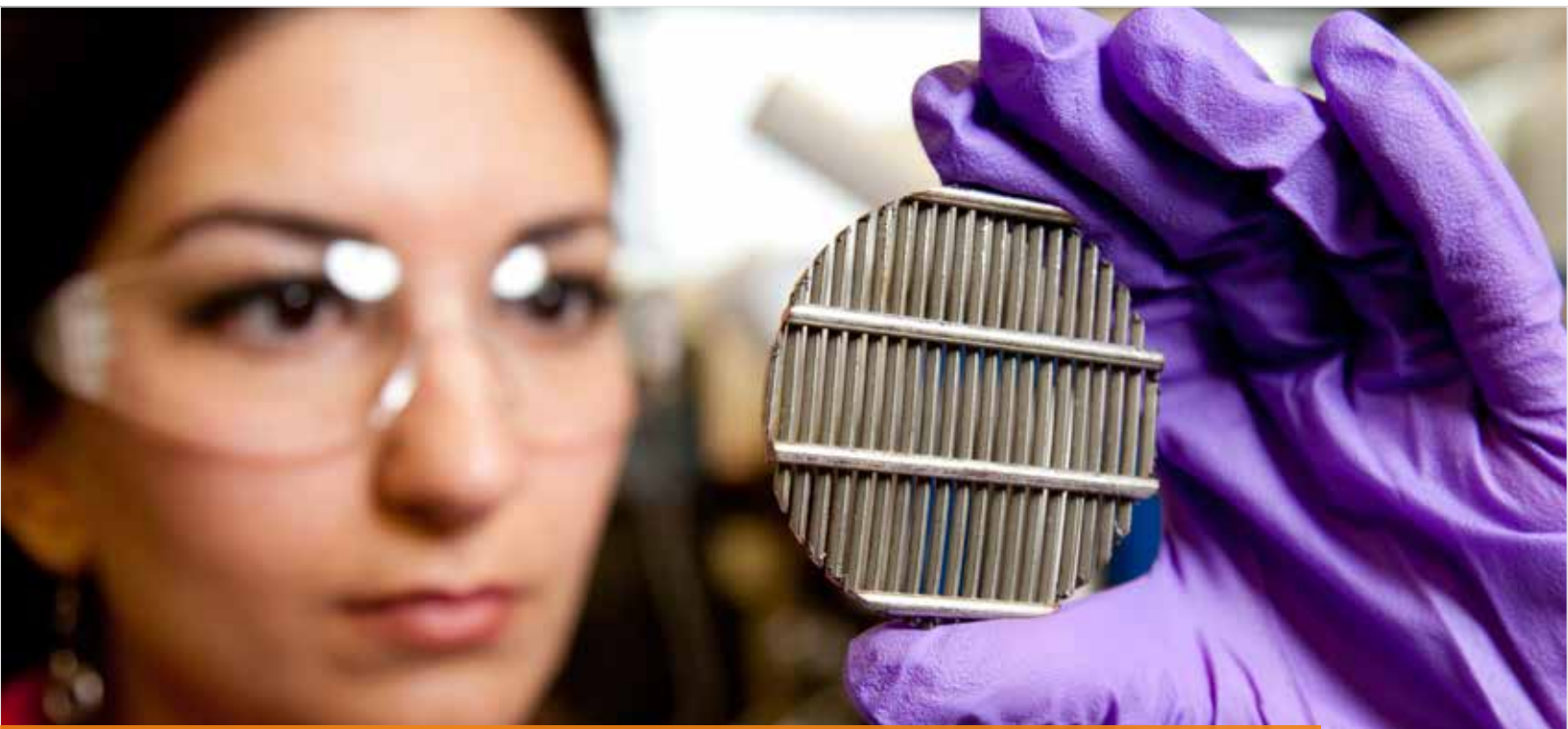




MUDSOLV NG

Integrated filter-cake removal service for optimizing performance of open-hole completions



MUDSOLV NG: Comprehensive filter-cake breaker service

A properly formulated and carefully maintained reservoir drill-in fluid (RDF) deposits a dense and ultra-low permeability filter-cake on the surface of the formation, preventing significant invasion of reservoir-damaging fluid and solids. Depending on the completion type installed, if the filter-cake is not uniformly and completely removed it may subsequently impair well productivity or injectivity.

