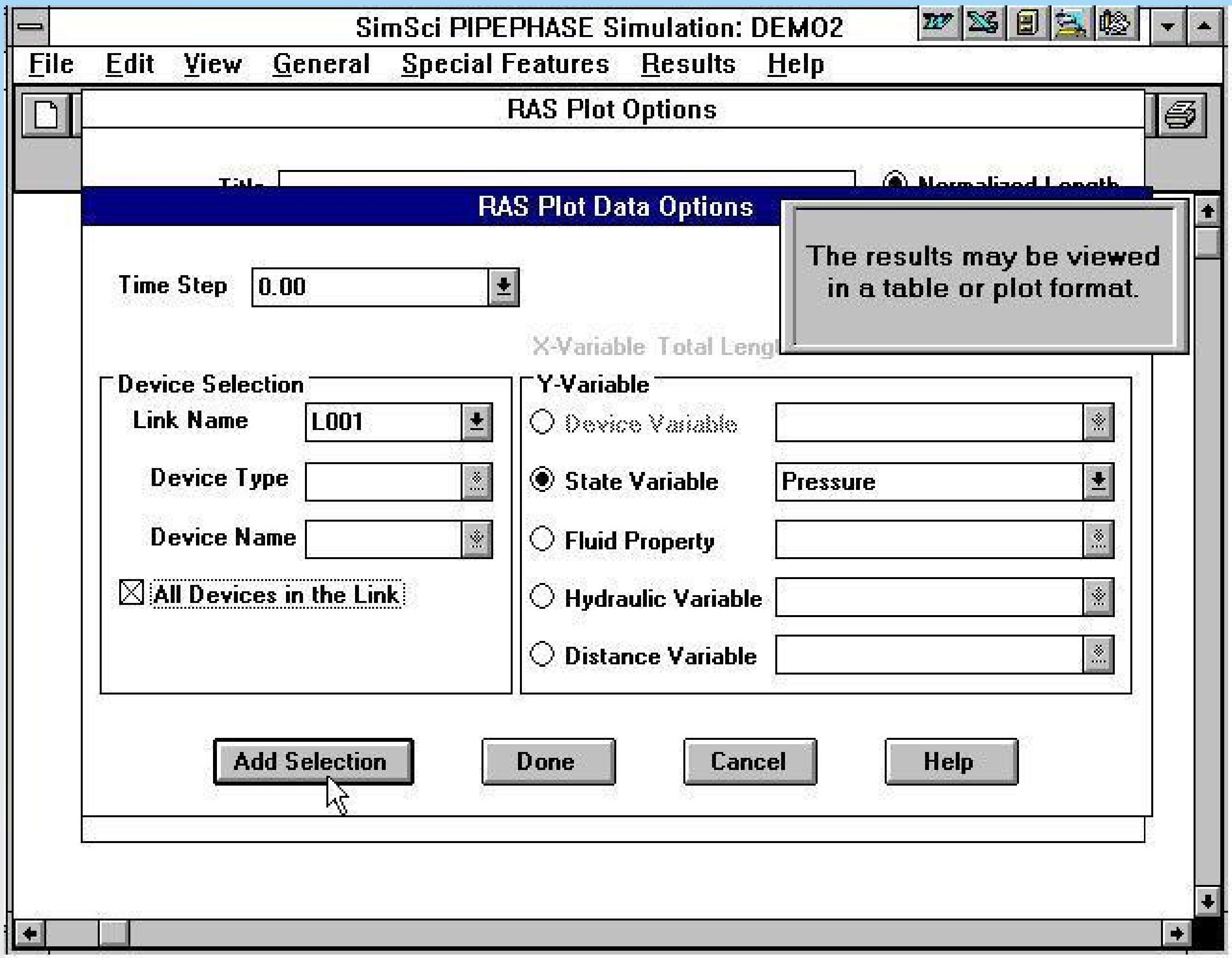

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
The user can access the results for every device in a link through the Results Access System.
Overwriting the RAS database files...

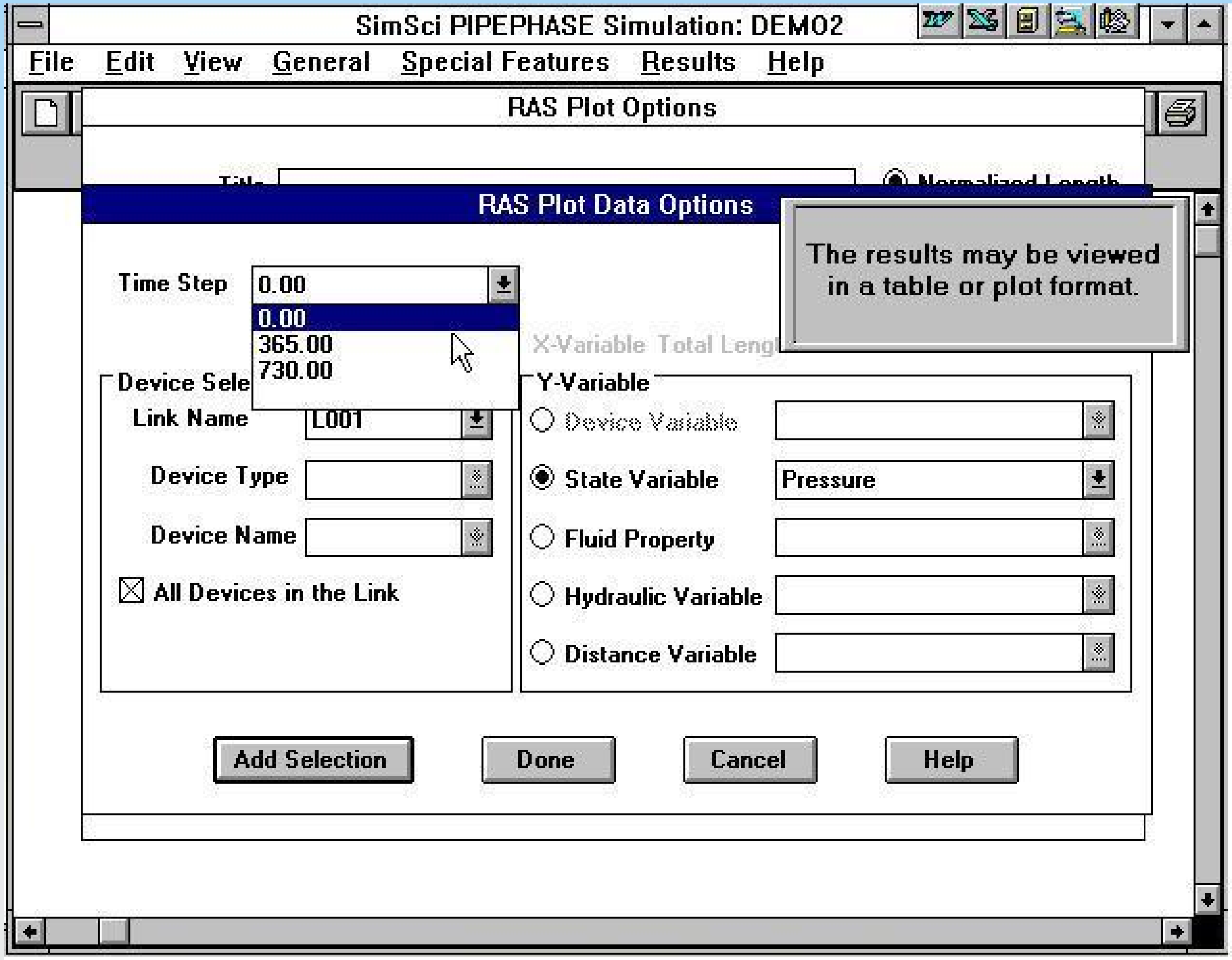

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Results Access System
Table Options
Plot Options
Special Plots
Other Options
OK
Help
The results may be viewed in a table or plot format.
L003
D004
S002

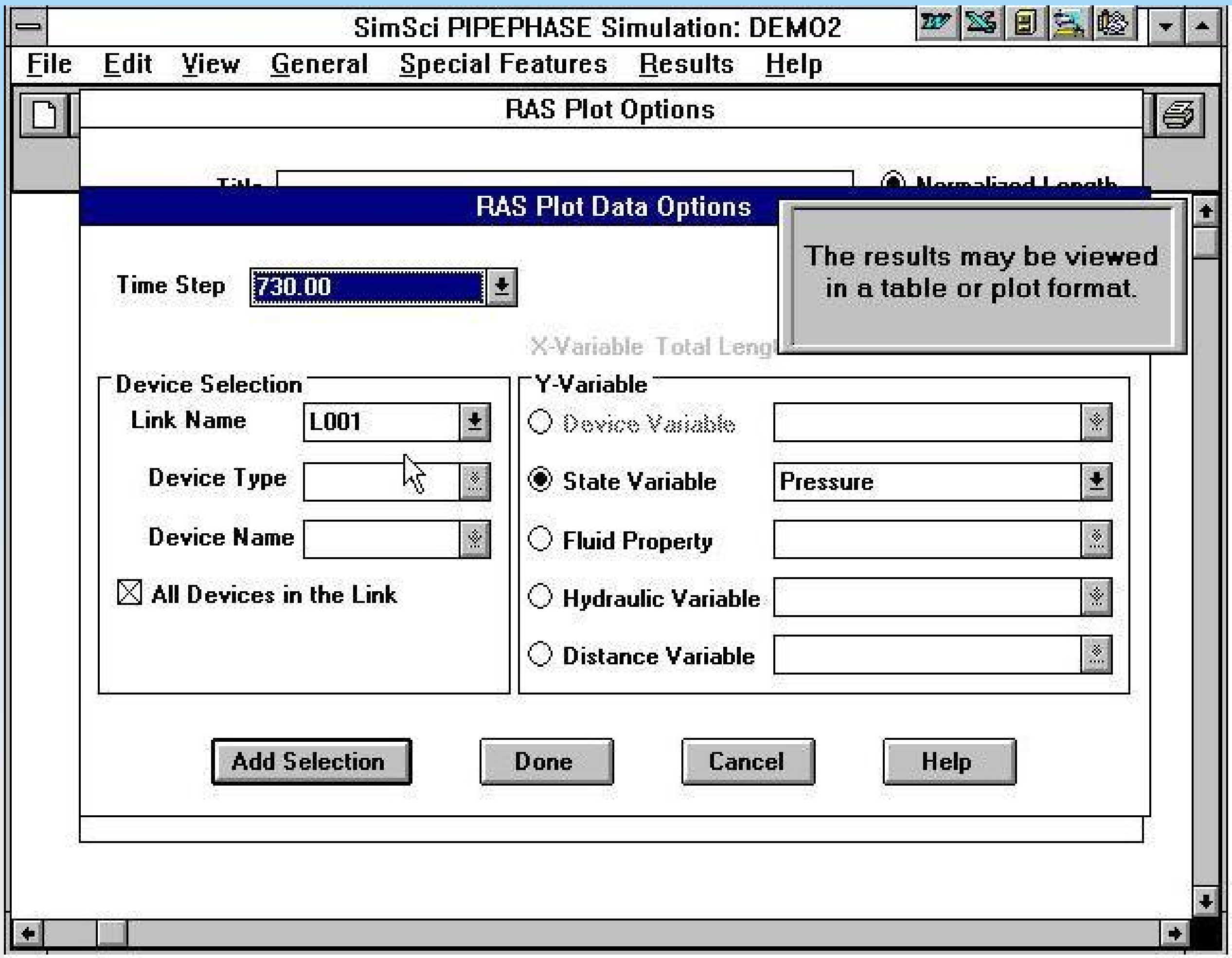

SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
RAS Plot Options
Title
X-Axis Label
Y-Axis Label
Normalized Length
The results may be viewed in a table or plot format.
Normalized Y-Axis
Plot Definitions
Add
Edit
Delete
View
OK
Cancel
Help

