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Introduction

Heavy oils are rich in asphaltenes; the heaviest and most polar fraction of a crude oil. Asphaltenes are generally defined as a solubility class of materials that are insoluble in nalkanes like n-pentane or n-heptane but soluble in aromatics solvents such as toluene.

Asphaltenes can precipitate along the whole oil production process due to changes in temperature, pressure and composition causing operational problems. During oil production, asphaltenes can block the porous channels of the reservoir rock making oil mobility very difficult. In the transportation process, the asphaltene precipitation makes pumping challenging due to a viscosity increment and at the surface, the oil needs to be blended with diluents to lower its viscosity. In refinery operations asphaltenes can plug refinery equipment increasing the frequency of maintenance intervention procedures.

One of the historical challenges in phase behavior simulation is the prediction of the conditions at which asphaltene precipitation occurs, the amount of precipitate, and the properties of the asphaltene-rich phase. To address these issues, the Symmetry process platform has recently added the **Asphaltene Precipitation for Live Oils** to the list of characterization options available in the Oil Source unit operation, this option is backed up by the Symmetry process platform's own PIONA Molecular based characterization procedure [1].

The characterization is complemented with Asphaltene Onset Pressure and Asphaltene precipitated fraction calculations at given conditions. The calculations can help in the monitoring process of asphaltene precipitation in a flowsheet.

The objective of this communication is to offer a walkthrough of the characterization process of a live oil that contains asphaltenes that may precipitate during oil production and, to highlight tools available in the Symmetry process platform to monitor and detect precipitated asphaltenes. This will be done with the help of an example based on a reservoir fluid described in open literature.

Asphaltene Precipitation for Live Oils

To start the characterization of a live oil or reservoir fluid with asphaltene content, we need the following data set: light ends analysis and Stock Tank properties (SARA distribution in wt %, Oil density, molecular weight (optional) and Gas to Oil ratio). These properties are enough to obtain asphaltene precipitation calculations since they provide the basis of internal correlations that arrange the PIONA slate components in a way that flash calculations can produce an asphaltene-like phase.

If experimental Saturation and Asphaltene Onset Pressures are available, they can be used to tune parameters and match calculated phase boundary pressures.

Gonzalez et al. [2] studied the asphaltene precipitation phase behavior of live oil samples, the following tables show the reported characterization data for one of them that include: stock tank oil properties, light ends analysis, and phase boundaries conditions. This reservoir fluid will be used to exemplify the characterization and tuning procedure for asphaltene precipitation.



STOCK TANK OIL PROPERTIES							
Density (kg/m3) at 60F	919						
GOR (Sm3 / m3)	100.63						
Saturates (wt%)	39.36						
Aromatics (wt%)	36.04						
Resins (wt%)	9.04						
Asphaltenes (wt%)	15.56						

Light Ends Composition							
Component	Mass %						
NITROGEN	0.078						
CARBON DIOXIDE	0.058						
METHANE	4.318						
ETHANE	2.005						
PROPANE	2.266						
ISOBUTANE	0						
n-BUTANE	0.537						
ISOPENTANE	0						
n-PENTANE	2.066						

SATURATION PRESSURES							
Temperature (°C) Pressure (kPa							
26.67	11718						
31.11	12063						
37.78	12752						
65.56	14668						
97.78	16681						

Asphaltene Onset Pressure						
Temperature (°C) Pressure (k						
27	59279					
31.11	55143					
38	46182					
65	34809					
98	31707					

As mentioned above, the asphaltene precipitation procedure in the Symmetry process platform is based on components created from it's PIONA Molecular based characterization; a key part in the characterization procedure is the setup of the PIONA components slate. Let's begin the process by opening a new case using the **Advanced Peng-Robinson** property package with the following pure light end components defined in the previous tables:



Configure Property Package	×
VMGThermo ✓ + Add ✓ Rename 	icate sign Prop I
9 Compounds 1 Flowsheet 0 Unit Ops	
Thermodynamic Models Compounds Settings	
Add Compounds	
Compound search	
9 Compounds	
NITROGEN	Sort
CARBON DIOXIDE	
METHANE	Compare
ETHANE	Clear All
PROPANE	Crowne M
ISOBUTANE	Groups +
n-BUTANE	New Group
ISOPENTANE Q 企 面	
n-PENTANE	
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	Done

Then we can open the **PIONA Slate** environment by clicking on the PIONA button from the previous window. In the PIONA Slate window enter the following values using the *Carbon Number (Cn) Cuts* Slate Style. Note that the *Asphaltene Precipitation* and *Include Aromatics* boxes are checked in order to create an extended list of aromatic and dehydrogenated aromatic components which will represent the Asphaltene–like components. When creating the PIONA Slate, it is recommended to use the Carbon Number (Cn) Cuts Style as this style allows the inclusion of heavy Aromatic and Dehydrogenated aromatic components that can act as asphaltene-like compounds.