The MUDSOLV NG⁺ filter-cake removal service from M-I SWACO, a Schlumberger company, is a key component in a comprehensive open-hole completion portfolio that also includes RDF, gravel packs, displacements, and specially engineered proprietary software packages, among others. The aim of the MUDSOLV NG service is to design the best possible open-hole filter-cake cleanup program for your specific application. Fundamental to this information-driven design are performance metrics and laboratory verification testing.

MUDSOLV NG service breaks the toughest filter-cake

Features

- Integrated filter-cake removal service for both producer and injector
- Wide range of water and oil-base breakers
- Component within all-inclusive open-hole completion strategy
- Wide variety of chemistry such as neutral pH, compatibility with divalent or monovalent brines, environmentally friendly
- Controlled breakthrough time
- BREAKER ADVISOR[†] software module to help narrow breaker options
- Simultaneous gravel packing and filter-cake removal
- Application-specific designs to disperse or dissolve filter-cake
- Economic risk and benefit analysis

Benefits

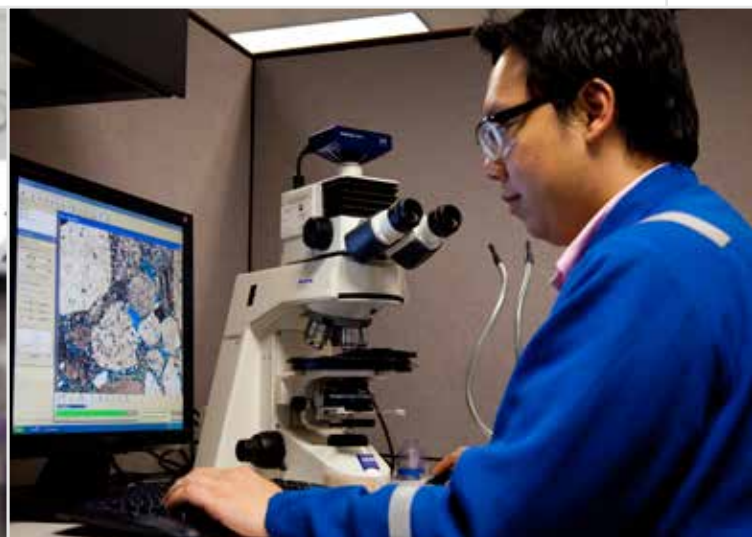
- Optimized well productivity from eliminating filter-cake related flow restrictions
- Enhances uniform inflow potential throughout open-hole
- Reduces sand production risk related to localized high fluid velocity
- Minimizes corrosion damage to completion hardware
- Decreases risks of premature water or gas breakthrough
- Eliminates remedial filter-cake cleanup costs
- Extends economic productive well life

The integrated MUDSOLV NG service optimizes the uniform removal of filter-cake through an integrated approach taking into consideration the overall open-hole completion process. Combined with the very latest analytical tools and novel breaker chemistries, the MUDSOLV NG approach consistently delivers uniform, controlled, and complete removal of the most tenacious filter-cake. The new generation oil- and water-base breakers within the MUDSOLV NG approach provide controlled breakthrough time for uniform filter-cake removal, are non-corrosive to completion hardware, and exhibit an exceptional HSE profile, making them ideally suited for the most sensitive offshore and onshore environments.

Fundamental to the MUDSOLV NG approach is recognizing and addressing all critical components of open-hole well completion:

- Reservoir characteristics
- Drilling and completion fluids
- Wellbore preparation, including cleanup and displacement
- Completion design and execution
- Economics
- Health, safety and environment

The MUDSOLV NG approach thoroughly considers all the components of an effective completion, beginning with an evaluation of the planned completion to determine the degree and type of impairment the filter-cake may present, and identifying the associated cleanup requirements. The results are used to help select the most effective and lowest risk chemical breaker technology, tools, and procedures that will achieve the ultimate objectives: An optimum completion and maximum production.



