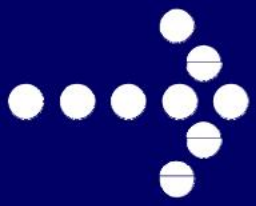
胜利油田工程设计咨询公司

PipePhase 高级培训班

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invensys
SIMSCI-ESSCOR

内容

- 热力学方法和物性计算
  - 黑油物性计算
  - 单相液体物性计算
  - 单相气体物性计算
  - 凝析油物性计算
  - 蒸汽物性计算
  - 组分模型和热力学方法的选择
  - 石油蒸馏数据的处理
  - 水化物的计算

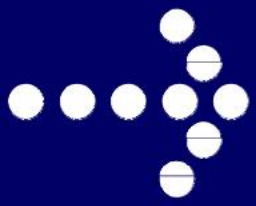
- 段塞流和清管的计算
  - 流型的确定
  - TDB流型图
  - 段塞流的计算
  - 段塞流报告
  - 清管球的计算

- 其它技巧
  - 管件压降的计算
  - 管网的收敛问题
  - 压降计算模型的选择
  - 一些软件应用的技巧

PipePhase高级培训第一部分

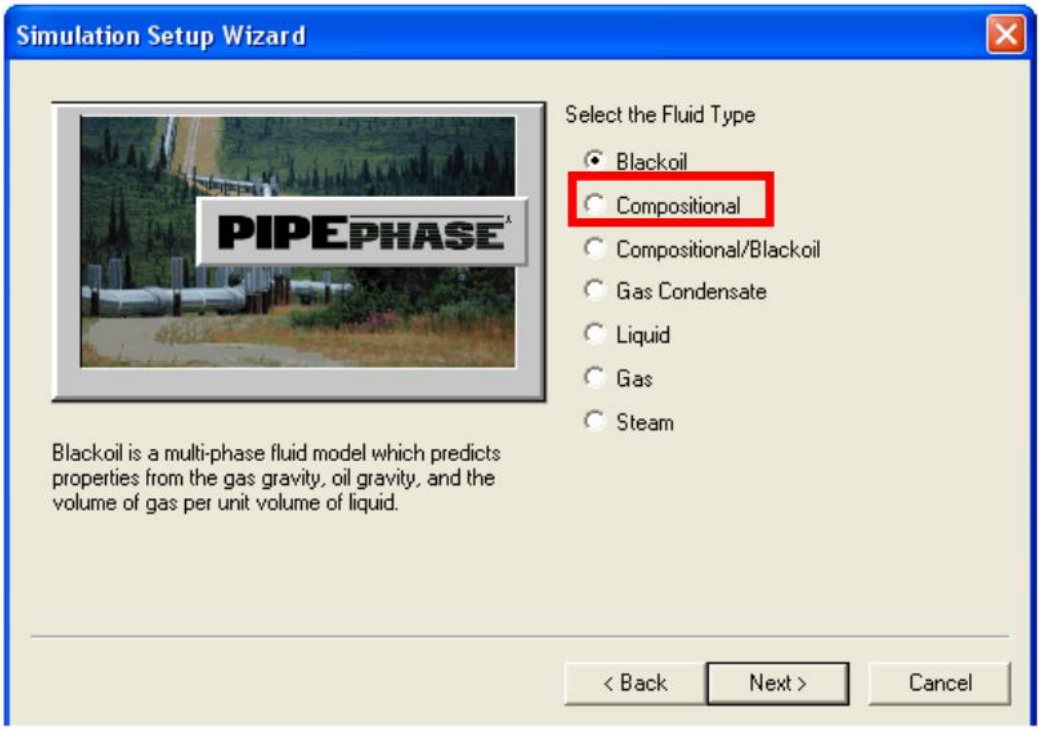
物性计算与热力学方法

PVT Calculation and Thermodynamic Data



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非组分模型和组分模型


Simulation Setup Wizard
PIPEPHASE
Select the Fluid Type
Blackoil
Compositional
Compositional/Blackoil
Gas Condensate
Liquid
Gas
Steam
Blackoil is a multi-phase fluid model which predicts properties from the gas gravity, oil gravity, and the volume of gas per unit volume of liquid.
< Back
Next >
Cancel



非组分模型

非组分模型
Non-Compositional Models

- 每个相需要定义密度
  Requires density (gravity) of each phase
- 其它物性通过经验方程计算
  Empirical correlations for physical properties
  - 粘度Viscosity
  - 压缩因子Compressibility factor (z-factor)

非组分流体类型

- 黑油
- 单相液体
- 单相气体
- 凝析油
- 蒸汽

什么是黑油（Black Oil）模型？

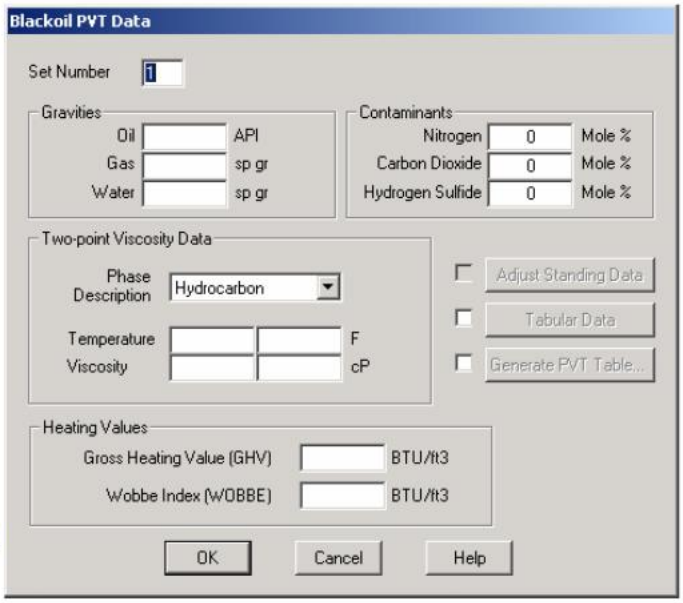
- 黑油模型是行业常用的多相流模型
  - 通过油气水比重和在标况下气液相体积比来计算流体性质
  - 实际工况下的气液相比则通过关联模型计算
  - 气液相性质则分别通过其关联模型计算

- 黑油模型假设条件
  - 在标况下的液相在所有条件下均保持液相
  - 标况下分离出的气相则可以气相和溶解在液相两种方式存在
  - 通常对API<45的原油适用

黑油模型
Black Oil Model

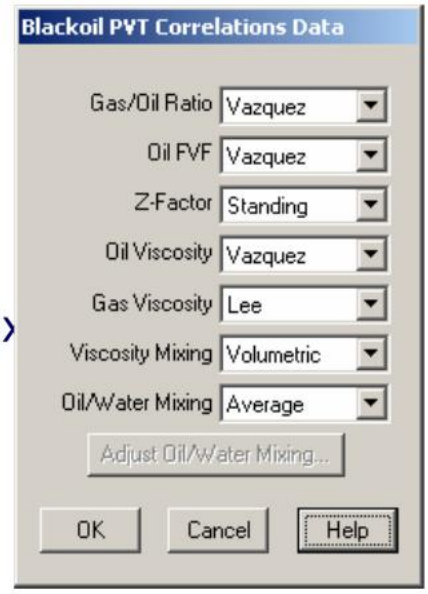
- 输入数据Input data
  - 油气水三相密度
    Oil, gas, and water density (required)
  - 两点粘度
    Two-point liquid viscosity (optional)
  - 气相杂质
    Gas contaminants: N_2, CO_2, H_2S (optional)

- 适用范围：
  - 油气水三相
  - 油气两相（water cut=0）
  - 油水两相（气油比=0）



黑油流体性质

- 溶解气油比Gas/Oil Ratio
- 油地层体积系数Oil FVF
- 压缩因子Z-Factor
- 油的粘度Oil Viscosity
- 粘度混合计算Viscosity Mixing
- 油水混合计算Oil/Water Mixing
- 调整油水混合Adjust Oil/Water Mix



溶解气油比SGOR
Solution Gas/Oil Ratio

- 定义
  - 地层油在一定温度和压力下进行脱气，脱气后计算在该压力下单位体积地面油所溶解天然气的标准体积。
    The solution gas-oil ratio is the volume of dissolved gas, expressed at standard conditions, per unit volume of stock tank oil, at a given condition of pressure and temperature.
  - SGOR随压力增大而增大，直至所有气相溶解在油中达到泡点压力。
    This ratio increases with pressure until all of the gas dissolves at the bubble point pressure.
- 计算关联式
  Correlations
  - Lasater
  - Standing
  - Glaso
  - Vazquez－缺省

Lasater Correlation

- 用于API>15的油
  Use for API > 15
- 和Vazquez方法一起计算FVF
  Use with VAZQUEZ for FVF
- 基于加拿大、美国西部和中部、南美的黑油数据
  Based on blackoils from Canada, the Western and Mid-Continental US, and South America
- 与实验对比的准确性7%
  Experimental accuracy was 7%

Standing Correlations

- 用于API<15
  Use for API < 15
- 基于加州气相—原油系统
  Based on California gas-crude systems
- 实验数据对比准确性10%
  Experimental accuracy was 10%

For $= \sim 1000$

$$R_s = \frac{\gamma_g (Px)^{1.20482}}{(18)^{1.20482}}$$

For $P < 1000$,

$$R_s = \gamma_g \left(x \left(\frac{P}{13.46} \right)^{0.93023} \right)^{1.20482}$$

where

$$x = 10^{(0.0125API - 0.000917)}$$

Vazquez Correlation

- 更新更通用的关联式－缺省
  Newer and more general than the Lasater and Standing correlations

For $API \leq 30$,

$$R_s = \frac{(SG)(P^{1.0937})10^{11.172A}}{27.64}$$

For $API > 30$,

$$R_s = \frac{(SG)(P^{1.187})10^{10.393A}}{56.06}$$

where

$$A = \frac{API}{(T + 460)}$$

Glaso Correlations

- 和Vazquez关联式类似
  It is similar to Vazquez correlation
- 基于欧洲不同油田原油数据
  And was based on crude oil data from a different set of fields in Europe.

