

## Reservoir Fluids

# N-FLOW™ 325 Filter Cake Breaker Applied in Long Reservoir Helps Increase Production 75%

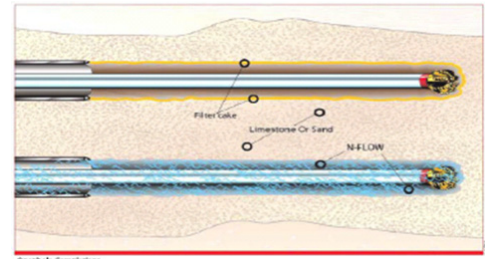
Location: Qatar

### Overview

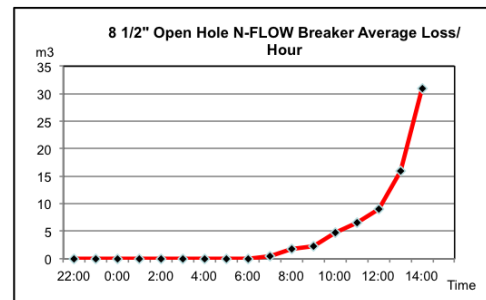
The operator wanted to stimulate the entire 3,741 m length of the reservoir by placing N-FLOW™ 325 filter cake breaker 325 inside the 8-1/2-in. open hole from 6,041 m to 4,923 m and inside the 6-5/8-in. perforated liner back to 2,300 m. Based on the Baroid global database, this would be the largest N-FLOW application performed to date. The calculated required volume was 159 m<sup>3</sup> (1,000 bbl), including 10% excess, to stimulate 3,741 m of hole. Key challenges included the following:

- Limited rig space to store ±140 drums of N-FLOW breaker
- On previous N-FLOW breaker stimulation jobs, the acid began reacting 3-4 hours after the start of pumping
- With an average pump rate of 0.5 m<sup>3</sup>/min, about 5 hours would be required to deliver a volume of 159 m<sup>3</sup>
- A premature acid reaction would affect total job efficiency.

The Halliburton Baroid team developed both logistical and technical solutions to the operator's challenges. First, the client agreed to accept



Open hole stimulation illustration



Downhole loss (m<sup>3</sup>/hr) after N-FLOW treatment

CHALLENGES	SOLUTIONS	RESULTS
<ul style="list-style-type: none"> <li>• Stimulate the entire 3,741 m length of the reservoir using N-FLOW™ filter cake breaker</li> <li>• Limited rig space for drum storage</li> <li>• 5 hours would be required to apply the treatment. Previous jobs resulted in a reaction time of 3-4 hours.</li> <li>• Premature acid reaction would affect total job efficiency.</li> </ul>	<ul style="list-style-type: none"> <li>• N-FLOW breaker was delivered in tote tanks, minimizing storage and mixing time</li> <li>• A combination of sodium bicarbonate and BARAVIS® viscosifier delayed the reaction.</li> <li>• A total of 159 m<sup>3</sup> N-FLOW 325 filter cake breaker was spotted over five hours.</li> </ul>	<ul style="list-style-type: none"> <li>• After six hours, significant downhole losses were observed, indicating that the N-FLOW breaker was entering the formation</li> <li>• Cumulative losses steadily increased with time.</li> <li>• The pH measurements demonstrated that organic acid started to release slowly after two hours, reaching a pH value of 3 after eight hours.</li> <li>• All filter cake had been dissolved and significant downhole loss rate was observed</li> <li>• A 75% increase in production was reported by the operator.</li> </ul>

N-FLOW breaker delivery in tote tanks, each holding 40 drums, to minimize mixing time. Then extensive testing was performed to increase the acid-activation delay time so that the N-FLOW breaker could be completely displaced downhole before losses occurred. To achieve this result, Baroid personnel applied specific design criteria. Field data showed that N-FLOW 325 breaker reacts with the carbonate reservoir at  $\text{pH} \leq 3$ . Testing proved that increasing the concentration of sodium bicarbonate and BARAVIS® viscosifier to 2.0 ppb each delayed reaction time to  $\pm 8$  hours.

PRODUCT	CONCENTRATION
1.04 sg NaCl Brine, v/v %	83
Sodium Bicarbonate, ppb	2.0
BARAKLEAN® (surfactant), v/v %	.05
MSA III (corrosion Inhibitor), v/v %	.05
BARAVIS, ppb	2.0
N-FLOW 325 (acid precursor) v/v %	15

*N-FLOW 325 Fluid Formulation*

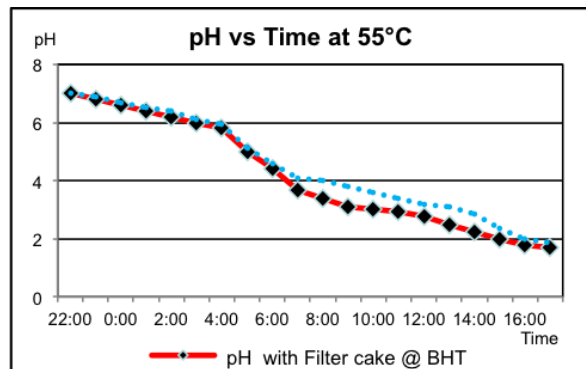
The reservoir was displaced to 1.06 sg NaCl, before pumping the N-FLOW breaker. The initial loss rate was 0.6 m<sup>3</sup>/hr. A volume of 159 m<sup>3</sup> N-FLOW 325 filter cake breaker was pumped at a rate of 0.24 – 0.64 m<sup>3</sup>/min, followed by 3 m<sup>3</sup> of 1.06 sg sodium chloride (NaCl) brine spacer. Total pumping time was 5 hours. No losses were observed.

The breaker was then displaced with 9.1 m<sup>3</sup> of 1.06 sg NaCl brine. Eight hours after starting the job, with the N-FLOW system fully in place, the loss rate increased to 2.5 m<sup>3</sup>/hr, indicating that the N-FLOW breaker reaction had begun.

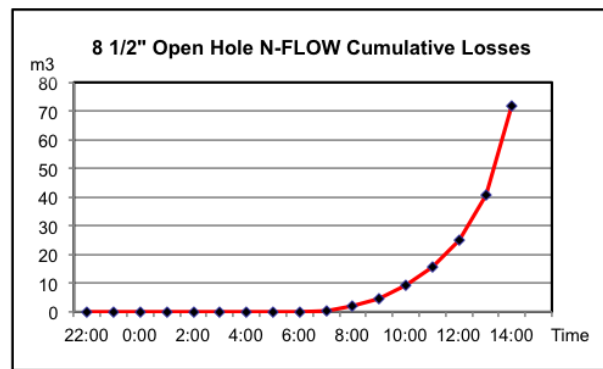
After six hours, significant downhole losses were observed. The loss rate increased from 2.5 m<sup>3</sup>/hr to 20 m<sup>3</sup>/hr. This indicated that the N-FLOW breaker was entering the formation. Cumulative losses steadily increased with time.

The pH measurements demonstrated that organic acid started to release slowly after two hours, reaching a pH value of 3 after eight hours. At this point, all filter cake had been dissolved and significant downhole loss rate was observed.

A 75% increase in production rate was reported by the operator. The expected production was 4,000 bbl/day. The actual production rate provided by the client was 7,000 bbl/day.



*pH vs time for surface samples*



*Cumulative downhole loss after N-FLOW™ treatment*