Maximize well productivity and asset value



Modern open-hole completions can significantly improve net productivity, reservoir drainage and the ultimate value of your asset. Consequently, they are increasingly common both onshore and offshore, especially in horizontal wells. The cost of drilling and completing a well, particularly in deepwater, demands that well performance meets or exceeds the design objectives and maximizes life expectancy for the completion. The MUDSOLV NG service uses operator objectives to determine whether filter-cake removal is necessary or beneficial and to establish prioritized performance metrics.

The MUDSOLV NG approach has three main goals within the completion continuum:

- Optimize well productivity by:
 - Eliminating filter-cake-related flow restrictions
- Minimize completion hardware failures by:
 - Eliminating or minimizing corrosive damage
 - Reducing non-uniform flow into completion hardware

- Extend the economic life of a producing well by:
 - Preventing premature water and gas breakthrough (coning)
 - Reducing sanding related to the velocity of the produced fluid

In open-hole and horizontal well completions, optimized well performance and extended economic life usually depend on uniform inflow along the wellbore. Uniform inflow enhances drainage efficiency, reduces the velocity of the produced fluid at the formation face, and distributes the drop in reservoir producing pressure over a greater area. These effects in turn can reduce fluid-velocity-related sand production and delay the production of unwanted water and gas.

Acid and other conventional filter-cake removal treatments generally are incapable of uniformly removing filter-cake without employing large volumes of chemicals and extensive placement operations. In addition, acid treatments are a concern for high corrosion of completion hardware. The MUDSOLV NG approach is to efficiently achieve uniform, effective filter-cake cleanup along the entire reservoir interval, using a suite of unique chemicals, procedures and tools.

Efficiency defines the MUDSOLV NG approach

Once the MUDSOLV NG service identifies a candidate well for filter-cake cleanup, our industry-recognized engineers analyze the collected information to characterize the reservoir, well path, RDF and completion design. Data analysis within the structured MUDSOLV NG approach uses the proprietary BREAKER ADVISOR[®] program to narrow the field of potential solutions.

Using samples of the RDF and reservoir rock and fluid, engineers at one of the M-I SWACO laboratories formulate, test and refine the most cost-effective solutions. The verification process helps identify potential incompatibilities between the reservoir and the fluid chemistry or completion process and confirms performance capabilities. The verified solutions are refined and re-evaluated for cost efficiency, and a customized plan for field application is prepared.

MUDSOLV NG service reduces the technical risks of your completion



Developing state-of-the-art breaker chemistries is one thing, applying them correctly is another thing altogether. Unlike conventional removal programs, the completely engineered approach of the MUDSOLV NG service considers the filter-cake cleanup a central component of the entire completion program. As such, our primary focus is preventing damage that would otherwise impair your open-hole completion, be it from corrosion or from filter-cake particulate/solids plugging of the screen or gravel pack.

Averting corrosion damage

Corrosion damage to expensive completion hardware is a common occurrence during conventional acid cleanup treatments, even when the acid is inhibited to industry-accepted rates. Like plugging, the corrosion of screens and liners compromises the functionality of the entire completion and shortens well life. The MUDSOLV NG approach evaluates the corrosion risk in selecting a treatment. A widely applicable MUDSOLV NG service for minimizing potential corrosion damage uses unique non-aggressive treatments based upon enzymes, chelating agent solutions (CAS), internal oxidizers, acid precursors or a combination thereof, depending on the specific type of RDF that deposited the filter-cake. The MUDSOLV NG approach consistently outperforms conventional acid cleanups.

Averting gravel-pack damage

The invasion and trapping of particulate material can severely damage gravel-packed completions. Since RDF filter-cakes are a primary source of particulates, their removal usually is necessary to establish and maintain optimum well productivity or injectivity in gravel-packed wells. The type and concentration of solids within the filter-cake, as well as the completion configuration, are important considerations in determining the need for filter-cake removal and selecting the treatment technique.

Partial plugging of well screens and liners redirects the flow of produced fluids to open areas of the hardware with a resulting increase in the local inflow velocity. These production hot spots are usually sites of erosion and reduce the life expectancy of the completion. Redirected flow also creates stagnant areas where trapped fluids can create corrosion cells within the completion. MUDSOLV NG service solutions have been developed that permit simultaneous gravel-packing and filter-cake cleanup.

