# Phase Behaviour Modelling from Confined Reservoirs in Symmetry* Process Software Platform

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## Introduction

A couple of decades ago, production from shale reservoirs with pore sizes in the range of nanometer was unthinkable. Several earlier studies on the effect of confinement on phase behaviour underestimate the value of their work assuming there is no realistic application. However, in recent years two technologies have mainly contributed to the increase in production from unconventional reservoirs - horizontal drilling and hydraulic fracturing.

One of the challenges in the simulation of such reservoirs is the alteration of PVT in confinement. This alteration is mainly dictated by the size of the pores and the resulting capillary pressure. Capillary pressure introduces different pressures in vapour and liquid phases which shift the fugacity values in the flash calculation. As a result of these phenomena, saturation pressure is decreased meaning light components stay in the hydrocarbon phase for a longer time. As a result, the hydrocarbon phase would have a lower viscosity, formation volume factor would be higher and GOR is going to stay constant at a larger pressure range before it drops.

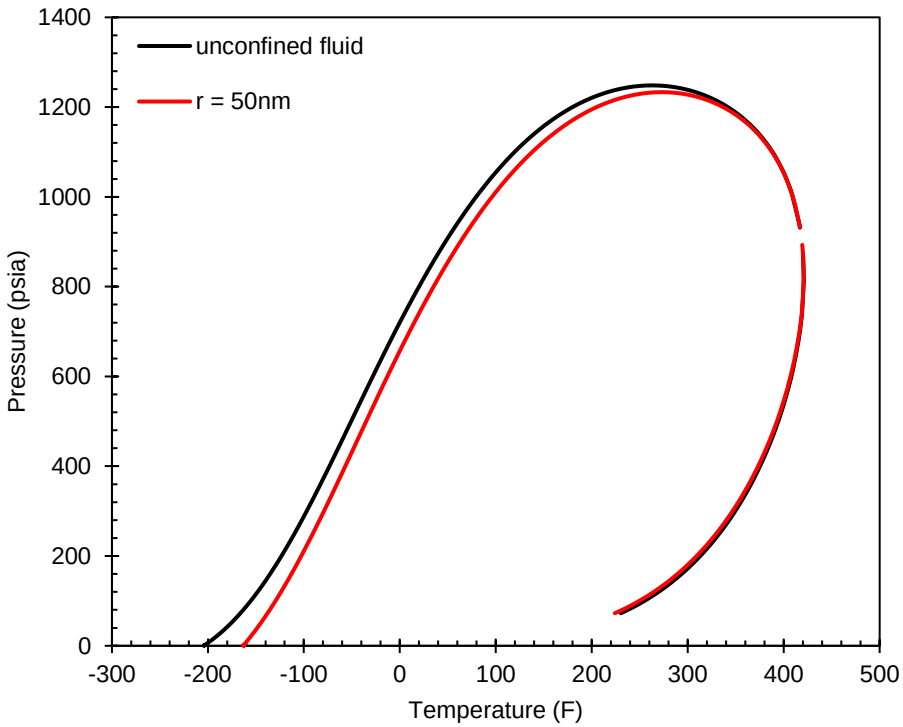



Figure 1. Pore size effect on the saturation pressure in binary system of 30% methane and 70% hexane

