FULL SERVICE
MAXIMUM PRODUCTION
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Schlumberger provides integrated production technology services that deliver tangible benefits and assurance to customers’ worldwide oil and gas operations.

Firmly established at the forefront of technology, Schlumberger integrates pioneering chemical and process solutions, equipment, and software with unrivaled technical expertise.

Working with the world’s largest oilfield services provider, customers benefit from a truly unique combination of outstanding technological capability, blended with a distinct understanding of how to successfully address their production challenges in an increasingly competitive marketplace.

Schlumberger’s global footprint and exceptional service delivery ensures that customers reliably, safely, and efficiently maximize production—regardless of system complexities or geography.

Applied expertise

Working together with customers in every global oil and gas hub, Schlumberger uses specialist research laboratories and field support operations to analyze issues across production operations and to engineer integrated solutions that help increase revenue and reduce operational costs through protecting asset integrity, safely maximizing production, and enhancing product quality.

To optimize performance, production chemicals can be used alone or be combined with mechanical solutions that are available to buy or rent with a full maintenance and retrofit service.

In addition, Schlumberger’s specialist and diverse knowledge and expertise means each solution is fully compliant with local regulations and will optimize and protect hydrocarbon flow with minimal environmental impact.

Offering

Production chemistry is the backbone of the oil and gas industry, covering flow assurance, integrity management, and separation performance.

Schlumberger’s production technology specialists deliver targeted, integrated strategies that proactively anticipate, address, and decisively remediate production issues in a complex, multifaceted international industry.

The company provides leading-edge production chemistry, backed by mechanical and software solutions and aligned under the PREVENT, PERFORM, and CURE segments to anticipate and prevent issues, enhance and enable production, and remove obstacles, respectively.

- **PREVENT**—Chemistry to mitigate production threats.
- **PERFORM**—Chemistry to achieve full field potential.
- **CURE**—Chemistry, services, and software to restore full production.

In addition, ChemWatcher* integrated chemical management software, powered by the Avocet* production operations software platform, delivers real-time information to prevent production issues and to optimize performance.
Increasingly remote and complex operations require greater alignment between operator and service provider to deliver excellence in execution and maximum value.

**Management services**

The race to keep up with market demand is driving the industry deeper and further to produce from ever-more complex reserves. This is why Schlumberger continues to attract some of the greatest engineers and chemists and remains focused on needs, delivery, people, technology, and value—not simply on products and unit price.

Providing a product, solution, or service is not enough. Schlumberger is committed to meeting the evolving and exacting needs of the industry by building the technology pathway and developing smarter methods of working. This will help us ensure that projects are delivered on time and budget as well as provide continuous value improvement from first oil to the end of field life.

**Risk appraised management process**

Throughout the tenure of the product and service supply, Schlumberger’s risk appraised management process (RAMP) confirms and ensures delivery of the resources and activities required to identify, develop, and secure production technology enhancements that will deliver value to our customers while ensuring top quartile QHSE performance.

Successful deployment of our customized chemical solutions and management services is supported by the ChemWatcher software, enabling operators to maximize production, mitigate nonproductive time, and minimize total operational cost.

**ChemWatcher software**

ChemWatcher software enables informed, real-time decisions about operational efficiency, safety, and performance. The system leverages Schlumberger’s global specialist knowledge and technical expertise, continually adding value right from field start-up through to cessation of production.

This software solution integrates with market-proven tools such as PIPESIM* steady-state multiphase flow simulator, OLGA* dynamic multiphase flow simulator, and dbrHydrate* fluid analysis software to manage the workflow related to chemical applications, injections, and production processes.

ChemWatcher software includes visualizations of asset status and trends from simple traffic lights to detailed interactive reports.

In addition to real-time production performance monitoring and analysis, ChemWatcher software is enabled for supervisory control and data acquisition (SCADA) and telemetry and works as a central repository hub, providing information exchange and analytics for all data relating to

- flow assurance and integrity management
- production and product performance
- inventory management and commercial performance
- laboratory data and trend analysis.

The IPCE management program is built upon 14 key principles:

- HSE
- Roles and responsibilities
- Processes and practices
- KPI
- Data acquisition, collation, and reporting
- Problem solving
- Application risk evaluation
- Project management (balanced scorecards)
- Best practices
- Environmental stewardship
- Commercial structures/contracts
- Peer review and audit
- Training and competency
- Interactive business performance review
IMPROVE PRODUCTION DECISIONS.
OPTIMIZE RESULTS.
With established technology groups led by industry-recognized discipline leaders, Schlumberger ensures that its customers receive the best support available.

Schlumberger ensures that applications are correctly assessed, that effective and fit-for-purpose products are selected, and that success in application is assured through accurate measurement. Results analysis drives development to ensure continuous improvement.

RAMP and the ChemWatcher software underpin this process, ensuring that tailored solutions are managed, accurately monitored, and delivered.

### Technology groups

The technology groups are the product-line custodians. As specialist advisory groups, they manage commercialization of new technology and support the global service organization that provides the direct application and support services to the field.

- **Separation solutions**—Water clarification, filtration, and demulsification
- **Organic flow assurance**—Wax, asphaltenes, and naphthenates
- **Inorganic flow assurance**—Scale and hydrates
- **Integrity management**—Corrosion, microbiology, and deep water
- **Gas purification**—H₂S and mercury

### Locations

Technology centers are located in Houston, St. Louis, Aberdeen, Stavanger, and Dubai.

Additional technical service centers are located in Nisku, Broussard, Bogota, Rio de Janeiro, Bergen, Volski, and Kuala Lumpur. These centers are supplemented by local facilities.
The Schlumberger production chemical research and development (R&D) group comprises Masters- and Doctorate-level personnel in the UK, Norway, and the US who have in-depth knowledge of organic and general chemistry, synthesis, structure-activity relationships, and scaleup.

The team develops active molecules that are then formulated by the company’s technology group and packaged for the intended application. The R&D group works closely with Schlumberger commercial and technical groups and its customers to identify and develop new products where there is market demand.

Schlumberger works closely with the chemical industry, leveraging innovation from its research as well as developing molecules in house that may be produced commercially under a toll manufacturing arrangement. When working with supply companies, Schlumberger works toward identifying exclusive joint projects where there is a good fit for both companies.

Understanding at the molecular level why and how select chemistries deliver the desired effect (e.g., corrosion inhibition, scale inhibition, and emulsion breaking) affords the opportunity to:
- determine structure-property correlations that can be used to ensure the development of optimal solutions
- minimize empirical testing through design of experiment concepts replacing a trial-and-error approach
- maximize value through understanding and optimization of the total cost of goods, including raw materials.

Outcomes of this approach include advances in:
- environmentally friendly corrosion inhibitors and demulsifiers
- low-dose kinetic hydrate inhibitors
- pour-point depressants for heavy crude oils and deepwater applications
- asphaltene dispersants for heavy crude oils.

**Ecotoxicity testing**

With a 35-year track record in this field, Schlumberger’s unrivaled strength in ecotoxicity testing complements its technical expertise and the performance characteristics of its production chemicals range, resulting in a genuinely unique offering to assess, manage, and deliver excellence in environmental stewardship.

Supporting Schlumberger in the Eastern Hemisphere, the Bergen ecotoxicological testing facility is internationally renowned for balancing scientific thoroughness with the public safety concerns of regulatory authorities.

This capability puts Schlumberger at the leading edge of what has become a global revolution in green chemistry to meet ever-growing demand for higher standards of environmental stewardship.

These efforts are further supported by the Houston laboratory, which serves the Western Hemisphere and offers marine, freshwater, and terrestrial testing.

Efforts are coordinated to provide routine testing and evaluation of new and existing products to drive continued progress.

Whether for well services, pressure pumping, cementing, drilling fluids, or production, all services are managed under the same process and their data stored in a central server network to enhance knowledge and advancements in the field of green and alternate chemistry solutions.

