SPE Brazil Flow Assurance Technology Congress
Rio de Janeiro, Brazil, November 06 – 08 2024

A methodology to address lab-to-field issues regarding CO_2 brine content in the context of scale inhibitor recommendation

Tiago C. Freitas[1*], Stefan S. Ferreira[1], Jussara M. Silva[1], Rosane A. Fontes[1], Humberto E. Lopes[1], João Cajaíba[2], Felipe B. Alvim[1], Alexandre B. M. Carvalho[1], Monica T. Silva[1], Giselle M. L. L. Silva[1]
[1]Petróleo Brasileiro S. A. – PETROBRAS, Brazil, [*]ticfreitas@petrobras.com.br
[2]Center of Development of Processes and Chemical Analysis in Real Time, Institute of Chemistry, Federal University of Rio de Janeiro.

Abstract
Oilfield Scale issues are prevalent in the oil and gas industry, affecting various stages of oil production, from well bottoms to wellhead, and, in wet completion scenarios, subsea pipelines and offshore facilities. Scale assessment in these stages differs significantly based on the type of scales and the level of CO_2 present in the reservoir. One crucial variable to consider is pH, which is heavily influenced by pressure and can increase substantially during the lifting process. This study presents a methodology to tackle scaling scenarios that require a CO_2 amount exceeding the capacity of cationic and anionic brines at atmospheric pressure. Additionaly, a field result is presented to demonstrate the impact of accurately assessing scaling scenarios. In this case, the contracted scaled inhibitor had to be evaluated for a “new brine” based on field samples from an untouched area of a field. By conducting lab testes with a more representative CO_2 content, the already qualified inhibitor was approved, thereby averting a specific bidding process for this area and eliminating the associated costs.

Keywords
flow assurance; scale remediation; scale inhibitor

Introduction
Flow assurance management is influenced by both the inherent properties of an oil/gas reservoir and the design/operation of the production systems. Oilfield scales, a consequence of unstable water flowing through an open system, are one of the flow assurance challenges.
Oilfield scale can be categorized in two types: pH-dependent and pH-independent. The well-known pH-independent scales consist of sulfate salts such as barium sulfate and strontium sulfate. For these scales, the scaling scenario mainly depends on total pressure and temperature. On the other hand, pH-dependent scales like calcium carbonate are highly influenced by CO_2 content, for given a brine composition, the pH can be considered as a function of dissolved acid gases alone.
pH-dependent scales pose a challenge for recommending field scale inhibitors due to the gradient between a high pressure-high temperature (HPHT) low-pH domain in the lower completion and the opposite condition at the production arrival.
One approach to reduce the need for lab tests for the scale inhibitor qualification is to calculate the worst condition using a simulation software such as MultiScale [1]. For calcium carbonate, this evaluation typically results in the most downstream point of the system, which is the production arrival. However, in reservoirs with high CO_2 content, even replicating this point in a lab test can be challenging.
This study presents a method to mitigate this issue and applies it to a new water production scenario in an untouched area of a field, which raised concerns about the reliability of the available scale inhibitor.

Methodology
Laboratory experiments play a crucial role in providing scale inhibitor recommendations for field applications. The scale inhibitor must be compatible with other aqueous fluids involved and efficient [2].

Experimental Procedure
Based on previous testing, a scale inhibitor with high calcium tolerance was selected. The properties of the sample employed are shown in Tab. 1.

Table 1. Scale inhibitor properties.

Density, g/cm³	1.2418
Solubility	Water
pH 50%vol, 21℃	4.502

Two brines, as shown in Tab. 2, were utilized in the laboratory experiments.

Table 2. Brine compositions in mg/l.

	"Old Brine"	"New Brine"
Na	66,210	64,005
K	0	1,931
Mg	1,081	437
Ca	10,067	4,357
Ba	504	365
Sr	3,663	494
Br	189	0
SO_4	272	420
HCO_3	1,735	2,607
pH	6,0	6,0

Efficiency

The effectiveness of the inhibitor was evaluated using a Tube Blocking Test – TBT (Tab. 3). Figure 1 illustrates the schematic of the test.