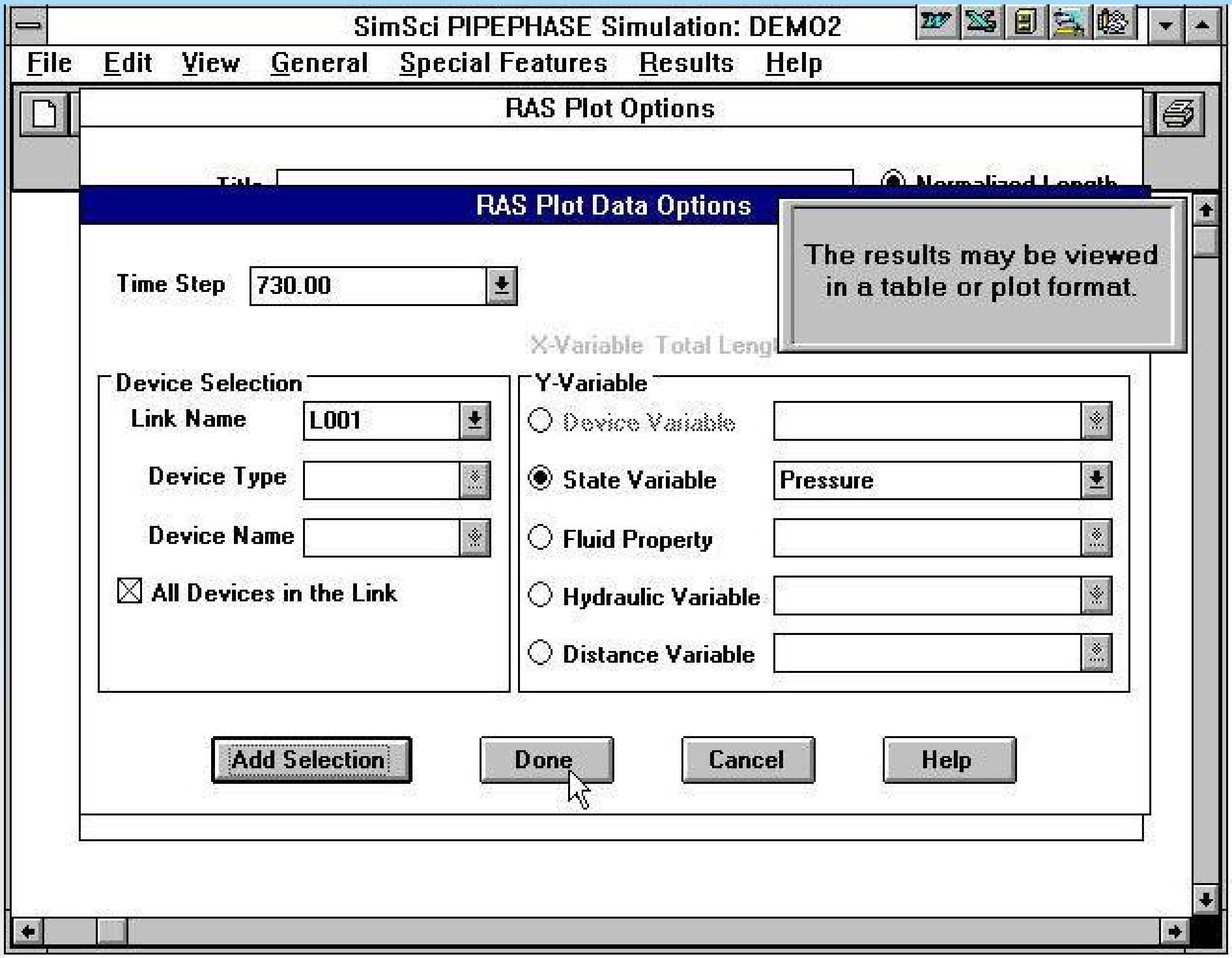


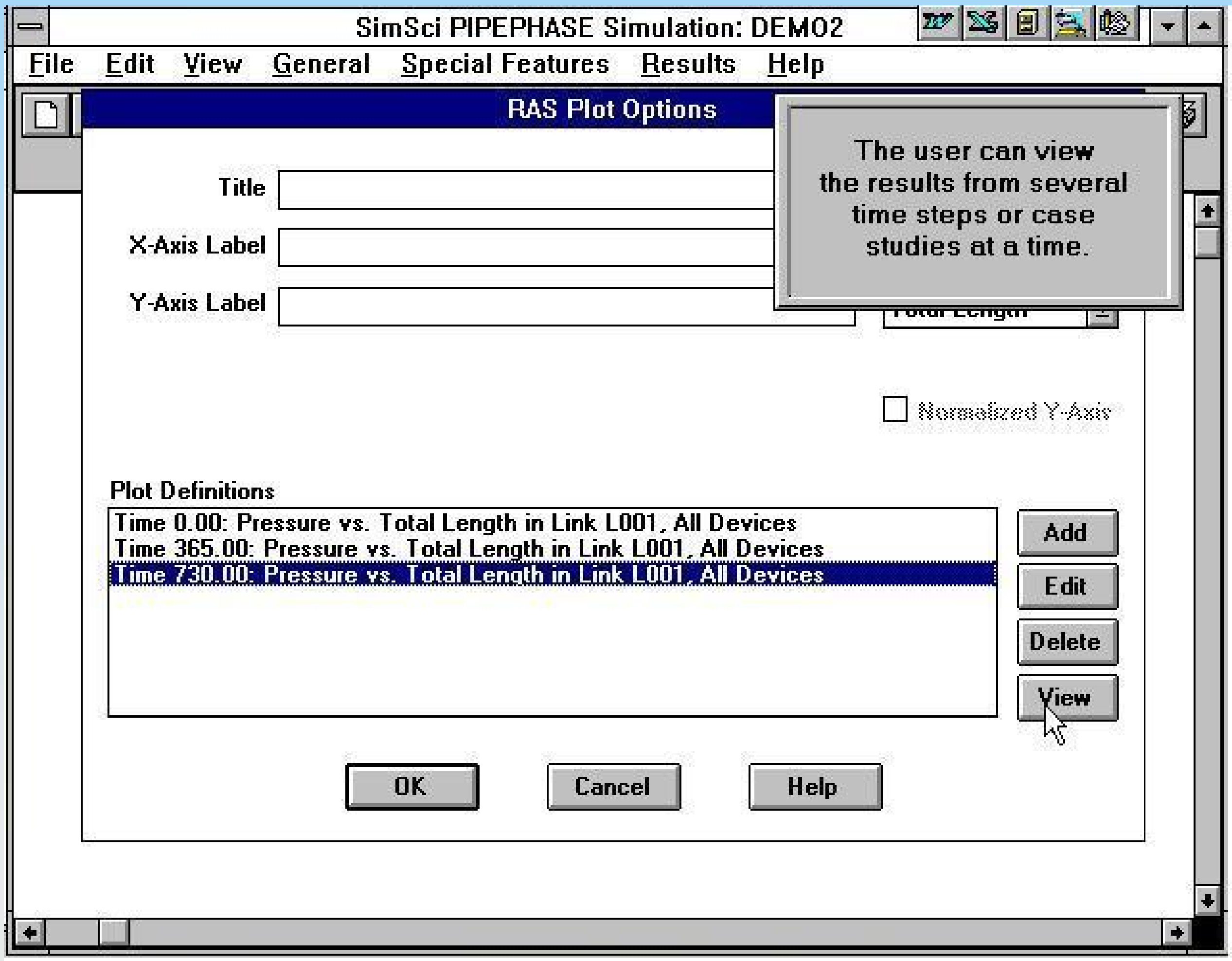
SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
RAS Plot Data Options
The results may be viewed in a table or plot format.
Time Step 0.00
Device Selection
Link Name
Device Type
Device Name
All Devices in the Link
Y-Variable
Device Variable
State Variable Pressure
Fluid Property
Hydraulic Variable
Distance Variable
Add Selection
Done
Cancel
Help

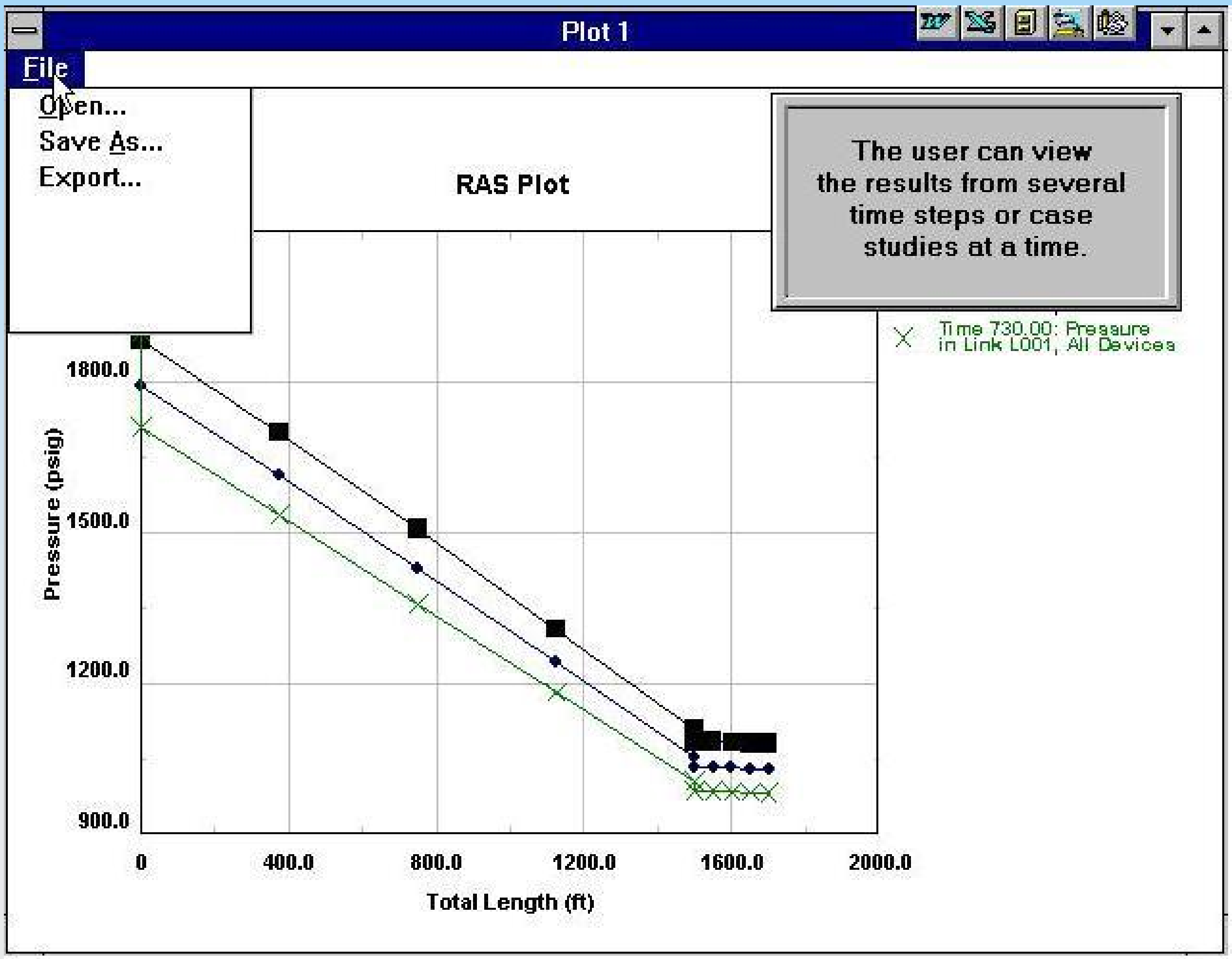

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
RAS Plot Data Options
The results may be viewed in a table or plot format.
Time Step 0.00
X-Variable Total Lengt
Device Selection
Link Name L001
Device Type
Device Name
All Devices in the Link
Y-Variable
Device Variable
State Variable Pressure
Fluid Property
Hydraulic Variable
Distance Variable
Add Selection
Done
Cancel
Help