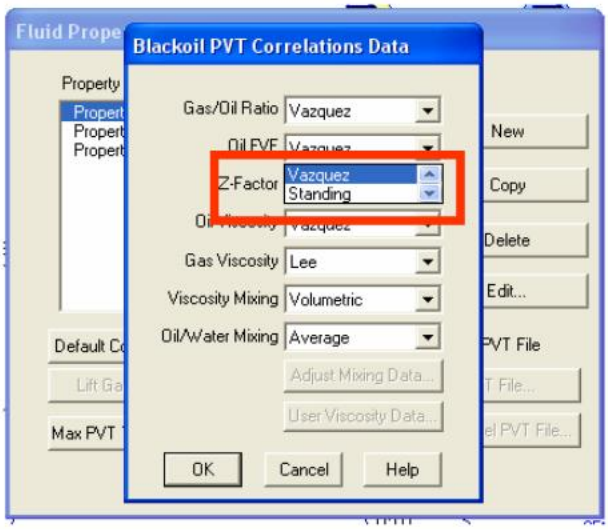
油层体积系数
Oil Formation Volume Factor (FVF)

Definition

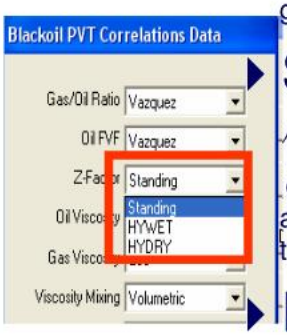
- 实际工况下油气体积除以脱气后油在标况下的体积比
  The oil formation volume factor is the in situ volume of the oil phase, comprising of both oil and dissolved gas, that is occupied by a unit volume of oil at stock tank conditions.
- FVF受油中溶解气相的量和油的可压缩性影响
  The formation volume factor is influenced by the amount of dissolved gas as well as the compressibility of the oil.
- 低于泡点压力，FVF随压力升高而增大
  Below the bubble point pressure, the oil formation volume factor increases as more gas dissolves with increasing pressure.
- 高于泡点压力，FVF随压力升高而降低
  Above the bubble point pressure, the formation volume factor decreases with pressure due to compressibility effects.

Oil FVF Correlations

- Vazquez
  - Used for API >15
- Standing
  - Experimental accuracy was 5%
- Glaso



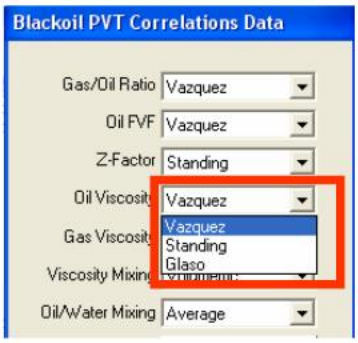
气相压缩因子
Gas Compressibility Z-Factor Correlations



- 两种方法：Standing-Katz7和HY。
  Two choices between the Standing-Katz7 (default) and Hall-Yarborough7 (for wet or dry gases) correlations
- Standing-Katz的数据取自天然气，其结果严重依赖比重数据的准确性。可考虑有杂质。
  data were taken from experiments with natural gas only, and the resultant z-factor accuracies are strongly reliant on a precise specific gravity entry, is also able to correct for the existence of contaminants such as nitrogen, carbon dioxide, or hydrogen sulfide.
- HY方法对Standing数据进行曲线拟合
  The Hall-Yarborough methods for dry and wet gases result from curve-fitting original Standing-Katz data, and are also able to correct for the existence of contaminants.
- 将压缩因子描述为比重、温度和压力的函数
  Both methods correlate z-factor as a function of specific gravity, temperature and pressure.

油相粘度
Oil Viscosity Correlation

- 油相粘度计算方法
  - Vazquez: TUFFP (Vazquez/Beggs)
  - Standing: Beal-Standing/Chew-Conally
  - Glaso

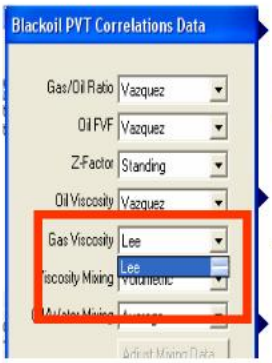


油相粘度
Oil Viscosity Correlation

	密度范围 API	温度范围 F	压力范围 psig
Vazquez	16－58	70－295	0－5250
Standing	<60	<300	1atm

气相粘度
Gas Viscosity Correlations

- 两种方法：Lee (缺省) 和 Katz



- 气相粘度作为比重、温度和压力的函数

Both correlations calculate the gas viscosity as a function of specific gas gravity, temperature, and pressure.

- Lee的方法更为通用

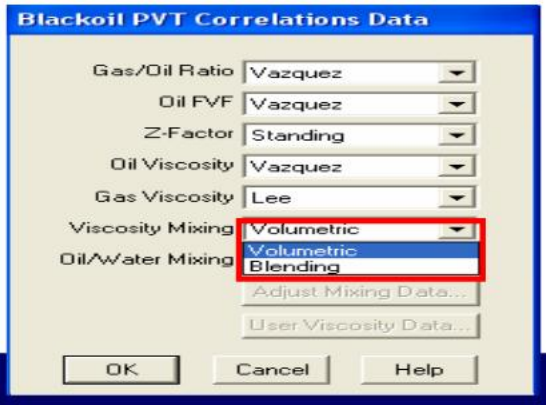
The Lee method is more general.

- Katz实验数据温度范围40-400F，对比压力1-20

The Katz method uses experimental data in the range 40-400ºF and 1<Pr<20.

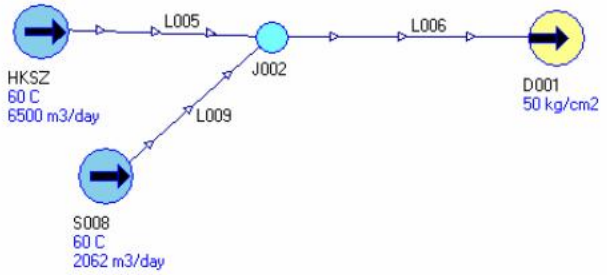
粘度混合方法
Viscosity Mixing Methods

- 用于混合多个两点粘度曲线
  It is a method for blending multiple two-point viscosity data sets.
- 两种：体积平均和混合指数
  Choose between the Volumetric method and the Blending Index method.
- 所有两点粘度曲线的温度点需相同
  For either mixing rule to work correctly all two-point viscosity data must be entered using the same two temperatures and,
- 如果用混合指数法，粘度数据需大于10 cp
  in the case of the Blending Index method, all viscosities should be greater than 10 cP.