This positions Schlumberger as the partner of choice for exploration in ever-deeper water, unconventional formations, and increasingly hostile environments that require a more sophisticated portfolio of chemical technologies.
SUPPLY CHAIN

Schlumberger’s comprehensive range of production technology products and services are supported by a supply chain organization designed to meet the requirements of the most responsive service company in the oil field.

The company’s chemical spend matches that of the largest chemical manufacturers and organizations.

In fact, with an annual spend of more than USD 23 billion, 500,000 procurement transactions completed each month, and a supply chain workforce exceeding 5,000, Schlumberger is twice as big as its closest oilfield services competitor when it comes to reach, distribution, procurement, and sourcing.

The supply chain system leverages years of global experience and comprises an extensive network of verified and approved suppliers and service providers. Therefore, customers can be assured of the highest quality at optimized cost.

Schlumberger continuously monitors the market for equivalent, alternative, and more cost-effective raw materials. Its general strategy is to have more than one approved supplier for each raw material to maintain cost control and to maximize supply security.

By adopting a “make-to-sell” strategy driven by customers’ needs, Schlumberger’s field operations and technical teams deliver the best solution each time and every time, providing agility in approach.

Where production quantities become significant, in-house manufacturing ensures the lowest cost of goods sold while not limiting the choice in application.

To achieve this goal, Schlumberger has established a global network to maximize local content. It starts with the primary manufacturing facility in Norway and is supplemented by qualified toll manufacturers at key locations across the globe and in-house blending facilities located close to customers.
The global oil and gas industry is dynamic, evolving, and increasingly competitive. It continues to present unrivaled opportunities for the brightest engineering and scientific minds.

Securing the sector’s continued prosperity, particularly in challenging times, means harnessing, focusing, and continuously developing that potential.

Starting with the basic building blocks for the job, Schlumberger quickly brings new production technology specialists up to speed in the disciplines required for them to deliver maximum value from the company’s products and services.

Standardized global training courses help to ensure employees are capable of supporting our customers to the highest level of consistent service around the world. Curricula are standardized within each business line and specialized content is available for specific geographical and environmental considerations.

Basic training is just the beginning of a successful career; structured learning continues through Schlumberger’s Management Development Program (MDP) for those employees interested in pursuing a career in line management. The Schlumberger Eureka Technical Career (SETC) is an alternative path for those employees wishing to advance within a petrotechnical domain or a research, engineering, manufacturing, and sustaining (REMS) métier.

Training resources
Schlumberger has developed a range of tools to support the training and development of its employees and has made a sizeable investment developing a global learning management system (LMS) known as iLearn. iLearn provides employees with access to a variety of learning opportunities through instructor-led courses and computer-based training.

Schlumberger’s state-of-the-art learning centers further enhance employees’ learning experience by optimizing the learning environment both inside and outside of the classroom. These facilities bring together multiple business lines to improve learning opportunities across the spectrum of our products and services, and hands-on training is facilitated through the use of fully functional drilling rigs and equipment installations that provide a lifelike environment.

Training programs
New-hire employees are introduced to the training program during their first week with Schlumberger. Every business line has a carefully crafted training program that outlines career progression, technical and soft skills training requirements, and specific knowledge and skill requirements that will help the employee achieve increasing degrees of proficiency during each phase of training.

As employees complete their technical training and develop the knowledge and skills outlined in their program, their progress is recorded and tracked in iLearn. Each individual’s learning history remains with them as they change assignments, providing managers with an effective means to ensure continuity as employees work towards completing their training program.

LEAP training program
The Learn, Excel, Apply, and Perform (LEAP) training program was developed to acknowledge the unique commitment to safety, environment, and service quality on which customers depend. The primary goal of the program is to help each employee meet their maximum potential.

Employees develop their core theoretical knowledge and technical skills via a number of activities, including instructor-led technical training, soft skills training, and on-the-job experience. To advance from one step of the program to the next, employees must demonstrate that they have achieved an appropriate level of proficiency that is validated on the job by a qualified lead-hand designated by local management.

ADVANCE training program for research or engineering, manufacturing, and sustaining
ADVANCE is the training program that was introduced for employees joining Schlumberger’s research, engineering, manufacturing, and sustaining (REMS) organization. The program was designed to help our scientists and engineers engaged in the REMS organization gain the essential skills to excel in their respective technical métier (such as chemistry, mechanical engineering, and electrical engineering).

Customer engagement
Schlumberger’s different business lines regularly provide customers with seminars and training programs that are tailored to their specific requirements. This may include topics such as production technologies, chemical handling, and environmental management.

NExT, a Schlumberger company, also provides training and career development services for E&P customers on a diverse range of topics spanning the exploration to production lifecycle. NExT has trained more than 70,000 oil and gas industry professionals, including its own employees and customers.

The company was recently recognized as the Getenergy Education and Training Provider of the Year in 2015, marking the third consecutive year in which the NExT training and competency development business has received the award.
NExT was recognized as the 2015 Getenergy Education and Training Provider of the Year.
PREVENT
MITIGATE PRODUCTION THREATS, OPTIMIZE PERFORMANCE

No matter how hostile or challenging the environment, Schlumberger’s highly effective and evolving portfolio of trusted products and services maintains optimal production, helping to prevent and inhibit issues such as scale, deposit formation, and corrosion.

Chemistry to mitigate production threats
- Asphaltene inhibitors
- Corrosion inhibitors
- Hydrate inhibitors
- Microbiocides
- Naphthenate inhibitors
- Paraffin inhibitors
- Scale inhibitors

100% SUCCESS RATE

A supermajor operating offshore Nigeria experienced severe corrosion issues and deployment failures in its deepwater operations. Following extensive studies and field trials, Schlumberger’s deepwater corrosion inhibitor DS-1916 was selected and has been successfully deployed for more than 1 year.
Asphaltenes can precipitate out of crude oil because of changes in process conditions. The precipitated asphaltenes can present significant flow assurance challenges such as plugs and deposits in the formation, tubing, separators, and other parts of the system.

Additional challenges include high fluid viscosity and migration into the water phase, leading to water treatment issues.

**Expertise**

Schlumberger provides specialist expertise and treatments to minimize flow assurance issues caused by asphaltene precipitation: minimizing nonproductive time and improving environmental compliance.

The most effective solution is formulated using field and fluid data. A range of laboratory tests is conducted based on this data to simulate field conditions including use of Schlumberger RealView® live-fluid organic solids deposition analysis.

Product performance is modified in the field by measuring changes to process and fluid properties using instrumental and chemical methods.

**Treatment options**

The inhibitors prevent asphaltenes from flocculating. They can be squeezed or continuously injected upstream of the process bubble point.

Squeezing the inhibitor into the reservoir can prevent deposition in the near-wellbore. It is important that the inhibitors are added to the crude oil before it becomes destabilized and flocculation occurs.
CORROSION INHIBITORS

Acidic gases such as carbon dioxide and hydrogen sulfide, as well as organic acids dissolved in produced water, will corrode carbon steel tubing, vessels, and pipelines if left untreated.

Failure to control corrosion rates can have catastrophic consequences such as equipment failure, potentially resulting in environmentally damaging leaks and compromising personnel safety.

Maintenance operations to repair the damage caused by corrosion require expensive system shutdowns and associated loss of production.

Schlumberger delivers a comprehensive portfolio of chemical treatments to preserve asset integrity. The treatments are specifically designed for application in all production conditions to mitigate corrosion regardless of environmental, production, or geographical challenges.

The range includes:
- CO₂ and H₂S corrosion inhibitors
- multifunctional hydrotest and mothballing products
- cooling water corrosion inhibitors
- environmentally acceptable corrosion inhibitors
- batch corrosion inhibitors
- high-temperature corrosion inhibitors
- gas corrosion inhibitors
- multifunctional products (combined scale and corrosion inhibitors)
- O₂ scavengers
- H₂S scavengers
- oil and gas pipeline inhibitors
- subsea and deepwater corrosion inhibitors
- top-of-line corrosion inhibitors.