VMGThermo - PIONA	Slate					
Hydrocarbon slate properties have been modified. Ready to create HC hydrocarbon slate						
Slate Style O Boiling Point Ran	nges 🔹 Carbon Nur	nber (Cn) C	uts 🔿 Blac	k Oil	Create Slate	e Delete S
Slate Settings		Carbon N	umber (Cn)	Cuts		
Slate Name	нс	Cut	Initial Cn	Final Cn	Initial BP	Final BP
Carbon Number (Cn) Cuts			_		[C]	[C]
No. of Cn Cuts	8	C6 - C9	6	9	36.6	151.3
First Cn Cut		C10 - C14	10	14	151.3	254.0
Starts at Cn	6	C15 - C19	15	19	254.0	331.1
🔺 Last Cn Cut		C20 - C29	20	29	331.1	441.1
Based on Fluid Type	User +	C30 - C49	30	49	441.1	571.1
Starts at Cn	100	C50 - C74	50	74	571.1	678.7
Settings		C75 - C99	75	99	678.7	754.6
Cut Boiling Points from	Katz-Firoozabadi 🕶	C100+	100		754.6	808.1
Viscosity Estimation	API-VMG +					
HAP's Slate		* One Slate	Componen	t per select	ted PIONA fa	mily will be
Asphaltene Precipitation						
Include Aromatics						
PIONA Inclusion	Aromatics Setting	gs	Deny. Arc	omatics sei	tings	
Parattins	Multipliers		H/C Ratio		0.6500	
	_		r iviultipli	ers		
Naphthonos V	-					
Aromatics	-					
Debydrogenated Aromatics	-					
Atomic Inclusion						
N Aromatics						
S Aromatics						
V Aromatics						
Ni Aromatics						
Fe Aromatics						



The asphaltene-like components are Aromatic and Dehydrogenated Aromatic compounds with large Carbon Numbers (Cn > 100). The equation of state (EOS) binary interaction parameters for these components with other non-asphaltene hydrocarbons have been tuned to allow the precipitation of a heavy hydrocarbon phase rich in asphaltene-like components. The EOS binary interaction parameters have been tuned for the following Symmetry process platform's property packages: Advanced Peng-Robinson, Advanced Peng-Robinson for Natural Gas, Advanced Peng-Robinson for Natural Gas 2 and Refinery-APR.

Once the PIONA Slate window is set up click on the Create Slate button to add the PIONA based components to the property package. Now, we are ready to start the characterization procedure.

Go to the flowsheeting environment, change the Unit Set to *SI* and add an Oil Source unit operation. Open the unit operation and select *Oil / Refinery* as the Application type and check the *Asphaltene Precipitation (Live Oil)* box. Observe that the Cut Ranges option is automatically enabled, this is because the Asphaltene Precipitation characterization will be based on cut ranges that will be defined by the SARA Distribution, light ends composition and the Yield and Density factors from the Settings tab.

