ANTI-AGGLOMERATE LDHI CHEMISTRY CONTROLS HYDRATES, HELPS IMPROVE OVERBOARD WATER QUALITY

SITUATION

As part of a flow-assurance program, the operator of a subsea oil and gas production system in the deepwater Gulf of Mexico was injecting 500 gallons per day (gpd) of a conventional low-dosage hydrate inhibitor (LDHI) to manage the risk of hydrates during production.

Production profile and field conditions:

- Total Oil Production: 6,581 bbl/d
- Total Gas Production: 74,164 mmscf/d
- Total Water Production: 6,348 bbl/d
- Depth of subsea well completion: 3,700 ft
- Ambient seabed temperature: 40°F (4.4°C)
- Wellhead temperature: 91°F (32.8°C)
- Platform arrival temperature: 54°F (12.2°C)
- Subsea Well Oil Production: 367 bbl/d
- Subsea Well Gas Production: 11,572 mmscf/d
- Subsea Well Water Production: 756 bbl/d

CHALLENGE

Historically, anti-agglomerate (AA) LDHI chemistries have negatively impacted operators' downstream separation processes, which resulted in operators struggling with increasing production and maintaining compliance with the produced-water quality standard for discharge into the environment embodied in the National Pollutant Discharge Elimination System (NPDES). In this case, the continual challenges the operator faced complying with NPDES overboard waterquality requirements became a concern because of plans to add incremental production in the near future.

Additionally, the operator was enduring frequent production changes, which exacerbated the challenge of complying with NPDES standards for produced-water quality. It was so challenging in 2013, Nalco Champion added supplemental treatment with a water clarifier and commissioned 78 days of technical support on the host platform to ensure oil and grease contamination in the discharge water didn't exceed 29 ppm and no sheen was visible upon discharge, as specified by NPDES.

INSIGHT

Although there was a very positive impact from the water clarifier changes, Nalco Champion understood that the addition of a flocculent to the operator's process could increase the complexity in other areas of the customer's operation.

So, Nalco Champion utilized a 'Total System Impact' mindset and took further action to improve water quality by deeming it necessary to develop an LDHI chemistry focused on improving water-quality concerns on the asset.

Based upon results of analytical methods in the laboratory and upon experience with offshore production projects, Nalco Champion understood the impact of LDHIs on produced water and developed a product that would meet the hydrate performance requirements and improve water quality.

Among the advanced LDHI chemistries Nalco Champion had developed for this application was SFPEC6798A. From laboratory testing to field trial, SFPEC6798A maintained hydrate control in the production environment with minimal-to-no effect on water-quality characteristics, at the same injection rate as the incumbent LDHI.

SOLUTION

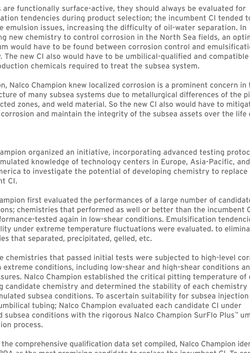
In a trial conducted on the host platform to test the impact of SFPEC6798A upon water-quality in the subsea production system, Nalco Champion maintained the dosage of the incumbent LDHI at the recommended 500 gpd and then injected SFPEC6798A on top of the incumbent LDHI at a rate of 100 gpd. No negative impact to water quality was observed. See Fig. 1

Based on the success of the topside water-quality trial and supporting hydrate-inhibition laboratory test data, the customer approved SFPEC6798A for field deployment.

Following continuous downhole injection of SFPEC6798A into the subsea production system, Nalco Champion observed significant improvement in the quality of water samples.

Fig.1

Left to Right: LPI – Low Pressure Separator
1 Water Sample, NPDES – Overboard Water
Sample, TW – Oil Treater Water Sample



RESULTS

By partnering with Nalco Champion and approving SFPEC6798A, the operator was able to confidently control overboard water quality within NPDES limits at a stable, reduced, and simplified level, all while maintaining hydrate control in the production environment. Control was improved so greatly, the need for technical support related to water quality was eliminated; the supplementary water clarifier was removed, resulting in a cost savings of $22,000 per year; and the operator's concern regarding water-quality control was no longer the limiting factor for increasing production in the field.

SFPEC1589A CONTROLS CORROSION SUBSEA, SOLVES WATER QUALITY ISSUE

SITUATION

The operator of an offshore gas-condensate field in the UK sector of the North Sea was managing corrosion in three high-temperature (HT), high-pressure (HP), high-shear subsea fields with a proven, umbilical-certified, corrosion inhibitor (CI). The treatment program called for injecting CI downstream of the subsea well heads to protect system pipelines.

CHALLENGE

For a period of time, quality tests of produced water to be discharged overboard following separation found oil-in-water (OIW) concentrations exceeding 2,000 ppm, well beyond the 30 ppm allowed by the Department of Environment and Climate Change (DECC), which oversees environmental protection in the UK North Sea. Additionally, DECC had classified several chemical components of the incumbent CI for substitution warnings.

