



The Halliburton Conformance Portfolio

**REDUCING UNWANTED
WATER PRODUCTION**

The Halliburton Conformance Portfolio

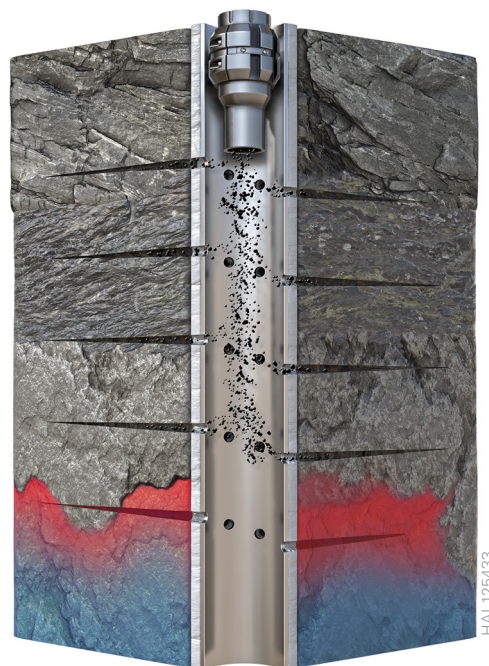
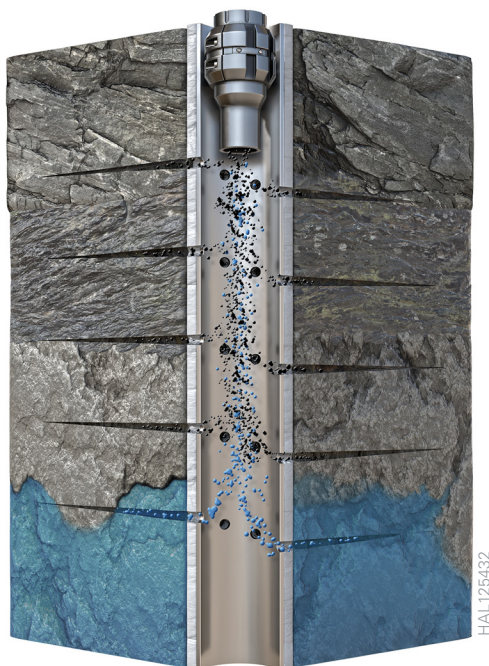
EXPERT SOLUTIONS FOR WATER SOURCE PROBLEMS

The oil industry estimates that tens of billions of dollars will be spent during the next decade to handle increased water production and to comply with water disposal regulations, which continue to become more stringent. Thus, it is not surprising that reservoir water management, commonly known as conformance, has become a much higher priority for oil and gas operators forced to either cost-effectively solve problems posed by unwanted produced water, or to shut in the wells that become uneconomical because of it.

Conformance technology is the application of processes to reservoirs and boreholes to help reduce the production of unwanted water and/or gas in order to efficiently enhance hydrocarbon recovery and/or satisfy a broad range of reservoir management and environmental

objectives. Although water management may not always result in increased hydrocarbon production, application of the technologies can often improve an operator's profitability by helping to achieve a longer productive well life, reduce lifting costs, and reduce environmental concerns and costs.

Just as there is a broad variety of causes of excess water production, Halliburton offers a broad variety of solutions to help mitigate these water problems. The Conformance Services Portfolio table and the Diagnostic Services Portfolio table provide a cross-reference of water source problems, along with the solutions that Halliburton offers, which vary from in-situ crosslinked water-based polymers, swelling/superabsorbent polymers, and relative permeability modifiers, to cement-type materials.