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
RAS Plot Data Options
The results may be viewed in a table or plot format.
Time Step
0.00
0.00
365.00
730.00
X-Variable Total Lengt
Device Sele
Link Name
L001
Device Type
Device Name
All Devices in the Link
Y-Variable
Device Variable
State Variable
Pressure
Fluid Property
Hydraulic Variable
Distance Variable
Add Selection
Done
Cancel
Help

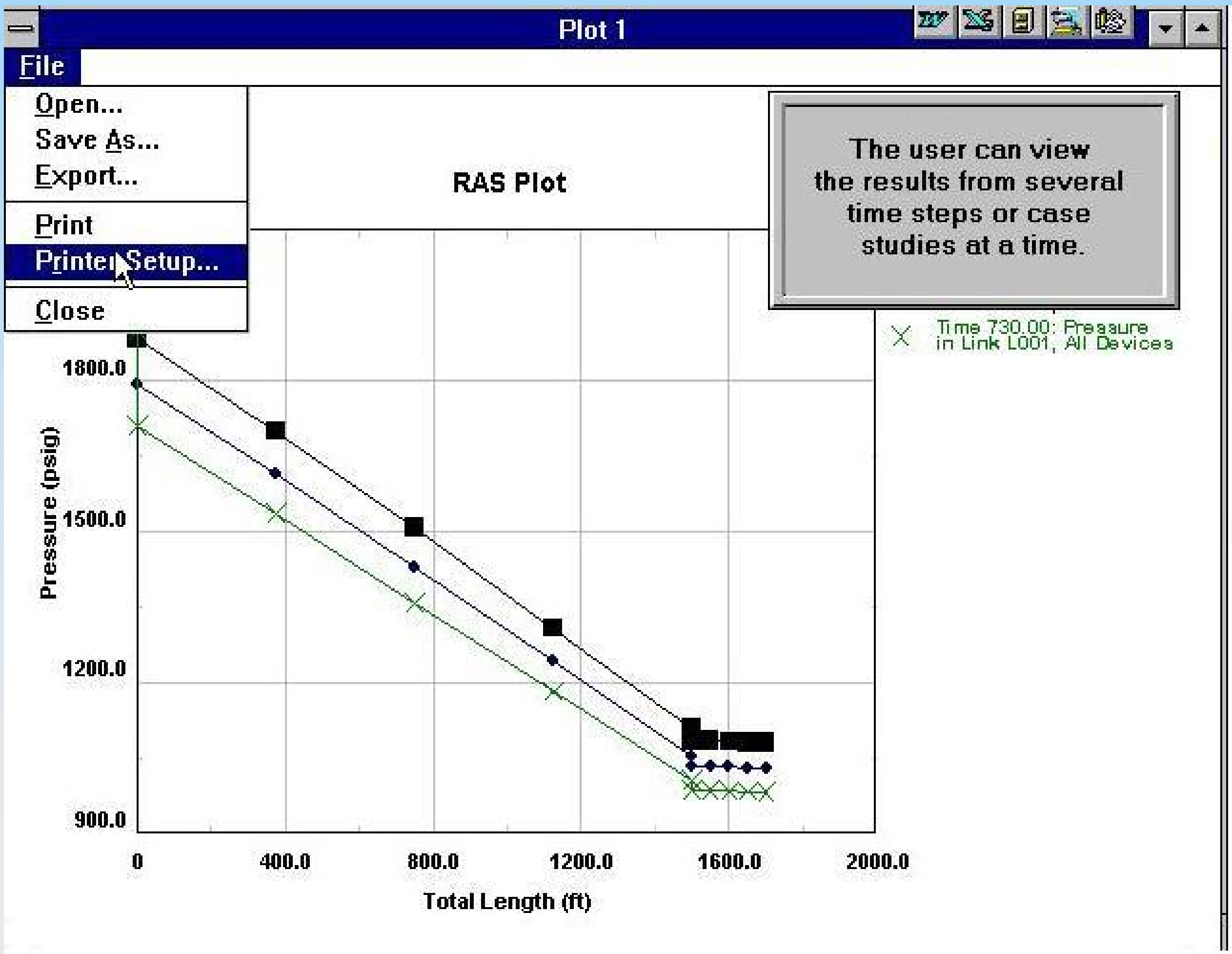

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
RAS Plot Data Options
The results may be viewed in a table or plot format.
Time Step
730.00
X-Variable Total Leng
Device Selection
Link Name
L001
Device Type
Device Name
All Devices in the Link
Y-Variable
Device Variable
State Variable
Pressure
Fluid Property
Hydraulic Variable
Distance Variable
Add Selection
Done
Cancel
Help

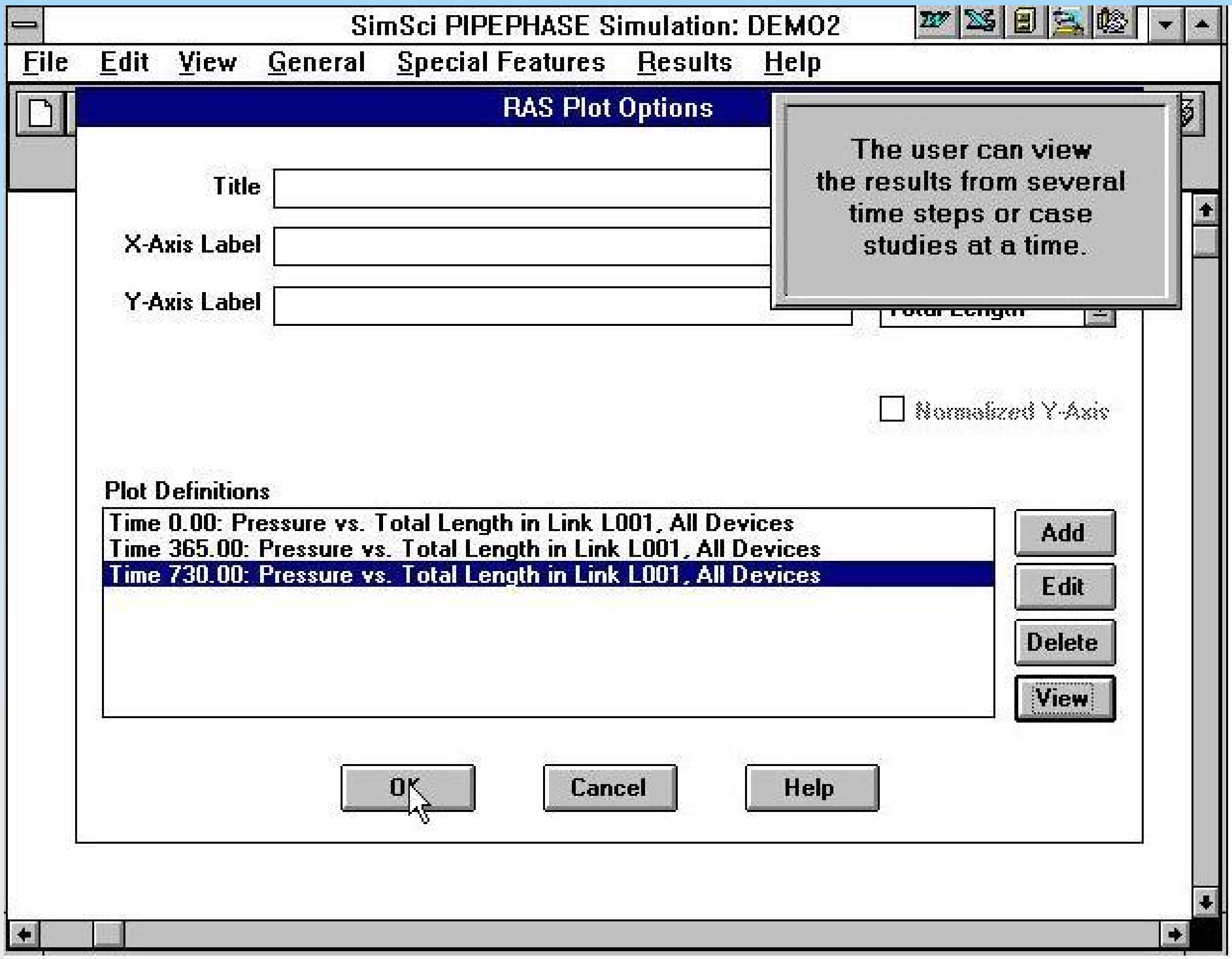

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
RAS Plot Data Options
Time Step 730.00
The results may be viewed in a table or plot format.
X-Variable Total Lengt
Device Selection
Link Name L001
Device Type
Device Name
All Devices in the Link
Y-Variable
Device Variable
State Variable Pressure
Fluid Property
Hydraulic Variable
Distance Variable
Add Selection
Done
Cancel
Help