🛢 🏮 /OilFeed1 (Oil Source					₩ _	• ×
		Missing SARA Distrib	ution			
Name OilFeed1					De	scription ~
		•				3
Load from HCAMS Load from DB	Save to I	DB				
Application						
🔿 Tight Fluids 🔎 Oil / Refinery	Deasphalt	ing 📀 Black Oil	_			
Summary Yields (Cut Range)	Saturation	/ Asphaltene Onset P	Settings	Equilibrium Results	Notes	Help
✓ Laboratory Analyses	×	Bulk Experimental Varia	ables			
Cut Ranges Cut Ranges Inputs PIONA Distribution	Na Sto Sto Sto Ga	ames ock Tank Oil Density [kg/i ock Tank Oil MW is to Oil Ratio (GOR) [Sm ²	Active m3]	Specified Calculat	ed Scale 1.0000 1.00	
Atomic Inclusion		Ontions	,,	SARA Distrib (Sto	ck Tank Oil)	
Properties		Reference Conditions		Saturates (mass) [%]		
Asphaltene Precipitation (Live Oil)		Source	Global 🗸	Aromatics (mass) [%]		
		Liq. Ref. T [C]	15.6	Resins (mass) [%]		
		Liq. Ref. P [kPa]	101.33	Asphaltenes (mass) [9	6] 🗸 🗸	
	As	phaltene Calculations				
Material						
PortName Out						^
Is Recycle Port						
Connected Stream/Unit Op	-					
VapFrac						
P [KPa] Mole Flow (kmal/b)						
Mass Flow [km0]/h]						
Volume Flow [m3/h]						
Std Lig Volume Flow [m3/h]						~
Regress Parameters Custom Regre	ssion Case					Ignore

Now enter the SARA distribution information from the tables above.



🛢 🗧 🛛 /OilFeed1 (Oil	Source)				L	□ ×
Name OilFeed1	lissing Live Oil Ligh	t Ends composition. Please ent	er data in Yileo	ds (Cut Range) tab	Des	cription ~
Load from HCAMS Load f Application • Tight Fluids • Oil / Ref Summary Yields (Cut Ra	from DB/ Save finery Deasp l ange) Saturati	to DB halting OBlack Oil	Settings	Equilibrium Results	Notes	Help
✓ Laboratory Analyses Cut Ranges ✓ Cut Ranges Inputs PIONA Distribution Atomic Inclusion Properties Asphaltene Precipitation (Live C		✓ Bulk Experimental Variat Names Stock Tank Oil Density [kg/m Stock Tank Oil MW Gas to Oil Ratio (GOR) [Sm3/ ✓ Options ✓ Reference Conditions Source Liq. Ref. T [C] Liq. Ref. T [C] Liq. Ref. P [kPa] Asphaltene Calculations	Active 3] m3] Global+ 15.6 101.33	Specified Calculated SARA Distrib. (Stock Saturates (mass) [%] Resins (mass) [%] Asphaltenes (mass) [%]	Scale 1.0000 1.00 1.00 Tank Oil) 39.36 36.04 9.04 15.56	
Material PortName Is Recycle Port Connected Stream/Unit Op VapFrac T [C] P [kPa] Mole Flow [kmol/h] Mass Flow [kg/h] Volume Flow [m3/h] Std Li Volume Flow [m3/h]	Out					
Regress Parameters Custor	m Regression Cas	ie			[Ignore

Note that the status bar is now asking for the Light Ends composition; to add it go to the Yields (Cut Range) tab and enter it in the corresponding frame.



Now, observe that five Cut Ranges have been automatically defined (Light Ends, Cut_1, Cut_2, Cut_3 and Asphaltenes), the last cut represents the asphaltene fraction and its yield has been normalized based on the stock tank asphaltene content and light ends information.



We now need to tune some parameters to find the best slate composition that matches the experimental asphaltene precipitation data. Go back to the Summary tab and enter the Stock Tank properties and define the following P, T and Mole Flow in the Material port: 60 C, 101.325 kPa and 1 kmol/h.

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		Solved				
Name OilFeed1						Description ~
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Load from HCAMS Load fr	om DB Save	to DB				
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Settings	Equilibrium Re	sults	Notes		Help	
Summary	Yields (Cut Ra	inge)	Saturation / As	phaltene	Onset P	
✓ Laboratory Analyses		✓ Bulk Experimental V	ariables			
Cut Ranges	I	Names	Active	Specified	alculated	Scale
Cut Ranges		Stock Tank Oil Density [kg/m3]	919.00	887.359	3 1.0000
Inputs		Stock Tank Oil MW			193.8	32 1.00
PIONA Distribution		Gas to Oil Ratio (GOR) [5	Sm3/m3]	100.	63 96.5	59 1.00
Atomic Inclusion		X Options			Distrib (Stock	Tank Oil)
Properties	Image: A state of the state	✓ Options		* SANA L	JISTIID. (SLOCK	
Asphaltene Precipitation (Live O	il) 🗹	Reference Conditions		Saturates	(mass) [%]	39.36
		Source	Global+	Aromatic	s (mass) [%]	36.04
		LIQ. RET. I [C]	15.6	Resins (m	(ass) [%]	9.04
		LIQ. RET. P [KPa]	101.33	Asphalter	nes (mass) [%]	15.56
		Asphaltene Calculations				
Material						
PortName	Out					^
Is Recycle Port						
Connected Stream/Unit Op	-					
VapFrac	0.56704					
T [C]	60.0					
P [kPa]	101.33					
Mole Flow [kmol/h]	1.00					
Mass Flow [kg/h]	114.62					
Volume Flow [m3/h]	15.485					
Std Liq Volume Flow [m3/h]	0.147					
Std Gas Volume Flow [Sm3/d]	5.6857E+2					*
Regress Parameters Custom	Regression Cas	se				Ign ored

