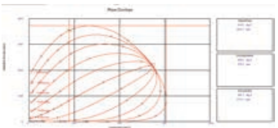
Petex

PVTP

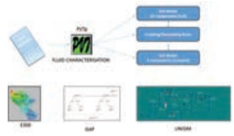
THERMODYNAMICS FLUID CHARACTERISATION PACKAGE

MATCHING ON LAB EXPERIMENTS

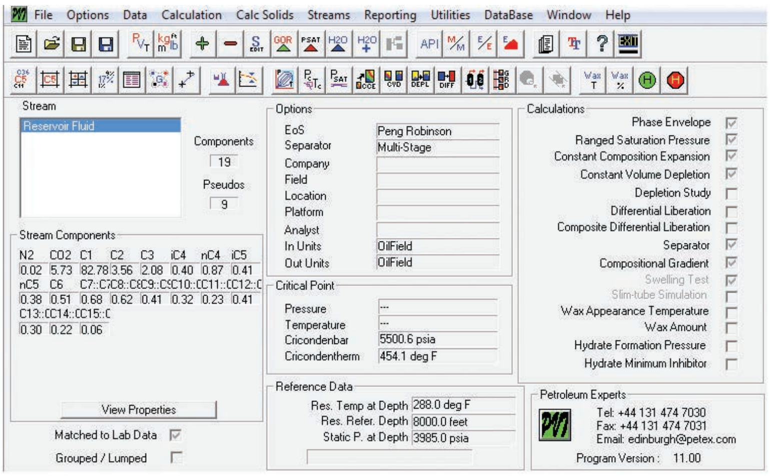
FLUID CHARACTERISATION



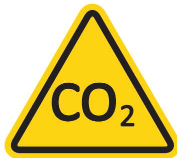
LUMPING /DELUMPING



HYDRATES

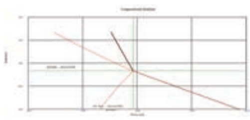


CARBON DIOXIDE

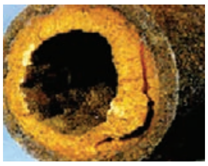


SALT PRECIPITATION

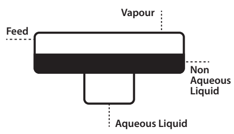
COMPOSITIONAL GRADIENTS



WAX FORMATION



3-PHASE FLASH CALCULATIONS



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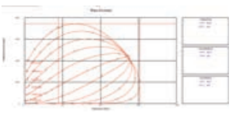

The IPM suite of applications was created to allow for integrated systems to be constructed, therefore eliminating artificial boundary conditions that engineers would have to impose on models of individual parts of any production or injection system. The basis of any integrated model is a solid and consistent PVT definition, which respects the behaviour of any fluid when it flows in the reservoir, in wells, in pipes and beyond. Traditional approaches of modelling each part of the system in isolation relied on PVT models that were bespoke and created for a single specific use. Integrated Models present challenges of not only ensuring that the same description is valid for any part of the system, but also in a vendor neutral environment, ensuring that different software from different vendors communicate dynamically and receive or pass PVT information that works for their own domain. An integrated model with reservoir simulation, facilities and process models from three or more vendors needs to ensure that the limited number of components or black oil models used in the reservoir simulator are translated into full blown compositions of large component numbers used in process models.

PVTP was created with the objective of not only creating thermodynamically consistent and precise Equation of State models for fluids, but also to deliver these models in ways that can satisfy the vendor neutral principles of integrated modelling. Unique lumping/delumping algorithms have been embedded into the program which satisfy this role and enable engineers to create integrated systems in a straight forward manner and with confidence that consistency in fluid thermodynamics is achieved.

MATCHING ON LAB EXPERIMENTS

PVT analysis and EOS creation is based on lab experiments and PVTP enables the user to perform these tasks by matching compositions to data available on CCE, CVD, Differential Liberation, Separator Tests and many others. Special treatment of pseudo components exists with quality checks that enable a consistent set of parameters to be used along the process. The program has been designed with flexibility in mind, so that procedures different companies rely on as standards in their organisation can be accommodated for. When matching the EOS models to lab data, PVTP offers a variety of regression techniques. The ones Petex recommends ensure monotonicity in the properties of the components being regressed on, so that consistency in the results can be guaranteed. Unique features in this domain include, but are not limited to:

- Proprietary database of component properties
- Preconditioning of Pseudo properties based on Standing-Katz or Costald models
- Special models for BI coefficients (reliable for pseudo components)
- Proprietary algorithms for pseudo component splitting or lumping
- Volume shift initialisation based on component densities
- Ability to invoke either traditional EOS based or black oil models for viscosity
- Advanced phase detection calculations
- Modifiers that overcome traditional limitations of EOS models in CO2 rich fluids

PVTP

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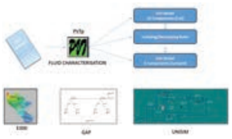
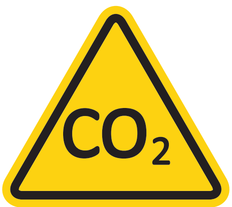
LUMPING /DELUMPING