粘度混合的例题－背景

- 胜利油田的数据－ViscMixing
- 60 C稀油和稠油的混合
  - 稀油：71 cp
  - 稠油：1164 cp
- 做一个简单模型－Isothermal维持60C
  - 计算混合后的粘度



粘度混合的例题－结果

BASE CASE

LINK "L006" PROPERTY DETAIL REPORT

VISCOSITY AND DENSITY RESULTS

DEVICE NAME AND TYPE	SEGM NO	VISCOSITY OIL (CP)	VISCOSITY LIQ (CP)	VISCOSITY VAP (CP)	DENSITY LIQ (KG/M3)	DENSITY VAP (KG/M3)	DENSITY SLIP (KG/M3)	DENSITY NO-SLIP (KG/M3)
P028 (PIPE)	0000							
	0001	351.582	359.217	0.013	895.82	36.53	895.82	895.82
	0002	351.580	359.215	0.013	895.82	36.53	895.82	895.82
	0003	351.578	359.213	0.013	895.82	36.53	895.82	895.82
	0004	351.576	359.211	0.013	895.82	36.53	895.82	895.82

体积平均

BASE CASE

LINK "L006" PROPERTY DETAIL REPORT

VISCOSITY AND DENSITY RESULTS

DEVICE NAME AND TYPE	SEGM NO	VISCOSITY OIL (CP)	VISCOSITY LIQ (CP)	VISCOSITY VAP (CP)	DENSITY LIQ (KG/M3)	DENSITY VAP (KG/M3)	DENSITY SLIP (KG/M3)	DENSITY NO-SLIP (KG/M3)
P028 (PIPE)	0000							
	0001	131.801	134.664	0.013	895.82	36.53	895.82	895.82
	0002	131.802	134.664	0.013	895.82	36.53	895.82	895.82
	0003	131.802	134.664	0.013	895.82	36.53	895.82	895.82
	0004	131.801	134.664	0.013	895.82	36.53	895.82	895.82

指数平均

油水混合物粘度计算
Oil-Water Viscosity Correlations

- 对非乳化物：
  - Average：体积平均
  - API

$$R = \frac{q_o}{q_w}$$

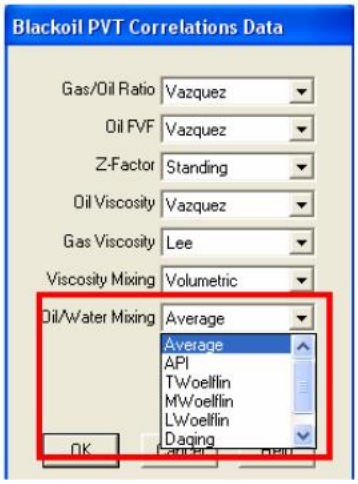
For R > 1,

$$\mu_L = \mu_1 + \mu_2\mu_3$$

For R < 1,

$$\mu_L = \mu_2(1 + 2.5R)$$

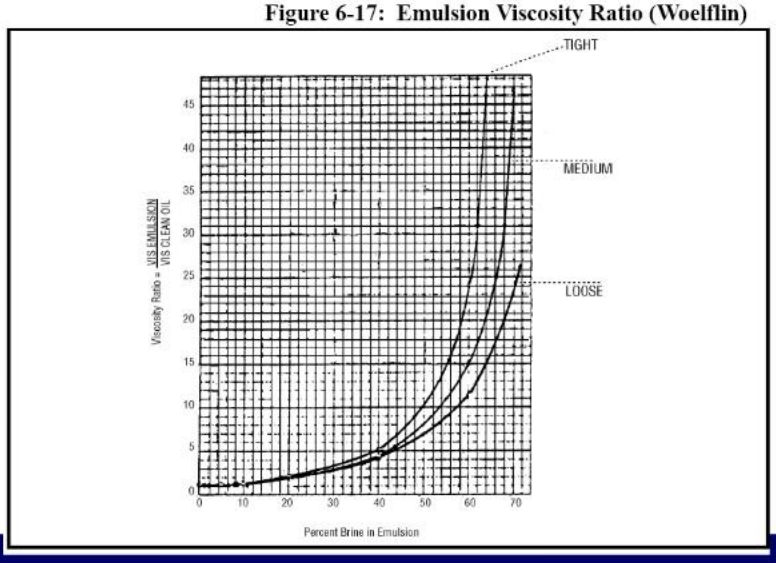
- 对乳化物
  - TWoelflin (Tight Woelflin)
  - MWoelflin (Medium Woelflin)
  - LWoelflin (Loose Woelflin)
  - **Daqing—大庆油田设计院开发的方法**



Woelflin乳化物模型

- 油水乳化物粘度预测最常用的模型
- 假设油包水乳化物粘度>纯油粘度，当到达转相点后转化为水包油，粘度和水接近
- 包括Tight/Medium/Loose三种曲线

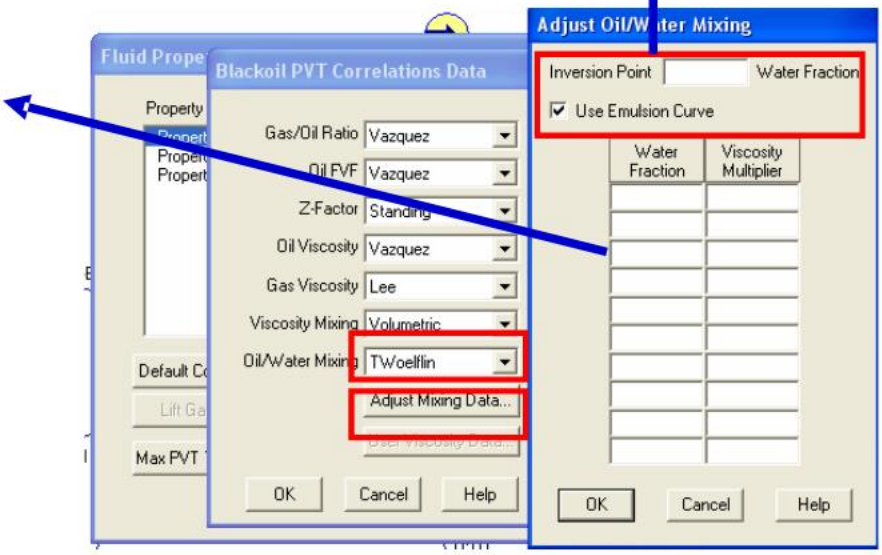
Figure 6-17: Emulsion Viscosity Ratio (Woelflin)



自定义乳化物粘度曲线

转相点，超过该点后用水的粘度。

自定义粘度曲线，Multiplier为乳化物粘度/纯油粘度。覆盖Woelflin模型



两个液相粘度的区别

- Oil Viscosity：由PipePhase模型推算的液相粘度
- Liquid Viscosity：由两点粘度曲线推算的液相粘度
  - 实际采用的粘度数据

Viscosity Density Report - Base Case

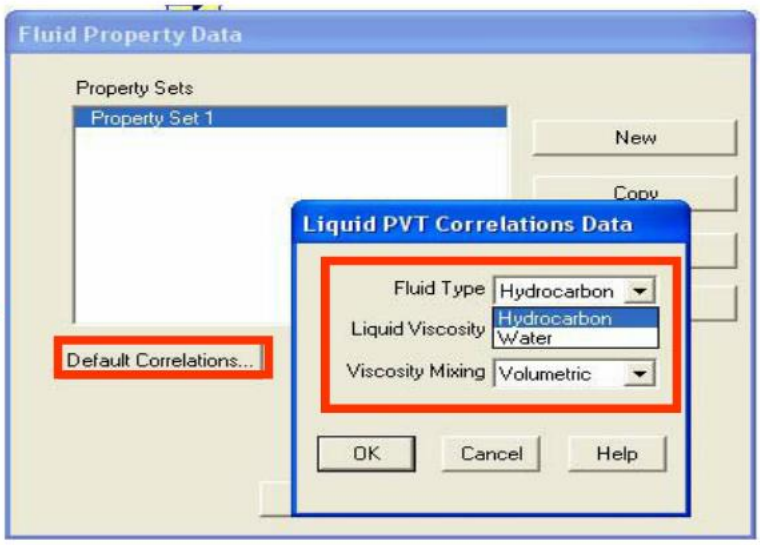
Name	Device Type	Device Seg	Oil Viscosity	Liquid Viscosity	Vapor Viscosity	Liquid Density	Vapor Density	Slip Density	No Slip Density
			CP	CP	CP	KG/MB	KG/MB	KG/MB	KG/MB
P030	PIPE	Inlet							
P030	PIPE	Seg 1	1,292.689	1,349.922	0.014	944.222	54.856	944.222	944.222
P030	PIPE	Seg 2	1,290.840	1,347.991	0.014	944.220	54.588	944.220	944.220
P030	PIPE	Seg 3	1,288.999	1,346.069	0.014	944.218	54.321	944.218	944.218
P030	PIPE	Seg 4	1,287.166	1,344.156	0.014	944.216	54.054	944.216	944.216
P030	PIPE	Seg 5	1,285.340	1,342.250	0.014	944.214	53.788	944.214	944.214
P030	PIPE	Seg 6	1,283.523	1,340.353	0.014	944.212	53.522	944.212	944.212

非组分流体类型

- 黑油
- 单相液体
- 单相气体
- 凝析油
- 蒸汽

单相液体模型
Single-Phase Liquid Model

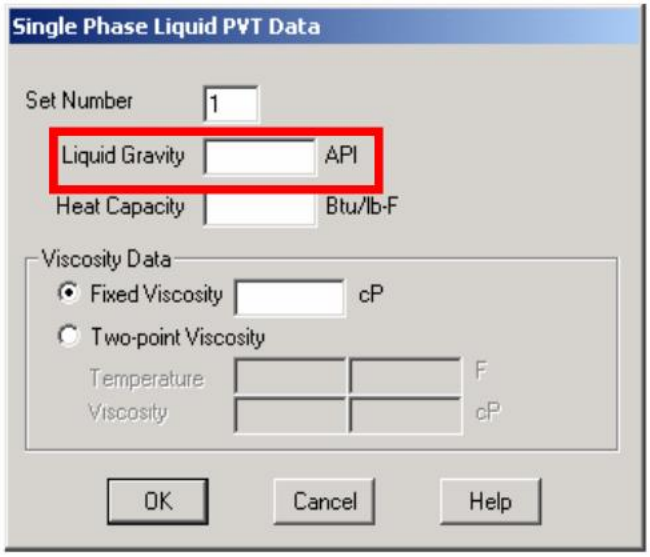
- 适用范围
  - –纯油系统
  - –纯水系统
  - –不适合油水混合物



