Minimal Facilities Satellite Wells

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Abstract

Undeveloped gas fields that are small and relatively remote require creative solutions to lower development costs and improve economic viability. Minimal facilities satellite well tie-backs to existing manifold slots represent a credible development option for such fields, depending on specific field characteristics and proximity to existing infrastructure. The focus of this project is to give an understanding of the technical feasibility, operational risk and cost of novel technologies and architectures to facilitate this development concept. Specifically, this project focuses on the technical flow assurance feasibility of configurations involving Technip's Integrated Production Bundle and ETH-PiP technologies in combination with concepts such as subsea MEG (Monoethylene Glycol) storage at well site. Results show the impact of the passive insulation properties of the aforementioned technologies reduces MEG requirements for the given scenario and potentially eliminates the need for continuous MEG injection at steady state. The effectiveness of using well site MEG to dissociate hydrate formed in the flowline on restart is investigated in the MEG Bladder scenario.

1. Introduction

Undeveloped gas fields that are small and relatively remote require creative solutions to lower development costs and improve economic viability. Such fields are often at sufficient offsets from existing subsea facilities such that they cannot be targeted from top-hole locations at existing, unpopulated manifold slots. Therefore a different, more simplified approach is required in order to reduce development costs and achieve economic viability for such fields; either by accepting more operational risk in exchange for reduced functionality, or by developing and deploying novel technologies, or a combination of the two.

One foreseeable scenario, which may cater for some discoveries, is the tie-back of 'satellite' wells to spare slots on existing manifolds. These satellite wells may be 1-20 km away from the existing manifolds. Thus, this project aims to exploit the opportunity to identify and evaluate alternative system configurations and novel technologies that will enable simpler, lower CAPEX solutions.

The current state of the art with regards to subsea gas-condensate production systems is described by long pipelines and the use of methanol or recirculated MEG for flow assurance. Examples of these architectures are documented by Bednar's paper on the Zinc field (Bednar, 1994) and more recently Lunde's paper on the Ormen Lange flow assurance system (Lunde, 2009).

A technology of interest in this study is Technip's bundled flexible riser/flowline technology, the Integrated Production Bundle (IPB) with increased passive insulation performance and the ability to combine chemical delivery, power and hydraulics in a single line (Teo et al, 2012). Additionally, the project considers Electrically Trace Heated Pipe-in-Pipe (ETH-PiP), a Pipe-in-Pipe product which claims excellent passive insulation performance as well as the capability to house power and hydraulic lines (Cam et al, 2011). Both these products potentially incorporate active heating as a novel flow assurance technology (Ansart et al, 2014). Additionally a concept of interest was the operational practice of utilising MEG stored at the well site for transient processes (shut-in and restart) using a delivery system similar to the one suggested by Total in 2012 (Beautonnet et al, 2012).

This project seeks to evaluate these technologies with a specific focus on hydrate prevention and technical feasibility.

