PETROSTREAMZ

CONTACT ADDRESS
Granåsveien 1
7048 Trondheim
Norway

TELPHONE NUMBER:
+47 73 84 80 80
FAX NUMBER:
+47 73 84 80 81

COMPANY E-MAIL:
info@petrostreamz.com
CORPORATE WEBSITE:
www.petrostreamz.com

REGISTER
OF BUSINESS
ENTERPRISES:
NO 989206230

Pipe-It White Paper

Providing Compositional Streams

By Mohammad Faiz Hoda, Pipe-It Software Manager at Petrostreamz AS

One of the driving forces of Pipe-It development is the provision of a petroleum streams infrastructure for an asset. You might have heard Curtis say on our website "If it ain't piped, it ain't sold". There exists a physically interconnected network of pipes delivering what exists down below in the bowels of the earth to the sales point.

With Pipe-It our motto is "If it ain't piped computationally, it ain't optimized". There needs to exist a network of computational "pipes" and nodes where the petroleum streams are computationally described. In as much detail as possible. In as many representations as possible. At as fine a resolution, time wise, as possible. This is what we mean by providing a stream infrastructure.

Mohammad Faizul Hoda directs the development of Pipe-It and uses Pipe-It for execution of large scale projects. Faiz holds a PhD from the Institute of Petroleum Technology (IPT), NTNU, Norway obtained in 2002. He earlier did his MS in Petroleum Engineering from IPT, NTNU in 1997 and his B. Tech. (Petroleum Engineering) from Indian School of Mines, India in 1986.

What is a stream?

A Pipe-It stream is the collection of data that defines a) quantities of all the components constituting the stream and b) additional attributes of those streams that qualify the streams further. Pipe-It streams are stored in stream files (often with the extension *.str). These stream files always have a characterization associated with them which, at a minimum, defines the names of the components comprise the characterization. A black-oil (BO) characterization consisting of the surface oil and gas (SO & SG) is a typical example. Such components are used in black-oil simulators like the Eclipse 100. Eclipse 300 on the other hand uses, typically, 5 or more components in the PVT model. The streams from such a simulator need a Pipe-It characterization consisting of the same number of components (e.g. N2C1, C2CO2,…). So a stream file will contain the quantity for each component. But the streams can be coming from different wells, so the stream file will use variables to set that attribute. Each well might be completed in multiple grids, and it might be needed to track the quantities from each such grid. Then the stream file can introduce another set of variables (the grid I, J, K) to hold the value of those attributes. Since a reservoir simulator is typically run to predict the production into the future, there is a need to qualify streams on a time basis. Introducing another variable, or in fact two. In reservoir simulators this is often T1 & T2 and the default unit is days.

Any number of such variables can qualify a particular stream data with special attributes, thus tagging the stream quantities with values of these variables.

To recap, in order to properly manage streams a system needs to be in place to handle characterizations (and its constituent components), quantities of those components, and variables to tag the quantities with special attributes.

Pipe-It's Streamz is such system and is designed for the specific purpose of stream management. Pipe-It works with stream files and a complete stream file, containing streams from a reservoir simulator, may contain thousands of stream data representing the production from wells, groups of wells and the entire field.

Streams at different aggregation levels:

In certain situations production from well-grid-connection needs to be used. This may be used to study differential depletion of layers, back flow, or performance of completions. Vastly different fluids may flow into a well from the different connections. Pipe-It's unique BOz technology relies on such connection level streams for its accuracy in converting black-oil rates to molar rates.

Wells may join together at templates, and analysis of sub-sea equipment may need compositions of fluids in a number of wells, now and at any time in the future. Wells and pipelines are likely to flow into satellite or central processing facilities, and the field aggregated streams may be needed to perform process simulations. These days fluids from more and more fields are being processed in large central processing facilities and tie-ins from other nearly located fields are being evaluated when production from the original participating fields decline, freeing up some capacity in the process facilities. In such cases streams from multiple fields, often with vastly varying fluid content, need to be commingled before flowing into the processes simulators.

Thus, streams often need to be handled at different levels of aggregation - again with possibilities of mixing different fluids in a consistent manner.

Streams at different time levels:

Reservoir simulators often run predictions for the entire producing life of reservoirs. To perform accurate calculations they must converge in mass balance and end up with time steps of days or even fractions of days. The original resolution of the streams on time basis needs to be maintained for as long as possible to obtain greatest accuracy when stream management tasks are applied. But when streams with different original time steps are aggregated, time-averaging comes into play. Typically, yearly averaged and monthly averaged streams are sufficient, but in some applications daily averaged streams may be required. This time-averaging should be done appropriately. Multiplying by the time interval of each participating stream and dividing by the time interval of the averaged stream is necessary for accurate aggregation.

Thus, for an asset an infrastructure of streams is necessary. This involves physical-level aggregation, time-level aggregation, and varied fluid conversions. Streamz is designed exactly for this task.

