SCALING NEW HEIGHTS:

High-Tech Monitoring Solutions for Better Scale Management

The presence of water in an oil field brings with it the potential for mineral scale formation. Scale deposition from many mineral sources, including calcium carbonate and sulfates of barium, calcium and strontium, creates flow assurance challenges for operators from the near wellbore to production tubing and topside processing equipment. An ideal scale management program maximizes hydrocarbon production and minimizes the cost of scale control, thereby maintaining the economic viability of the operation.

Mitigation and prevention programs are critical for sustained production in oil and gas fields. Chemical methods of scale control include scale squeeze treatments, in which a scale inhibitor is pumped into the water-producing zone of a formation and returns with the produced fluid at sufficiently high concentrations to prevent scale precipitation. Continuous chemical injection is also an option. Monitoring for the presence of scale inhibitor chemical and the scaling ions in the produced fluid is a key part of a successful scale management program. Monitoring for suspended solids in terms of their concentration, mineral type, composition, and morphology is also recommended to improve the understanding and gauge the risk of scale formation.

Fig. 1 The cross section of a pipe that experienced scale build-up and flow assurance challenges

Brine chemistry monitoring

Frequent monitoring for changes in water chemistry is recommended for all water-producing wells, and becomes even more critical in the case of a seawater flood, a secondary recovery technique in which seawater is injected into the formation via an injection well to displace residual oil and sweep it to adjacent production wells. Because the compositions of the formation and injected waters can differ significantly, the use of preliminary modeling to predict scaling tendency and risks associated with well production fluids is common.

A laboratory-derived Minimum Inhibitor Concentration (MIC) is used to define whether a particular system is protected against predicted scale formation risks. If the scale inhibitor chemical is present at a concentration above the MIC, then it is assumed that the well is protected. It is often observed that the actual "field" MIC differs significantly from the laboratory-derived MIC; however, this approach works reasonably well if combined with monitoring of the scaling-ion concentrations (those present as well as those apparently missing in action).

Suspended-solids monitoring

Monitoring for suspended solids is also often recommended, especially in relatively long-reach horizontal wells. It is useful to understand not only the amount of suspended solids recoverable from a given volume of produced water, but their composition and morphology as well. Figure 2 outlines a process to recover and characterize suspended solids contained in produced water.

A Scanning Electron Microscope equipped with Energy Dispersive X-Ray Spectroscopy (SEM/EDS) can be used to identify the chemical composition of the solids, in addition to their crystal morphology. This enables the operator to distinguish between scale particulates and drilling or completion additives containing barite or calcite. SEM/EDS systems equipped with a low-vacuum mode are recommended to reduce specimen changing and eliminate the need to apply a conductive coating to the specimen. In low-vacuum mode, the instrument introduces a small amount of air into the specimen chamber. These air molecules, oxygen and nitrogen, are ionized by the incident electrons. These ions neutralize electrons on the surface of the specimen and eliminate charging so that a non-conductive specimen can be observed.