New corrosion-inhibition technology was needed that would perform as well as or better than the incumbent CI, could be formulated with active chemical components not targeted for substitution under environmental rules, and could enable more effective operations by not contributing to the stability of emulsions in the production stream.

INSIGHT

Nalco Champion knew that many produced fluids, including oil, water, and gas condensate, have a natural tendency to form emulsions when subjected to agitation. This tendency can be aggravated by addition of chemistries that exhibit high surface-active properties, such as CIs, which can severely impair oil-water separation and gas dehydration.

Since CIs are functionally surface-active, they should always be evaluated for emulsification tendencies during product selection; the incumbent CI tended to aggravate emulsion issues, increasing the difficulty of oil-water separation. In developing new chemistry to control corrosion in the North Sea fields, an optimized equilibrium would have to be found between corrosion control and emulsification tendency. The new CI also would have to be umbilical-qualified and compatible with other production chemicals required to treat the subsea system.

In addition, Nalco Champion knew localized corrosion is a prominent concern in the infrastructure of many subsea systems due to metallurgical differences of the pipe, heat-affected zones, and weld material. So the new CI also would have to mitigate localized corrosion and maintain the integrity of the subsea assets over the life of the project.

SOLUTION

Nalco Champion organized an initiative, incorporating advanced testing protocols and accumulated knowledge of technology centers in Europe, Asia-Pacific, and North America to investigate the potential of developing chemistry to replace the incumbent CI.

Nalco Champion first evaluated the performances of a large number of candidate formulations; chemistries that performed as well or better than the incumbent CI were performance-tested again in low-shear conditions. Emulsification tendencies and stability under extreme temperature fluctuations were evaluated, to eliminate chemistries that separated, precipitated, gelled, etc.

Candidate chemistries that passed initial tests were subjected to high-level corrosion testing in extreme conditions, including low-shear and high-shear conditions and high pressures. Nalco Champion established the critical pitting temperature of each remaining candidate chemistry and determined the stability of each chemistry under simulated subsea conditions. To ascertain suitability for subsea injection through umbilical tubing; Nalco Champion evaluated each candidate CI under simulated subsea conditions with the rigorous Nalco Champion SurFlo Plus™ umbilical certification process.

Based on the comprehensive qualification data set compiled, Nalco Champion identified SFPEC1589A as the most promising candidate to replace the incumbent CI. To complete in-house testing, Nalco Champion compared the potential of SFPEC1589A and the incumbent CI for inhibiting localized corrosion in high-shear conditions. When a surface-active CI is injected into produced fluids, a significant portion will reside at the oil-water interface, and high concentrations of CI can cause significant emulsion problems. Results of emulsification testing showed the emulsion tendency of SFPEC1589A were significantly lower than that of the incumbent CI, as illustrated in Table 1 below.

The photo set below offers visual confirmation of emulsion test results. SFPEC1589A showed significant resolution from 1 minute to 10 minutes at 100ppm.

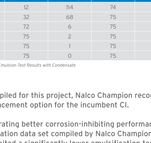


Photo 1: emulsion test after 1 minute

Photo 2: emulsion test after 10 minutes.

Emulsion testing also confirmed the low OIW properties exhibited by SFPEC1589A, a performance characteristic that would enable it to comply with the 30 ppm ceiling set by the DECC for oil contamination in wastewater discharged offshore. Additionally, DECC had approved SFPEC1589A for use in the UK North Sea with no component-substitution requirements.

	Incumbent CI (200ppm)			SFPEC1589A (200ppm)		
	Water (ml)	Oil (ml)	Emulsion (ml)	Water (ml)	Oil (ml)	Emulsion (ml)
30 seconds	24	12	114	74	70	6
1 minute	50	32	68	75	75	0
2 minutes	72	72	6	75	75	0
5 minutes	73	75	2	75	75	0
10 minutes	74	75	1	75	75	0
15 minutes	75	75	0	75	75	0

Table 1: Incumbent CI and SFPEC1589A Emulsion Test Results with Condensate

RESULTS

Based on the data compiled for this project, Nalco Champion recommended SFPEC1589A as a replacement option for the incumbent CI.

In addition to demonstrating better corrosion-inhibiting performance, the comprehensive qualification data set compiled by Nalco Champion showed that SFPEC1589A also exhibited a significantly lower emulsification tendency, which reduced oil contamination of waste water discharged overboard to less than 30 ppm, allowing the operator to comply with DECC quality requirements. Complying with environmental standards enabled the operator to avoid:

- DECC fines for overboarding out-of-specification waste water.
- Potential costs associated with storing waste water on-board the host platform while awaiting pick-up by a support vessel.
- Risk of upsetting the production system by reinjecting waste water downhole.

SFPEC1589A also proved to be compatible with the incumbent chemistry, ensuring that SFPEC1589A could be introduced to the same storage tanks and umbilical or capillary lines without fear of subsea system upset.

By developing SFPEC1589A, Nalco Champion was able to comply with the required North Sea criteria and develop a sustainable chemistry. These attributes greatly improved the overall environmental profile of the product.

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