The next step is to add the vapor pressure data. Go to the **Saturation / Asphaltene Onset P** tab and enter the Saturation Pressure data from Gonzalez et al. [2]:





The Saturation pressure data is calculated based on the defined cut ranges which depend on the *Yield* and *Density Regression Parameters* from the **Settings** tab. To match the data, we need to tune these parameters and to accelerate the solution set the *Max. Iteration* parameter to *50* in the **Settings** tab, then click on the *Regress Parameters* button to run a regression that will match the Saturation Pressure and Stock tank properties by manipulating the Regression Parameters.



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		Ready to regress pa	rameters				
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oad from HCAMS Load	from DB Save t	o DB					
Application							
O Tight Fluids • Oil / Re	finery ODeaspha	alting 🛛 Black Oi	i				
Summary	Yields (Cut Ran	ge)	Satura	ation / Asphaltene	Onset P		
Settings	Equilibrium Res	ults	Note	S	Help		
Load Parameters for Aspha	ltene 🕶			_			
✓ Main Settings		✓ Regressed Par	ameters				
Cut Group Delta T [C]	20.00	Split P	2.00				
PIONA Distrib, Delta T [C]	405.00	Split I	2.00				
A Regression		Split O	0.00				
Max. Iterations	50	Split N	1.50				
Regression Tolerance	0.1000	Split A	1.00				
Optimization Method	Nelder Mead +	Split Adh	0.3500				
Obj. Function Type	Least Squares -	Yield Factor 1	2.30				
✓ PIONA Family Inclusion		Yield Factor 2	1.49				
Desetting Includion		Density Factor 1	1.00				
Paramins		Density Factor 2	715.00				
Olefee		Alpha (Asp)	3.00				
Naphthanas Z		Eta (Asp)	1000.00				
Napittieries		MW (Asp)	2500.00				
Aromatics							

Once it is done (it may take a few minutes depending on the computer) observe the new results:

🛢 🌻 🛛 /OilFeed1 (Oil	Source)					μ.		• •
		Ready to regress para	meters					
Name OilFeed1							Desc	cription -
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Load from HCAMS Load f	rom DB Save	e to DB						
Application								
🔿 Tight Fluids 🌘 Oil / Ref	finery ODeasp	halting 🛛 Black Oil						
Settings	Equilibrium Re	esults	Notes		1	Help		
Summary	Yields (Cut Ra	ange)	Saturatio	n / As	phaltene Or	nset P		
✓ Laboratory Analyses		✓ Bulk Experimental	Variables					
Cut Ranges	~	Names	μ	ctive	Specified	Calculate	d :	Scale
Cut Ranges		Stock Tank Oil Density	[kg/m3]	-	919.0000	905.5	467	1.0000
Inputs		Stock Tank Oil MW				17	4.91	1.00
PIONA Distribution		Gas to Oil Ratio (GOR)	[Sm3/m3]	 Image: A set of the set of the	100.63	9	8.85	1.00
Atomic Inclusion						trib (Sto	ck Tar	
Properties	~				· JAIN DIS			
Asphaltene Precipitation (Live C	Dil) 🔽	A Reference Condition	is and		Saturates (n	nass) [%]		39.36
		Source	GIO		Aromatics (mass) [%]	-	36.04
		Liq. Ker. T [C]	10	15.0	Resins (mas	S) [76]		9.04
		Asphaltene Calculation		1.33	Asphaitene	s (mass) (s	0]	5.50
Material								
PortName	Out							1
Is Recycle Port								
Connected Stream/Unit Op	-							
VapFrac	0.55245							
T [C]	60.0							
P [kPa]	101.33							
Mole Flow [kmol/h]	1.00							
Mass Flow [kg/h]	108.38							
Volume Flow [m3/h]	15.070							
Std Liq Volume Flow [m3/h]	0.137	,						
Std Gas Volume Flow [Sm3/d]	5.6857E+2							
Regress Parameters Custor	n Regression Ca	se					E	Ignore