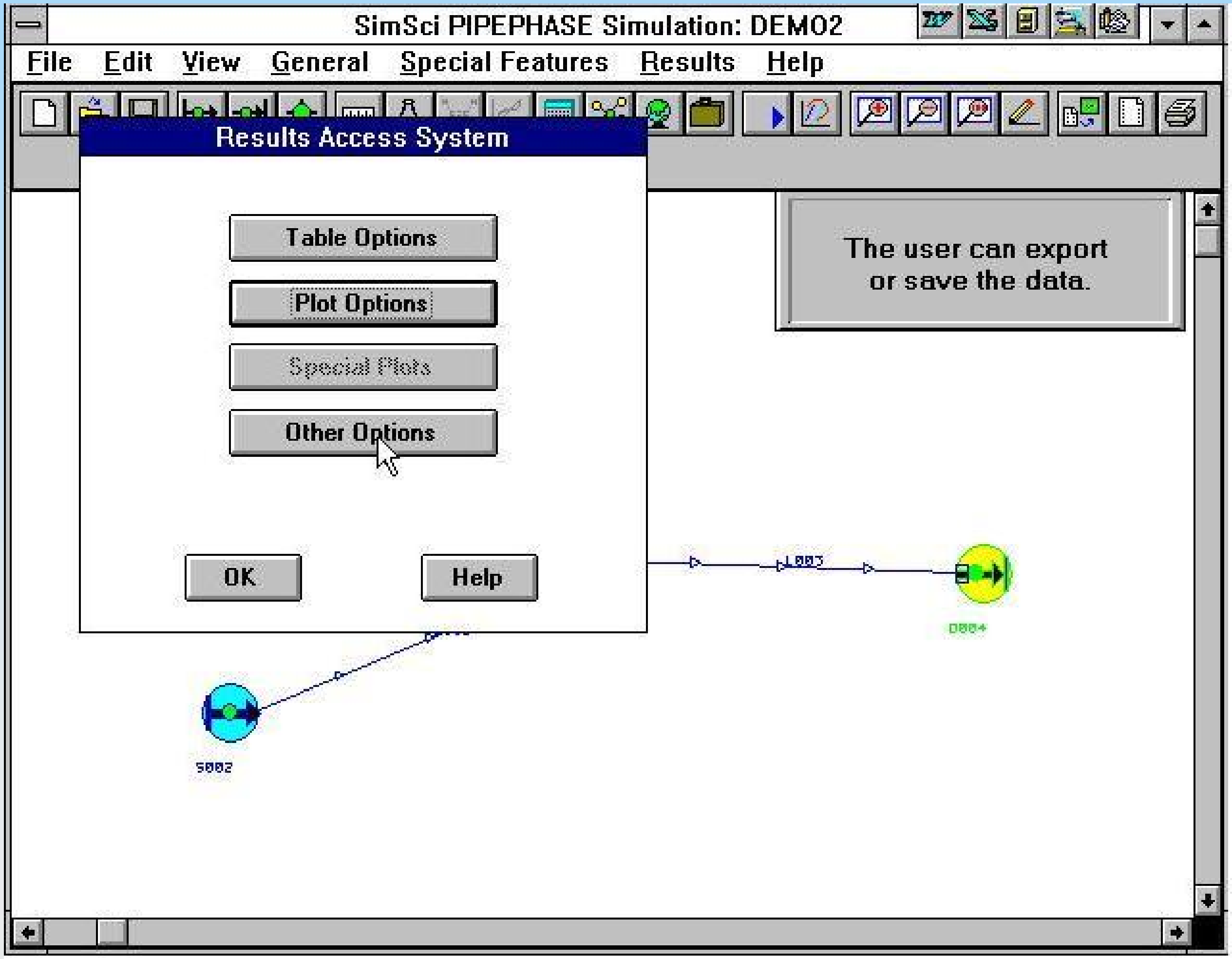

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
Title
X-Axis Label
Y-Axis Label
The user can view the results from several time steps or case studies at a time.
Normalized Y-Axis
Plot Definitions
Time 0.00: Pressure vs. Total Length in Link L001, All Devices
Time 365.00: Pressure vs. Total Length in Link L001, All Devices
Time 730.00: Pressure vs. Total Length in Link L001, All Devices
Add
Edit
Delete
View
OK
Cancel
Help

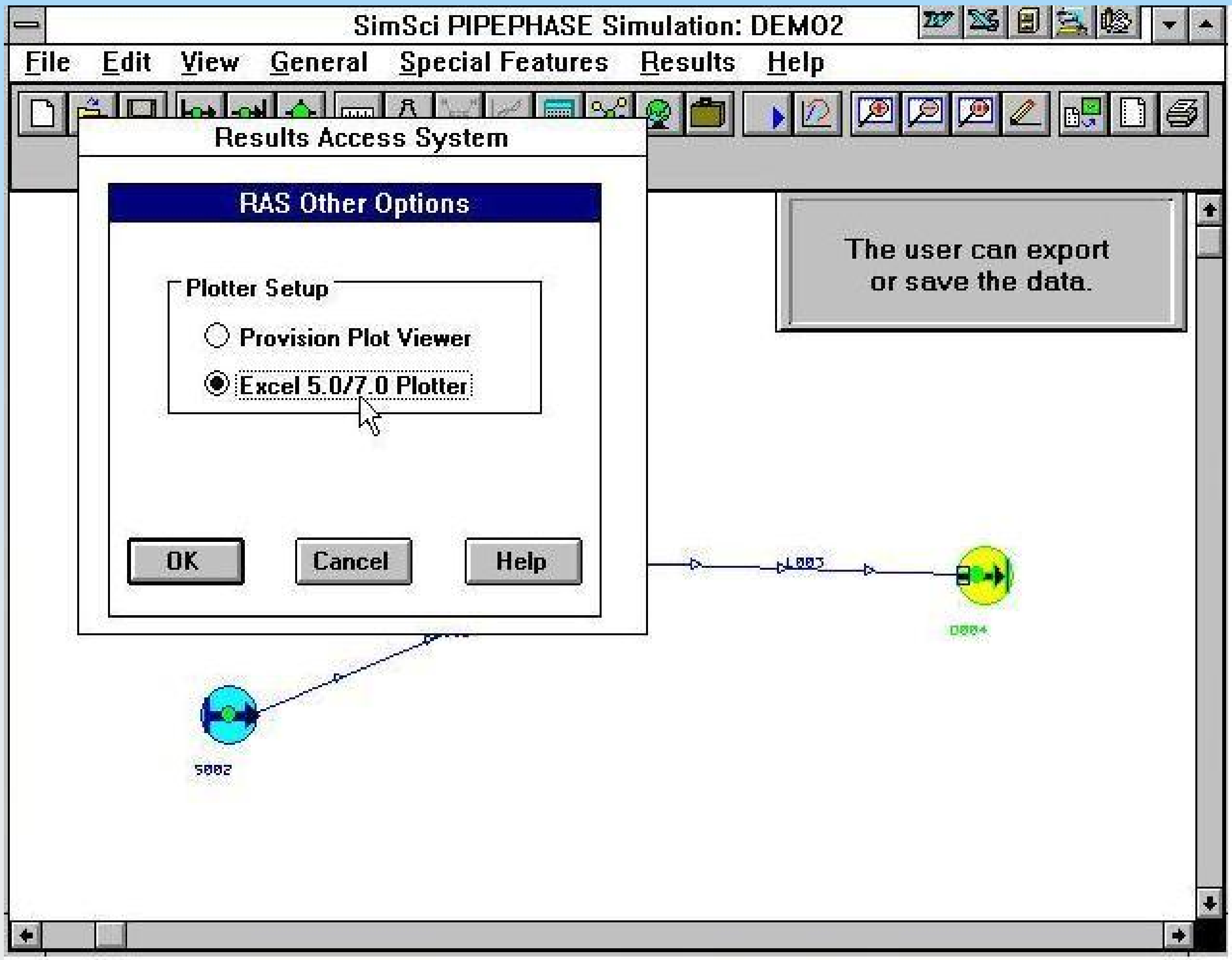


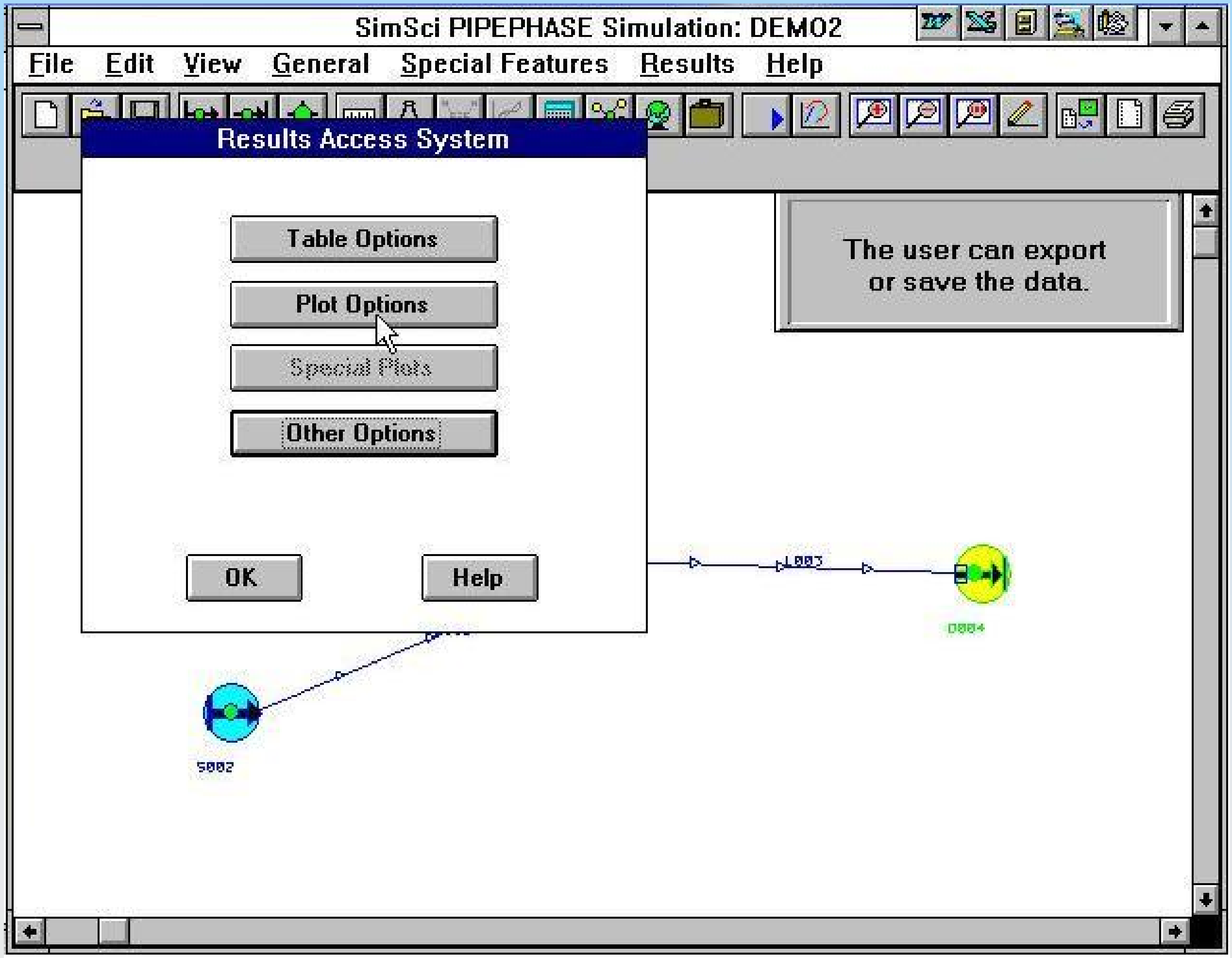
Plot 1
File
Open...
Save As...
Export...
RAS Plot
The user can view the results from several time steps or case studies at a time.
Time 730.00: Pressure in Link L001, All Devices
Pressure (psig)
1800.0
1500.0
1200.0
900.0
0
400.0
800.0
1200.0
1600.0
2000.0
Total Length (ft)