2. Process

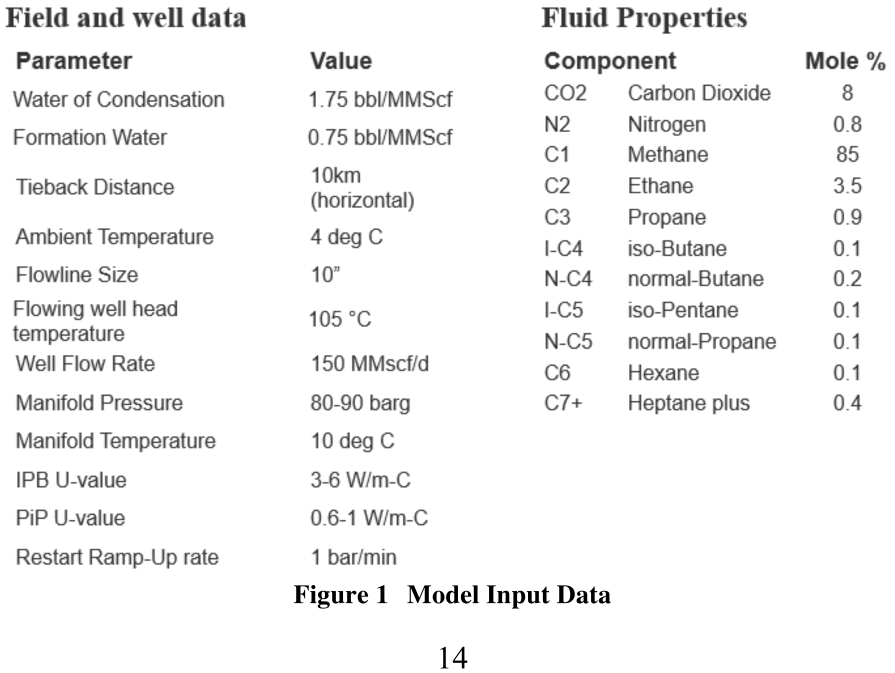
2.1 Selection and Evaluation Criteria

Initial selection of candidate technologies and alternatives was made based on an overlying theme: The reduction of CAPEX via the removal of chemical and/or utility lines. This led to the selection of the above technologies of interest.

Evaluation criteria for configurations was set to be hydrate risk in three situations; steady state, transient and high water cut (to simulate end of field life). A final evaluation criteria of a high level cost estimate was also added.

2.2 Single Well Tieback Model

It was decided that in the initial stages of the project that a single well, 10km tieback to subsea manifold for initial modelling and inhibitor calculations would be most representative of a real scenario. A representative fluid composition was provided by Chevron to represent a generic, dry gas condensate that was not asset specific. Model inputs are tabulated in Figure 1 below, where ranges indicate sensitivities that were tested as part of the modelling process.



Field and well data

Parameter	Value
Water of Condensation	1.75 bbl/MMScf
Formation Water	0.75 bbl/MMScf
Tieback Distance	10km (horizontal)
Ambient Temperature	4 deg C
Flowline Size	10"
Flowing well head temperature	105 °C
Well Flow Rate	150 MMscf/d
Manifold Pressure	80-90 barg
Manifold Temperature	10 deg C
IPB U-value	3-6 W/m-C
PiP U-value	0.6-1 W/m-C
Restart Ramp-Up rate	1 bar/min

Fluid Properties

Component		Mole %
CO2	Carbon Dioxide	8
N2	Nitrogen	0.8
C1	Methane	85
C2	Ethane	3.5
C3	Propane	0.9
I-C4	iso-Butane	0.1
N-C4	normal-Butane	0.2
I-C5	iso-Pentane	0.1
N-C5	normal-Propane	0.1
C6	Hexane	0.1
C7+	Heptane plus	0.4

Figure 1 Model Input Data

OLGA and Multiflash were used for the modelling in this project. The chemical composition provided as well as the given water cuts were input to Multiflash and its advanced Peng-Robinson implementation was used to generate tabulated PVT data to be imported into OLGA, ensuring accurate phase calculations throughout the modelling. The same process was carried out for incremental concentrations of MEG using Multiflash's inhibitor calculator. Multiflash was also used to generate the hydrate formation curves for the simulation.

The set up in OLGA was a relatively simple scenario where a 10km horizontal flowline connects a closed wellhead node to a pressure node manifold. The driving force for fluid flow was a pressure source set to simulate flowing wellhead pressure. The heat transfer model used was OLGA's inbuilt water model and in the hydrate modules the FULLDISPERSION variable was set to true on all flow scenarios (i.e. all except shut-in cases) to enforce full dispersion of water in other phases.

From here the simulations ran in three stages: firstly a 6 hour simulated run to allow the system to equilibrate at steady state, followed by a 48 hour shut in to manifold pressure, and finally a restart where pressure was increased in 10 minute increments until steady state was once again reached (although this was also simulated at 48 hours). The appropriate variables were then altered over many runs to produce data indicating the performance and MEG requirement impact of the passive insulation of IPBs and PiP, with an uninsulated line used as a benchmark.

2.3 MEG Bladder

The "MEG Bladder" Concept involves using MEG stored subsea at well site in an unconventional operational practice. In a scenario with a short tieback with a flowline that has high performance passive insulation, it is feasible that for steady state operations inhibitors may not be required. Initial results confirm that this is possible with the passive insulation of a PiP flowline (more in section three) for the 10km tie-back scenario. Given that inhibitor will only be required during transient operations (shut in and restart) it is proposed that the flowline be allowed to cool and form hydrate during shut-in. To ensure no hydrate plug forms upon restart, the MEG stored at the well site will be emptied into the line, sending a "MEG front" down the line to dissociate the hydrate as the well is brought back into steady state operation.

