GATE KEEPER
A Technical Newsletter for the Oil & Gas Industry
OCTOBER 2016

Wax Management Strategy Part 3: Design, Development & Maintenance

In the previous parts of this series, it was established that wax deposition is an issue that arises whenever an oil composition containing appreciable wax content encounters flow, temperature, and pressure that are conducive for solids formation. The effective development of wax management strategies during Front End Engineering Design (FEED) can serve to mitigate or perhaps even prevent the high costs associated with wax remediation.

The design and development of a viable, robust wax management strategy relies upon the economical evaluation of available management techniques. A singular approach (e.g. pigging) may be chosen, but often a combination of techniques can be implemented to provide the most cost effective approach.

In this conclusion of the Wax Management Strategy GATEKEEPER series, the objective is to highlight available wax management techniques commonly used in the industry and provide an example of a wax management strategy for the hypothetical field introduced in Part 1 of this series.

Wax Management Techniques

Once wax deposition is identified as a flow assurance issue to the production flow pathway, prevention and/or remediation techniques are investigated to determine their viability given the project basis of design and budget. The following wax management techniques are commonly examined:

- Prevention – Thermal Control / Chemical Inhibition
- Remediation – Thermal and Chemical Wax Dissolution / Physical Removal

Prevention: Thermal Control

Wax will not form or deposit, to significant degree, if the wax appearance temperature (WAT) of the crude is not breached during transport. This type of thermal control is imposed on the bulk fluid and can be accomplished by conservation (pipeline insulation) or addition of thermal energy (pipeline heating) in the production flow path [1]. These techniques are expensive, but they can become financially attractive if other temperature related flow assurance issues are to be mitigated as well – most notably hydrates.

Prevention: Chemical Inhibition

Chemical inhibition is accomplished by deployment of wax inhibitors, also known as crystal modifiers. These chemicals are designed to affect the WAT and wax deposition propensity of the crude by disrupting the ordered aggregation of the growing crystalline structure. Although complete wax inhibition is rarely achieved by chemical deployment, chemical usage can be a powerful synergistic component to an optimized wax management strategy.

Unlike wax solvents or dispersants, these chemicals must be deployed before the bulk temperature of the crude drops below the WAT, hence, they are often injected downhole. The concentration and choice of the wax inhibitor is field-dependent, but industry expectations of an injection concentration of 100 to 2,000 ppm (based on net oil) are routinely used for design basis development [2].

Remediation: Thermal & Chemical Wax Dissolution

Thermal and chemical wax dissolution has been used for many decades in the remediation of wax deposits. This method uses the injection of heated fluid (e.g. crude oil, water) into the production pathway to melt and remove wax deposits. The fluid is heated well above the melting point of the wax and circulated to remove the deposition. Additives should also be included to the heated fluid to improve its application (e.g. wax dispersants, demulsifiers). Although hot oiling/watering is elementary to implement, un-optimized programs can provide significantly lower wax deposit removal efficiency due to limitations associated with the delivery temperature of the heated fluid.

Solvents can also be deployed as a batch or "soak" treatment to dissolve wax deposits. Xylene is the most common solvent used, but deposit testing has been shown to dramatically improve the success of dissolution treatment [3]. Other important factors to consider during dissolution treatment include proper "spotting" of the solvent at the deposit location and temperature and time of wax dissolution.

Figure 1: Common Pipeline Pig Types [6]

Pig Type	Pigging Purpose				
	Wax Removal	Soft Dirt Removal (internally lined pipe)	Soft Dirt Removal (non-lined pipe)	Hard Deposit Removal	Liquid Removal
Foam - Plain					●
Foam - Brush			●		
Plastic Disc	●	●	●		●
Sphere					●
Metal Blades				●	
Plastic Blades	●	●	●	●	
Metal Brush			●	●	
Seals Only					●

Table 1: Pig Type and Purpose

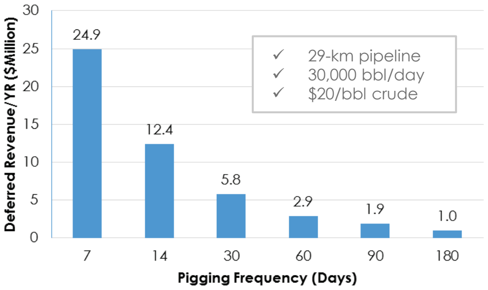


Figure 2: Pigging Frequency Effect

GATEKEEPER
OCTOBER 2016
GAT2004-GKP-2016.10

Wax Management Strategy Part 3: Design, Development & Maintenance

Remediation: Physical Removal

Physical removal of wax deposits is accomplished in the wellbore and flowline by deploying wax/gauge cutters and pigs respectively. There are multiple proprietary designs within the industry for both.

Pigging programs are the most common wax management strategy for in-field flowlines when a significant portion of the non-wellbore production flow path is subjected to wax deposition risk. Figure 1 and Table 1 depict some of the pig types and their respective purposes. Because normal production is usually interrupted during the physical removal campaign, significant deferred production revenue can be incurred; therefore, experienced operations, engineering and vendor staff are critical for reducing the learning curve of an effective wax removal campaign. Figure 2 demonstrates the magnitude of the effect pigging frequency can have on deferred revenue [4].