Streams in various fluid characterizations:

Black-oil reservoir simulators are the most popular versions of simulators due to their speed. Huge number of realizations and case scenarios can be simulated in a comparatively short amount of time. However, for the purpose of providing compositional profiles for facility design and continuous operations, engineers often resort to a compositional reservoir simulator. Pipe-It's unique BOz technology has alleviated this particular need since early 2000. We have shown that any black-oil model where the performance is comparable to an equivalent compositional model, the BOz technology can be used to convert the black-oil rates to molar rates matching those of the compositional model to near line-thickness. Our colleagues at PERA have given clear guidelines on situations where a black-oil model can be used. In any such situation the BOz technology can be used to provide very accurate output compositional molar rates. However, this conversion must be performed at the grid-connection level, and the resulting molar rates are described by the characterization of the original EOS model used to develop the BO PVT model for the reservoir simulator.

Each different PVT region in a single reservoir model thus may potentially result in streams of a different characterization. Definitely one can expect the converted streams from another reservoir model to be in yet another characterization. Some models in an asset may be sufficiently complex to require a reduced EOS (e.g. 5-component or 8-component) characterization. All such streams have to be represented in the stream infrastructure. Finally, some of these streams may be aggregated at or before a processing facility requiring ways to convert characterizations. We introduce the concept of a common-denominator characterization which has been used with Pipe-It for many years now. Typically we have used a single-carbon number characterization facilitating the use of the Gamma Distribution model to convert from any reservoir characterization to this single carbon number characterization. Only molecular weights of the two are needed for this conversion. This makes the later conversion of commingled feed streams to a process facility trivial since it is only a lumping of the single carbon number (SCN) fractions.

Thus, we see the existence of a number of streams in very different characterizations.

A Pipe-It project containing the compositional and black-oil stream infrastructure is not only a collection of stream files, but also the graphical layout of the asset with hierarchical structure. This could involve hundreds and thousands of graphical Pipe-It elements laid out in a layout specific for each asset. The project will include the files linked to the appropriate **Resources** and Streamz executions linked to appropriate **Processes** that perform appropriate stream managements tasks. It will involve the appropriate Streamz launches for BOz conversions. It will involve various Processes to perform QC at key points. It may involve plotting of streams at various points. How can it be humanly possible for an engineer to manually build a Pipe-It project to provide compositional streams?

Enter the Project Builder!

Project builder is a Pipe-It utility designed to address this issue, and more. The Project Builder combines a template (a dummy Pipe-It project defining only the structure provided by PZ engineers) and case-specific data (provided by the client engineer using the template) to automatically generate a Pipe-It project containing the entire stream infrastructure. There might be hundreds of wells, each containing scores of completions. The wells might be grouped into multiple groups and then diverted to different groups later on. The Project Builder can use the parent-child relationship in a reservoir model to lay out the complete and a very complex Pipe-It project ready to run. Apart from the case specific data supplied to the Project Builder wizard, no further user intervention is required. After the execution of the generated Pipe-It project all the streams (black-oil, reservoir EOS model compositional and SCN compositional) are available at appropriate Resources. This execution might take a long time; from a few minutes to a few hours but once done the entire stream infrastructure is populated for the particular reservoir model. Bingo!

For an asset each participating reservoir model would be post-processed individually via an execution of the Project Builder. Each resulting Pipe-It project can be imported into a Master project to get the infrastructure of compositional streams for the entire asset. The field level SCN streams can then be aggregated to feed to the process facility simulator, which can itself be integrated into the same master Pipe-It project.

Thus in a very short time a starting point of an asset-wide compositional stream infrastructure can be built. But there is a catch.

Fluid Consistency

If you've read my white paper featured in the March 2012 newsletter, I pointed out the fluid consistency as one of the key ingredients. This consistency is extremely important and ensuring it often takes up a bulk of the time. Our BOz technology is remarkable but its touted accuracy is dependent on this fluid consistency. The black-oil tables in a reservoir model are the basis of the volumetric rates produced by the simulator. This is usually developed from an existing EOS model. Generation of the BOz conversion factors needs to be consistent to the way the BO tables are generated. Our engineers usually gather all the data related to the generation of the BO-tables and re-generate them. This task is often not trivial due to lack of proper documentation with the client. However, if the original data is well documented and consistent with the reservoir simulators BO tables, this is straight forward. Furthermore it needs to be performed only once. Once done, generation of consistent BOz factors is trivial and can be used as input to the Project Builder and you soon get all your compositional streams you can do wonders with.

What can you do with compositional streams?

An infrastructure of compositional streams is the basis for technically cool things that can be done using Pipe-It to optimize the asset. The business development manager can start automating the rigorous and yearly chore of reporting accurate **reserves** (Revised National Budget (**RNB)** numbers in Norway). Accurate values of sales products (oil, gas, NGL, condensate) are required using accurate process simulations that, in turn, need accurate feeds. The Pipe-It project with compositional streams not only provides that automatically but goes one step further, performing the simulations and generating the sale products numbers directly. Technically involved workflows of **recovery factor** calculation and **production allocation** can be automated. Get prognosis of crude assays into the future, at a level of detail not even imagined before. Ask questions you did not even dare to imagine before.

Challenge your discipline engineers and engineering groups to “Go fetch the molar profiles and do some accurate modeling”. We have just scratched the surface, a wealth of possibilities exist with the existence of these compositional streams.