Multifunctional H₂S Scavenger, Corrosion Inhibitor for Subsea Application

**SITUATION**
A deepwater asset located off of the coast of Equatorial Guinea in West Africa in proximity to the area known as the “Golden Rectangle” is a high-producing sour (H₂S) reservoir. Currently, production rates for comingled wells for the asset are approximately 7500 BOPD, 8100 BWPD, and gas production ranges from 50 to 75 MMSCFD. Historically, H₂S levels in subsea production have been measured topside at the test separators between 70 and 100 ppm, with an average of 80 ppm. The origin of the H₂S is unknown, but it is understood that it has been generated from the formation. A subsea scavenger chemical program was recommended based on its ability to reduce H₂S and its compatibility with production parameters specific for gas treating (Table 1). A secondary scavenger program, was recommended for topside application to polish any residual H₂S concentrations from subsea deployment.

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**CHALLENGE**
Although the deployment of the scavenger program was highly successful in reducing H₂S concentrations from 80 ppm down to 20 ppm before topside application (a 75 percent reduction in H₂S), concern arose over the integrity of the subsea infrastructure from potential corrosion. As a result, **There was no significant pH increase to the production brine with the application of HSCV10115SP, which indicates the product will not promote inorganic scale precipitation.**
the operator was looking to deploy a chemical product that not only reduces the H2S levels to field specifications, but also provides corrosion protection to the subsea production pipeline and infrastructure. To achieve this goal, several potential challenges needed to be considered:

1. **Limited Injection System**
   Only one umbilical line was available for treatment for downhole application. Also, the chemical delivery system had limited pump capacity. Therefore, equipment limitations and delivery systems had to be taken into account.

2. **Product Formulation and Development**
   Functionality of each product for H2S scavenging and corrosion inhibition can often be hindered in multiphase systems. Performance of one product or both needed to be tested to ensure stability and protection.

3. **Water Cut and Composition for Scavenging**
   The aqueous phases can pose significant challenges with regard to partitioning of a product. If the product is unable to partition from the aqueous phase to the oil phase, the interaction between the scavenger and H2S becomes hindered. The average water cut for this field is around 40 percent, so challenges with mass transfer of the scavenger could potentially lead to overtreating to compensate for low efficiencies. Given these challenges, ChampionX was awarded an opportunity to propose a new subsea strategy to mitigate the sour production. The new treatment strategy also needed to encompass a corrosion inhibition component to ensure subsea infrastructure integrity.

**SOLUTION**

HSCV10115SP is a novel, triazine-based product formulated with a specifically designed corrosion inhibitor. The new technology was designed to remove hydrogen sulfide from production streams, in addition to providing substantial protection from corrosion.

This novel product was the result of a collaborative effort between ChampionX and the customer to develop a state-of-the-art technology to meet all needs of the asset. Development of HSCV10115SP encompassed approximately 30 different iterations before a candidate formulation was selected based on the criteria for the field.

The efficacy of HSCV10115SP to inhibit corrosion also had to be vetted out. Samples of the final formulation were sent to a third-party laboratory to ensure that it was thoroughly evaluated for use in this application. The procedure looked at both localized and general corrosion rates using field production fluids and conditions. Results indicated that HSCV10115SP does inhibit corrosion for the asset compared to the subsea corrosive environment with no chemical/corrosion inhibition component present.

Following testing and a full recommendation for an application strategy, HSCV10115SP was deployed subsea for the asset.

### Table 1 – Calculated Retention Time and Gas Velocity for Subsea Treatment

<table>
<thead>
<tr>
<th>Location</th>
<th>Gas Flow</th>
<th>Pressure</th>
<th>Temperature</th>
<th>Line Id</th>
<th>Line Length</th>
<th>Gas Velocity</th>
<th>Retention Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsea Umbilical</td>
<td>1</td>
<td>50</td>
<td>900</td>
<td>166</td>
<td>16</td>
<td>20000</td>
<td>8.21</td>
</tr>
</tbody>
</table>

**Figure 1 – Subsea Application of HSCV10115SP**
RESULTS
Subsea Application: Full Well Stream
A baseline H₂S concentration was established shortly after a brief suspension of subsea scavenger program to test the efficacy of the new subsea scavenger. The application of HSCV10115SP subsea yielded similar results to the incumbent scavenger program. Higher removal efficiencies were observed in the flowlines as a direct result of the application of the new scavenger (Figure 1). This is due in part to the longer flowline length providing more time for the scavenger to mix/contact with the H₂S in the produced fluids (mass transfer). Ending H₂S concentrations continued to decrease during the field trial without stabilization, which indicates the application of HSCV10115SP may not have reached a “scavenger treatment equilibrium” in situ. Thus, further H₂S reduction and injection optimization may be realized.

Additional Evaluations & Product Offerings
During the injection of HSCV10115SP, water samples taken from the production vessels were analyzed for corrosion inhibition residuals. The results indicated the presence of significant concentrations of the corrosion inhibitor package formulated in the new scavenger product, indicating adequate integrity protection of the asset from corrosion. Measurements of pH of the water samples were taken as well. It was confirmed no changes in pH were observed with the introduction of HSCV10115SP that would exhibit a shift that would promote inorganic scaling.

It is also important to note that H₂S concentrations within the water vessels also reduced during the field trial of HSCV10115SP (Table 2). This was in comparison to the incumbent program in the same application.

SUMMARY
• The results of the field trial indicate that the new H₂S scavenger, HSCV10115SP, is able to exhibit H₂S scavenging ability comparable to the historical scavenging program.
• Corrosion inhibitor residuals measured on water samples indicate sufficient corrosion protection for the asset.
• There was no significant pH increase to the production brine with the application of HSCV10115SP, which indicates the product will not promote inorganic scale precipitation.
• Continued decrease in H₂S levels during the field trial of HSCV10115SP illustrates the potential for further optimization.

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Incumbent Scavenger Program</th>
<th>HSCV10115SP Inj</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Vessel 1</td>
<td>240 ppm H₂S</td>
<td>210 ppm H₂S</td>
</tr>
<tr>
<td>Production Vessel 2</td>
<td>670 ppm H₂S</td>
<td>320 ppm H₂S</td>
</tr>
<tr>
<td>Production Vessel 3</td>
<td>477 ppm H₂S</td>
<td>280 ppm H₂S</td>
</tr>
</tbody>
</table>

Table 2 – H₂S Concentrations in Production Vessels