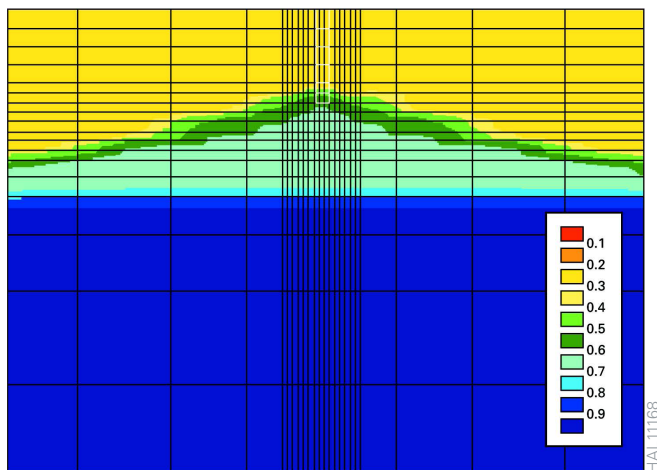


Conformance treatment for Water Coning application > Conformance treatment is strategically placed into the formation through the rock matrix, filling the pore spaces while displacing reservoir fluids. In-situ gelation occurs through a process activated by the well temperature, which plugs pore spaces and channels, thereby limiting undesired water flow. Conformance treatment helps delay the water-oil-contact from reaching the upper intervals .

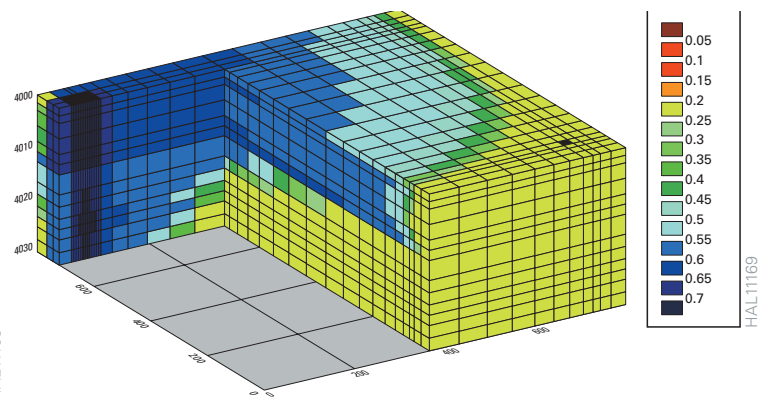
Halliburton conformance solutions have proved effective in vertical, highly deviated, and horizontal wellbores, including challenging completions such as gravel packs, slotted liners, and openhole completions. In addition to the wide variety of chemical solutions that Halliburton offers, the QuikLook® conformance simulation service was developed to optimize the design and placement of unwanted fluid shutoff treatments. By numerically simulating the flow of oil, gas, water, conformance fluids, and heat through a porous medium in 3D, the simulator allows data to be interpreted with unprecedented speed and accuracy, simulating applications such as:

- » Water coning
- » Channeling through high-permeability streaks
- » Squeeze jobs and shut-off treatments using sealants
- » Zonal isolation

With QuikLook simulator service, well interventions can now be designed to enhance value to the operator in terms of forecasting hydrocarbon production resulting from treatments, and reducing economic and operational risks by allowing better candidate selection.



Time = 304 Days



Time = 200 Days

QuikLook® software gives both 2D and 3D representations of water distribution inside the reservoir. Issues such as coning or water channeling can be identified quickly, so that action can be taken.