🛢 🏮 /OilFeed1 (O	il Source)		⊥ _
	Ready to re	gress parameters	
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		_	1
		•	
Load from HCAMS Load	from DB Save to DB		
Application			
🗆 Tight Fluids 🌘 Oil / R	efinery ODeasphalting OB	lack Oil	
Settings	Equilibrium Results	Notes H	Help
Summary	Yields (Cut Range)	Saturation / Asphaltene On	iset P
Sat P Points Asphaltene Onset P (AOP) C T Sat P Specified [C] [kPa] 26.7 11718.00 31.1 12063.00 37.8 12752.00 97.8 16681.00	Sat P Calculated Scale (RPa) (RPa) 0 12281.90 12007.29 100.00 0 13078.91 0 14827.29 0 16452.00	16000 15500 15500 15000 14500 14500 13000 13000	P Sat.(Spec.) P Sat. (Calc.)
		12000 12000 1500 20 40 60 80 100 Temperature [C] X = 50.1370, Y = 10518.46	
Regress Parameters Cust	om Regression Case		Ignore

Note how the Yield and Density parameters had been adjusted to match the Saturation Pressure and Stock Tank Oil properties. Now click on the *Asphaltene Onset P (AOP) Curve* box from the Saturation / Asphaltene Onset P tab to add the asphaltene onset pressure data from Gonzalez et al. [2].

🛢 🏮 /OilFeed1 (Oil Source)			≖ _
	Solved		
Name OilFeed1	-		Description ~
Load from HCAMS Load from DB Application	Save to DB		
Summary Yields (Cut Range) Sa	turation / Asphaltene Onset P	Settings Equilibrium Results	Notes Help
Options Saturation P (Sat P) Curve Sat P Points Asphaltene Onset P (AOP) Curve AOP Phase Frac Criterion # Apphaltene Distribution Parameters Alpha (Asp) Regress Asphaltene Distribution Parameters T Sat P Specified Sat P Specified Sat P Specified Sat P Specified T I(Pa) I(Pa)		a construction of the second s	P Sat.(Spec.) P Sat. (Calc.) Onset P (Spec.) Onset P (Calc.)
<	>		
	an Casa		Ignored



Observe that there is an extra parameter called *AOP Phase Frac Criterion*, this is the mole phase fraction value at which one can consider the appearance of an asphaltene phase. The default value is 1E-06 but can be customized or used as tuning parameter if necessary.

Now click on the *Regress Asphaltene Distribution Parameters* button, this will adjust the average molecular weight of asphaltenes, MW (Asp) parameter, to match the asphaltene onset pressure. Once the regression is done observe the new results.

🛢 🔻 🛛 /OilFeed1 (Oil Source)	≖ ∣_ = ×
Regressed	
Name OilFeed1	Description ~
Load from HCAMS Load from DB Save to DB Application	36
Summary Yields (Cut Range) Saturation / Asphaltene Onset P Settings Equilibrium Results	Notes Help
Options Saturation P (Sat P) Curve Saturation P (Sat P) (Saturation P (Saturation P (Saturation P (Sat P) (Saturation P (SaturationP (Saturation P (Saturation P (S	P Sat.(Spec.) P Sat. (Calc.) P Sat. (Calc.) Onset P (Spec.) Onset P (Calc.)
[C] [kPa] [kPa] [kPa] Temperature [C] 65.0 34809.00 34199.87 1.00 X = 131.090, Y = 84.5070 98.0 31707.00 26614.13 1.00 × X = 131.090, Y = 84.5070	1
Regress Parameters Custom Regression Case	Ignored

Now the Oil Source has found the best fluid compositions that can match Stock Tank, Saturation and Asphaltene Onset Pressure data.