Table 3. TBT parameters.

Flowrate	10 ml/min
Coil ID	0.5 mm
Coil Length	1 m
Pressure	1,000 psi
Temperature	105℃

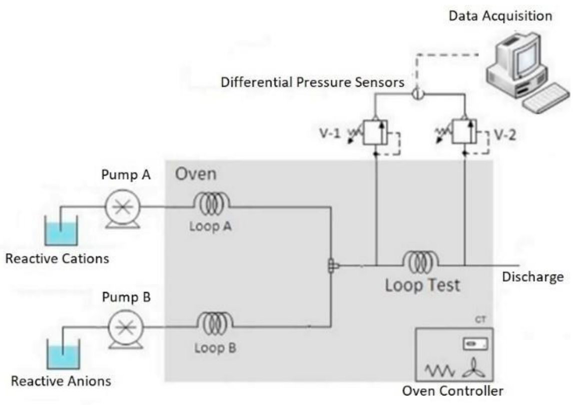

Figure 1. Tube Blocking Test

An alternative design was also adopted, replacing the pair of reactive anions plus pump B with two syringe pumps in series. One pump containing the reactive anions, while the other pump contained CO_2. These fluids were continuously circulated between the pumps. Finally, the TBT was conducted as usual, with one of the syringe pumps delivering the reactive anions with the dissolved CO_2 brine into the equipment.

Results and Discussion

Feasibility of a conventional TBT

To assess the feasibility of performing a conventional TBT with these brines, the simulation software MultiScale was employed. This tool can estimate the chemical equilibrium of water based on its composition and the equilibrium gas composition. It can also perform flash calculations, helping define the pH range that can be achieved inside the TBT equipment using these open brine vessels. The minimum possible pH was calculated as 6.05 for the old brine and 6.55 for the new brine.

Is the pH close enough?

The pH value for the old brine might be considered close enough, but some adjustments may be necessary for the new brine. TBT were conducted with both brines fully saturated with CO_2 to evaluate the efficiency of the inhibitor, as shown in figures 2 and 3.

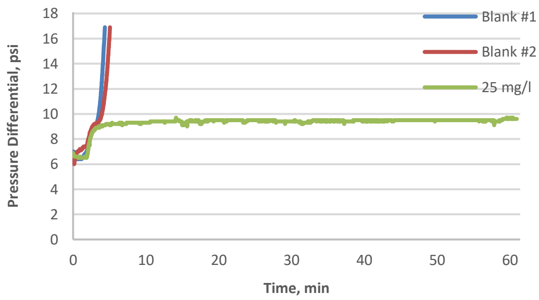

Figure 2. TBT for the old brine

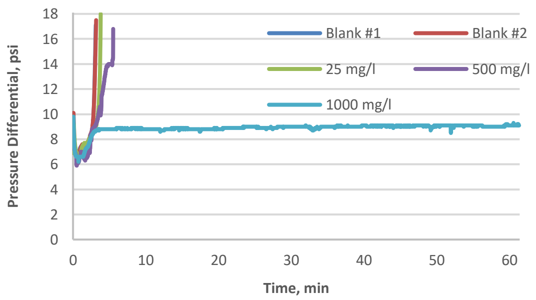

Figure 3. TBT for the new brine
with open reactive anions vessel

The results obtained for the new brine suggest that pH played a significant role in influencing the performance of the inhibitor. The water compositions alone do not appear to justify the observed decrease in performance.

Evolving the TBT rig

To effectively test the new brine considering its real pH, it is known that a larger mass of dissolved CO_2 is required. This can be achieved by replacing the open vessel acting as a reservoir for the reactive anions brine with a bottle capable of withstanding a certain amount of pressure. Figure 4 illustrates the relationship between different CO_2 concentrations inside the bottle and the TBT rig.