Causes of corrosion

In oil and gas production, corrosion manifests itself in various forms, including localized, general, underdeposit, and galvanic. It generally takes place where water is present, with the rate affected by variables including CO₂, H₂S and O₂ concentration, temperature, pH, water cut, salinity, pressure, solids loading, and flow velocity.

Application

Corrosion inhibitors can be applied anywhere in the production system—downhole, at the wellhead, production manifold, gathering and export pipelines, and in produced water reinjection systems. Corrosion inhibitors are normally applied either continuously or via batch treatment. In all applications, corrosion monitoring is vital to ensure performance and optimize cost.

Before deploying a corrosion inhibitor, a number of factors need to be considered.
- Method of application—This depends on several parameters, including system conditions, injection location, and the availability of chemical injection equipment.
- Solubility—Inhibitors are generally classified as being oil-soluble, water-soluble, or oil-soluble and water-dispersible.
- Emulsification and foaming tendencies at the required dose rate—These must be assessed to ensure product stability under typical storage temperatures for prolonged periods and at injection temperature.
- Compatibility of corrosion inhibitors versus system metallurgy and other process additives.
HYDRATE INHIBITORS

Hydrate plugs, once formed, are difficult and costly to remove. They can result in lost production, equipment failure, and safety issues.

Hydrate prevention becomes even more challenging as production increasingly focuses on marginal fields, deeper waters, and more hostile environments where pipelines are routed along the seabed over considerable distances and where pressure gradients and low fluid temperatures promote formation.

Schlumberger is at the forefront of industry efforts to develop low-dosage hydrate inhibitors (LDHIs) as more environmentally acceptable, capex-efficient alternatives to commonly used thermodynamic inhibitors such as methanol and glycol.

These inhibitors maintain flow either by interfering with the mechanism of hydrate formation or by preventing small gas hydrate particles agglomerating, assuring production is maximized and equipment unaffected.

Tailored solutions
Gas hydrates are ice-like structures comprising water and gas. Hydrate formation is a function of a number of parameters, including temperature, gas composition, and presence of water.

Hydrates can easily form under subsea conditions, as found in the North Sea and deepwater Gulf of Mexico, offshore Brazil, and West Africa.

Optimal inhibitor choice is determined by fluid and field characteristics. Schlumberger provides detailed support to customers for LDHI applications—studying system conditions using phase-equilibrium modeling and advanced equipment for testing under field conditions to select the most effective treatment.

Modes of action
Kinetic hydrate inhibitors (KHI) interfere with hydrate crystal growth or nucleation by embedding themselves into the lattice structure, delaying significant growth for longer than the fluid’s residence time.

Antiagglomerants (AAAs) prevent the agglomeration of hydrate crystals into large masses by dispersing water droplets within the condensate or oil phase.

In comparison to methanol and MEG-based treatments, the reduced treatment application levels of LDHIs, in combination with their low toxicity, renders them attractive for many hydrate inhibition applications. Because no recovery stage is required, leakage risks from storage, treatment, and transportation facilities are significantly reduced.
Case Study

KHI REDUCES OPERATING COSTS BY 50% IN ALBERTA, CANADA

CHALLENGE

A gas pipeline transports around 2,430 m³/d of gas to a remote amine plant across difficult terrain. Produced water is introduced into the pipeline mainly after a compressor station. To prevent hydrates from forming, the line is treated with 4,000 L of methanol. However, the methanol is carried into the amine plant, contaminating the reflux water and increasing corrosion risks.

SOLUTION

Schlumberger introduced a hydrate inhibitor program using the KHI GT-7569. The KHI was initially applied at 1,500 L/d, approximately 40% of the methanol injection volume. Pig returns and inlet pipeline pressures were then monitored for hydrate formation indicators.

RESULTS

Injection rates were reduced in incremental stages before being optimized at just 700 L/d without hydrate formation. Analysis of reflux water showed no contamination. KHI application saved the operator over 50% in chemical and operational costs.
Schlumberger’s effective range of microbiocides is proven to control a broad spectrum of anaerobic and aerobic bacteria, particularly sulfate-reducing bacteria for water-injection and produced-water systems. These products are effective through direct microbiological activity and by modifying the environment to prevent bacteriological activity.

Schlumberger was at the forefront of developing the pioneering nitrate application to prevent water reservoir souring by shifting the consortia from sulfate-reducing bacteria (SRB) to nitrogen-reducing bacteria (NRB).

**Applications**

Product applications are supported through monitoring programs, including the installation of devices such as sidestream equipment to develop sessile biofilm colonies on retrievable studs and near-real-time monitoring techniques through the use of a patented quantification technique for oil and gas applications.

**Product selection**

Inorganic microbiocides are cost-effective disinfectants used in all types of industrial systems, while organic microbiocides are a less corrosive option and can be used as the sole treatment or together with inorganic alternatives.

When selecting suitable chemistries for maximum performance, several factors must be assessed:

- mammalian and marine toxicity
- ease of handling
- solubility in oil and water
- compatibility with materials of construction and other process additives
- ability and requirement to penetrate biofilms and or solid deposits within the system
- cost efficiency.

**Microbiocides fall into three categories:**

- Chemistries such as aldehydes that penetrate the cell to denature the protein
- Surfactants that coat the membrane and block the passage of nutrients across the cell wall
- Oxidizing biocides that destroy the cell wall.
NAPHTHENATE INHIBITORS

Certain crude oils contain long-chain organic acids, also referred to as naphthenic and carboxylic acids. Under reservoir conditions, these acids remain dissolved in the crude oil. As the production fluids depressurize, certain compositional changes lead to a reaction between metal ions in produced water, forming insoluble salts such as naphthenate and carboxylate soaps and scales.

Schlumberger has developed patented technology, covering application methodology and high-performance nonacid chemistry, that provide trusted expertise and a highly effective approach, addressing customers’ specific needs around the world.

Challenges

Two types of naphthenate soaps and complexes present flow assurance challenges—the metal carboxylate formed by the reaction of monocarboxylic naphthenic acids with metal cations, and calcium naphthenate hard scales formed due to the reaction between high-molecular-weight polycarboxylic acids with calcium.

Naphthenate soap accumulations can occur quickly and lead to plugged valves, separator internals, and pumps. This may eventually result in permanently off-specification oil and water qualities, potentially leading to system isolation or shutdown.

Partitioning of naphthenate soaps into the produced water phase may cause oil in water to exceed discharge regulations. Furthermore, a propensity to form hard naphthenic deposits can reduce vessel residence times and result in interface pad formation, loss of separator vessel level control, and even total production shutdown.

Removal of these hardened naphthenate accumulations typically require significant physical labor over extended shutdown periods.

Treatment options

Chemical treatment options include the use of organic acids, acid demulsifiers, as well as nonacidic naphthenate inhibitors.

Organic acids are commonly used to treat naphthenate soaps. Acetic acid and phosphoric acids are often employed. One of the drawbacks of acid treatment is that large volumes are needed to suppress the pH of bulk water. There are also safety and environmental considerations related to the handling of these acids.

Both acid demulsifiers and nonacid surfactants have been used successfully when added early in the system. These products may also significantly reduce the requirement for organic acids. Nonacid inhibitors can be injected at much lower dose rates compared with acids and pose fewer health and safety risks.

Factors that must be considered include field pressure and temperature, as well as fluid characteristics. Laboratory test methodologies are designed based on the proposed type of naphthenate treatment required to meet the desired results. Schlumberger’s field monitoring techniques are designed to encompass treatment economics, effectiveness, and environmental and safety issues.
Where hydrocarbons undergo depressurization and cooling, paraffins can nucleate and grow into crystal structures that can impact flowthrough. Gelation, pour point, viscosity, and deposition can all lead to reduced flow, higher backpressure, and waxy sludge formation in storage tanks.

Paraffin treatment
Schlumberger’s proven approach starts with the gathering and examination of field information and the subsequent design and implementation of laboratory tests using RealView® live-fluid organic solids deposition analysis.

Schlumberger’s paraffin inhibition range includes

- **Paraffin inhibitors**—High-molecular-weight polymers that interact with the paraffins in the crude to modify (inhibit) wax crystal formation, shape, size, and adhesion characteristics.