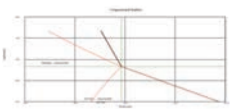
As mentioned at the introduction of this document, the foundations of an integrated model rely on a strong PVT definition that holds across applications from multiple vendors. The role of PVTP has always been as a platform that not only provides the engine for PVT calculations for all the Petex software, but also to facilitate characterisations that are applicable in such integrated modelling efforts. To this end, proprietary Lumping/Delumping schemes have been developed, uniquely associated with the implicit generation of rules that enable the recipient software to either lump or delump compositions that can seamlessly be used from reservoir to process. Traditional techniques (such as using marker components) for the same purpose have been of limited use and only work in certain conditions. The novel approach used in PVTP allows the resulting compositions to carry with them the rules by which they were created. These same rules can then be used by the recipient programs (such as RESOLVE) to have the fundamental methods by which the full compositions have been lumped and as such, enable delumping to be done in a consistent and generic fashion.

CARBON DIOXIDE



The Peng Robinson and SRK EOS models in their original form have well known limitations when dealing with polar molecules, such as water and CO2. For CO2 in particular, normal practice in the industry has traditionally been to use bespoke equations of state for 100% C02 (e.g. Span and Wagner). This approach has severe limitations for field applications, as mixtures are not handled and also, many recipient programs (such as reservoir simulators) only work with traditional EOS descriptions. To overcome these limitations, Petex spent a considerable amount of time in researching how traditional EOS models could be modified to predict accurately properties of CO2 and the result of this has been to create a unique correction that is now available to all the IPM software when the Peng-Robinson EOS model is used. PVTP can model all of the properties of C02 up to 20,000psig, in line with the NIST data, and capturing both dense and light phases depending on pressure and temperature.

COMPOSITIONAL GRADIENTS



In reservoirs with significant pay thickness, gravity segregation of components will cause a change in fluid properties with depth. This will in turn lead to the reservoir pressure and the bubble point of the fluid being different from the top to the bottom of the structure. As samples depend on the depth from which the fluid is obtained, models need to take into account how the fluids change with depth, not relying on a fixed description obtained at the sampling depth. The compositional gradient function in PVTP, allows the user to characterise the equation of state based on the sample characteristics, and then using this description, to generate a variable composition and hence properties with depth. This can then be fed directly into the reservoir model, giving a more accurate fluid characterisation over the whole reservoir.

PVTP

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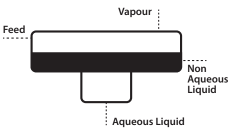
WAX FORMATION

Wax deposition can create significant problems in fields where fluids have the potential to drop out paraffinic compounds. This phenomena depends on the the pressure and temperature condition of flow. Being able to understand this behaviour and create suitable operating envelopes is paramount in such situations. PVTP includes models that can predict wax deposition envelopes as well as amount of wax to be deposited at a given set of conditions. The models are based on Won's original work, which analyses the behaviour of a fluid based on a thermodynamic cycle and the changes in Gibbs free energy along various paths. Various modifications to this model have been proposed, improving on the assumptions made by Won and these are also included in PVTP. These include the Won model with solubility parameters, two versions of a model by Chung and also the wax model by Pedersen.

3-PHASE FLASH CALCULATIONS



PVTP includes two and three phase flash engines that facilitate a range of calculations depending on the desired outcome. The Soreide and Whitson method provides the basis of the three phase flash with two more models being available from Hydrafact (Cubic and Cubic Pus Association). The speed penalty that has traditionally restricted the use of these models to very specialised domains, can be overcome by using a proprietary algorithm, referred to as “Pseudo Multi Phase”. This is the result of internal research on speeding up three phase flashes and achieves very similar results as the full thermodynamic models but at a fraction of the time they would require.

SALT PRECIPITATION

Salt deposition is increasingly becoming a topic that engineers in the industry are concerned with, especially when expensive offshore wells have been compromised by salt that deposits and inhibits production. This is especially relevant in wells producing gas from reservoirs that include water saturated with salts. A drop in pressure while the gas is being produced means that more water will saturate the gas, leaving the rest of the water being unable to dissolve the salt, hence the deposition in the reservoir or the wells. PVTP allows the user to study this phenomena and understand at which conditions salts will deposit as well as the amount. This can either be done from the water composition itself, or through the salinity of the water.

HYDRATES

Complementing all the flow assurance calculations in PVTP, the hydrate modelling capabilities in PVTP include both industry wide available models (such as Munc) as well as models created from research done in Hydrafact and JIPs with Heriot Watt University (Hydrafact Modified Cubic and Hydrafact CPA). Operating envelopes that would enable safe conditions of flow can be created. In the event of inhibitors needing to be introduced, the calculations allow for evaluations to be done on which inhibitor would be most effective and at what quantity it would need to be injected.

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