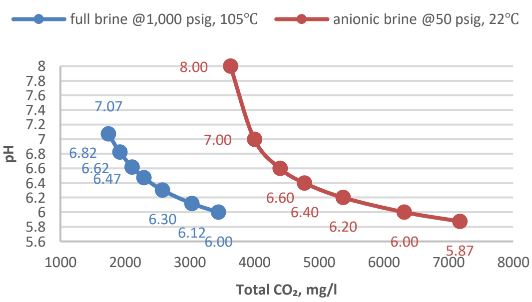

Figure 4. relationship between different CO_2 concentrations inside the bottle and the TBT rig.

Now that it is clear that increasing the amount of CO_2, even at the somewhat low pressure of 50 psig, leads to the desired pH target, a new set of simulations was conducted to provide a range of options for injecting CO_2.

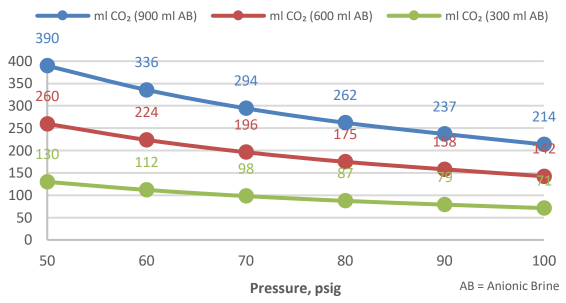

Figure 5. CO_2 volumes required to achieve pH 6.0 inside the TBT equipment.

To evaluate this new approach, two sets of blank tests were conducted, and the results are presented in Fig. 6.

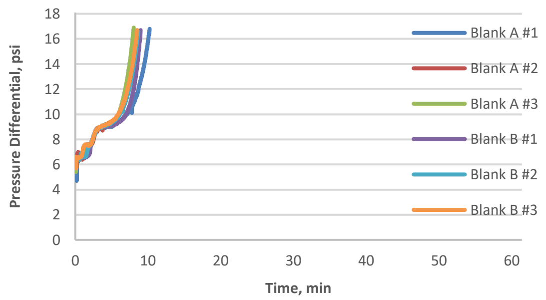

Figure 6. blank TBT for the new brine with syringe pumps.

The results depicted in Fig. 6 indicate that the approach exhibits the required repeatability/ reproducibility, which are essential for a reliable scale inhibitor qualification. Figure 7 displays the results for two inhibitor dosages that were deemed ineffective in a conventional TBT (Fig. 3).

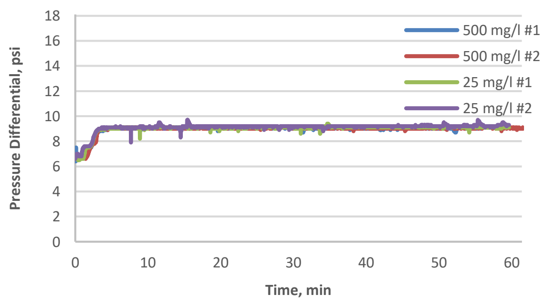

Figure 7. inhibitor TBT for the new brine with syringe pumps.

The results depicted in Fig. 7 demonstrate that the inhibitor is effective for the new scenario. It also highlights the necessity of injecting more CO_2 than what can be dissolved in cationic and anionic brines at atmospheric pressure in select cases.

Conclusions

The methodology can be deemed successful in providing a more accurate representation of field scenarios in the laboratory. As an initial application, it was utilized to confirm the suitability of an already contracted inhibitor for a new field scenario, eliminating the need for a specific tender process. There is other two significant benefits associated with this approach. Firstly, if this methodology becomes part of the Petrobras technical specifications, it could enable the selection of more appropriate chemistries. Secondly, it has the potential to result in cost savings by allowing for fine adjustments in inhibitor dosages.

Acknowledgments

The authors would like to thank Petrobras S.A. for the permission to publish this paper.

References

[1] Kaasa, B., et al., Multiscale 8.3©. Expro Petrotech, Haugesund, Rogaland, Norway.

[2] Rosa, K. R. S. A. da, Fontes, R. A., Rosário, F.F. do, Freitas, T. C., Penna, M. O., Castro, B. B., Silva, M. G. F. da, Silva, G. M. L. L. da, Silva, J. M., Figueiredo, M. R., *Offshore Technology Conference Brasil*. OTC-29683, 2019.