EXPERT SOLUTIONS FOR WATER SOURCE PROBLEMS

| Conformance Services Portfolio | Best Applications (✓ = Yes) | Temp. Range, °F (°C) | Water Shutoff | Gas Shutoff | Wellbore & Perfs | Near-Wellbore | Deep | Acid Resistant | H ₂ S Resistant | CO ₂ Resistant | Plug-Back | Shutting Off Perfs | Fluid Losses While Drilling | Fluid Losses During Workover | Temporary Chemical Isolation |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------|-----------------------|------------------|---------------|----------------------|----------------|----------------------------|---------------------------|-----------|--------------------|-----------------------------|------------------------------|------------------------------|
| | | | Application | Treatment Penetration | | | Treatment Resilience | | | In the Wellbore | | | | | |
| Cementing | From primary to remedial cement slurries that can be designed to withstand the cumulative stresses from well events such as pressure testing, well testing, and multiple stimulation treatments. | > 400° (> 204°) | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| BackStop SM Service | A porosity-fill sealant with near-wellbore penetration for water and gas shutoff. It provides a controlled, shallow penetration allowing future re-perforation of the targeted zone, if desired. | 32° to 350° (0° to 177°) | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | | |
| Thermatek [®] Service | A temperature-activated, rigid-setting fluid with a controlled right-angle set capable of quickly developing high compressive strength for near-wellbore water and gas shutoff applications. | 0° to 350° (-18° to 177°) | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| MOC/One SM Service | A hydrocarbon-based Micro Matrix [®] cement slurry system designed for selective water control. The system only reacts upon water contact; otherwise, it remains inactive. For near-wellbore water shutoff applications. | 60° to 350° (16° to 177°) | ✓ | | ✓ | | | ✓ | ✓ | ✓ | | | | | |
| H ₂ Zero [®] Service | A porosity fill-sealant for water and gas shutoff. Deeper penetration into the formation than chrome-crosslinked gel systems, resulting in a strong, permanent seal throughout the entire treated interval. | 32° to 350° (0° to 177°) | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | |
| EquiSeal [™] Service | A porosity-fill sealant specifically designed to help control unwanted fluid production in horizontal or highly deviated wellbores. It allows precise placement of the gel system due to its stress-dependent rheological properties. | 140° to 250° (60° to 121°) | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | |
| Foam_Zero [®] Service | A high-quality, stable foamed solution that effectively seals natural fractures and fissures for water and/or gas shutoff applications. It optimizes placement in naturally fractured or fissured carbonate reservoirs. | 32° to 350° (0° to 177°) | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | |
| Matrol SM Service | A sealant system mainly designed for deep penetration in naturally fractured reservoirs. Utilizes low concentrations of a high molecular weight polymer which produces lipping gels. | 80° to 220° (27° to 104°) | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | | |
| WellLock [®] Resin System | Essentially impermeable to water and/or gas with unique mechanical properties, chemical resistance, and superior mechanical bonding strength. Exceptionally well suited for remediation. | 50° to 225° (10° to 107°) | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| K-Max Plus SM Service | Solids-free, non-damaging crosslinked gel that serves as a temporary chemical plug (reversible) for fluid loss control or placement aid during conformance operations. | 70° to 325° (21° to 163°) | | | ✓ | | | | | | | | | ✓ | ✓ |
| CrystalSeal [®] Service | A water-swelling polymer designed to shut off fractures, fissures, or highly vugular zones in injection wells to improve sweep efficiency of water and/or gas injection. | 60° to 275° (16° to 135°) | ✓ | | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | | |
| WaterWeb [®] Service | A relative permeability modifier (RPM), bullhead-type treatment designed to selectively reduce water flow from the treated area with little or no damage to hydrocarbon production (oil or gas). | 60° to 325° (16° to 163°) | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | | | |
| CW-Frac SM Service | Halliburton fracture-stimulation technology with an RPM polymer to help increase hydrocarbon production while reducing water production that can occur when a fracture intercepts a nearby water-producing zone. | 60° to 325° (16° to 163°) | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | | | |
| Guidon AGS SM Service | A solids-free acid-diversion system that changes the effective permeability of the rock to aqueous fluids for optimum acid coverage of the treated interval. It can potentially help reduce formation water production. | 60° to 350° (16° to 177°) | ✓ | | | ✓ | | ✓ | ✓ | ✓ | | | | | |
| LO-Gard [®] Service | A solids-free, low-viscosity system that helps minimize completion fluid losses to the formation during or prior to overbalanced workover interventions, such as wellbore cleanups and stimulation treatments, among others. | 60° to 350° (16° to 177°) | | | | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | |

[illegible]

EXPERT SOLUTIONS FOR WATER SOURCE PROBLEMS

[illegible]