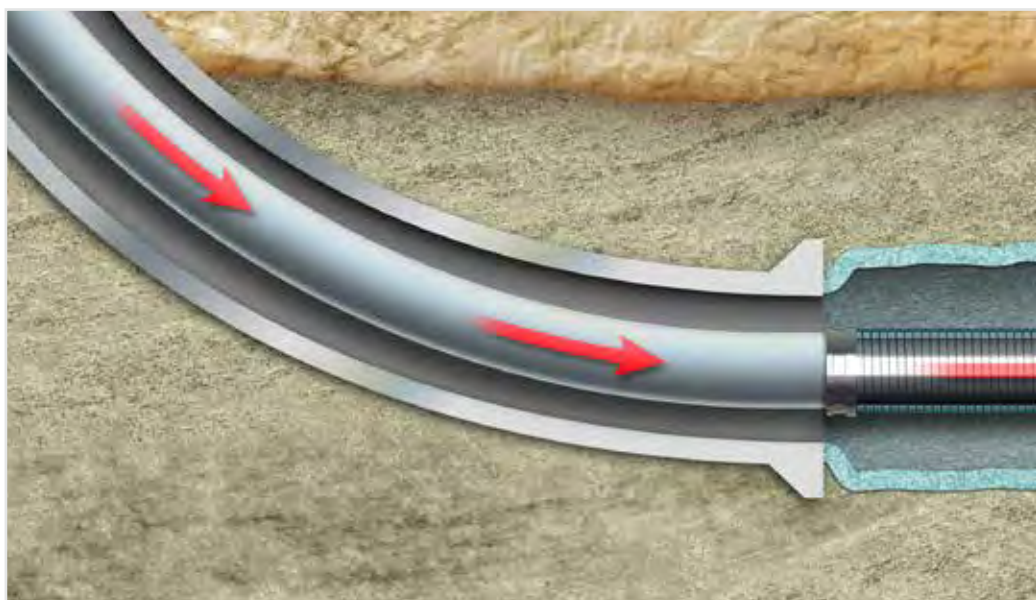
Post-job evaluations validate job efficiency

Following the completion of a MUDSOLV NG service, post-well analysis of the job execution is conducted. Completion performance and job execution are evaluated against the performance metrics established during the initial design stage. The resulting report from the Schlumberger design - execute - evaluate process is a sound basis for continuous improvement of future MUDSOLV NG approaches.

How the MUDSOLV NG service works

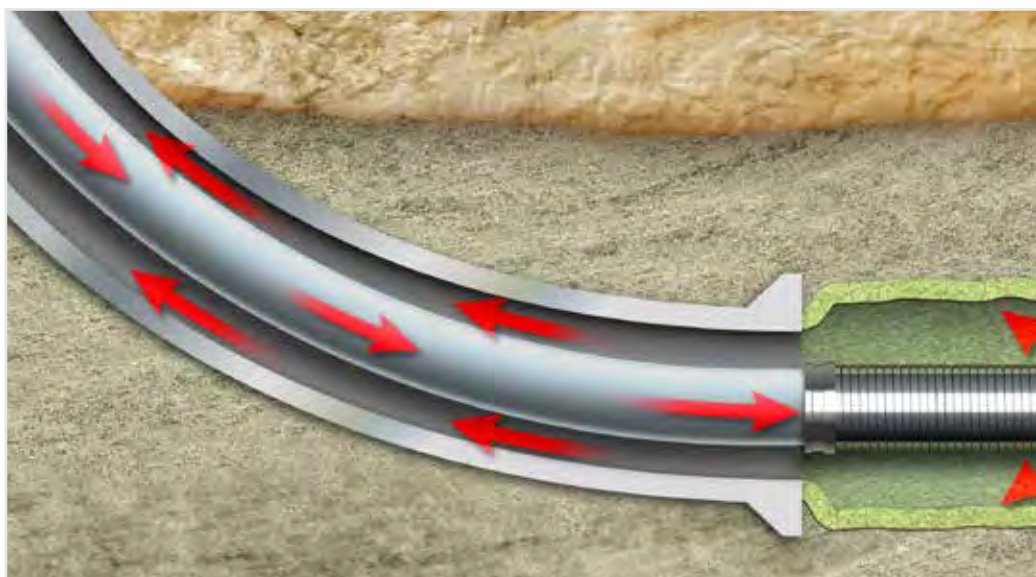
Fast-acting (aggressive) treatments typically break down and remove the filter cake at the first point of contact, allowing the cleanup treatment to exit the wellbore and leaving significant areas of the wellbore untreated with filter cake intact.