- **Pour point depressants**—Polymers with n-alkyl chains that similarly impede wax crystal formation, leading to lower fluid viscosity, pour point, and yield stress.

- **Paraffin dispersants**—Used when produced fluid contains a significant percentage of water. Dispersants are surface-active agents that prevent paraffin deposition in oilfield systems. They cause repulsion between paraffin particles as well as paraffin particles and the pipewall surface.

**Advantages of using inhibition technology include**

- reduction in crude oil viscosity
- reduction in heating demands, saving energy
- maintained fluid flow through the pipeline
- reduction in solids buildup
- mitigation of lost production.
CASE STUDY

WAX DEPOSITION PREVENTED FOR MORE THAN 5 YEARS, NORTH SEA

CHALLENGE
The multiphase flowlines of an offshore field were at risk of wax deposition. Because of the area’s environmental sensitivity, an inhibitor was needed that combined high performance with low environmental impact, and remained effective within flowlines between 8-in and 12-in diameter and nearly 20 mi [32 km] long.

SOLUTION
Following laboratory testing and field optimization, PI-7258 was applied continuously into the multiphase production lines at dose rates of 50–500 ppm depending on conditions.

RESULTS
PI-7258 has successfully mitigated wax deposition for more than 5 years. It has also been batch injected on shutdown, startup, and pigging operations. Improved demulsification has also resulted from the effective long-term prevention of wax formation.
Schlumberger is the leading provider of scale-squeeze treatments in the North Sea, designing effective scale-management strategies based on scale formation and location prediction, evaluation of potential chemistry, and deployment techniques for long-term effectiveness.

As operational demands on scale management increase, Schlumberger has invested heavily in developing new technology, creating a comprehensive line of inhibitor chemistries that include deployment techniques focusing on three areas:

- preemptive squeezing of reservoirs using nonaqueous base scale inhibitors
- conventional squeeze technologies including tagged and end-capped polymeric inhibitors
- continuous injection via gas lift, capillary, and direct surface injection.

### Tailored solutions

Schlumberger’s technical service scale laboratories possess considerable expertise combined with the tools to carry out all the necessary tests to qualify a suitable package, including

- static prescreening for compatibility, efficiency, and adsorption
- low pressure, low temperature (LPLT) for determination of injection dosage or minimum inhibitor concentration
- dynamic tube-blocking tests at high pressures and high temperatures (HPHT)
- full core study to enable squeeze sensitivity modeling.

### Treatment design

Schlumberger has been a life-time member of the Herriot Watt FAST JIP group that provides direct access to the leading squeeze design model, Squeeze X. Allied with our ECLIPSE® industry-reference simulator, OLGA simulator, and PIPESIM simulator, Schlumberger is positioned at the forefront of reservoir scale management science.
PERFORM

ACHIEVE FULL FIELD POTENTIAL

Schlumberger’s wide range of trusted flow performance technologies, equipment, and services are proven to improve and assure production and asset operations as well as extend field life.

Our suite of flow performance chemical technologies, together with complementary services such as ChemWatcher software, ensure enhanced operating efficiency and cost effectiveness for Schlumberger’s customers in an exceptionally competitive global industry.

Chemistry to achieve full field potential

- Defoamers
- Demulsifiers
- Water clarifiers
- Foamers
- Flow improvers
- Tracer dyes

30% PRODUCTION INCREASE

FI-1820 enabled an operator of a heavy oil field to increase export flow rates by 30% by reducing crude viscosity upon addition of 500 ppm.
DEFOAMERS

During oil and gas production, depressurization of hydrocarbons can ultimately lead to the formation of a stable foam, potentially leading to consequences if liquid carryover occurs in the associated gas stream.

Under these conditions, a chemical defoamer is required to counteract the formation of stable foam while promoting fluid degassing.

The severity of the foam in the production system is dependent on several factors, including oil production rate and associated gas, pressure and temperature, system design, and other chemicals in the process such as corrosion inhibitors or contaminants like scale and corrosion by-products.

Tailored solutions

Schlumberger offers a wide range of effective defoamers for all oilfield applications. Silicones are the most commonly applied in crude oil and water injection systems, and nonsilicone products are available for amine gas treatment units, glycol units, and water-injection systems.

Mechanical systems

Schlumberger supplies mechanical augers that are designed to remove up to 80% of the free gas from the wellstream prior to the separator, preventing the formation of foam and potentially eliminating the need for a defoamer.

Defoamer operations

Production systems can be optimized with respect to oil production rate and pressure to reduce the risk of foaming, but this might not be enough or may impose unacceptable constraints on production. In such a case, defoamers might be necessary for constant, smooth operation. Defoamers can be highly cost-effective and can work at injection rates of just a few ppm.
DEMULSIFIERS

It is critical that crude oil is efficiently separated from produced water to allow dry oil to be exported and clean water to be discharged, thereby maximizing crude oil value and minimizing operating costs.

Demulsifier formulations help ensure that the residual water and salt content in the crude, and oil-in-water content of the separated water, meet required specifications.

When developing a cost-effective demulsifier, Schlumberger investigates application-wide factors including location, nature of the oil, environment, and limitations of the equipment and facilities. Each item is thoroughly evaluated so that the facility can operate with minimum disruption and lowest cost.

Mode of action

The demulsifier disrupts the ordered structure of the natural surfactants that stabilize the emulsion, allowing the dispersed droplets to coalesce as they collide to form a larger droplet size. The droplets then move to the oil/water interface via gravity.

Demulsifier bases

In the formulation of a demulsifier, it is rare that single-component chemistry will address all performance elements. The following comments are generally directed toward emulsions containing water dispersed in a continuous oil phase:

- Solvents keep intermediates and active ingredients in solution and help deliver them to the emulsion interface. They also help make crude components such as paraffins more soluble.
- Alcohols can stabilize a demulsifier where individual components might otherwise separate and can be used to winterize them for cold-climate application. Certain solvents are restricted by environmental legislation or flammable handling concerns.
- Flocculants are characterized by nonionic surfactants that congregate droplets so that they combine when in close proximity.
- Coalescers effectively disrupt the stabilized film by causing water droplets to combine on collision.
- Water droppers cause coalescing droplets to combine rapidly, forming a continuous phase. They are critical for short residence systems such as offshore applications where weight and space are at a premium.
- Wetting agents alter the interfacial tension of fluids so that solids can move into the water phase. These solids include sands, clays, scales, naphthenates, carboxylates, bitumens, and other insolubles that collect at the interface.
Increasing volumes of water produced as a field matures can limit production, particularly when this water must meet purity specifications before injection, reuse, or disposal. Water clarifiers remove oil and other insoluble matter from the water.

**Treatment**

When recommending a water clarifier solution that will lower costs and minimize facility disruption, Schlumberger considers important factors including location, environment, and the limitations of the equipment and facilities.

Schlumberger’s comprehensive water clarification range covers all product types and can be tested on site, in any variation of separation equipment, to deliver the best solution.

Handling characteristics and method of use must be considered when designing the field application. In arctic conditions, water clarifiers must be winterized or applied in a climate-controlled environment to avoid separation, freezing, and thawing.

Schlumberger deploys three basic types of water clarifiers—nonionic, cationic, and anionic—ensuring that water meets discharge requirements while still maximizing recovery from produced fluids.

These are generally supplied as:

- **Low-solids solutions** due to the high molecular weight and are generally used as filtration aids in mixed-media filters.

- **Concentrated emulsions**, whereby polymers in water droplets are then emulsified in oil. This technology is widely used; however, the treatment requires an initial residence in the system for the polymer to invert and yield.

- **High-activity dispersions** in a nontoxic, organic carrier. These organic dispersions have become commonplace, with the solids levels of these products achieving up to 50%, but again require residence in the system. Recent developments have led to brine dispersions of high-molecular-weight polymers that are ready for use.
Case Study

WATER QUALITY INCREASED WHILE DOSAGE HALVED, NORTH SEA

CHALLENGE
A major operator experienced issues with the produced water quality being discharged overboard from two adjoining platforms while injecting demulsifier. The operator also required greater onboard emulsion resolution and separation.