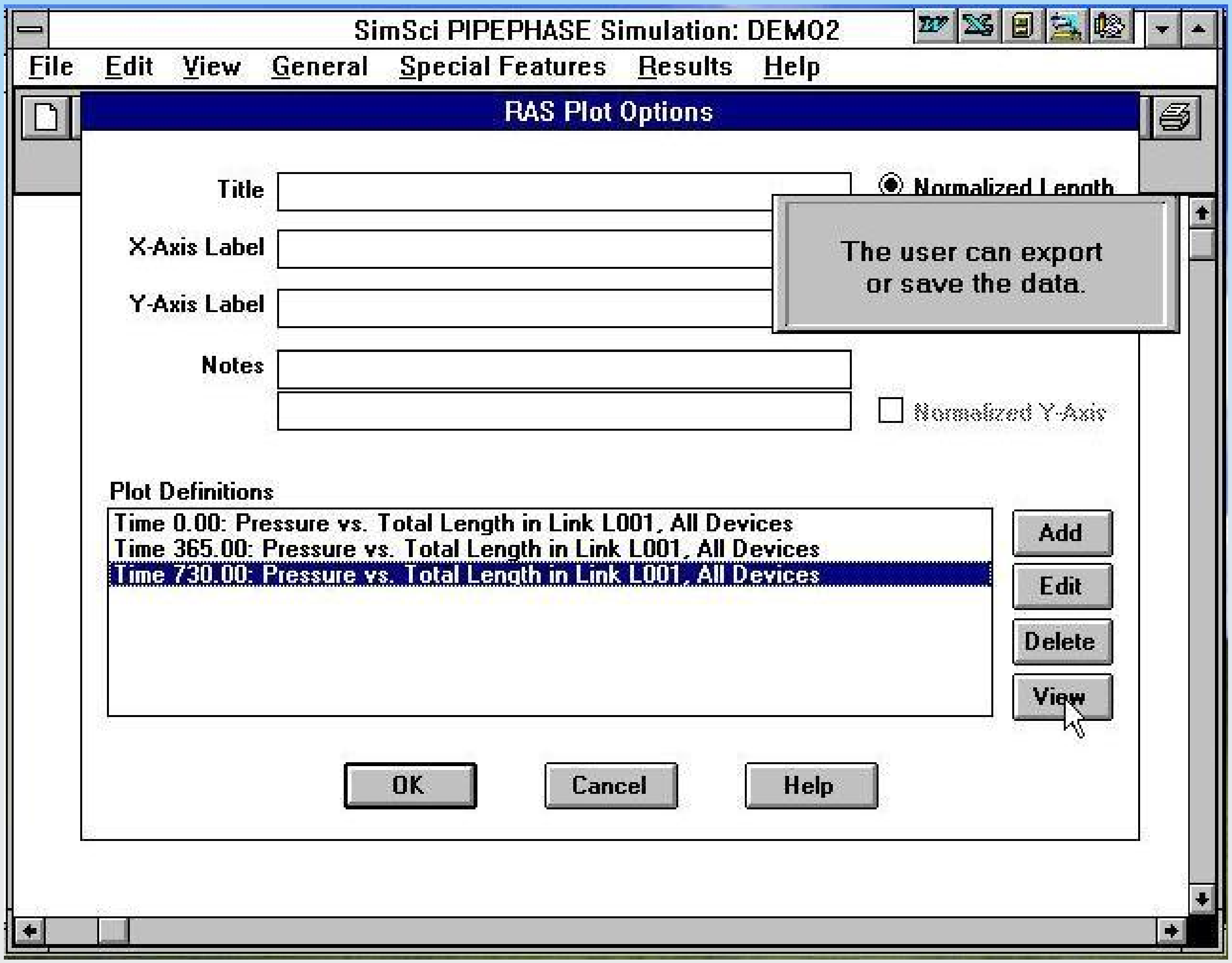

Plot 1
File
Open...
Save As...
Export...
Print
Printer Setup...
Close
RAS Plot
The user can view the results from several time steps or case studies at a time.
Time 730.00: Pressure in Link L001, All Devices
Pressure (psig)
1800.0
1500.0
1200.0
900.0
0
400.0
800.0
1200.0
1600.0
2000.0
Total Length (ft)

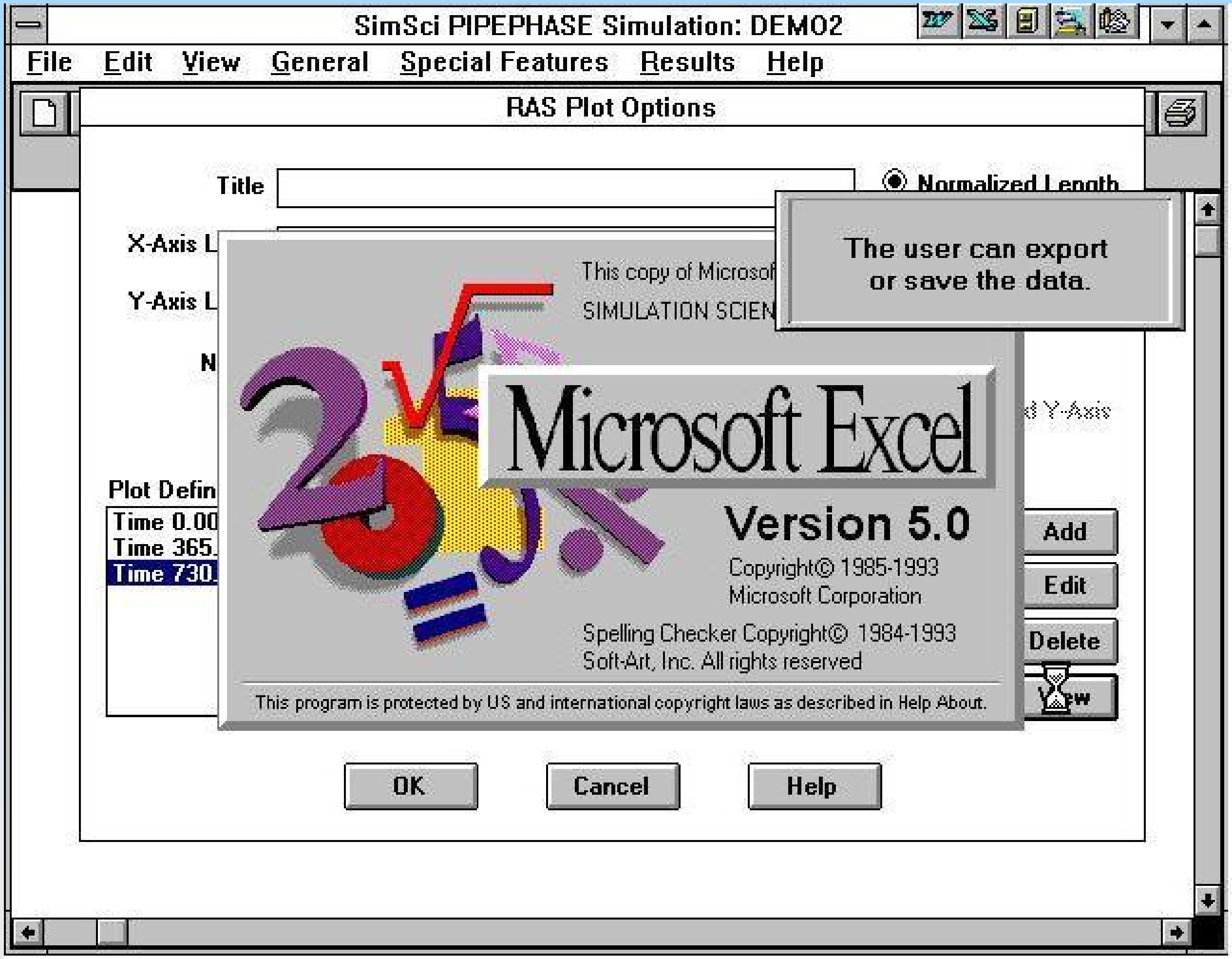

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
The user can view the results from several time steps or case studies at a time.
Title
X-Axis Label
Y-Axis Label
Normalized Y-Axis
Plot Definitions
Time 0.00: Pressure vs. Total Length in Link L001, All Devices
Time 365.00: Pressure vs. Total Length in Link L001, All Devices
Time 730.00: Pressure vs. Total Length in Link L001, All Devices
Add
Edit
Delete
View
OK
Cancel
Help

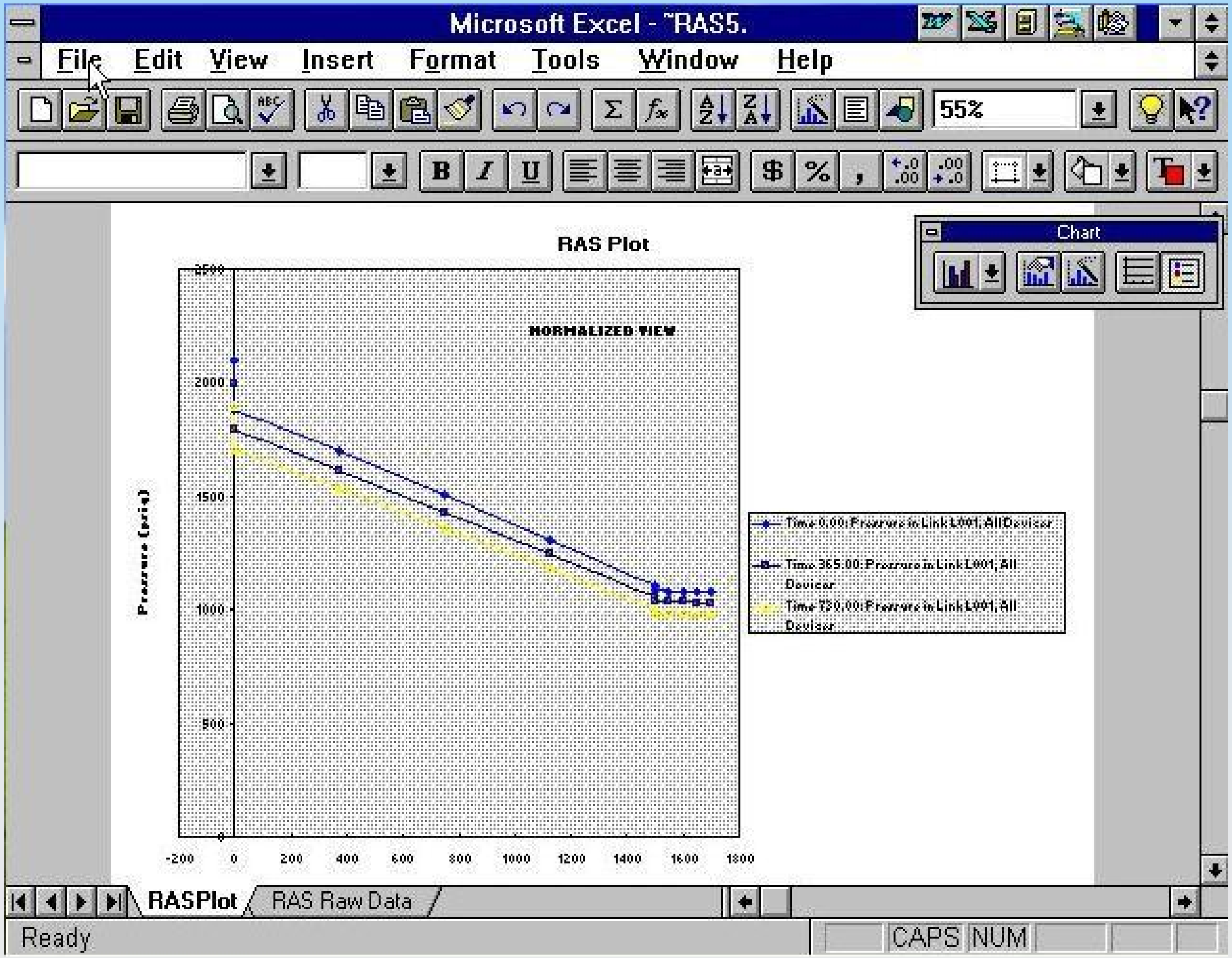

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Results Access System
Table Options
Plot Options
Special Plots
Other Options
OK
Help
The user can export
or save the data.
L003
D004
S002


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Results Access System
RAS Other Options
Plotter Setup
Provision Plot Viewer
Excel 5.0/7.0 Plotter
OK
Cancel
Help
The user can export
or save the data.