- 经验公式计算
  - –油的粘度
  - –水的粘度

单相液体模型输入数据
Single-Phase Liquid Model

- 液体密度－必须
  - –油 －缺省
  - –水
- 两点粘度
- 热容



单相液体模型性质
Single-Phase Liquid Fluid Properties

- 液相粘度计算
  - 油
    - VAZQUEZ – TUFFP (Vazquez/Beggs, default)
    - STANDING - Beal-Standing/Chew-Conally
    - GLASO
  - 水
    - Beal (default)
    - ASME Steam tables

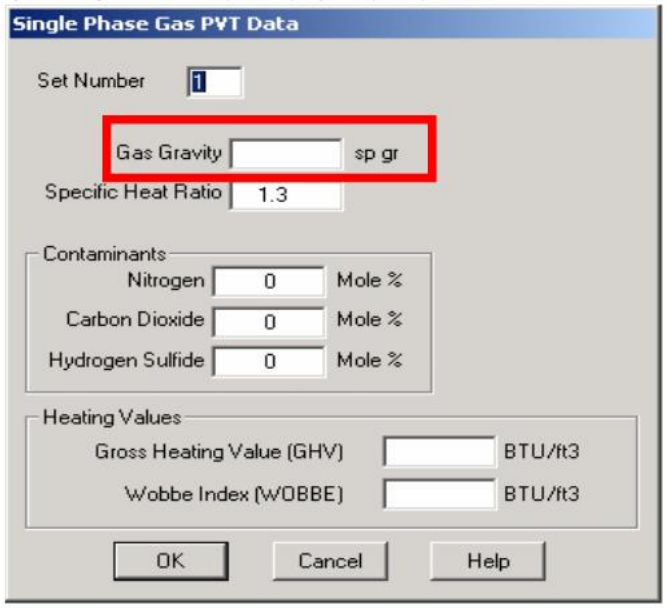
- 粘度混合方法
  Viscosity Mixing correlation to be used when calculating the viscosity of a mixture of two liquids.
  - Volumetric
  - Blending

非组分流体类型

- 黑油
- 单相液体
- 单相气体
- 凝析油
- 蒸汽

单相气体模型
Single-Phase Gas Model

- 适用范围
  - 仅有气相
  - 没有组分和组成数据，仅知道大宗类性质
- 输入数据
  - 气相密度—必须
  - 杂质
  - 热容比Cp/Cv
- 经验物性计算：
  - 气相粘度
  - 压缩因子
  - 比热Cp



单个气相性质计算
Single-Phase Gas Fluid Properties

- 气相粘度
  - 两个气体混合时粘度计算
  - Lee
  - Katz
- 压缩因子
  - Standing-Katz
  - H-Y Wet Gas
  - H-Y Dry Gas
- 热容 $C_{pG} = 0.39 + 0.00085(T - 100)$

非组分流体类型

- 黑油
- 单相液体
- 单相气体
- 凝析油
- 蒸汽

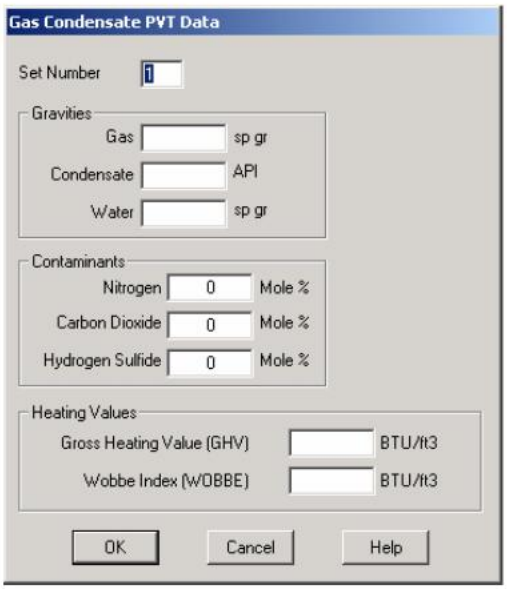
什么是凝析油（Condensate）模型？

- 采用API Procedure 14B模型
  - 气相是否有凝析油取决于实际温度和压力
  - 假设低于露点压力时没有液相
  - 实际工况下凝析油量 = 标况下流量 × 虚拟FVF
  - 模型假设凝析油密度恒等于其在标况下的密度
  - 虚拟FVF是凝析油的比重、露点压力、操作压力和温度的函数
  - 凝析油的露点压力、气油相质量分率、表面张力通过经验公式计算
  - 露点压力 = f (SPGR, T)

- 适用范围
  - 轻油 API > 45

气体凝析油模型
Gas Condensate Model

- 输入数据
  - 气相、凝析油、水相密度－必须
    Gas, condensate, and water density (required)
  - 气相杂质
    Gas contaminants: N_2, CO_2, H_2S (optional)
- 物性计算基于经验公式
  Empirical Correlations (no choice)

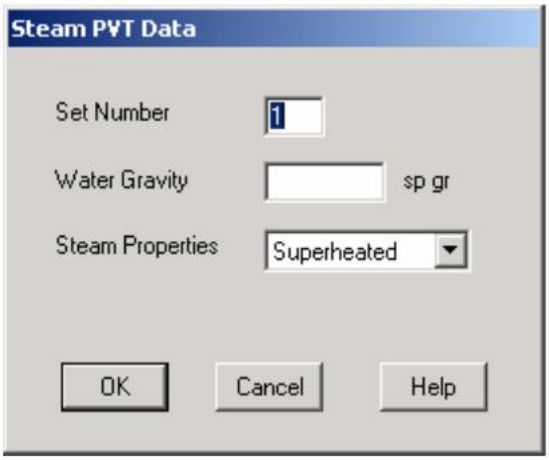


非组分流体类型

- 黑油
- 单相液体
- 单相气体
- 凝析油
- 蒸汽

蒸汽模型
Steam Model

- 输入数据
  - 水的密度－必须
  - 不低于1000 kg/m3
- 物性计算基于蒸汽列表
  Empirical correlations based on steam table data
- 保持焓平衡
  Maintains enthalpy balance





组分模型

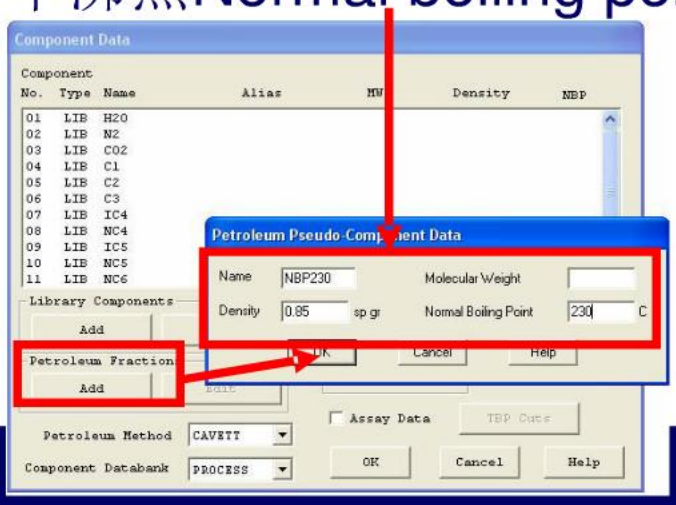
组分模型Compositional Model

- 通过下述方法定义的流体
  - –纯组分
  - –石油组分
  - –原油蒸馏数据

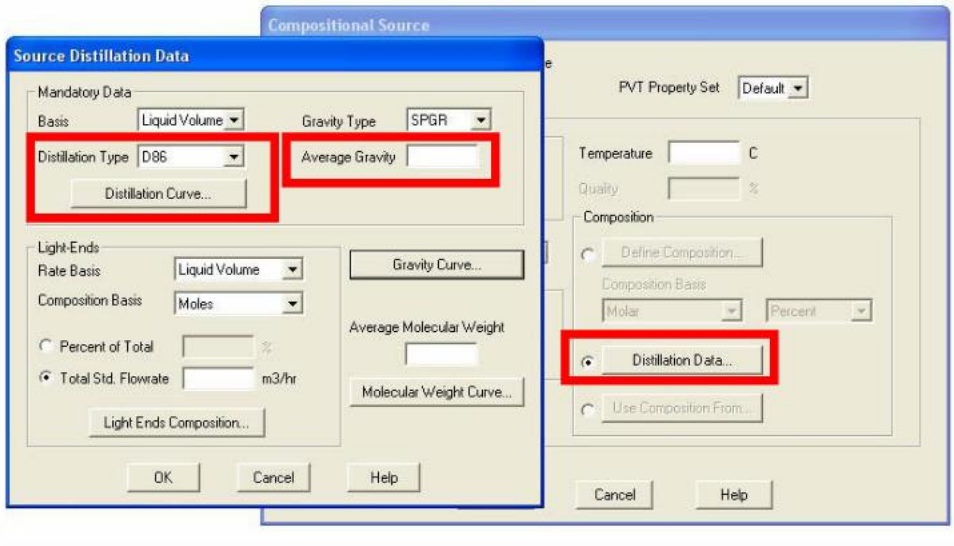
纯组分Pure Library Components

- 2000多种组分
  Over 2000 pure library components
  - 如果有水，需放在第一个组分
    If water present, must be the first component to be decanted
- 物性数据
  - Density (gravity)
  - Molecular weight
  - Normal boiling point
  - Critical pressure
  - Critical temperature
  - Critical volume
  - Critical compressibility
  - Acentric factor
  - Binary interaction
  - Parameters
- 输出报告中打印所有组分的物性数据