SOLUTION
Schlumberger suggested EB-8035, an emulsion breaker formulated to break water-in-oil emulsions and deliver clean produced water. It does this while leaving minimal residual emulsion in process separation systems.

RESULTS
Demulsifier volumes were reduced by around 50%. Water-in-oil results were also significantly improved, averaging 5–15 ppm overboard while maintaining zero emulsion at the export pumps. Postshutdown separator upsets were also handled without water-quality reductions. Ongoing data shows oil in water remains at acceptable levels today with no residual emulsion buildup in the separators or carryover to the export pumps.
FOAMERS

As the gas velocity in the production wells drop with time, the speed at which liquids are produced by the gas slows even faster, causing liquid to accumulate in the bottom of the well—slowing or stopping gas production altogether.

Schlumberger’s wide range of tested and proven foamer technology safely and effectively deliquesces and rejuvenates aging gas wells, removing liquids such as water and condensate from the wellbore and restoring gas production.

Chemical evaluation

To accommodate all kinds of oilfield applications, Schlumberger offers a range of foamer technology, including liquid foamers that have been developed for varying brine chemistries, temperatures, and the presence of condensate. Liquid foamers can be formulated as single or combined products with scale and corrosion inhibitors.

Solid stick foamers have been developed for a wide range of application conditions and condensate levels, including for temperatures of up to 338 degF [170 degC].

Treatment options

- Topside
- Batch
  - Liquid batch
  - Sticks
  - Squeeze
- Continuous
  - Drip
  - Capillary string

Foamer requirements

Requirements for gas well deliquification:

- Foam stability to carry liquids to surface (half-life)
- Thermal stability
- Fluid/material compatibility
- Ability to unload hydrocarbon
- Surface break before entering process equipment
- Delivery (batch, continuous)
- Winterization (in low-temperature environments and applications)

Gas well production can also be enhanced mechanically, for example by plunger lifts, recompletion, compression and velocity strings, or by the use of foaming agents like soap sticks and liquid foamers.
Production of medium, heavy, and extraheavy crude oils requires significant investment from operators to lift, process, and transport these highly viscous fluids at ambient temperatures.

Heating vessels, heated pipelines, addition of diluents, power lifting, and booster pumps are some of the technologies used to assist with flow and processing challenges caused by the effects of viscosity.

Schlumberger has developed a range of chemicals that reduce the viscosity of the oil for lifting, processing, and transport, helping to reduce operational costs and improve production performance.

Additionally, Schlumberger specialists add value through assessing production systems, identifying bottlenecks, and developing customized solutions.

**Flow improvers and viscosity reducers**

The application of flow improvers and viscosity reducers at low concentrations (100–400 ppm) or high concentrations (0.1–3%) can help reduce viscosity by up to 95% depending on the causes for the increased viscosity, type of chemistry, and production system.

The application of flow improvers consistently results in reduced operational and capital expenditure as well as increased oil production and revenue.
Knowing where fluids are flowing can be a vital element in protecting the environment, maximizing recovery, and enhancing production.

As an established part of Schlumberger’s production chemicals portfolio, tracers have been applied in the oil and gas industry for decades for a number of purposes, including:

- leak detection (proactively in hydrotreating and reactively in association with a spill) to monitor near-wellbore and interwell connectivity to assist in reservoir management and maximize recovery rates
- minimizing water injection and water production rates by optimizing flow patterns
- optimizing inhibitor squeeze programs.

Available solutions include radioactive species, stable isotopes, and chemicals such as fluorescent dyes, inorganic ions, and aromatic acids.

Perhaps the most commonly used tracer in the oil and gas industry is fluorescein. It is stable in reservoirs as hot as 482 degF (250 degC) and has a detection limit of approximately 10 parts per trillion using conventional spectrofluorometry. In addition, since it fluoresces in the visible spectra, fluorescein can be detected using a simple, inexpensive, and easily operated fluorometer.

A compound closely related to fluorescein is rhodamine. While rhodamine does not possess the same level of thermal stability, it is a viable option where temperature is not a key factor, such as surface or pipeline applications.
Schlumberger’s production technology specialists deliver targeted, integrated strategies to decisively remediate production issues such as deposit formation and naturally occurring gases, helping customers safely restore and improve flow performance and revenue while avoiding costly repairs and shutdowns.

The team’s global footprint, together with the exceptional CURE suite of chemical removal portfolio and all-inclusive EXKAL services, ensure that customers reliably, safely and efficiently maximize production, regardless of system complexities or geography.

Chemistry to restore full production
- Asphaltene dissolvers
- Cleaners
- Hydrogen sulfide scavengers
- Naphthenate dissolvers
- Oxygen scavengers
- Paraffin dissolvers
- Scale dissolvers
- EXKAL all-inclusive software, chemical, and mechanical services
A major operator offshore Malaysia experienced accelerated production decline. BASOL 2000 HP recovered over 7,000 bbl/d.
Asphaltenes can deposit in reservoirs, forming plugs in wellbore tubing, flowlines, separators and other parts of the production system. If left untreated, they can interrupt and potentially stop production.

Schlumberger designs asphaltene dissolver treatments to effectively remove unwanted asphaltenic deposits and restore production.

**Expertise**

The company provides considerable expertise in designing treatments to meet each customer’s specific asphaltene challenges. Based on field information, laboratory tests are designed and performed to evaluate these solutions and to identify the safest, most effective approach.

**Treatment options**

A range of mechanical and chemical options is available. Mechanical cleaning methods include pigging, wireline cutting, and coiled tubing, which can complement solvent treatments to remove unwanted deposits.
The four most important characteristics to achieve the best cleaning result are:

- **temperature** — a higher temperature will give a better result
- **solubility dispersibility** — the more soluble, or easily dispersed the dirt, the better the clean
- **mechanical treatment** — scrubbing and high-pressure spraying
- **soak time**.

**Solvent-based compounds**

Solvent-based products should be used when the dirt is mainly organic and particularly when temperature cannot be increased to soften the foulant.

Aromatics, white spirit–based, low-aromatic naphthas, kerosene, and diesel-based products are all included in the Schlumberger portfolio.

Cleaning compounds can also be designed to give either a stable or self-separating (quick-break) emulsion upon flushing with water.

**Aqueous cleaning compounds**

Aqueous cleaning compounds have definite advantages over solvent-base products in terms of handling properties and price. They can also be made more environmentally acceptable but are not necessarily as efficient.

Aqueous products can be used in almost all cases and particularly for solid-particle dirt; however, they are not particularly suitable for the removal of hard, mechanically resistant organic dirt when the temperature cannot be raised to soften it.

Smaller amounts of organic solvents can be included in aqueous products to increase solvent properties. Aqueous cleaning compounds act by dispersing the dirt into the aqueous phase.

**Chemical cleaning**

There are six cleaning techniques Schlumberger uses to augment its range of solvent-based and aqueous-based cleaning compounds:

- fill and soak
- circulate
- cascade
- online
- foam
- vapor-phase.
HYDROGEN SULFIDE SCAVENGERS

Hydrogen sulfide (H₂S), a corrosive and extremely dangerous gas, can be a natural component of some petroleum reservoirs or may arise from bacterial reduction of sulfur compounds in produced water. Other sulfides that can be present include sodium hydrosulfide, sodium sulfide, and various lower mercaptans and disulfides.

In addition to the ground-breaking SULFATREAT® hydrogen sulfide removal system and SELECT® system products, Schlumberger offers a range of amine- and aldehyde-base liquid sulfide scavengers that have been developed for application in gas, water, and oil streams. The most appropriate product is selected for the application based on the process conditions and the operational requirements.

Hydrogen sulfide

Hydrogen sulfide is corrosive even at low levels and has a toxicity level similar to that of hydrogen cyanide. The occupational exposure limit is set at 10 ppm, and exposure to concentrations above 150 ppm could be fatal. Gas pipeline requirements often specify the maximum permitted levels of H₂S, typically less than 5 ppm.