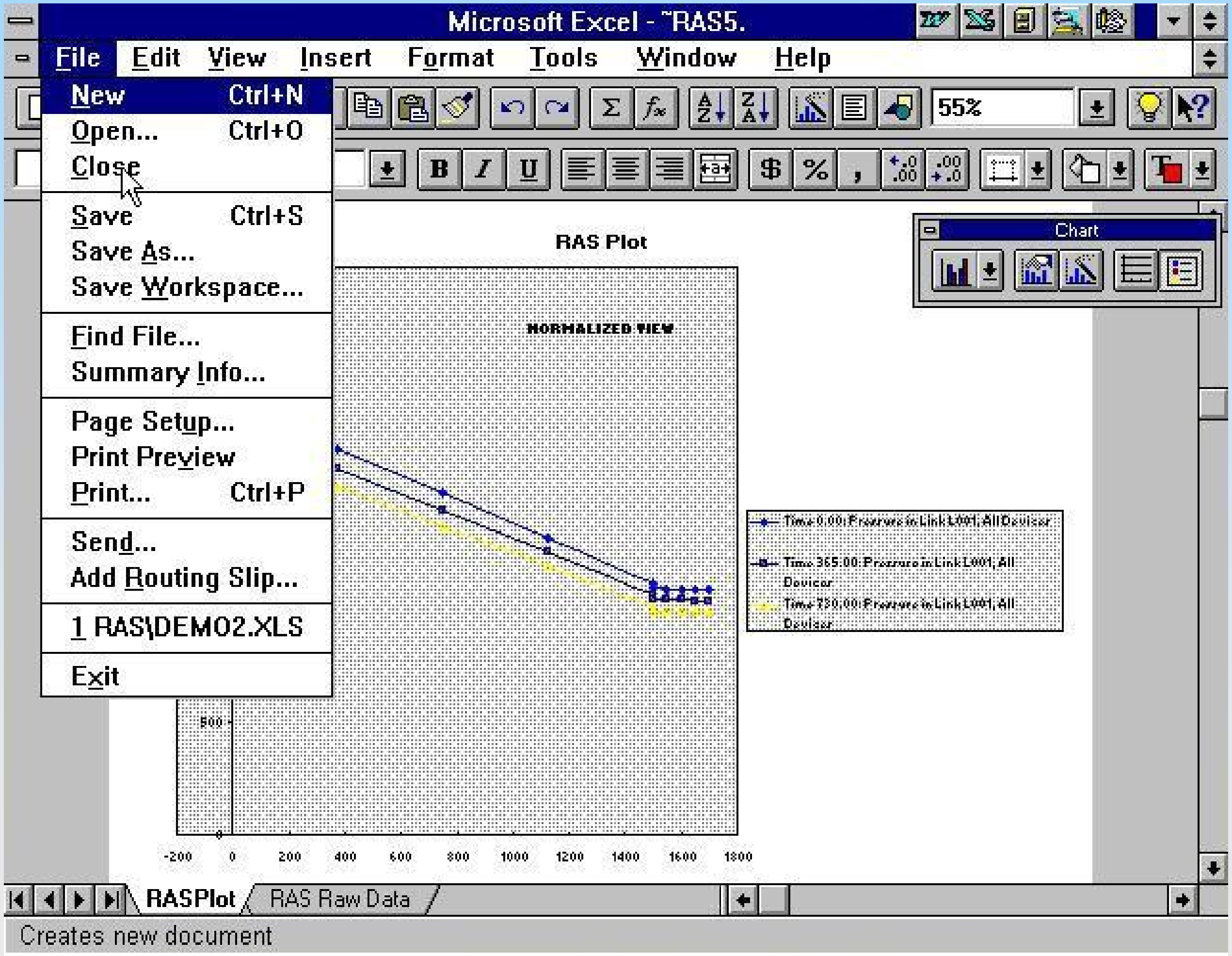

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Results Access System
Table Options
Plot Options
Special Plots
Other Options
OK
Help
The user can export or save the data.
L003
D004
S002

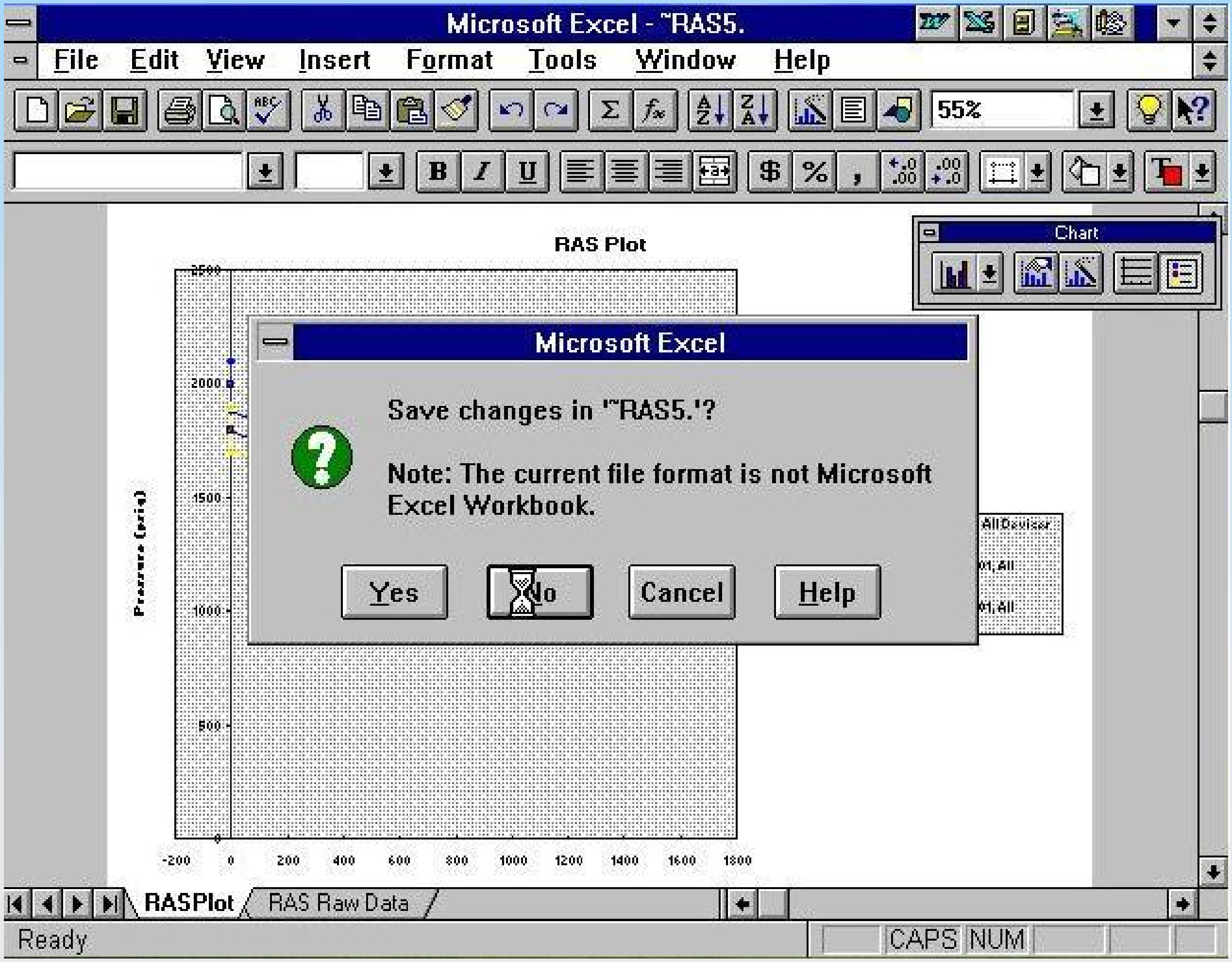

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
Title
X-Axis Label
Y-Axis Label
Notes
Normalized Length
The user can export or save the data.
Normalized Y-Axis
Plot Definitions
Time 0.00: Pressure vs. Total Length in Link L001, All Devices
Time 365.00: Pressure vs. Total Length in Link L001, All Devices
Time 730.00: Pressure vs. Total Length in Link L001, All Devices
Add
Edit
Delete
View
OK
Cancel
Help

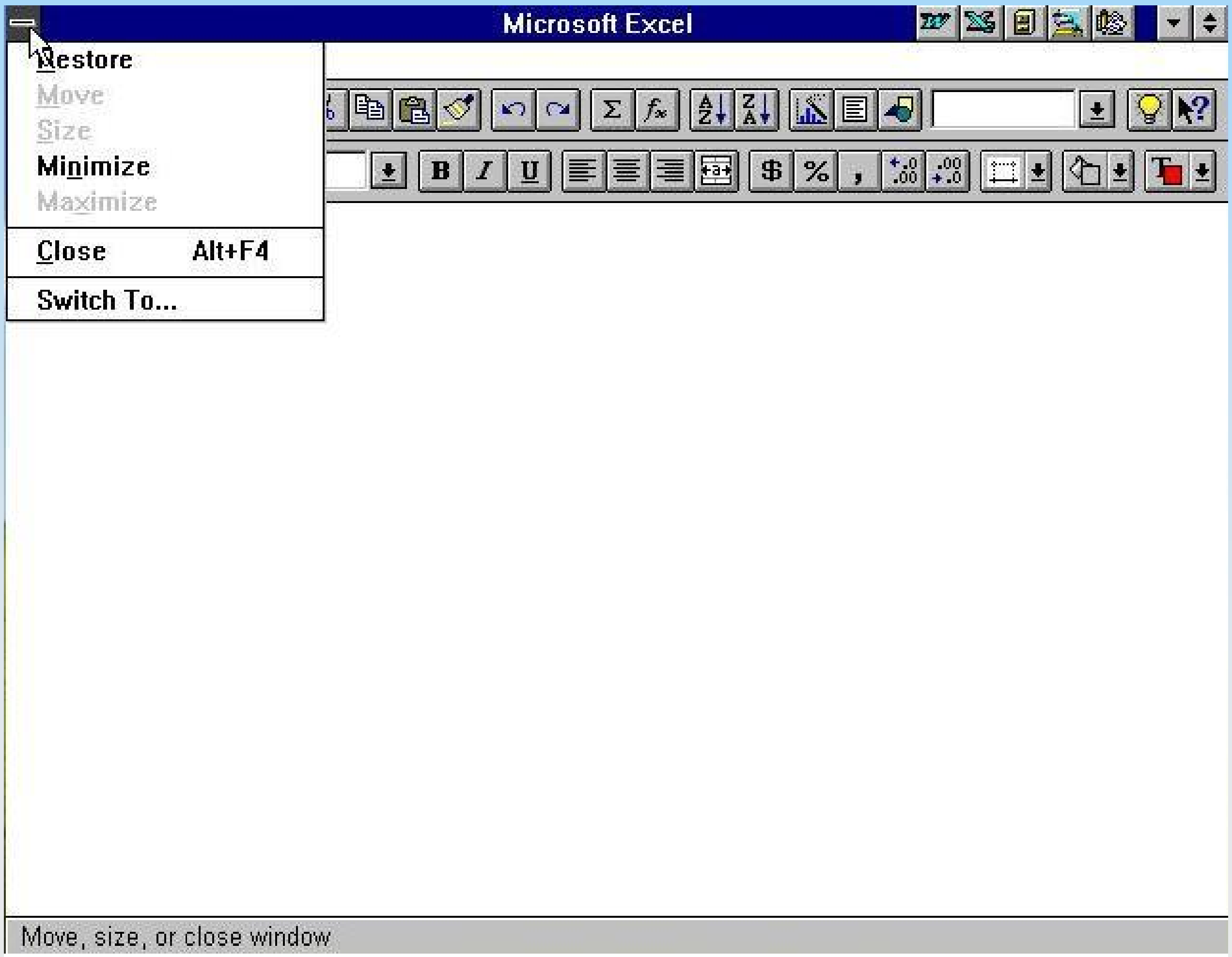

SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
Title
X-Axis L
Y-Axis L
Normalized Length
The user can export or save the data.
This copy of Microsof
SIMULATION SCIEN
Microsoft Excel
Version 5.0
Copyright© 1985-1993 Microsoft Corporation
Spelling Checker Copyright© 1984-1993 Soft-Art, Inc. All rights reserved
This program is protected by US and international copyright laws as described in Help About.
Plot Defin
Time 0.00
Time 365.
Time 730.
Add
Edit
Delete
OK
Cancel
Help