EXPERT SOLUTIONS FOR WATER SOURCE PROBLEMS

| | Diagnostic Services Portfolio (continued) | Best Applications (✓ = Yes) | Coning or Cresting | High-Perm Streaks | Channel from Injector | Acidizing Near a Water Zone | Chemical Inefficiencies | Fractures, Fissures, Voids | Fracturing Near a Water Zone | Frac Job Went to Water |
|---------------------|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------|-----------------------|-----------------------------|-------------------------|----------------------------|------------------------------|------------------------|
| | | | Matrix Inefficiencies | | | | Fractures | | | |
| | | | | | | | | | | |
| Diagnostic Services | Production Logging | Production logging provides detailed measurements of downhole flow, indicating entries, phases, temperature profiles, rates, and more. PL sensors read inside the pipe but temperature & pressure are influenced the environment outside the pipe. | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | CAST™ Tool | The Circumferential Acoustic Scanning Tool accurately measures the internal diameter and the thickness of the pipe. The tool can be run in image mode to see features on the inside wall. | | | | | | | | |
| | ACX™ Tool | The Acoustic Conformance Xaminer® tool uses an array of hydrophones to locate leaks/flow in and near the wellbore. It identifies radial and vertical locations in real time and creates a 2D flow map image of the flow/leak. | | | | | | | | |
| | CAST™/CBL Tools | Using the Circumferential Array Scanning Tool and a VDL log, this combo measures the cement integrity and degree of isolation of the well in high detail and accuracy. CAST determines the bond to casing and measures the impedance of the cement, while the CBL, 5ft VDL measures the bond to formation. | | | | | | | | |
| | EPX™ V Tool | The Electromagnetic Pipe Xaminer® V tool uses electromagnetic technology to measure metal loss in tubing and casing in wells where corrosion issues exist. | | | | | | | | |
| | RMT-3D™ Tool | The Reservoir Monitor Tool 3-Detector tool is a versatile technology. This is accomplished by using spectral and other measurements off the three detectors, which makes it very accurate for oil, water, gas, and enhanced oil recovery (EOR) fluid saturations. Oxygen activation can see water movement inside and outside the pipe. | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | TMD-3D™ CO Tool | The Thermal Multigate Decay 3-Detector tool uses three-detector technology for sigma and saturation gate (SATG) measurements to calculate water, oil, and gas saturations. Oxygen activation can see water movement inside and outside the pipe. | ✓ | | | | | ✓ | ✓ | ✓ |
| | MFC Tool | The MFC tool is a multifinger caliper log that gives internal diameter information of the pipe it is in. | | | | | | | | |
| | Armada® Tool | This cased-hole, pressure-compensated, single-phase sampler recovers 400 cc of pressure-volume-temperature (PVT) type samples while monitoring the pressure and temperature of the wellbore for accurate results. Used for PVT analysis and other fluid tests. | | | | | ✓ | | | |
| | SPECTRUM® | Coiled tubing service providing reservoir, wellbore, and treatment assessments through real-time, fiber-optic distributed sensing, distributed temperature sensing (DTS), and distributed acoustic sensing (DAS) | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | SPECTRUM® 360 | Coiled tubing real-time camera service. The tool provides 360-degree vision for optimal diagnostic and is a flow-through, all-chemical service. Any mechanical and electric logging tool can be run with the camera in a single trip. | | | | | | ✓ | | |
| Deployment | E-line, Slickline, or Combo | Traditional conveyance using electric wireline, slickline, or a combination to provide diagnostic logging surveys and/or mechanical well intervention services. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | RELAY™ Digital Slickline | The RELAY™ digital slickline system bridges the gap between slickline and e-line conveyed services by providing mechanical and electric wireline logging, and intervention capabilities in a single line. | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| | Wireline Tractor | Wireline tractors used for diagnostic logging surveys, perforating, and mechanical well interventions in highly deviated or horizontal wells. | ✓ | ✓ | ✓ | ✓ | | ✓ | | |
| | SPECTRUM® FUSION Coiled Tubing | When equipped with SPECTRUM® FUSION real-time service, coiled tubing offers full diagnostic and intervention possibilities. It combines electric and fiber-optic capabilities to perform DTS/DAS, camera, and electric logging. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Sales of Halliburton products and services will be in accord solely with the terms and conditions contained in the contract between Halliburton and the customer that is applicable to the sale.

H013297

10/19 © 2019 Halliburton. All Rights Reserved.