Corrosion due to hydrogen sulfide can lead to catastrophic failures, which may occur without warning. Additionally, hydrogen sulfide can form insoluble salts with many different types of metal ions that might be present in the produced water, causing fouling, filter blocking, and injection well damage.

Direct injection scavengers

Schlumberger’s liquid scavengers may be applied as a solution in bubble towers for gas treating, either atomized directly into produced gas streams or via direct application in mixed fluid flow streams.

The most common application for H₂S scavengers is direct injection into a wet gas stream, frequently from separator gas outlets in the phase separation train. It is typical for the largest proportion of the H₂S to be removed at the high-pressure separator.

In many cases, the water present in the scavenged wet gas stream will consist solely of condensed water. Where produced or formation water is present, carbonate scale problems may be anticipated and mitigated.

When used in water systems, rapid sulfide removal is possible and, in many cases, insoluble metallic salts of sulfides can be re-dissolved with these products.

Products designed for water and gas application form water-soluble, low-toxicity, biodegradable compounds that are noncorrosive and will not release hydrogen sulfide, even over extreme pH variations.

Products destined for use in oil systems can be pumped directly into the stream. They are completely soluble and yield soluble, environmentally friendly reaction by-products.

In all cases, the reaction by-products are complex organic molecules containing sulfur, nitrogen, and carbon.

Direct injection scavengers can be very cost-effective in applications where the total mass of H₂S to be treated is comparatively low and where offshore space limitations restrict equipment size.
FIXED-BED SCAVENGERS

Setting the industry standard for more than 25 years, Schlumberger is a world leader in providing cost-effective solutions for the removal of contaminants from gaseous and liquid hydrocarbon streams using fixed-bed technology, treating nearly 3 trillion cubic feet of gas a year in more than 1,500 applications in at least 30 countries.

Schlumberger’s purification products are used in fixed-bed processes that are easy to operate and require minimal operator attention. The most suitable product is selected based on the process conditions and operational parameters.

Proprietary software modeling is used to deliver treatment system designs that are technically robust, reliable, and effective.

Product consumption is dependent only on the amount of contaminant passing through the bed. The flexibility of fixed-bed processes allows the system to adapt to variations in process conditions that may result from changes in operating preferences or tighter regulations, often without additional capital equipment or system retrofitting.

Engineered technical solutions

Schlumberger designs treatment systems that address specific process conditions and defined operating philosophies. Tailored support ranges from basic media provision through to a fully engineered technical solution comprising basic system design, media supply, detailed engineering, fabrication package, equipment supply, and spent-media handling.

Setting the standard in H₂S removal

Schlumberger offers two primary product lines for H₂S removal: SULFATREAT system and SELECT products. Both are formulated metal oxides.

SULFATREAT system products use proprietary iron chemistry to selectively remove H₂S from water vapor–saturated gas. The application scope is broad and includes natural gas, light liquid hydrocarbons, CO₂, water, air, geothermal vapors, landfill gas, and biogas. The products are nonpyrophoric and safe to handle in both unreacted and ready-for-disposal forms.

SELECT products use mixed metal oxide chemistry to selectively remove H₂S contaminants from gaseous and light liquid hydrocarbons at low temperatures. The products are suitable for use in both dry and wet gas applications. These products are high capacity, fast-reacting absorbents with patented technology for enhanced porosity and improved activity. This allows for smaller vessels and smaller product volumes in a given process application, providing flexibility in system design.

Schlumberger purification technology delivers considerable operating expenditure savings compared with other H₂S removal technologies. In 2014, a study conducted in North America proved switching to SULFATREAT system reduced opex by 50% in less than one year compared with the existing liquid scavenger solution.
Treatment options

In addition to the fixed-bed absorbents, Schlumberger offers a range of liquid-based H₂S removal scavengers. Customer requirements are assessed to identify the most cost-effective treatment solution, which may be a fixed-bed system, a liquid system, or a consolidated solution of bulk removal with liquids followed by fixed-bed polishing. This flexibility is particularly beneficial when plot space or footprint is a concern.

Purification applications

While upstream natural gas processing is the primary market for Schlumberger purification technology, the range of absorbents will work effectively in most gaseous streams. The diverse range of operating applications includes

- gas processing plants
- offshore platforms
- floating production storage and offloading (FPSO) vessels
- early production systems
- gas storage
- vent gas treatment
- wastewater treatment
- landfill gas
- biogas
- food-grade CO₂
- odor control
- petrochemical plants
- refineries

Protecting operations through efficient mercury removal

Mercury is a naturally occurring contaminant in some hydrocarbons. It is highly toxic and represents a risk to health and the environment and can also cause serious equipment failure through liquid metal embrittlement (LME) or amalgam corrosion.

The SULFATREAT SELECT HG™ mercury purification system uses proven mercury removal chemistry based on reactive metal sulfides. These individually formulated products react with elemental mercury to form mercuric sulfide, reducing mercury to extremely low levels.

Tailored SULFATREAT SELECT HG system products are chosen dependent on process conditions. The resulting spent product can be simply and safely handled through well-established recycling routes within the metals recovery industry.

Equipment and operations

Years of experience across diverse applications and markets give Schlumberger unrivaled resources and expertise to design a purification treatment solution to suit any operator’s specific requirements.

The basic single-vessel configuration, while fully functional, requires a temporary bypass or interruption to the gas flow to replace spent media. Conversely, a lead-lag configuration provides the greatest operating flexibility, enabling continuous production while media is replaced.

Upstream of the vessels, the installation requires an inlet separator, filter coalescer, or both to remove free liquids from the gas. For selected chemistries, a water injection system may also be necessary to ensure water vapor saturation of the gas.

Patented mobile units are also available for H₂S and mercury applications that require only periodic attention. Such units are designed for use at locations where environmental limits prohibit any contaminant from being emitted to the atmosphere—for example, tank servicing and gas flaring during well test operations.

Monitoring

Typically, outlet levels of H₂S or mercury rise gradually at the end of the bed’s life, indicating the need for replacement. Incorporating this early-warning period into routine monitoring allows for planned, convenient product changeout.

Computer modeling provides information on predicted performance parameters, with bed loading determined by flow and contaminant levels.

Optional monitoring around the treatment system envelope can include gas temperature and pressure differential measurement. These measurements are used to confirm anticipated design operating conditions and the impact of changes over time.

Changeouts and disposal

It is recommended that changeouts are handled by catalyst handling specialists. Assistance is available in determining the best option for the recycling or disposal of spent material. Disposal routes are well established, and personnel are available for onsite installation and removal support as needed.

Quality assurance and technical support

SULFATREAT system and SELECT products are manufactured to stringent quality specifications. Bespoke software modeling and performance predictability allows the development of best-fit system design and operation for each site supported by highly trained personnel at every stage.

Global expertise and support

Schlumberger has dedicated specialist laboratories for the research, development, and testing of fixed-bed absorbent media and alternative purification systems. As part of a global network of advanced oilfield research and development laboratories, these world-class facilities offer customers fast access to new product developments.
Case Study
H₂S SCAVENGER ALSO INHIBITS CORROSION AND SCALE, NORTH LOUISIANA

CHALLENGE
A pipeline company’s produced gas averaged 13 ppm of H₂S within a range of 4–30 ppm. A multifunction chemical treatment program was required to scavenge H₂S, reduce pipeline corrosion, and inhibit scale deposition. The solution was to be applied to two fields, each with several wells.

SOLUTION
Schlumberger recommended HR-2636, a unique combination of a triazine H₂S scavenger, mixed amine corrosion package, and a phosphonate scale inhibitor. For high efficiency and maximum gas contact, the atomized product was continuously injected into the pipeline.

RESULTS
Calcium and barium scale were effectively controlled, and average corrosion rate was 0.15 mm/a. H₂S content was reduced to a maximum of 2 ppm.
NAPHTHENATE DISSOLVERS

Naphthenate soap accumulations can occur very quickly and can lead to plugged valves, separator internals, and pumps. With a propensity to accumulate as hard, consolidated deposits, naphthenate soap scales can significantly reduce process system capacities, residence times, and operational efficiency. If untreated, total production shutdown and consequential revenue decrease can result.