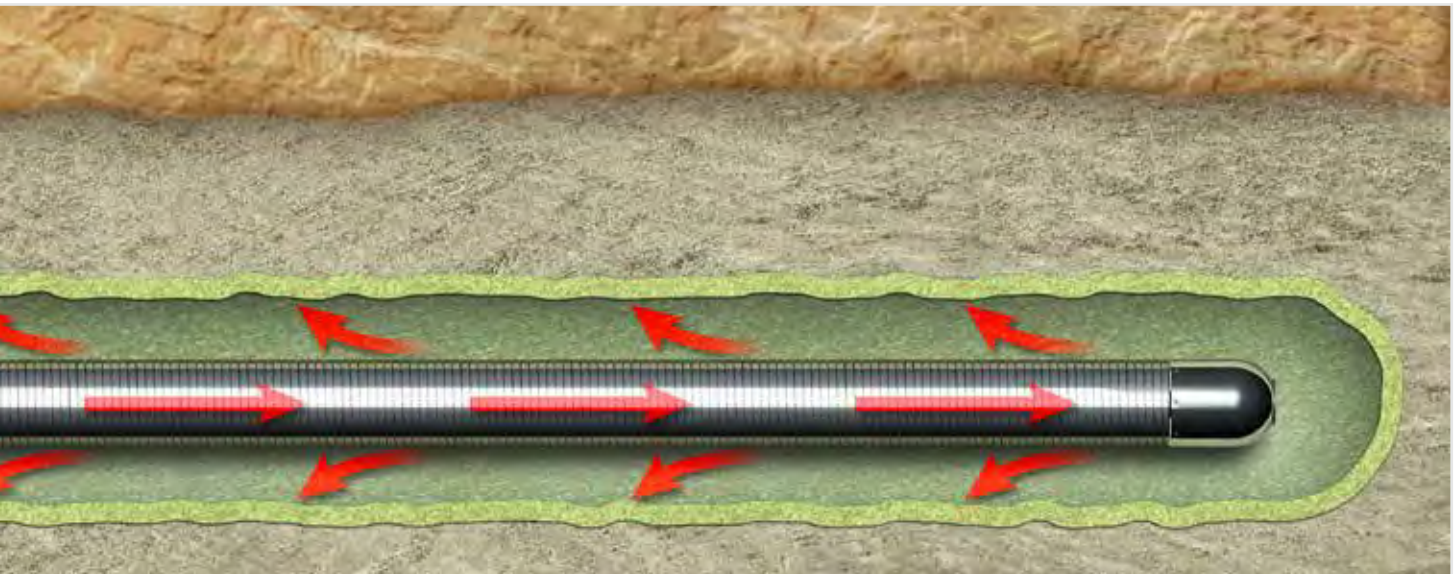
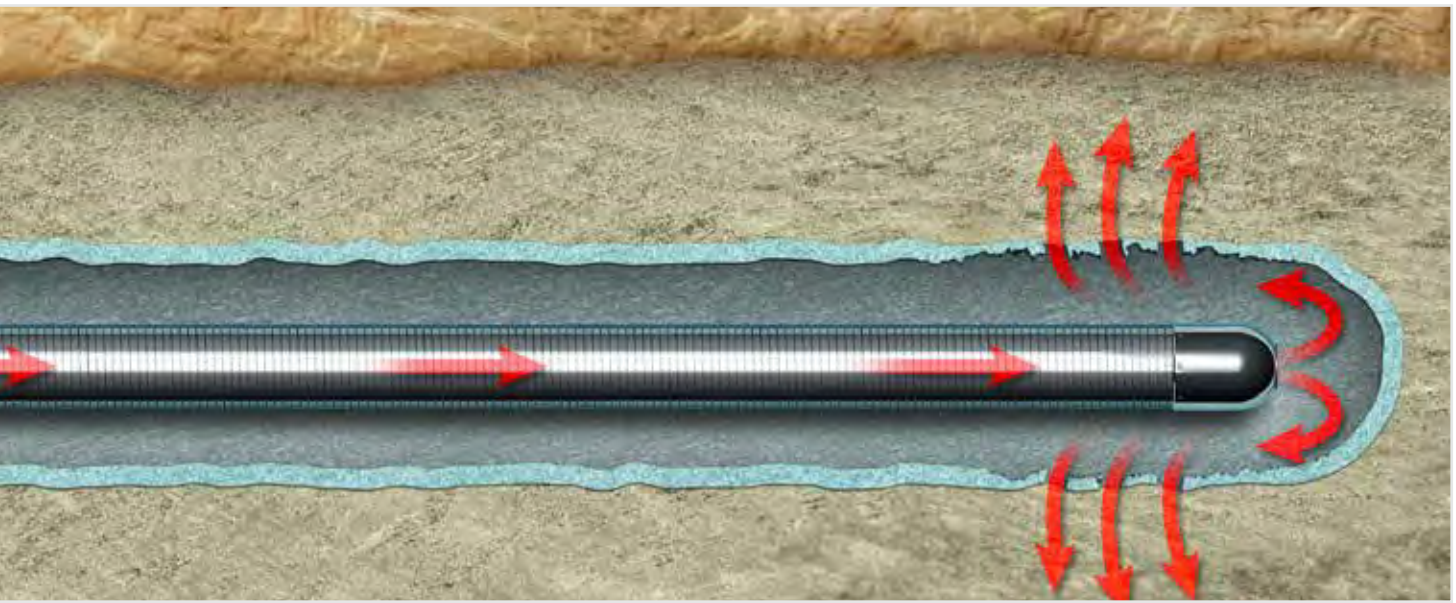
With conventional acid treatment, nonuniform (localized) filter-cake removal causes the required producing pressure drop to be taken over a smaller area and may promote gas and/or water coning.