## Equation of State Modelling for Confined Fluids

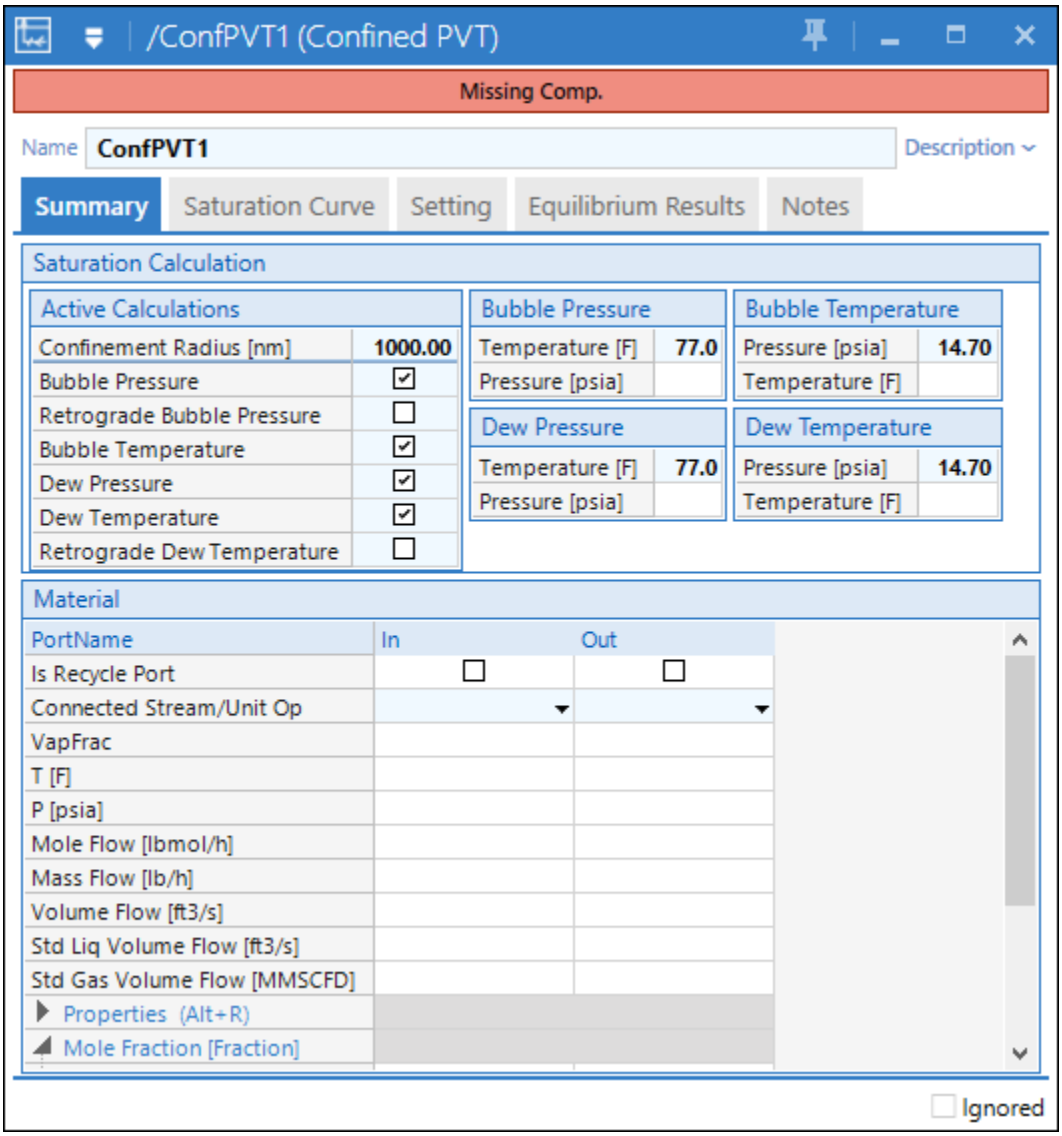
In Symmetry, the phase behavior modelling for confined fluid is done in the new “Confined PVT” unit operation. The unit operation can be found under the Property Calculations menu.


In addition to the typical input for flash calculation (pressure and/or temperature and feed composition), pore size (in nm) is also needed to perform these calculations. By reducing the pore radius, saturation properties start deviating from bulk properties. To use this unit operation the following steps must be followed:

1) Provide the composition of the fluid based on mole fraction or weight fraction
2) Specify the confinement radius
3) Perform the PVT calculations; there are four equilibrium calculation available in this calculator:
    I. Bubble Pressure
    II. Bubble Temperature
    III. Dew Pressure
    IV. Dew Temperature

These calculations can be done as a single point calculation in the Summary tab or for a range of conditions provided by the user in the Saturation Curve tab.