Treatment options
Mechanical options to clean deposits are limited and depend on the type of naphthenate formed. Heat does not mobilize the soaps and, in certain instances, has been demonstrated to make them worse.

Removal of these hardened naphthenate accumulations typically require significant physical labor over extended shutdown periods.

Schlumberger brings considerable expertise in designing dissolver packages tailor-made to give optimal removal efficiency against naphthenate deposits.

Using field information, laboratory evaluations are designed and conducted to validate dissolver packages, ensuring that the safest and most effective remedial chemical treatment is selected.

OXYGEN SCAVENGERS

In seawater injection systems, corrosion can occur due to oxygen in injected water; however, oxygen can be removed from water using a combination of chemical or mechanical methods.

Schlumberger’s oxygen scavengers, part of its extensive production chemicals portfolio, are normally applied together with deaeration towers.

Typical chemistries include organic and inorganic sulphites and catalyzed derivatives where required.
**PARAFFIN DISSOLVERS**

Paraffin removal uses mechanical, thermal, and chemical means to physically treat waxes after they form.

Chemical dissolution treatment necessitates application of solvents that will effectively and efficiently remove existing paraffin wax deposition.

A good solvent dissolves paraffin regardless of its structure, size, and melting point. This requires much less energy than is needed to melt the crystal. The effectiveness of the solvent improves with increasing temperature and agitation.

Solvents available include chemistry based on condensate light gas oil, xylene, toluene, terpenes, and carbon disulfide.

**SCALE DISSOLVERS**

Mineral scale deposition can seal even the most permeable reservoir, meaning operators have to find or create alternative pathways to maximize production. Regardless of scale type and location, deposition must be dealt with quickly, effectively, and safely.

Whether downhole or topside, scale species vary greatly and may also be associated with naturally occurring radioactive material (NORM), requiring specialist knowledge and management systems to provide safe controls in practice. Scale can also be a challenge during decommissioning. As this area requires special attention, Schlumberger established a stand-alone business line to manage and service the specific challenges. This business line is known as EXKAL services.
Combining chemical and mechanical decontamination solutions, EXKAL services minimize even the most challenging scale deposition, helping customers quickly restore and optimize production by maximizing throughput and delivering cleaner streams.

Supplied as concentrated blends, EXKAL services’ scale dissolvers effectively reduce chemical volumes to help manage overall treatment costs.

Every component of the services demonstrates the best possible environmental performance and elastomer compatibility while posing little or no corrosion threat when in contact with any of the standard oilfield metallurgies.

The very latest in mechanical solutions complement the chemical components of EXKAL services, including ultrahigh-pressure water jetting and proprietary plasma-cutting technologies.

The EXKAL services package can be delivered onsite, making it ideal for remote locations or projects with restricted water and energy consumption.

## Descaling, decontamination, and decommissioning

Scale deposition restricts production and increases the costs and risks associated with decommissioning and NORM decontamination. All-inclusive EXKAL services give operators a project-specific, single-source solution for their most challenging scale problems. The services deliver

- integration of scale, production chemistry, and waste management technologies
- comprehensive suite of cost-effective scale dissolvers
- mobile, on-site NORM decontamination
- downhole, topside, and midstream scale treatment
- preproject analytical services
- decommissioning technologies and services.

### A comprehensive service package

EXKAL services effectively remove the obstacles that restrict production while reducing the costs and hazards of decommissioning and decontamination.

## EXKAL services advantages

- Compliance with strict environmental regulations
- Removal of scale-related production restrictions
- Reduced personnel risks
- Effective operation in remote, constrained locations
- Minimized environmental impact
- Recovery of valuable hydrocarbons during decommissioning
- Safer, cost-effective decommissioning
- Maximized value of producing asset
- Reduced treatment and waste management costs
Integrated solutions
Schlumberger specialists analyze each situation and devising a treatment strategy incorporating the wide portfolio of safe and nondamaging scale dissolvers and related services. These solutions include:
- waste injection technology with EXKAL services
- production chemistry expertise
- drilling waste management capabilities
- chemical recycling and reuse
- modifying waste streams to meet local regulatory requirements
- solids reinjection
- Integration with EPCON CFU* compact flotation unit technology to separate and treat waste materials prior to discharge or injection
- Integration with Schlumberger coiled tubing services, flow-assurance processes, Jet Blaster* engineered high-pressure jetting service, and related services.

Schlumberger’s global specialists determine the location of scale accumulation, whether it is reducing reservoir permeability downhole, or restricting fluid flow in surface process equipment. The next key step is to then identify the precise nature of the mineral scale.

A major operator offshore Malaysia experienced accelerated production decline. After deploying BASOL 2000 HP, the customer recovered over 7,000 bbl/d.
Examples are

- **Sulfate**—the result of mixing brines such as barium-rich formation water and sulfate-rich seawater for reservoir pressure maintenance. This mixture leads to the deposition of barium sulfate scale.

- **Carbonate**—the most common oilfield scale, which occurs when CO₂ comes out of solution during production, resulting in calcium carbonate deposition.

- **Sulfide**—formed in the presence of sour waters. H₂S can occur naturally or as a result of sulfate-reducing bacteria that produce H₂S gas as a by-product of their respiratory process. In the presence of ferrous iron, this gas can form pyrophoric iron sulfide deposits. Other metal sulfides may also occur, such as zinc or mercury.

- **Elemental radioactivity**—the result of electrochemical processes in wells and process streams that can lead to the radioactive plating of surfaces and contaminate equipment with lead-210 and other isotopes.

Experts analyze scale deposit samples to determine factors such as dissolution rate and sequestering capacities, which are used as input data for treatment designs. For downhole applications, the deposit thickness, specific intervals where scale has accumulated, and candidate dissolver performance are evaluated to calculate the treatment volumes, placement procedure, and contact times.

**Posttreatment analysis**

As a routine part of its descaling operation, the EXKAL services team relies on the proprietary D-SCAL diagnostic software package to provide posttreatment analysis. This package determines the efficiency of the treatment by separating the complex mixture of returning fluids into spearhead, dissolver, formation water, and seawater.

The known chemical compositions of each of the component fluids then allow the mineralogy of the removed scale species to be identified.
PRODUCTION CHALLENGES
HIGH-PERFORMANCE TECHNOLOGIES ADDRESSING GLOBAL CHALLENGES

Schlumberger’s high-performance technologies and services protect assets and maximize production rates in even the most extreme, sensitive, and challenging conditions, helping to minimize issues such as paraffin and hydrate formation while protecting the environment.

30% PRODUCTION INCREASE

FI-1820 enabled an operator of a heavy-oil field to increase export flow rates by 30% by reducing crude viscosity.
DEEP WATER
DEMANDS HIGH PERFORMANCE

Schlumberger’s chemical products and services give the industry more ways to protect critical process equipment, maintain pipework integrity, and assure production flow. Its specialty deepwater products are engineered to retain integrity and performance under the high-pressure, high-shear environments and long retention times of the subsea umbilical.

From scale and corrosion management to wax, asphaltene, and naphthenate inhibition, Schlumberger helps optimize process performance and maintain production, even in the most challenging conditions.

Maintaining hydrocarbon quality

The company’s wide variety of production chemicals and contaminant-removal products and services help maintain optimal hydrocarbon quality. Using tailor-made demulsifiers to swiftly resolve oil-in-water emulsions, Schlumberger ensures that customers achieve excellent dry crude quality and clean water required for discharge or reinjection.

Combined with purification solutions, fixed-bed media, and liquid scavengers, H₂S, mercury, and mercaptans are removed to meet export specifications and maximize gas sales revenues while reducing QHSE risk and protecting asset integrity.

Maximizing production

EXKAL services and produced water and sand management (PWSM) products ensure increased production. Our purpose-built technology manages and removes normally occurring radioactive material (NORM), and our tailored chemistry optimizes PWSM systems, enhances separation, maximizes throughput, and delivers cleaner streams.