- 下列性质中至少需定义两个
  At least two physical properties required
  - 密度Density (gravity)
  - 分子量Molecular weight
  - 中沸点Normal boiling point



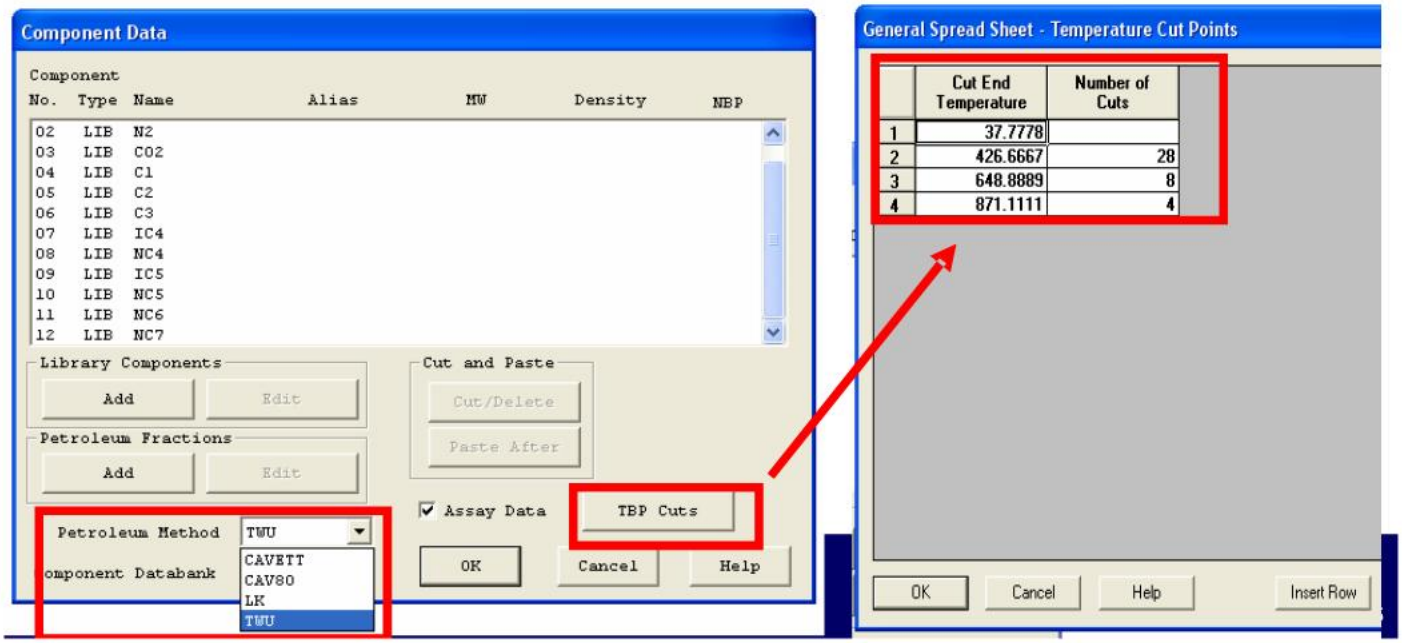
原油蒸馏数据
Assay Data



- 所需数据
  - 沸点曲线
  - 平均密度
  - 可选
    - 分子量曲线
    - 密度曲线
- 可定义轻端
- PipePhase根据上述数据生成虚拟组分

石油馏分计算方法
Petroleum Method

- Simsci (Black and Twu in 1983 and Twu in 1984)
- Cavett (in 1962)
- Cavett (in 1980)
- Lee-Kesler (in 1975 and 1976)





invensys
SIMSCI-ESSCOR™

原油的表征化

实验数据Laboratory Tests

- API度
  API Gravity
- 雷氏蒸气压
  Reid Vapor Pressure (RVP)
  - Volatility measure for vapor pressures < 25 psia (173 kPa)
- 特性因数
  Characterization Factors
  - Watson (UOP) K Value
- 蒸馏曲线
  Distillation Curves
  - True Boiling Point (TBP)
  - ASTM D86
  - ASTM D1160
  - ASTM D2887

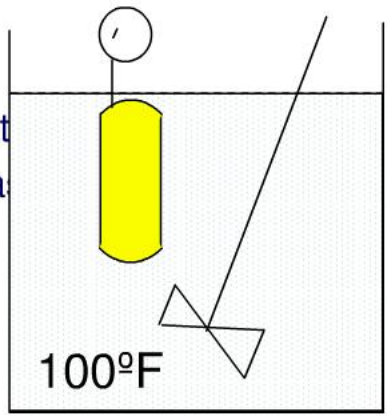
API Gravity

API Gravity is a specific gravity scale developed by the American Petroleum Institute (API) for measuring the relative density of various petroleum liquids. API gravity is graduated in degrees on a hydrometer instrument and was designed so that most values would fall between 10 and 70 API gravity degrees.

- $API = 141.5/SPGR_{60} - 131.5$
- Examples
  - Water = 10.0 API
  - Kerosene = 45.0 API
  - Gasoline = 58.0 API
  - Natural Gasoline = 75.0 API

Reid Vapor Pressure (RVP)

- Technique
  - Place chilled sample in bomb
  - Shake and place in 100° F bat
  - Read RVP on dial and report a "PSI"
- Typical RVP's
  - Military Jet Fuel = 1.5
  - Motor Gasoline = 6.0 - 10
  - Natural Gasoline = 15 - 20



Reid Vapor Pressure (RVP)

- For gasoline in range 5-15 psi, RVP and TVP are nearly identical
- Rule of thumb: 1 % NC4= 1 psi RVP
- Accuracy is approximately 0.5 psi and is affected by:
  - Sampling technique
  - Reproducibility of test
  - Laboratory technique

特性因数Characterization factor (UOP K or Watson K)

The UOP Characterization Factor, commonly called K, is indicative of the general origin and nature of a petroleum stock.

$$"K" = \frac{\sqrt[3]{NBP}}{SPGR}$$

Where: NBP = average boiling point, degrees R
SPGR= specific gravity at 60° F

特性因数Characterization factor (UOP K or Watson K)

- Examples
  - Paraffins = 13+
  - Kansas Crude Oil = 11.8
  - Cracked Gasoline = 10.9
  - Condensed Aromatics = 10.0

Values of 12.5 or higher indicate a material predominantly paraffinic in nature. Highly aromatic materials have characterization factors of 10.0 or less.

蒸馏曲线Distillations Curves

- Distillation curves used to develop the characteristics of complex hydrocarbons
  - Over 16,000 components identified in common crude stock
- Crude Boiling Point Range
  - Methane – 1600F
- Crude Gravity Range
  - 10-45 API
- Types
  - TBP
  - ASTM D86
  - ASTM D1160
  - ASTM D2887
- converts all ASTM distillations into a TBP to define the petroleum stock.