We can do now more studies using other tools from the Oil Source, like plotting saturation and asphaltene onset pressure lines with no more tuning required. To do, so go back to the Summary tab and click the *Asphaltene Calculations* box from the *Options* frame.



🛢 🌻 🛛 /OilFeed1 (Oil S	ource)				Ŧ	_ = ×
		So	lved			
Name OilFeed1						Description ~
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Load from HCAMS Load from	om DB Save	to DB				
Application						
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Settings	Equilibrium	Results	Notes		Help	
Summary Yields	(Cut Range)	Saturation /	Asphaltene Ons	et P	Asphaltene Calcu	lations
✓ Laboratory Analyses		✓ Bulk Experimental \	/ariables			
Cut Ranges	~	Names	Active	Specified Cal	culated Scale	
Cut Ranges		Stock Tank Oil Density	[kg/m3]	919.0000	905.3310 1.0000	
Inputs		Stock Tank Oil MW			174.81 1.00	
PIONA Distribution		Gas to Oil Ratio (GOR)	[Sm3/m3]	100.63	98.82 1.00	
Atomic Inclusion					(C) 1 7 1 0 10	
Properties		✓ Options		✓ SARA Distrib	. (Stock Tank Oil)	
Asphaltene Precipitation (Live Oi		Reference Conditions	5	Saturates (mass) [%] 39.36	
and a second		Source	Global v	Aromatics (mas	s) [%] 36.04	
		Liq. Ref. T [C]	15.6	Resins (mass) [9	6] 9.04	
		Liq. Ref. P (HPe)	101.22	Asphaltenes (m	ass) [%] 15.56	
		Asphaltene Calculations	5			
Material						
PortName	Out					^
Is Recycle Port						
Connected Stream/Unit Op	-					
VapFrac	0.5522					
T [C]	60.0					
P [kPa]	101.33					
Mole Flow [kmol/h]	1.00					
Mass Flow [kg/h]	108.35					
Volume Flow [m3/h]	15.063					
Std Liq Volume Flow [m3/h]	0.137					
Std Gas Volume Flow [Sm3/d]	5.6857E+2					~
Regress Parameters Custom	Regression Cas	e				Ignore

This enables a new tab called Asphaltene Calculations. Here single point or envelope onset pressure calculations can be done. The calculation results can be reported in Table or Plot formats:

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					Solved								
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O Tight Fluids • Oil	/ Refiner	y O Deasp	halting) Blac	COIL								
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Options			Asphalt	ene On	set Pressu	re							
Asphaltene Onset Pressu Asphaltene Envelope Solvent Deasphalting Dat Asphaltene Onset Press AOP Phase Frac Criterion	ta sure 1.00E		Name AOP [kPa Vapor P Lower A0 Asphalto	a] [kPa] DP [kPa ene Env	 Value 3578 1453 1453 753 relope 	82.51 82.51 82.51	0	100					
Lower AOP		5.0	[C]	ture 10.0	AOP [kPa]	Vapo [kPa]	r P 04.11	[kPa]					
Vapor P	Ľ			20.0	74160.01	117	93.59	2485.00					
Asphaltene Envelope Asph. Env. Phase Frac Cri	iterion	.00E-06		30.0 40.0	57546.99 48254.06	125	46.99 54.06	3171.99 4754.06					
Min. Temperature [C] Max. Temperature [C]		10.0		50.0 60.0	40165.48 35782.51	139 145	15.48 32.51	6165.48 7532.51					
Low AOP Envelope	L	10		70.0	32294.24	151	06.74	8919.24					
Vapor P Envelope		-		80.0	29702.41	156	39.91	10108.66					
View Option		Table -		100.0	26582.61	165	89.93	12054.05					
Regress Parameters	ustom Re	gression Ca	se									Ign	ored

The Plot option shows the phase boundary lines between asphaltene, vapor and liquid phases; this plot can help user to identify the conditions for region where asphaltene precipitation may or may not happen.





A Material Stream that contains asphaltene–like components can monitor their formation based on the temperature and pressure condition of the stream. To see how this works connect a Material Stream to the characterized Oil Source.



In the Material Stream, go to the More Properties tab and check the *Solids Formation* box, this will open a new tab called **Solids Formation**.