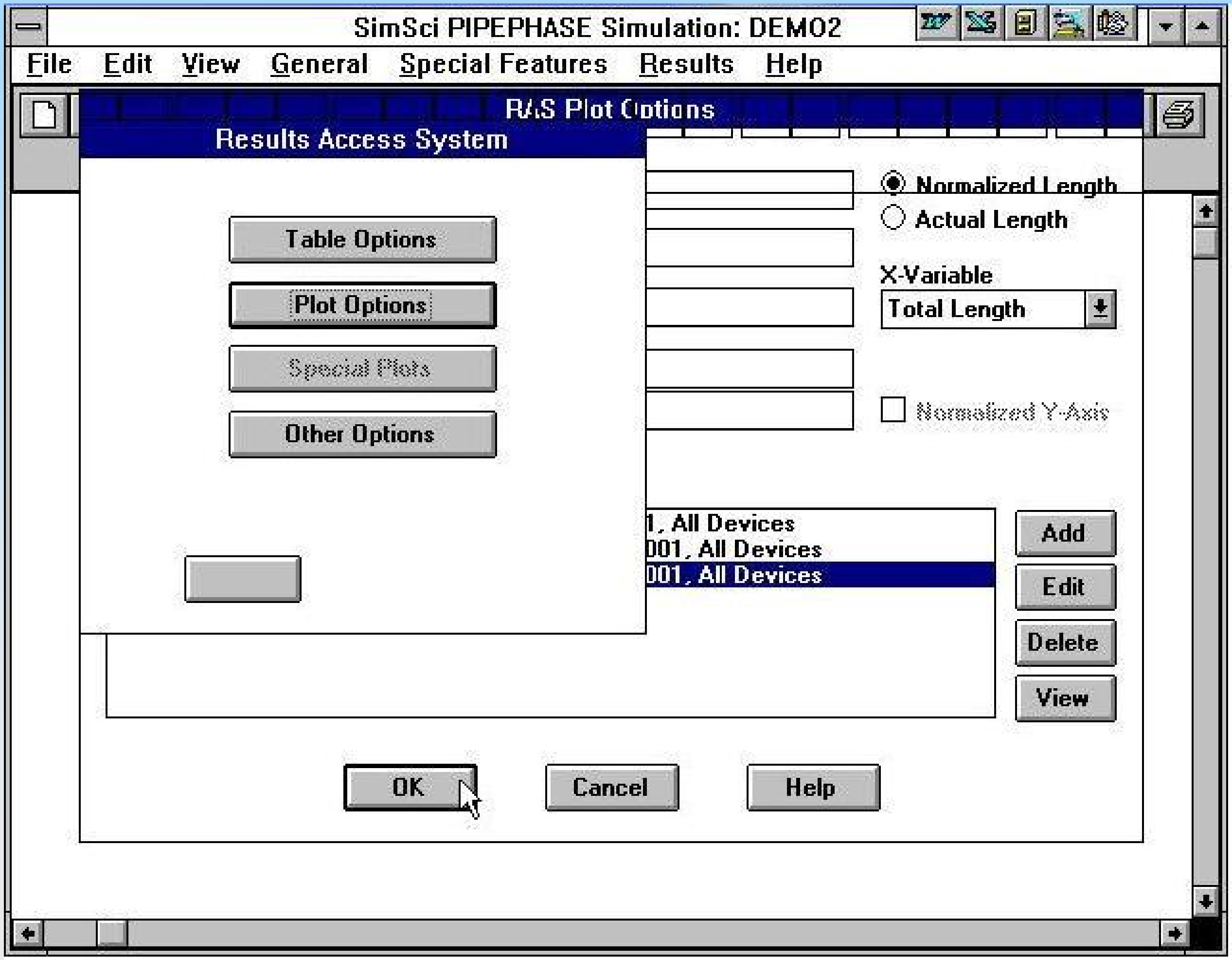


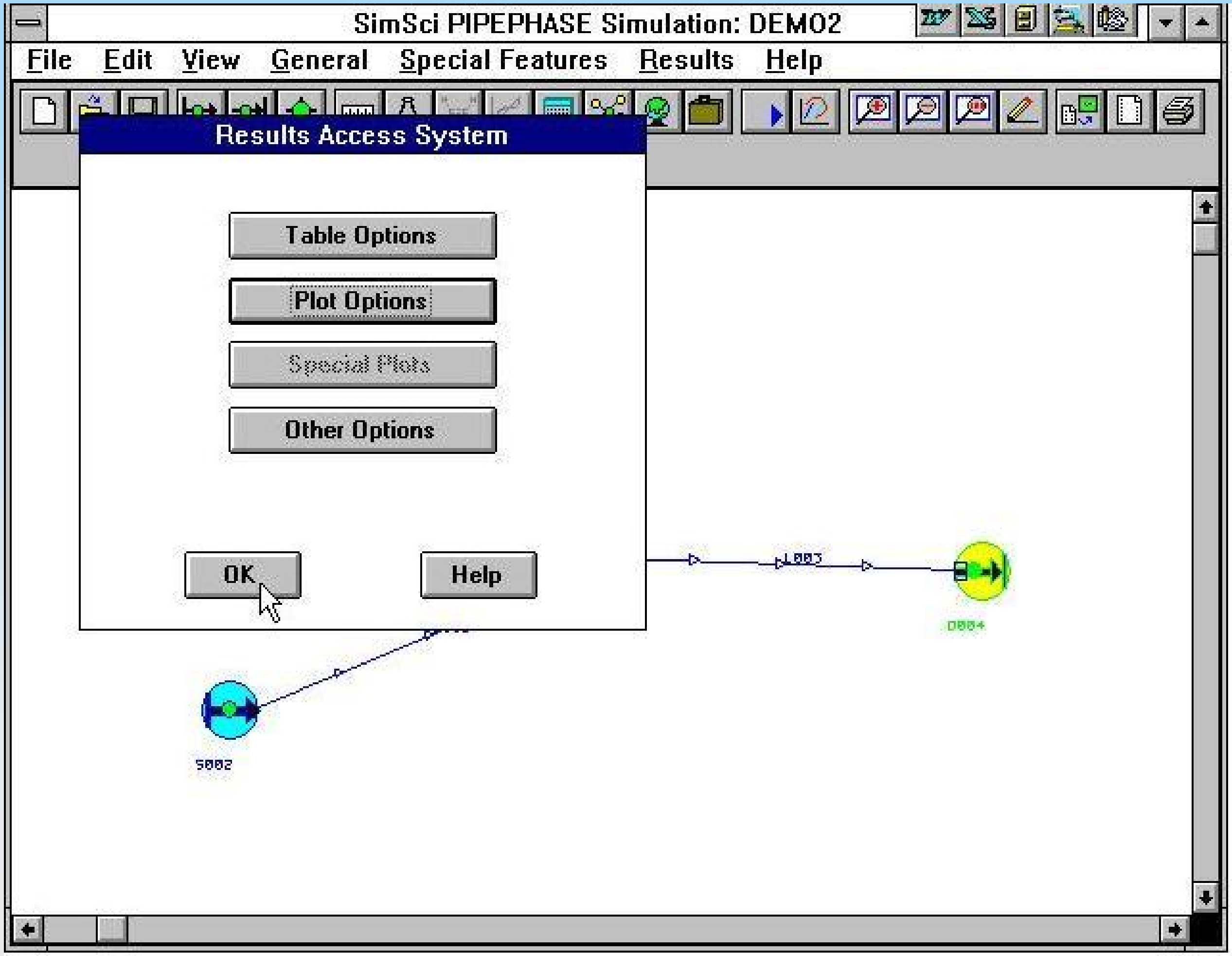
Microsoft Excel - ~RAS5.
File Edit View Insert Format Tools Window Help
55%
Chart
RAS Plot
NORMALIZED VIEW
Pressure (psig)
RASPlot
RAS Raw Data
Ready
CAPS NUM