实沸点TBP

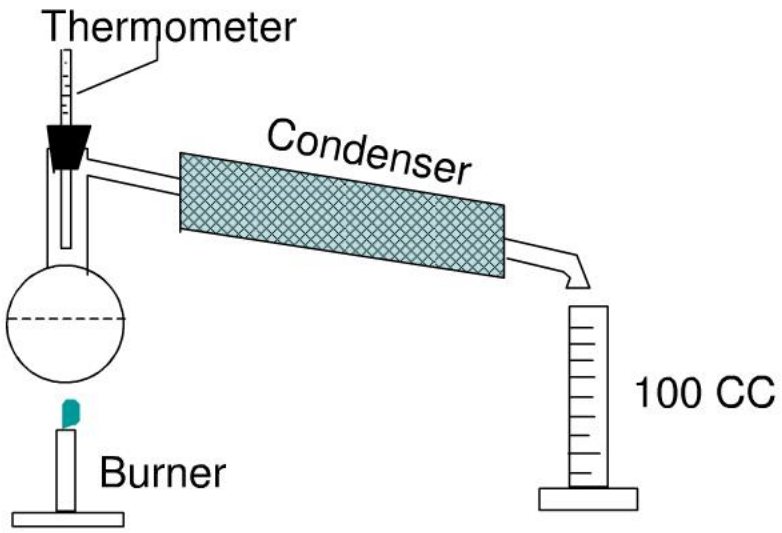
- True Boiling Point (TBP)
  - Fractionating still with reflux
  - Separates component by component
  - Upper limit is approximately 650° F or 900-950° F NBP Material (483-510° C)

TBP Distillation Data

Butanes and lighter	55-175 °F
Light Gasoline	175-300 °F
Light naphtha	300-400 °F
Heavy naphtha	400-500 °F
Kerosene	500-650 °F
Atmosphere Gas Oil	650-800 °F
Light Vacuum Gas Oil	800-1000 °F
Hvy. Vacuum Gas Oil	1000 °F
Vacuum Residue	> 1000 °F

ASTM D86

- *Purpose:* fast, inexpensive control test, little fractionation occurs



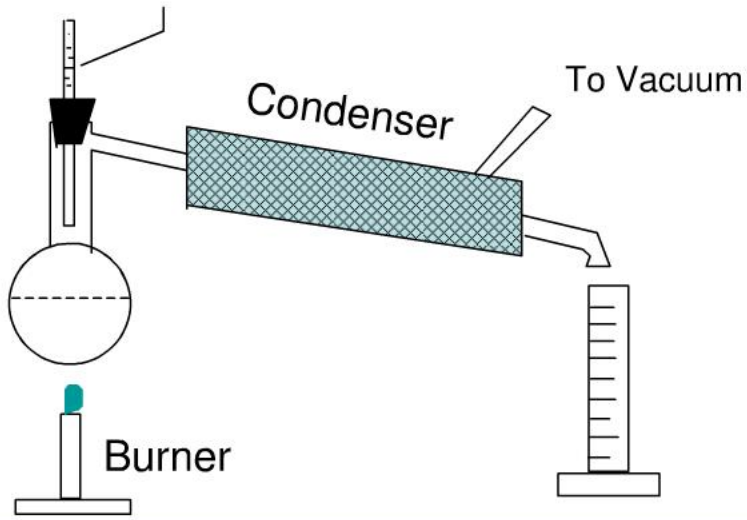
ASTM D86

- Single stage atmospheric pressure for gasoline through distillates
- Upper limit is approximately 700° F
- Accuracy is approximately 5 - 10° F and is affected by:
  - Sampling technique
  - Test reproducibility
  - Laboratory technique
- Should be corrected for lab pressure

Lab pressure, mm Hg	Observed temp, ° F	Corr., ° F
600	100	+ 10
(Denver, Colorado)	300	+ 15
	600	+ 20

ASTM D1160

- Purpose: control test for heavy stocks. Run under vacuum (2-10 mm Hg)



Distillations ASTM D1160

- Single stage vacuum distillation for gas oil and heavier. Pressure 2-10 mm Hg
- Upper limit is approximately 1000° F
- Most labs apply pressure corrections and report at 760 mm Hg
- Initial point is higher that TBP, from 50% to end point test is nearly identical to TBP distillation

- Accuracy is affected by:
  - Sampling techniques
  - Reproducibility
  - Lab technique

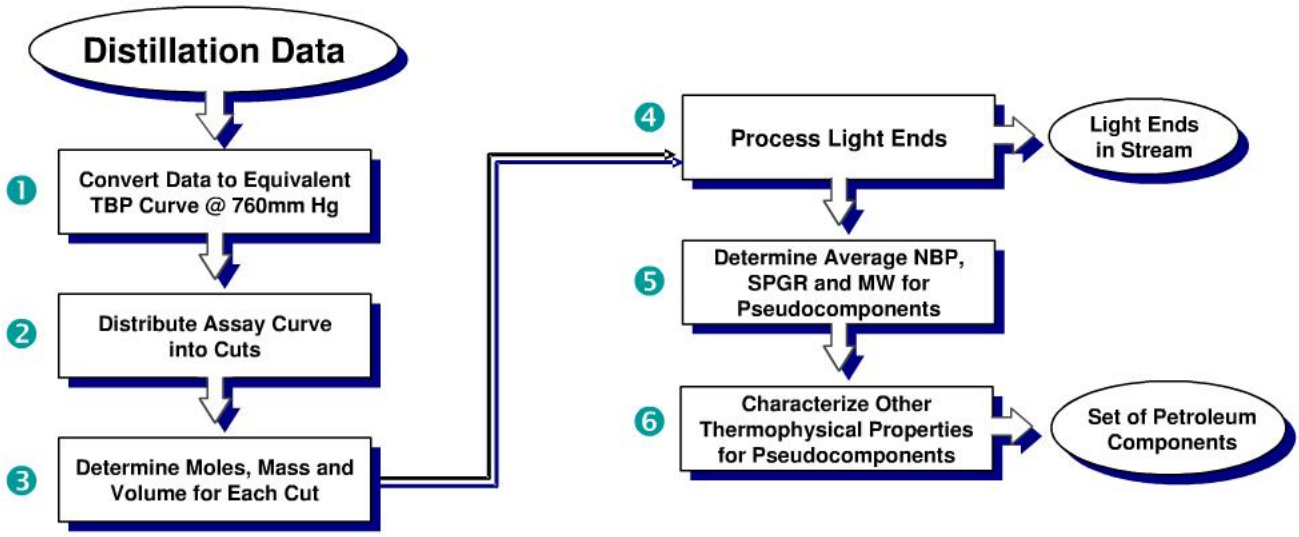
ASTM D2887

- G.C. simulated distillation approximates TBP distillation
- Upper limit is approximately 1100° F
- Used for “Gasoline” material down to “Resid”
- Highly reproducible

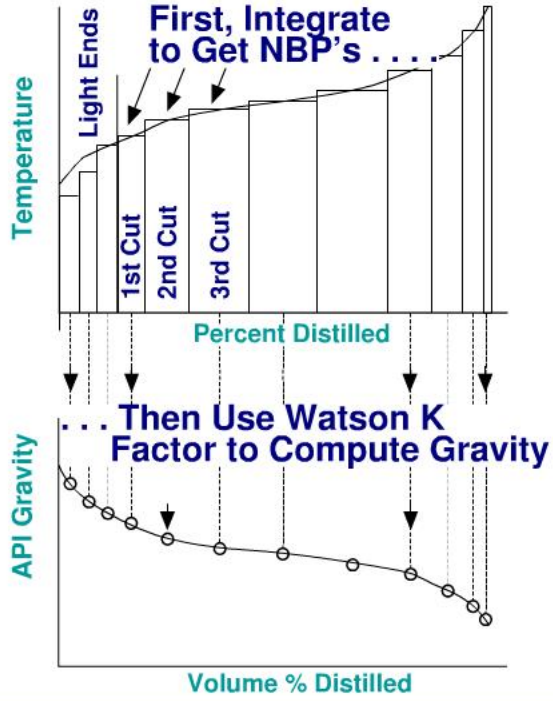
	REFERENCE	RUN 1	RUN 2
0.5% (IBP)	115	112	112
5%	151	148	147
10%	176	173	175
15%	201	197	198
20%	224	221	220
25%	243	241	240
30%	259	255	256
35%	275	271	272
40%	289	287	288
45%	302	298	299
50%	312	309	308
55%	321	318	318
60%	332	329	330
65%	343	339	340
70%	354	350	352
75%	365	362	363
80%	378	374	376
85%	391	388	387
90%	407	404	404
95%	428	426	425
99.5%	475	474	475

蒸馏数据的转化

蒸馏数据转换Assay Conversion



计算中沸点和密度Compute NBP's and Gravities



Assay Conversion - Tips

- 分子量是最难计算的物性
  Molecular weight is the most difficult property to predict
  - 只要可能，应尽量提供分子量数据
    Whenever possible, you should supply the molecular weight to increase the accuracy in characterization
- 尽可能提供密度曲线
  Input gravity curve when possible
  - 用馏分油取样或
    Sample cut into fractions or
  - 各个产品的收率和物性都已知
    Product yield and properties are known