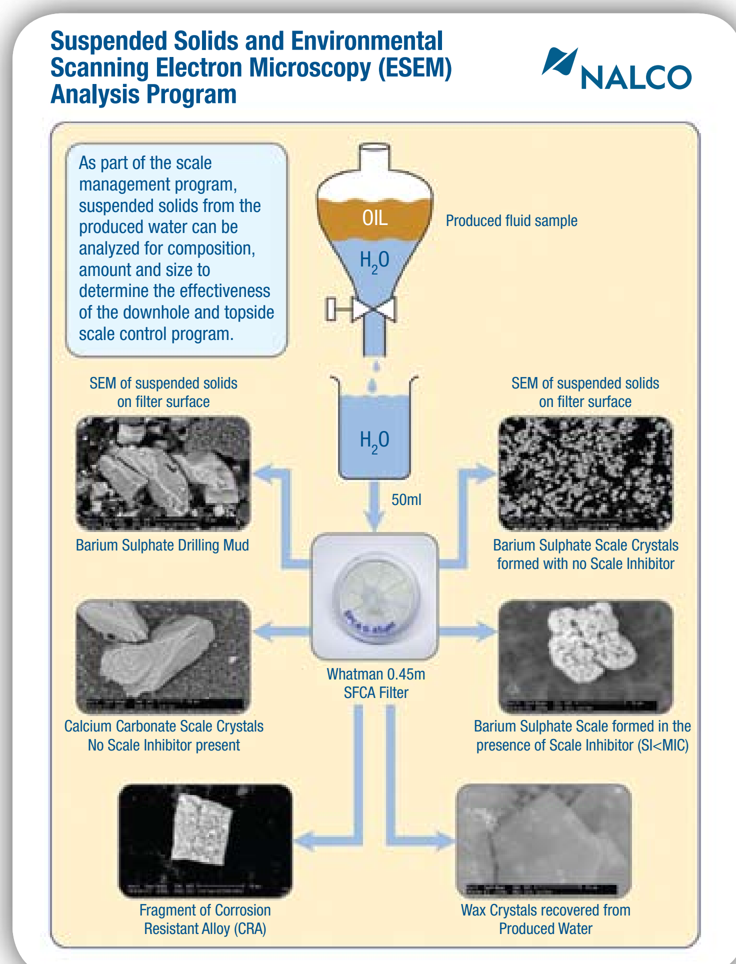

Fig. 2 Suspended solids analysis by SEM/EDS

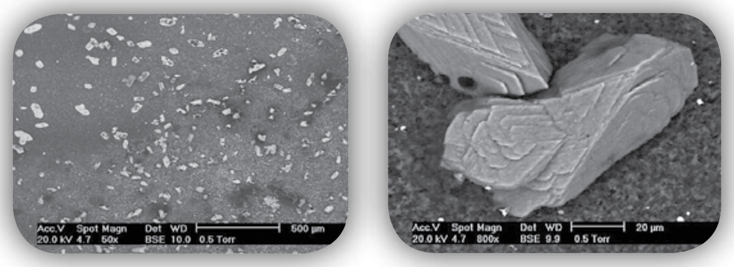

Fig. 3 SEM micrographs coupled with elemental analysis using EDS confirmed calcium carbonate in a well, despite steady scaling ion concentrations

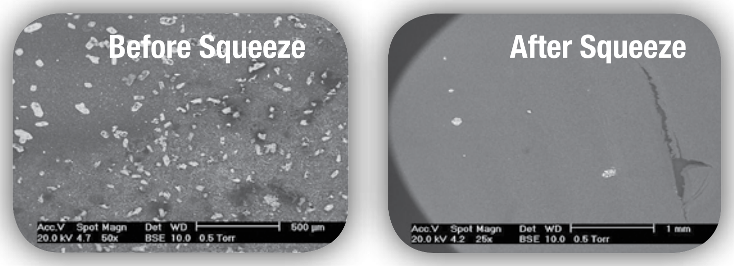

Fig. 4 SEM micrographs comparing suspended solids on a filter at 50X before the squeeze (left) and at 25X after the squeeze treatment (right)

Fig. 5 SEM/EDS systems are used to support scale management programs at Nalco Sugar Land, TX; Naperville, IL; Macae, Brazil; Leiden, The Netherlands; and Aberdeen, UK facilities.

Suspended-solids monitoring is an effective tool to assess the frequency at which a scale squeeze must be repeated in production wells. It can also help the operator determine the root cause of overboard oil-in-water excursions. Of critical importance for long-reach wells, this monitoring identifies those areas in the formation where an inhibitor squeeze has not achieved optimal placement, (i.e., where high inhibitor residuals, well above MIC, are accompanied by high concentrations of suspended solids).

Suspended-solids monitoring also offers opportunities to simplify scale surveillance in complex subsea architectures, where the need for frequent sampling of individual wells can cause significant hydrocarbon deferment. It achieves this by the fact that, so long as suspended-particulates counts in a commingled flow stream are sufficiently low, all wells in this stream should—in principle—be under effective control. Only when counts begin to rise is frequent individual sampling of wells recommended. Of course, the risks associated with this reduced level of surveillance for much of the scaling lifecycle must be balanced against the benefits of reduced sampling.

SEM/EDS analysis can identify scale issues when traditional methods of monitoring (scaling ion concentration and scale inhibitor residuals) show no immediate concerns. For example, Figure 3 shows calcium carbonate grains observed in a well that also exhibited steady scaling ion concentrations. Based on these findings, a scale squeeze treatment was recommended and executed. SEM/EDS analysis after the squeeze confirmed that the treatment was necessary and successful (Figure 4).

Nalco widely employs a suspended-solids surveillance method in offshore and onshore operations around the world to support scale programs and optimize both continuous and batch inhibitor applications. The recent purchase of a new SEM/ EDS unit by the Diagnostic Solutions Group in Sugar Land, TX further strengthens Nalco's capabilities to provide a more 'real-time' assessment of a scale control program's efficacy. Ultimately, this will give the operator greater confidence in their flow assurance management strategies and their ability to optimize production.

Publications

1. Jordan, M.M, Mackin, K., Johnston, C.J and Feasey, N.D. "Control of Hydrogen Sulphide Scavenger Induced Scale and the Associated Challenge of Sulphide Scale Formation within North Sea High Temperature/High Salinity Fields Production Wells. Laboratory Evaluation to Field Application" SPE 87433. Presented at SPE International Symposium on Oilfield Scale, Aberdeen, 26-27 May 2004.

2. Jordan, M.M, Johnston, C.J. and Robb, M. "Evaluation Methods for Suspended solids and Produced Water as an aid in Determining Effectiveness of Scale Control both down-hole and Topside" SPE 92663. Presented at SPE International Symposium on Oilfield Chemistry 2-4th February 2005, Houston, Texas.