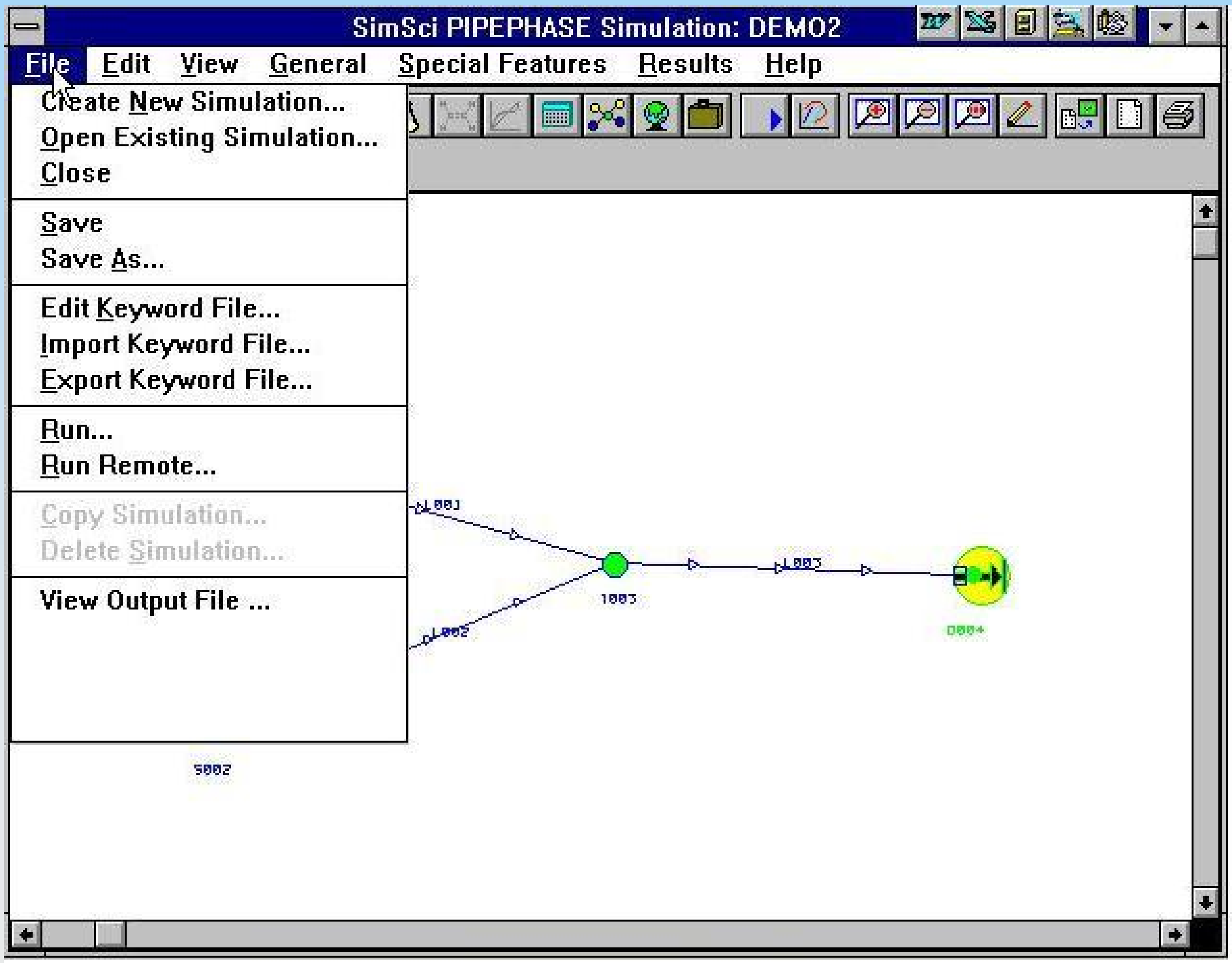

Microsoft Excel - ~RAS5.
File
Edit
View
Insert
Format
Tools
Window
Help
New Ctrl+N
Open... Ctrl+O
Close
Save Ctrl+S
Save As...
Save Workspace...
Find File...
Summary Info...
Page Setup...
Print Preview
Print... Ctrl+P
Send...
Add Routing Slip...
1 RAS\DEMO2.XLS
Exit
55%
RAS Plot
NORMALIZED VIEW
Chart
RASPlot
RAS Raw Data
Creates new document

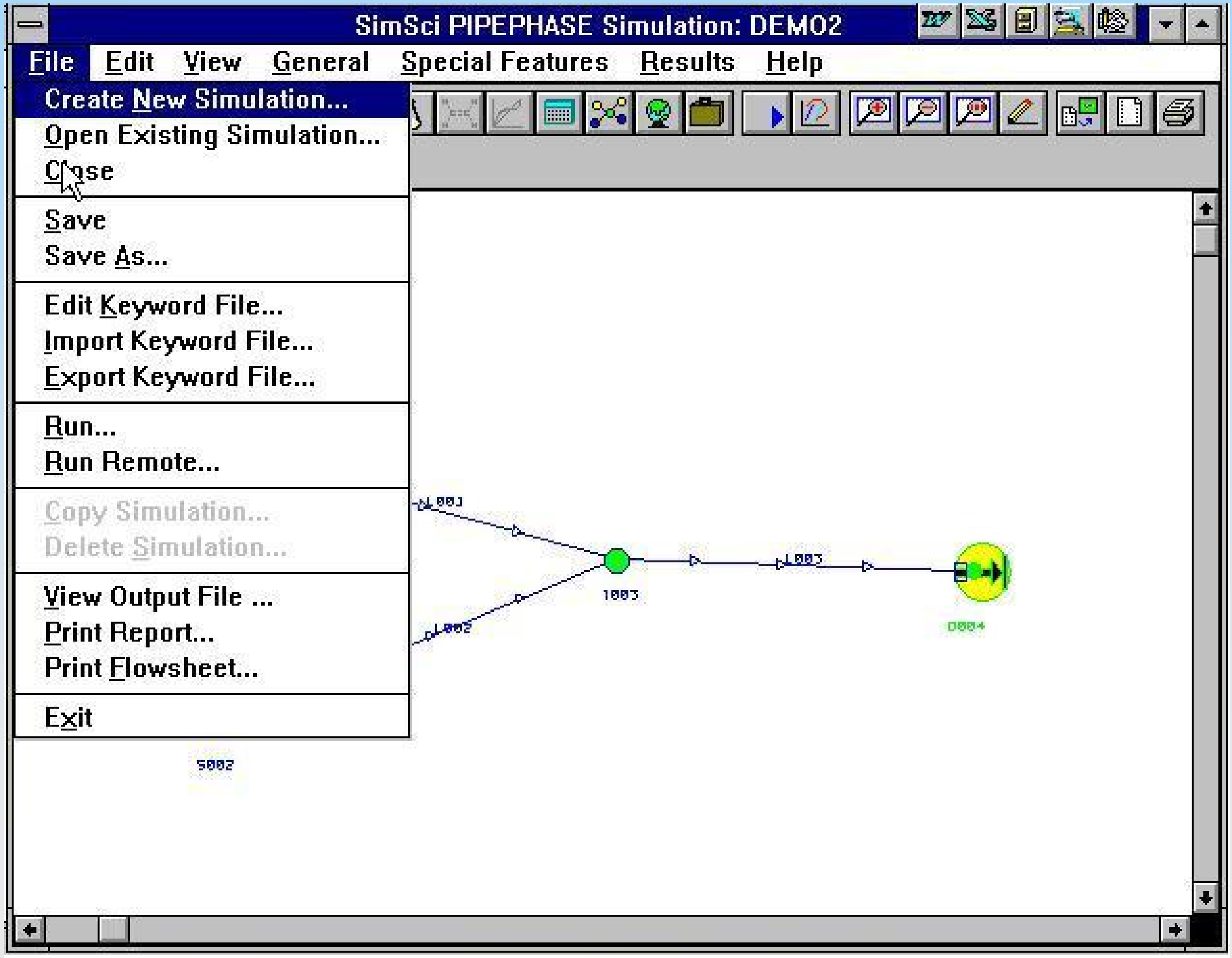

Microsoft Excel - ~RAS5.
File Edit View Insert Format Tools Window Help
55%
RAS Plot
Chart
Microsoft Excel
Save changes in '~RAS5.'?
Note: The current file format is not Microsoft Excel Workbook.
Yes
No
Cancel
Help
RASPlot
RAS Raw Data
Ready
CAPS NUM

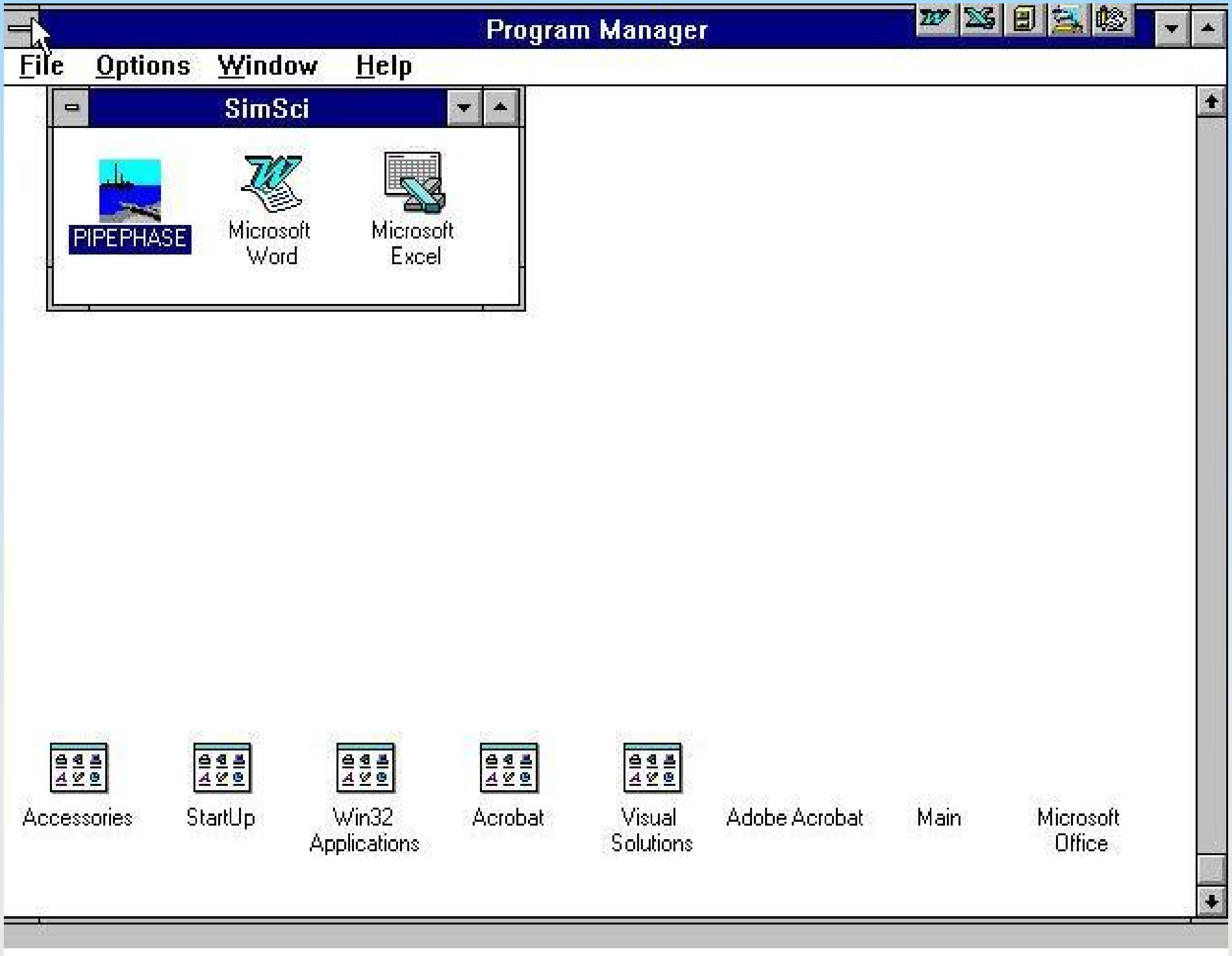

Microsoft Excel
Restore
Move
Size
Minimize
Maximize
Close Alt+F4
Switch To...
Move, size, or close window


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
RAS Plot Options
Results Access System
Table Options
Plot Options
Special Plots
Other Options
Normalized Length
Actual Length
X-Variable
Total Length
Normalized Y-Axis
1, All Devices
001, All Devices
001, All Devices
Add
Edit
Delete
View
OK
Cancel
Help


SimSci PIPEPHASE Simulation: DEMO2
File Edit View General Special Features Results Help
Results Access System
Table Options
Plot Options
Special Plots
Other Options
OK
Help


SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Create New Simulation...
Open Existing Simulation...
Close
Save
Save As...
Edit Keyword File...
Import Keyword File...
Export Keyword File...
Run...
Run Remote...
Copy Simulation...
Delete Simulation...
View Output File ...


SimSci PIPEPHASE Simulation: DEMO2
File
Edit
View
General
Special Features
Results
Help
Create New Simulation...
Open Existing Simulation...
Close
Save
Save As...
Edit Keyword File...
Import Keyword File...
Export Keyword File...
Run...
Run Remote...
Copy Simulation...
Delete Simulation...
View Output File ...
Print Report...
Print Flowsheet...
Exit


Program Manager
File Options Window Help
SimSci
PIPEPHASE
Microsoft Word
Microsoft Excel
Accessories
StartUp
Win32 Applications
Acrobat
Visual Solutions
Adobe Acrobat
Main
Microsoft Office