Development of Wax Management Strategy for Hypothetical Field

As mentioned in the previous GATEKEEPERS in this series, the production flow path for the hypothetical field has shown the propensity for wax deposition in the flowline.

Therefore, a pigable flowline riser system was added to the project's basis of design once wax deposition was identified as a flow assurance issue. Periodic pigging was chosen as the primary wax management strategy based upon the following criteria:

- Pipeline insulation, heating, and periodic chemical dissolution soaks were not deemed viable techniques due to economical implementation considerations.
- Chemical inhibition was not able to reduce the risk of flow assurance impairment to acceptable project levels.
- Installation of a periodic pigging campaign offered the lowest flow assurance risk while maintaining implementation cost to acceptable project levels.

In accordance with general industry preferences, a conservative 4 mm (0.16 in) maximum deposit thickness was chosen to guide the initial pigging frequency set at 90-day or 4 runs per year [5]. Each pigging run has an associated $150k OPEX cost. The total cost of the program was approximately $2.1 million annually when deferred production was considered.

After completing the implementation of the wax management strategy, the following optimization efforts were completed to reduce cost while maintaining performance:

- Pigging frequency was reduced by 1 run per year after an operational review was conducted that determined the initial strategy included excessive conservatism and the identification of an improved pig type for implementation.
- Implementation of a downhole wax inhibition chemical injection (400 ppm injection based on net oil at a $8/gal cost) to further reduce the frequency of pigging runs annually to 2 - a 50% reduction from the original pigging frequency.

Figure 3 and Table 2 summarize the improvements to the initial wax management strategy. Two optimization efforts were able to reduce the $2.1 million program by $648k (-31%).

Conclusion

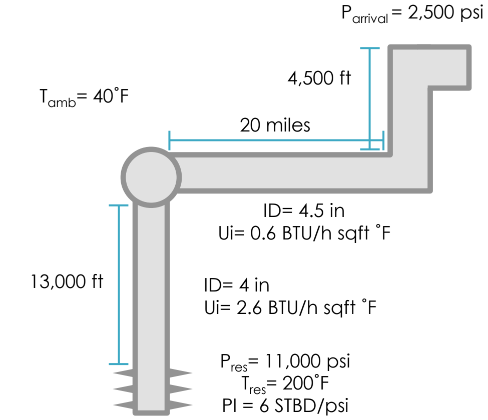
Wax deposition remediation is a costly endeavor, but sound engineering and design can drastically improve the cost to any producer's bottom line. The main steps are:

1. Understand the production pathway, conduct wax characterization testing and produce the production window early during the FEED stage of design to identify any problem areas.
2. If problem areas are identified, determine wax deposition risk with modeling.
3. Then develop a wax mitigation strategy to include wax deposition prevention and remediation activities .

These steps will ensure that the necessary information is available to create a robust, viable wax management strategy that will alleviate flow assurance risks and minimize associated remediation costs.

References

1. Denney, D. (2004, June 1). Active Heating For Flow-Assurance Control in Deepwater Flowlines. Society of Petroleum Engineers. doi:10.2118/0604-0045-JPT
2. Kelland, M. A. (2009). Production Chemicals for the Oil and Gas Industry. Boca Raton: CRC Press
3. Tiratsoo, J. (pg. 43-56, 2013). Pipeline Pigging and Integrity Technology, 4th edition. London: Clarion Technical Publishers
4. Niesen, V. (2002). The Real Cost of Subsea Pigging. E&P Magazine, 97-98.
5. Stevenson, C. J., Davies, S. R., Gasanov, I., Hawkins, P., Demiroglu, M., & Marwood, A. P. (2015, May 4). Development and Execution of a Wax Remediation Pigging Program for a Subsea Oil Export Pipeline. Offshore Technology Conference. doi:10.4043/25889-MS.
6. https://www.asgco.com/conveyor-products/urethane-cast-products/pipeline-products-and-pigs/



Hypothetical Field Layout

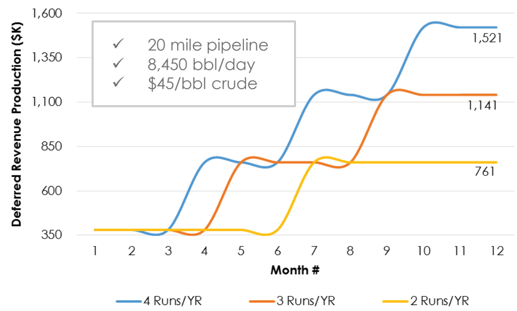


Figure 3: Pigging Deferred Revenue

Improvement	Cost ($k)	Savings ($k)		Δ ($k)
		Pigging OPEX	Deferred Revenue	
Pigging Review	100	150	380	+430
Wax Inhibitor	312	150	380	+218
TOTAL	**412**	**300**	**760**	**+648**

Table 2: Summary of Wax Management Program Optimization Efforts

From discovery to abandonment, upstream to downstream, GATE provides a systems approach to oil and gas facilities through our engineering, commissioning and marine services. Our goal is to provide solutions that allow our clients to make sure their projects work right the first time.

GATEKEEPERs are published for the benefit of our friends and clients. If you have any questions about this article, please contact us at **info@gateinc.com** or **281.398.5781**

QUALITY SYSTEM CERTIFICATION DNV·GL ISO 9001

www.gateinc.com