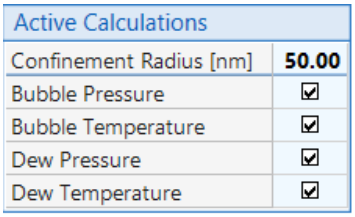
*Note: Currently these calculations are made assuming vapor-liquid equilibrium.*




The model can be used for phase behavior modelling of reservoir fluids. The below example is for fluid from the Bakken field. The pure components with averaged properties similar to hypos from Nojabaei et al [1] have been used.

| Component | Mole fraction |
|---|---|
| methane | 0.3674 |
| ethane | 0.1489 |
| propane | 0.0933 |
| n-butane | 0.0575 |
| n-pentane | 0.0641 |
| n-decane | 0.1585 |
| n-heptadecane | 0.0733 |
| n-hexapentacontane | 0.0370 |

The "Confinement Radius" is specified based on the reservoir characteristics in the **Summary tab**.




Figures 2 and 3 show bubble pressure, bubble temperature, dew pressure and dew temperature for two different pore sizes. Observe the properties change with respect to the pore size.

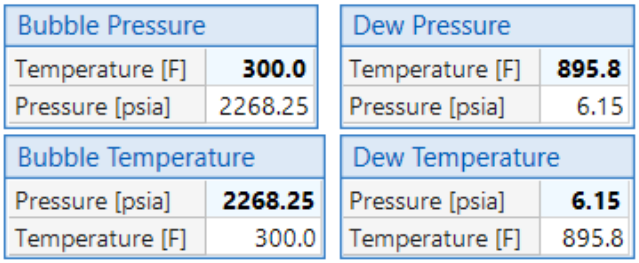



Figure 2. Saturation properties for fluids from Bakken field in 50 nm pore size

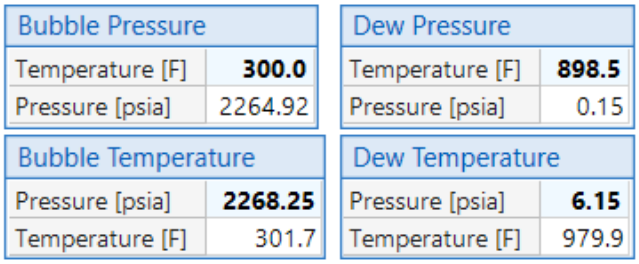
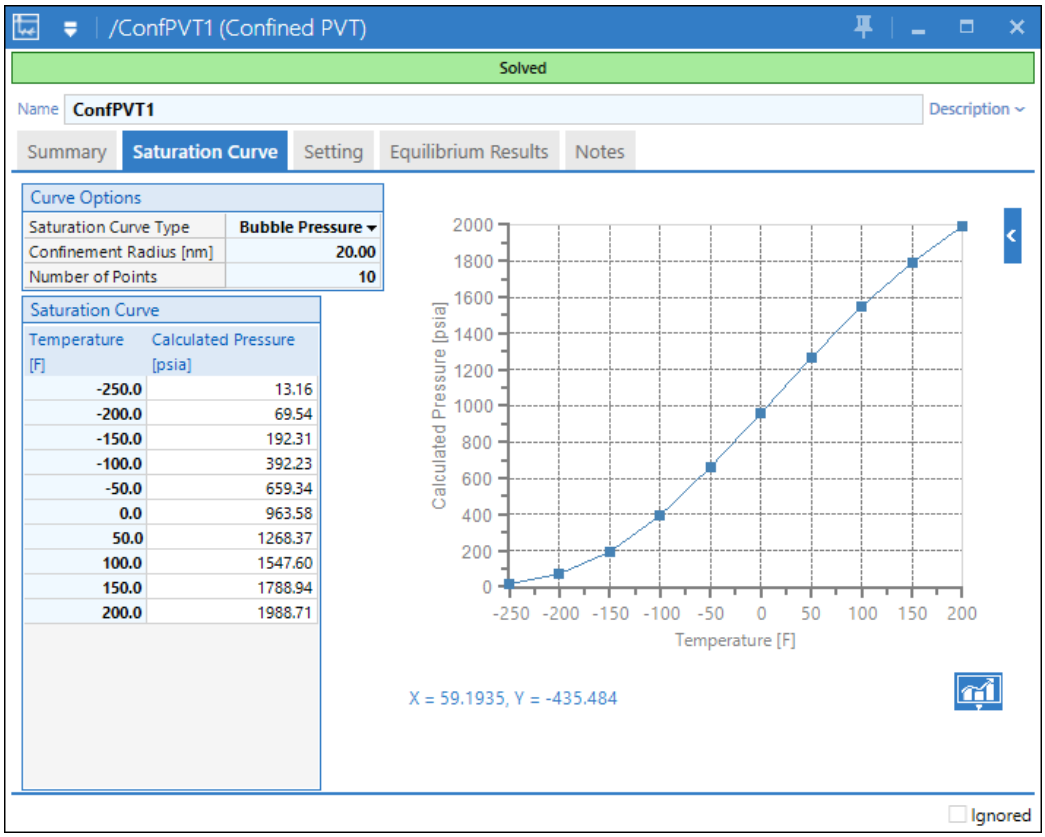