This process was simulated in OLGA by breaking up the flowline in ten discreet sections, to enable a different hydrate curve to be assigned to each section and enabling the simulation of the effect of a MEG front progressing down the line. Then, the restart case was broken into time steps to simulate the progression of the MEG front down the flowline, by changing the hydrate formation conditions in different sections at different times. The fluid velocities during restart were observed to determine the residence time of the MEG front in each section. The front itself was approximated as a section of 70 wt% MEG concentration followed by a section of 20%.

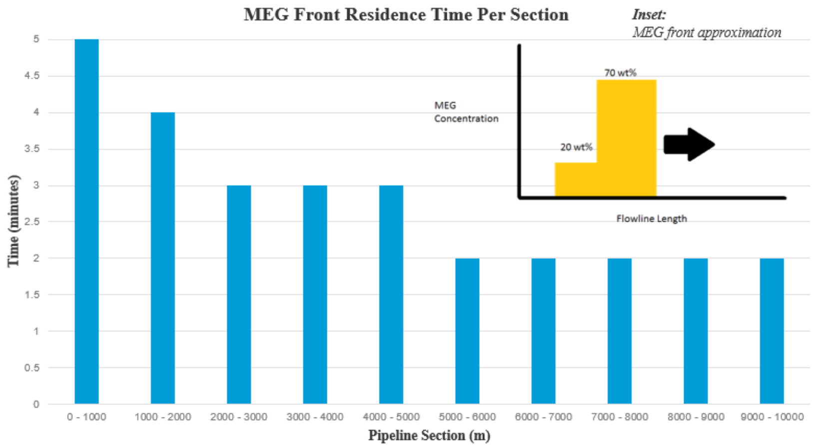


Figure 2 MEG front residance times

3. Results and Discussion

3.1 Single Well Tieback

Results when investigating the implications of the varying passive insulation performances of the IPB and PiP compared to an uninsulated line showed the impact of MEG requirements for the 10km tieback scenario. As a result of the extremely low ambient temperature being simulated (4 degrees Celsius) a lack of insulation causes the line to cool rapidly and form significant volumes of hydrate, even at steady state.

The most important result to come out of this stage is to confirm that at all modelled sensitivities (0.6 – 1 W/mC) representing the passive insulation of Pipe-in-Pipe were sufficient to prevent hydrate formation at steady state with no inhibitor present.

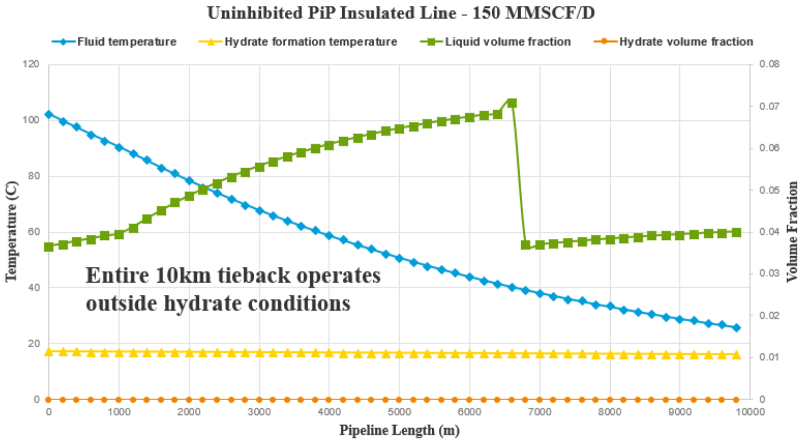


Figure 3 PiP steady state (U = 1 W/mK, The discontinuity in liquid volume fraction at ~6700m is a numerical error as part of OLGAs momentum balance)

Table 1 below summarises the MEG requirements for steady state and transient processes, with an uninsulated steel line listed for comparison purposes. These values are quoted for a well flowrate of 150MMscf/d (the target well flow rate) or a pressure drop of approximately 30 bar. The modelling shows that an IPB would result in a 25% reduction in MEG requirement based on its passive insulation alone. The lack of requirement for inhibitor during steady state PiP flow is an important result that enables pursuit of the MEG bladder concept and could potentially drastically reduce potential MEG requirements.