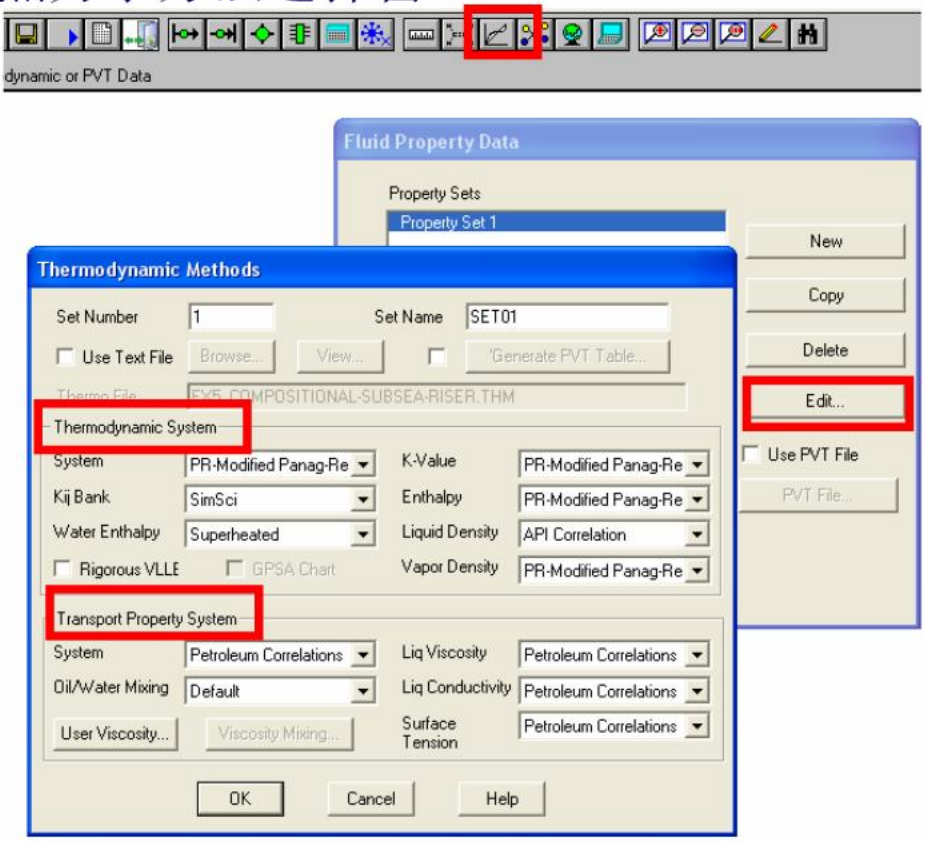


组分模型热力学方法
Thermodynamic Methods

请记住：只有组分流体才需要选择热力学方法！

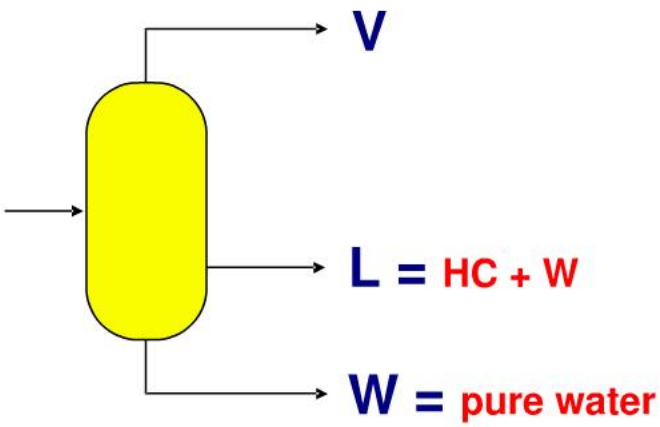
- 需要选择热力学方法计算：
  - 相平衡常数
  - 焓值
  - 密度
  - 粘度
  - 表面张力
  - 热传导率

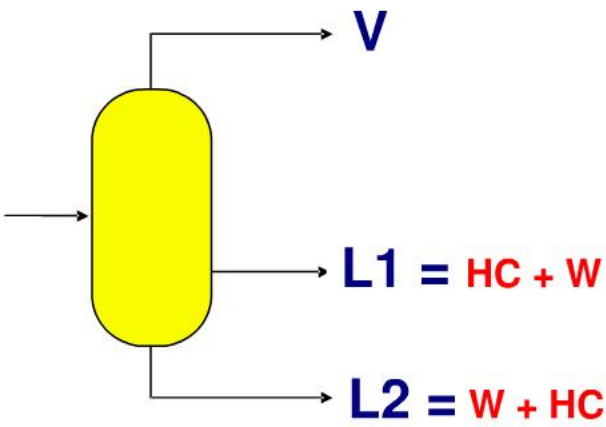
热力学方法选择窗口


dynamic or PVT Data
Fluid Property Data
Property Sets
Property Set 1
New
Copy
Delete
Edit...
Use PVT File
PVT File...
Thermodynamic Methods
Set Number
1
Set Name
SET01
Use Text File
Browse...
View...
Generate PVT Table...
Thermo File
EX5_COMPOSITIONAL-SUBSEA-RISER.THM
Thermodynamic System
System
PR-Modified Panag-Re
K-Value
PR-Modified Panag-Re
Kij Bank
SimSci
Enthalpy
PR-Modified Panag-Re
Water Enthalpy
Superheated
Liquid Density
API Correlation
Rigorous VLLE
GPSA Chart
Vapor Density
PR-Modified Panag-Re
Transport Property System
System
Petroleum Correlations
Liq Viscosity
Petroleum Correlations
Oil/Water Mixing
Default
Liq Conductivity
Petroleum Correlations
User Viscosity...
Viscosity Mixing...
Surface Tension
Petroleum Correlations
OK
Cancel
Help

两个液相计算

- Water decant
- 严格三相平衡计算





热力学方法选择

- 轻烃气体：SRK、PR
- H2含量高的轻烃气体：SRKM、PRM
- 高压下的烃水系统：SRK-KD

- 原油：GS、SRK



传递性质算法

- 选择计算下列物性的方法
  - 气液相热传导率
  - 液相表面张力
  - 气液相粘度
- 选择油水混合粘度计算方法
  - 体积平均
  - API procedure 14B
  - Woelflin乳化物方法
    - 支持自定义曲线
- 可提供两点粘度数据

练习 1:

蒸馏曲线
Distillation Curve

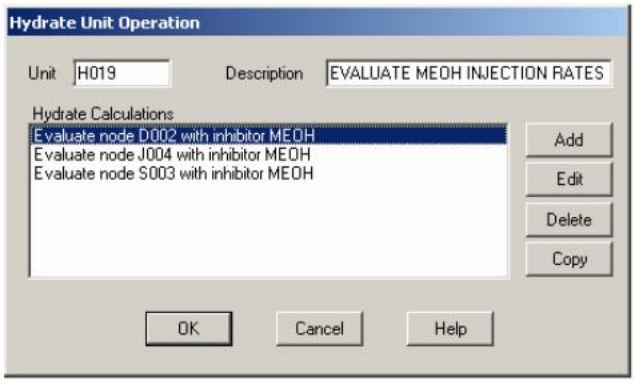
水化物模型
PIPEPHASE Hydrates Modeling

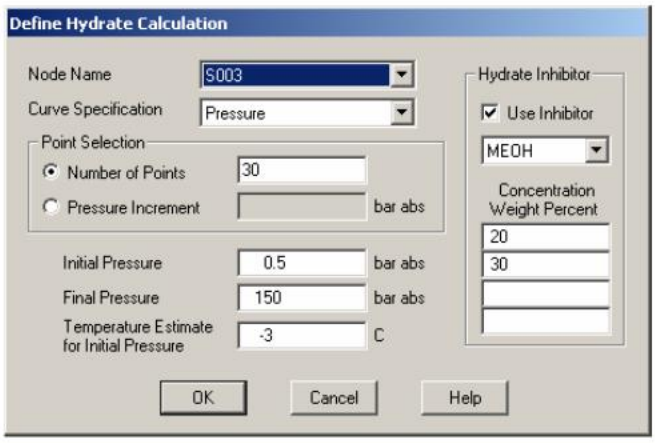
PipePhase水化物模型

- 模拟的水化物类型
  - Type I: 每个单元含46个水分子
  - Type II: 每个单元含136个水分子
- 仅用于组分模型
- 预测节点处可能生成水化物的温度和压力条件
- 假设系统存在自由水用于形成水化物
- 可计算NaCl/甲醇/EG/DEG/TEG等抑制剂的作用

水化物模块的规定

- 添加水化物单元
- 双击
- 规定水化物单元和Source、Sink和Junction关联





在Heat Transfer Report中的水化物报告

Hydrates in Heat Transfer Report

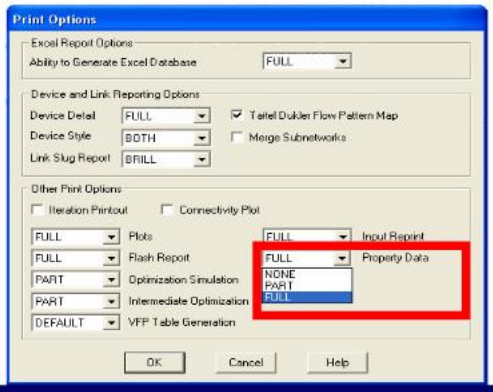
LINK "L008" PROPERTY DETAIL REPORT

HEAT TRANSFER CALCULATIONS

DEVICE NAME AND (TYPE)	SEGM NO:	FLUID THERMAL CONDUCTIVITY (KCMC)	THERMAL RESISTANCE INSIDE FILM (HR-M2-C/KCAL)	PIPE (HR-M2-C/KCAL)	INSULATION (HR-M2-C/KCAL)	SURROUNDING (HR-M2-C/KCAL)	ENTHALPY LIQ (KCALKG)	ENTHALPY VAP (KCALKG)	HYD
P018	0000								
(PIPE)	0001	0.094	0.0001	0.0002	0.0000	0.0534	18.968	0.000	N
	0002	0.094	0.0001	0.0002	0.0000	0.0534	18.903	0.000	N
	0003	0.094	0.0001	0.0002	0.0000	0.0534	18.802	0.000	N
	0004	0.093	0.0001	0.0002	0.0000	0.0534	18.620	0.000	N
	0005	0.093	0.0001	0.0002	0.0000	0.0534	18.448	0.000	N
	...	...	...	...	...	...	...	...	
	0017	0.092	0.0001	0.0002	0.0000	0.0534	16.884	0.000	P
	0018	0.087	0.0001	0.0002	0.0000	0.0534	16.151	41.220	P
	0019	0.084	0.0001	0.0002	0.0000	0.0534	15.561	41.659	P
	0020	0.083	0.0001	0.0002	0.0000	0.0534	15.407	41.818	P
	0021	0.083	0.0001	0.0002	0.0000	0.0534	15.381	41.818	P