The MUDSOLV NG approach allows slow-reacting (non aggressive) treatments to be carried to all areas of the filter cake in the wellbore (as during simultaneous gravel packing and cleanup). Uniformity of cleanup is improved, and the pressure required to flow into the completion along its entire length is reduced.

Using the MUDSOLV NG service, uniform cleanup promotes more uniform inflow all along the wellbore, reducing produced fluid velocity within the formation near the wellbore and into the lower completion.





MUDSOLV NG approach proves itself in the field

Gulf of Mexico: The MUDSOLV NG approach puts long-dormant deepwater well on line

The Situation

The ultra-deepwater well was completed open-hole with a horizontal gravel pack employing 30/50-sized gravel and shunts to compensate for the ultra-low fracture gradient. The 2,395-ft (730 m) open-hole with a bottom hole temperature (BHT) of 110°F (43°C) was drilled with a FLOPRO NT[†] water-base reservoir drill-in fluid (RDF) incorporating the D-STROYER[†] internal breaker. The well had been shut-in for nearly two years prior to flowback and required complete filter-cake cleanup and protection of the downhole hardware before being put on production.

The Solution

After an evaluation, M-I SWACO recommended a MUDSOLV NG service comprising a BREAKDOWN[†] chelant-based breaker system mixed in the carrier fluid with the BREAKDOWN 7[†] neutral pH breaker used post-gravel pack. The carrier fluid was formulated with a CLEARPAC MS[†] viscoelastic surfactant in a 9.7 lb/gal (1.16 sg) NaCl/KCl brine.

The Results

The gravel pack was executed flawlessly, achieving 100% pack efficiency. After a two-year shut-in, the well was put on production with excellent cleanup observed and zero skin. Production rates exceeded expectations.

West Africa: FAZEOUT fluid cleanup of OBM filter-cake cuts FIP 73%

The Situation

Reducing flow initiation pressure (FIP) was a primary concern in preparing for the filter-cake cleanup of the 984-ft (300 m) horizontal open-hole. The horizontal gravel pack completion contained shunts and 20/40-sized gravel. The open-hole has been drilled with a FAZEPRO[†] reversible oil-base RDF.