Flowline	Steady State	Transient
Uninsulated Line	40 %	40 %
IPB	30 %	30 %
PiP	0 %	30 %

Table 1 MEG Volumes (mass percentage of water + inhibitor, 150 MMscf/d case)

Another observation made is that the degree of subcooling (degrees of fluid temperature below the hydrate formation temperature) does not exceed 11 degrees in any of the modelled scenarios, even when the line is allowed to cool to ambient temperature during a shut-in. This raises the possibility that Kinetic Hydrate Inhibitors (KHIs) could be another viable technology to replace thermodynamic inhibitors based on the heuristic that they have been known to prevent hydrate formation at subcooling up to 13 degrees for approximately 48 hours (Lovell & Pakulski, 2002).

3.2 MEG Bladder

When hydrate is formed during shut-in to the point of complete water consumption, simulations show an approximate 5% volume fraction throughout the horizontal line. As the MEG front enters the system the fluid and hydrate is subject to a significant "negative subcooling" or temperature above the hydrate formation temperature. While the MEG front initially appears effective during the first few timesteps as the hydrate present in the line appears to dissociate in its wake, there is a point after which the progress of the simulated front outstrips the dissociation of the hydrate. The figure below shows the MEG front clearly visible as a region of "negative subcooling" in the line. However, at this point (when the front is about halfway down the line) there is a point behind the front at which hydrate is once again stable, and dissociation ceases.

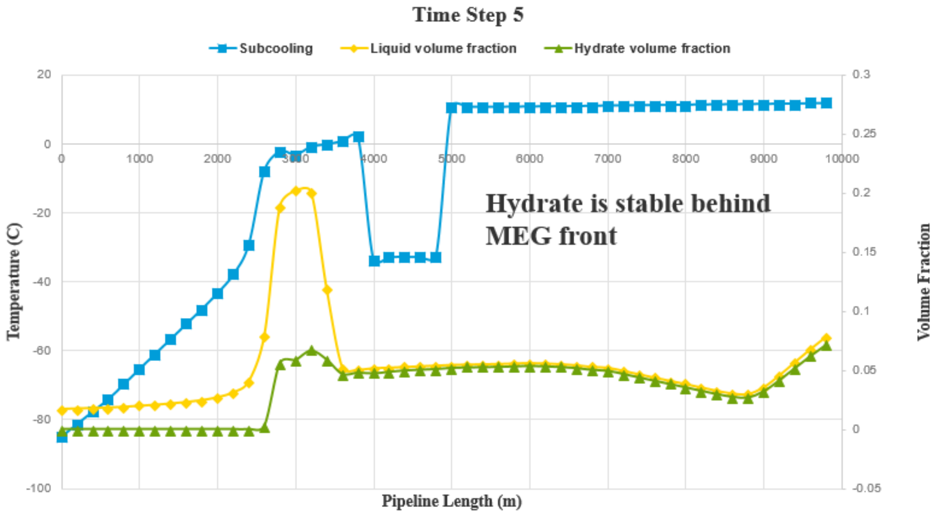


Figure 4 Progress of MEG front shown by volume fractions and subcooling.

After this point the remaining hydrate is only dissociated when the warm fluid coming from the well heats the line to above the uninhibited hydrate formation temperature. The final result at the time when the MEG front has cleared the line is that hydrate is still present in the region from 6000m to 10000 length, at the original 5% volume fraction and a small region of 10%

volume fraction hydrate, believed to be explained by mobile hydrate accumulating as the liquid flows. With no plug forming in the simulated horizontal line, remaining hydrate does dissociate as the line returns to steady state, however this result assumes that the line does not plug after the MEG front has passed and is highly sensitive to bathymetry changes.

4. Conclusions and Future Work

So far the merit of IPBs and Pipe-in-Pipe has been shown in the effect that effective passive insulation has on MEG volumes; namely the IPB requiring 25% less MEG by mass and the significant result that PiP insulation is shown to eliminate the requirement for continuous inhibitor injection at steady state.

The MEG bladder concept has been investigated by constructing a scenario in OLGA which indirectly models the effect of a MEG front travelling down a horizontal line. Initial results suggest that the solution is highly sensitive to bathymetry however more resolution on the scenario would be required to reach a final conclusion.

The major outstanding component of the project is an assessment of active heating in IPBs and ETH-PIP, and particularly how it may be used to further reduce or eliminate MEG requirements or be used in tandem with operational practices such as the MEG bladder.

5. Acknowledgements

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6. References

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