HYD列的字母含义
Hydrate Column Label Means

- 在Print Options中的Property Report中选择Full
  - **U** – 不能预测
    Unable to predict
  - **N** – 非水化物区域
    Non-Hydrate Region
  - **P** – 是水化物区域系统自由水不足
    Hydrate region but insufficient free water
  - **I,II** – 将有Type I和Type II水化物生成
    Type 1 and/or Type II hydrates formed



Hydrate Unit Report

UNIT 1, 'H019', 'EVALUATE MEOH INJECTION RATES'

FEED STREAM IS D002

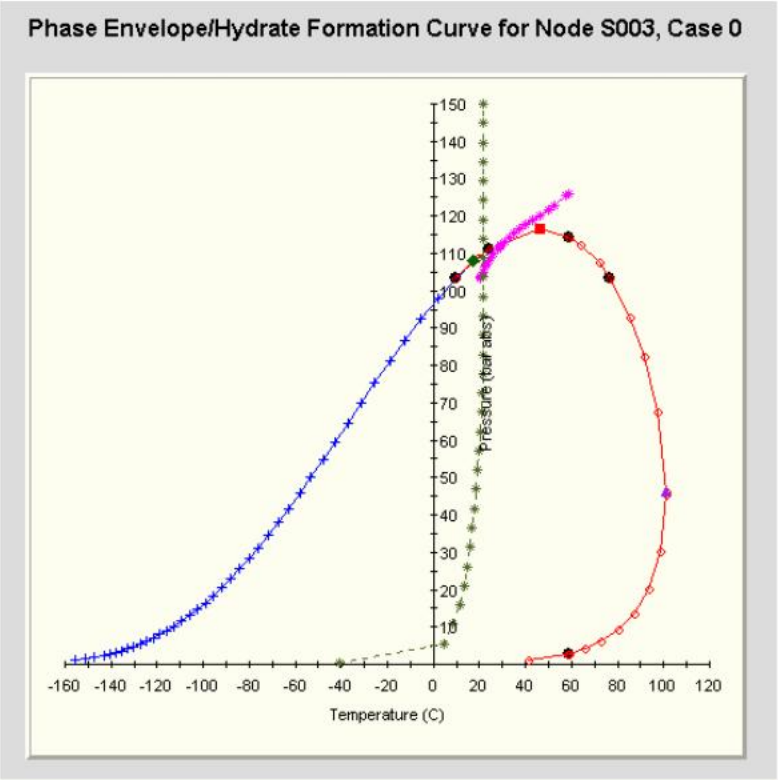
	0.00 PCT. MEOH			20.00 PCT. MEOH			30.00 PCT. MEOH		
	TEMP C	PRESS BAR	FLAGS	TEMP C	PRESS BAR	FLAGS	TEMP C	PRESS BAR	FLAGS
1	-40.61	4.0E-01	* II	-43.49	1.61	* II	-19.49	2.28	II
2	4.37	5.56	II	-16.58	6.73	* II	-11.58	7.37	II
3	8.68	10.72	II	-5.89	11.84	II	-7.97	12.47	II
4	11.29	15.87	II	9.0E-01	16.96	II	-5.49	17.56	II
5	13.14	21.03	II	2.71	22.08	II	-3.72	22.66	II
...	...	...	...	...	...	...	...	...	...
25	21.87	124.21	II	10.37	124.42	II	3.41	124.53	II
26	21.88	129.37	II	10.39	129.53	II	3.42	129.62	II
27	21.88	134.52	II	10.41	134.65	II	3.43	134.72	II
28	21.89	139.68	II	10.42	139.77	II	3.44	139.81	II
29	21.89	144.84	II	10.44	144.88	II	3.45	144.91	II
30	21.89	150.00	II	10.46	150.00	II	3.47	150.00	II

NOTES: I - TYPE I HYDRATE II - TYPE II HYDRATE

* - AT (OR BELOW) THE AQUEOUS ICE TEMPERATURE

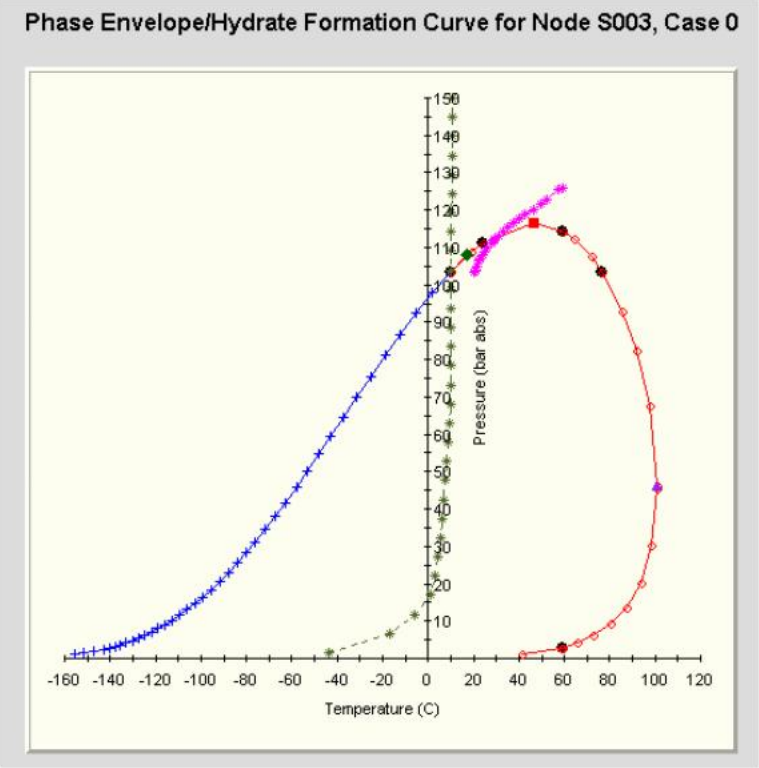
Hydrates Phase Envelopes

- Without MEOH Hydrate Inhibitor



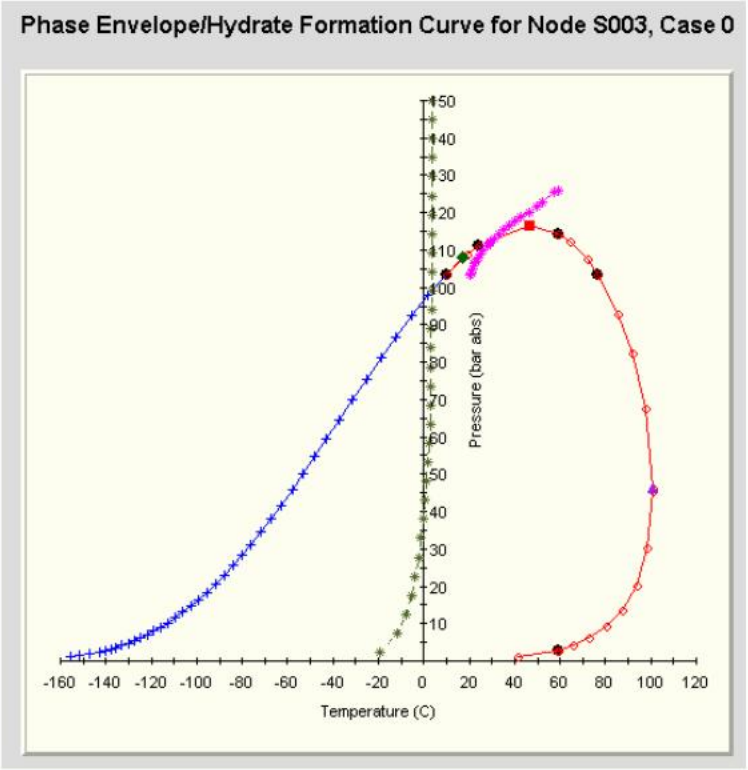
RAS Hydrates Phase Envelopes (Cont'd)

- With 20 wt% MEOH Hydrate Inhibitor



RAS Hydrates Phase Envelopes (Cont'd)

- With 30 wt% MEOH Hydrate Inhibitor



练习 2：
多相流和水化物分析