Figure 3. Saturation properties for fluids from Bakken field in 10 nm pore size

Saturation properties can be calculated for reservoir conditions in the Saturation Curve tab. Bubble Pressure, Bubble Temperature, Dew Pressure, and Dew Temperature can be selected as the "Saturation Curve Type". The "Confinement Radius" can be changed and it is independent from the one in the Summary Tab, this variable can be used in Case Studies as an Independent variable to study the phase behavior with respect to the pore size, as seen in Figure 4. The "Number of Points" can also be set to an appropriate value for needed resolution.



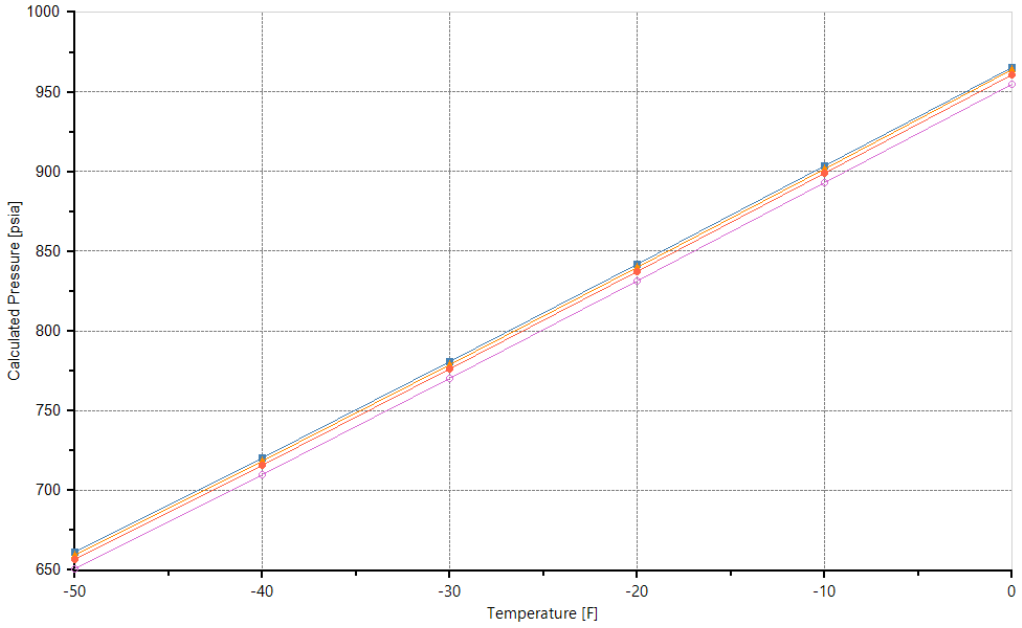




Figure 4. Saturation pressure curve for fluids from Bakken field in different pore sizes. Blue, orange, red, and purple are 50 nm, 20 nm, 10 nm, and 5 nm; respectively.

## References

[1] Nojabaei, B., Johns, R.T. and Chu, L., 2013. Effect of capillary pressure on phase behavior in tight rocks and shales. SPE Reservoir Evaluation & Engineering, 16(03), pp.281-289.

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

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