The Solution

M-I SWACO specialists analyzed the situation and recommended a MUDSOLV NG cleanup program using the FAZEOUT[†] water-base acid precursor specially formulated to break the FAZEPRO oil-base filter-cakes. The breaker would be mixed with the xanthan 10.2 lb/gal (1.22sg) NaBr-based carrier fluid.

The Results

By incorporating the FAZEOUT breaker, the operator achieved a remarkable 73% reduction in FIP in the cleanup from 8.2 to 2.2 psi. The gravel pack was successfully executed, but the well remained off line pending completion of the production facilities.



Norway: Breaker exceeds all HSE and operational requirements

The Situation

In this extremely environmentally sensitive region, the filter-cake breaker chosen for the open-hole gravel pack would be required to have an exceptional HSE profile. The cleanup would involve two wells with open-hole lengths between 285-328 ft (87-100 m), BHT of 194°F (90°C) and deviation of 75-80°. The open-hole was drilled with a water-base RDF.

The Solution

The operator selected a MUDSOLV NG approach that would feature the BREAKDOWN HD chelant-based breaker system that carries the prestigious green North Sea environmental rating. The breaker would be incorporated in the carrier fluid that consisted of MS in a 9.3 lb/gal (1.12 sg) NaCl brine.

The Results

The filter-cake cleanup was completed with zero environmental incidents with lab tests showing retained permeability of more than 67%.

Trinidad: Large bridging agents no match for MUDSOLV NG breaker

The Situation

Four open-hole gravel packs using shunts and 30/50-size gravel were completed in an offshore gas field. The open-holes, which ranged from 164-558 ft (50-170m) in length and 169°F (76°C) BHT, were drilled with a FLOPRO NT water-base RDF. The RDF incorporated large-particle bridging agents to compensate for the extremely high permeability, raising concerns over gravel-pack plugging during the filter-cake cleanup.