	Solved		
ame S1			Description
Dec From			Is Recyc
Refinery	Solids Formation	Settings	Notes
Summary	Equilibrium Results M	ore Properties	Line Sizing
Emissions - Flash Emissi Natural Gas - Compor Phase Flows - Gas, Oil Phase Boundaries - En Hydrocarbon Propertie Thermal Properties - C Extended Physical Prop Solids Formation - Hyc	ions, CO2 Equivalence, etc. ent Content, Gas SG, NGL Content, etc and Water Flows, GOR, Water Cut, etc. lelope, Bubble Point, Dew Point, etc. s - API Gravity, Viscosity, RON, MON, b, H, S, etc. erties - Cp/Cv, dp/dV, Z, etc. rates, Waxes, Solids		

In the Solids Formation Box, open the Asphaltene node to observe the different calculations for asphaltenes.

→ 🗧 🛛 /S1 (Mate	erial Stream)			∓ _		
		Solved				
Name S1				Description ~		
Spec From				Is Recycle		
Summary	Equilibrium Results	Мо	re Properties	Line Sizing		
Refinery	Solids Formation		Settings	Notes		
Conditions Name > Value Current T [C]	e 60.0		Phase Envelope	Unit Operation for more		
Current P [kPa] 1000 > Hydrate	00.00		information on Solid Formation Curves Hydrate Add a Hydrate Unit Operation for more information on Hydrate formation			
> Wax						
Name		> Value				
Is Formed		✓				
Phase Frac (Mole) [Fract	ion]	0.0004	8			
Asphaltene Onset Pressu	ure (AOP) [kPa]	35782.5	1			
Lower Asphaltene Onset	Pressure (AOP) [kPa]	7532.5	1			
AOP Phase Frac Criterio	n	1.00E-0	6			
AOP App P [kPa]		-2467.4892	5			
Formation Warnings		_				
Warning App P [kPa]		100.0	0			
> Solid						
Create Port Delete P	ort			Ignored		

The calculations include a box to know if the Asphaltenes are formed, the asphaltene mole phase fraction, the Asphaltene Onset Pressure and Approach Pressure, and a box to activate Formation Warnings. The last box is used to set up Material Stream asphaltene formation alarms; if asphaltenes are formed, the status bar of the Material Stream will turn red and show a message about the possible formation. Activate the Formation Warnings box and change the Oil Source Material Port Pressure to 10 MPa, now observe the message in the Material Stream status bar:



\rightarrow = /S1 (Material Stream)				₩ .	•	×
Asphaltene forms at these Stre	am condition	ns (A	pproach P [kPa] = -2.4	7e+03)		
Name S1					Descript	tion
Spec From				•••	🗌 ls Re	cycl
Summary Equilibrium Results	N	lore	Properties	Line S	Sizing	
Refinery Solids Formation		:	Settings	Note	es	
Conditions Name > Value Current T [C] 60.0 Current P [kPa] 10000.00			Phase Envelope	Jnit Opera lid Forma	ation for tion Curv	mor es
 > Hydrate > Wax > Asphaltene 			Hydrate Add a Hydrate Uni information on Hy	it Operati drate forr	on for mo mation	ore
Name	> Value					
Is Formed	~					
Phase Frac (Mole) [Fraction]	0.00	048				
Asphaltene Onset Pressure (AOP) [kPa]	35782	.51				
Lower Asphaltene Onset Pressure (AOP) [kPa]	7532	2.51				
AOP Phase Frac Criterion	1.00E	-06				
AOP App P [kPa]	-2467.48	925				
Formation Warnings	~	_				
Warning App P [kPa]	100	.00				
> Solid						
Create Port Delete Port					🗌 lg	nore

In a flowsheet environment, these alarms can be set up in any Material Stream providing a monitoring asphaltene formation system into your Symmetry process platform flowsheet.

References

[1] Loria, H. "PIONA Characterization in VMGSim 8.0" VMG's Technical Newsletter, December 2013.

[2] Gonzalez, D. L.; Mahmoodaghdam, E.; Lim, F.; Joshi, N. *Effects of Gas Additions to Deepwater Gulf of Mexico Reservoir Oil: Experimental Investigation of Asphaltene Precipitation and Deposition*. SPE 159098

To learn more about the Symmetry Process Software Platform please contact your local Schlumberger office.



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