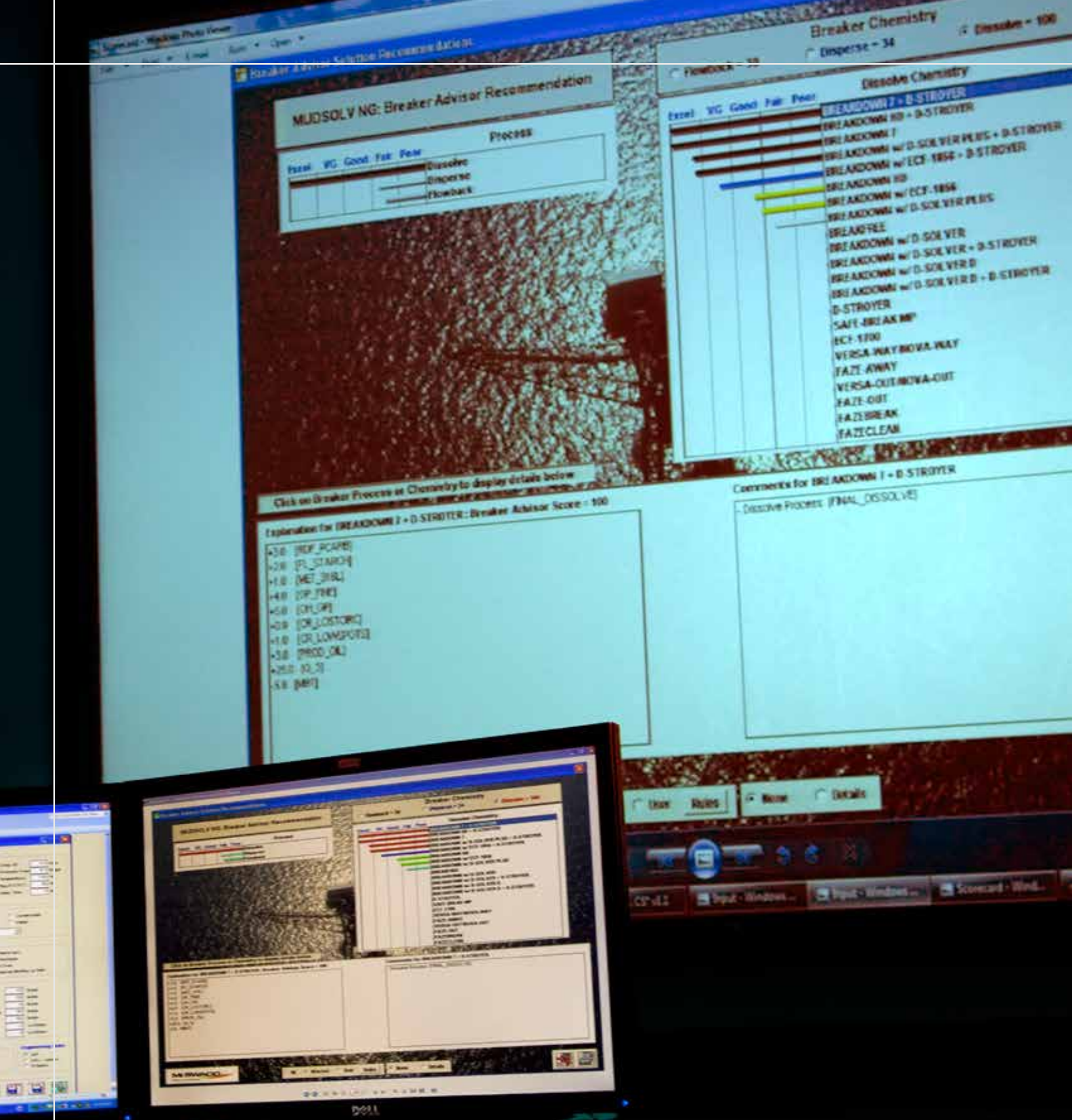
The Solution

A MUDSOLV NG service assessment recommended the operator employ the BREAKDOWN HD⁺ chelant-based breaker system, which carries a Green North Sea rating attesting to its exceptional HSE profile. The breaker system was incorporated in the carrier fluid that consisted of HEC in a 10.6 lb/gal (1.27 sg) CaCl₂ brine.

The Results

All four wells were gravel packed successfully achieving 100% pack efficiency. The drawdown was 80% lower than offset wells and average gas production was 200 MMscfd.





BREAKER ADVISOR

BREAKER ADVISOR is an expert designed computer program to aid in selection of the appropriate breaker system. A wide selection of chemistries are used for the most compatible system to formation properties, completion hardware, economics and operations.

The user enters critical data and BREAKER ADVISOR program scores MUDSOLV NG Breaker Systems for the best fit. MUDSOLV NG Breaker Systems achieving top scores may be further optimized and tested in the laboratory to make sure the best solution is applied for a well-specific application.

Put the MUDSOLV NG service to work for you

To find out more about how our MUDSOLV NG filter-cake removal service is working for our other customers worldwide, contact your local M-I SWACO representative.



Proven breaker success

North Sea: MUDSOLV NG service enhances production of a stand alone screen completion

The Situation

In order to minimize water encroachment, increase wellbore contact with the reservoir to maximize recovery, the well was sidetracked as a horizontal openhole Stand Alone Screen (SAS) completion. The openhole length was 1846 ft and screen was 230 micron premium mesh. FLOPRO NT¹ water-base reservoir drill-in fluid (RDF) was used to drill the openhole section.

The Solution

After an evaluation, M-I SWACO recommended a MUDSOLV NG service comprising of a BREAKDOWN chelant/enzyme-breaker system for its ability to fully remove the FLOPRO NT filter cake from the sandface, while controlling breakthrough time. This would ensure that the well did not take losses prior to pulling out of the hole with the washpipe and closing the Fluid Loss Control Valve (FLCV). The FLOPRO NT reservoir drilling fluid/ BREAKDOWN breaker yielded positive results in an independent return permeability study.

The Results

The BREAKDOWN enzyme/chelant effectively broke down the filter cake in a controlled time, allowing the wash string to be recovered from the lower screen completion without any fluid losses. When the well was put on production, cleanup was achieved in a short time, with well test Pressure Buildup (PBU) analysis indicating no damage.



ONLINE RESOURCES

Completion Fluids

www.miswaco.com/completion

Breakers

www.miswaco.com/breakers

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