Environmental stewardship

The industry must consider the importance of applied chemistry and operations on the environment. Schlumberger’s strength in ecotoxicity testing over 35 years, combined with expertise in produced water and sand process systems, results in a unique offering to assess, manage, and deliver excellence in environmental stewardship.

Increasing offloading efficiency

Flow improvers enhance transfer capacity and build in offloading efficiency, shortening loading times and reducing shuttle tanker demurrage to increase profitability. The technologies can also be used to increase flow rates in export pipelines as well as enhance water injection rates to maximize secondary recovery.

Integrity in deployment

As a founding member of the Blockage Avoidance in Subsea Injection and Control Systems (BASICS) Joint Industry Project (JIP), which resulted in API Specification 17TR6, the company’s technologists continue to set the standards for deepwater flow assurance.

In deepwater applications, quality control increases in criticality. Therefore, products selected for these applications are developed and tested in our dedicated research and development center in Houston against the strict requirements of the deepwater program, assuring retained performance following extreme testing under conditions of cycling pressure, temperature, and shear as experienced during deployment via smallbore umbilicals.

Deepwater products are assessed for viscosity, compatibility with fluids and process system materials, and cleanliness according to NAS standards.

Manufacture and supply chains have to meet stringent quality control over product cleanliness according to NAS and ISO standards. Strict procedures are established for deepwater-rated products, including NAS cleanliness checks, vessel inspection routines, and base filtration prior to loading for dispatch offshore. Selective couplings and routine field checks provide the final line of assurance that the products will meet the demanding challenges in application.

As a company that provides both production and completion fluids technology, Schlumberger is ideally placed to meet these demands as every location worldwide has filtration packages to ensure that products meet these tight cleanliness specifications.

For critical applications, specifically those where physical property measures cannot necessarily assure product performance, application tests supplement the routine checks (for example, low-dose hydrate inhibitors).
Case Study

SCALE FORMATION PREVENTED IN DEEPWATER FLOWLINES, OFFSHORE CONGO, WEST AFRICA

CHALLENGE

The flowlines of a deepwater oilfield in 1,400 m of water encountered flow-assurance problems including scale deposition. Chemical injection was challenging, as the FPSO vessel was 140 km offshore. Any inhibitor needed to withstand severe conditions and not degrade over prolonged residence periods.

SOLUTION

Formulated for deepwater use, DS-1618 scale inhibitor was selected. Initial testing ensured that it would remain pumpable at high pressures, avoid blocking subsea umbilicals, and be fully compatible with the produced water. The inhibitor’s compatibility with a wide range of elastomers, plastics, and metals was also evaluated.

RESULTS

Since injecting 75–100 ppm of DS-1618, there have been no scale-related flow assurance problems. The deepwater chemical umbilical and injection equipment have remained blockage free.
Protecting thousands of miles of pipelines and hundreds of wells is a major challenge for oil and gas producers and chemical suppliers.

Pipelines from oil and gas fields that transport hydrocarbons and produced water are spread out over thousands of miles across land operations. Comprehensive pipeline monitoring and appropriate treatments are needed to mitigate the risk of catastrophic failures that could affect the environment and the communities that live around these natural resources.

Global footprint
Schlumberger is strategically located worldwide, providing products and services that meet and exceed customers’ expectations for safeguarding production wells and pipelines including specialist technicians and pioneering equipment right at the cusp of technological development.

The vast experience gained from treating thousands of wells every day has given the company the expertise to solve virtually any production issue.

Corrosion identification, mitigation, spill prevention, and risk management are key program offerings in the service portfolio. These services provide a link between producers and environmental agencies, creating a chain of custody in analytical data and reporting.

Data collection and reporting
Corrosion testing, biological control testing, and metallurgical analysis form the cornerstones of the mitigation program. These tests provide producers with supporting data for regulatory agencies regarding pipeline permitting and environmental compliance.

Mobile field laboratories
Schlumberger has local technical field support for plant and field evaluations as well as support of the daily operations for product applications. Local technical support includes qualified, experienced personnel and fully equipped mobile labs.

The mobile lab not only allows for demulsification testing capabilities, but is also equipped to perform solids analysis, residuals, chemical compatibility, solvent evaluations, bacteria studies, and several other tests to help ensure data is relevant and of the highest quality.
While unconventional hydrocarbons now represent some of the largest remaining sources of oil and gas around the world, the high level of technical complexity and environmental impact involved in their production can threaten the economic viability of projects.

As these developments require significant technical capability to manage and deliver, Schlumberger has established a team dedicated to managing the flow assurance challenges associated with harsh environments and demanding conditions, working with customers to produce reserves such as shale reservoirs, tight gas, tight oil, and coalbed methane in more cost-effective, more environmentally acceptable ways.

A common factor in the extraction of these reserves is the need to hydraulically fracture the formations using significant volumes of water that must be treated to preserve quality, transport key additives, and prevent the introduction of potentially damaging bacteria. The same water then has to be handled at surface when the well is brought into production.

Challenges with flowback include
- water clarification
- desalination
- naturally occurring radioactive materials (NORMs)
- scale control
- corrosion and integrity management.

Schlumberger provides a full suite of technologies to support these applications, including chemical additives that enhance flow, mixed oxidant technology to manage bioactivity, and coagulant and electrostatic coalescence technology. We also offer unique NORM-management and remediation offerings allied to leading expertise in scale and corrosion control technologies and management practice.

**Coalbed methane (CBM)**

The unique cleated structure and dual gas storage mechanism of coal deposits necessitate specialized technologies for successful production of coalbed methane, an increasing component of global natural gas production. As with other unconventional resources, it is water management, specifically how the water is sourced, treated, disposed, or reused, that enables cost-effective productivity and can make or break a project’s economic and regulatory viability.
REVENUES INCREASE THANKS TO PARAFFIN INHIBITION, EAGLE FORD SHALE

CHALLENGE
Various Eagle Ford Shale wells produce oil containing high concentrations of paraffin that can plug production tubulars and flowlines as well as create residues during storage. A treatment program was required to reduce solids deposition during railway car transit.

SOLUTION
Schlumberger recommended PI–7060, a comprehensive blend of wax modifiers and dispersants effective across a range of crude oils, including the high-carbon-chain paraffins of Eagle Ford Shale. It is formulated to prevent paraffin precipitation and agglomeration.

RESULTS
Through continuous injection of PI-7060, Eagle Ford Shale operators have maximized their product transport capacity while reducing the time lost removing paraffin buildup and increasing overall revenues.
HEAVY OIL
LARGE RESERVES, ASSURED RETURN

Some of the world’s largest reserves are heavy oil reservoirs, with oil in place equal to the largest conventional oilfields in the Middle East.

While these large reserves are found in more than 30 countries around the globe, relatively few have been extensively developed. The significant operating investment involved requires a high market price to financially justify heavy oil recovery.

Heavy oil recovery challenges

Heavy oil extraction, recovery, production, and sale present complex challenges to delivering consistent value throughout project life.

In recent years, Schlumberger’s R&D focus has been predominantly dedicated to heavy oil and deepwater practices, developing technologies that enable the extraction, separation, and transport of heavy oil fractions while dealing with flow-assurance issues such as asphaltene, naphthenate, and paraffin deposits.

A number of patented technologies are now commercialized, providing a step change in the cost of managing asphaltene deposition in North America and the North Sea and delivering game-changing wax dispersion performance results during crude production and transportation for operators in the Eagle Ford and Bakken shale plays.

The unique nonacid or low-acid naphthenate inhibition technologies the company pioneered in Asia have been transferred across the globe, most recently in the demanding conditions of offshore Brazil.
Case Study

DEMULSIFIERS REDUCE BACK PRESSURE BY 80%, ENSURE CRUDE QUALITY IN EGYPT

CHALLENGE
A heavy-oil field in Egypt suffered backpressure at the wellheads due to the highly viscous emulsion being produced. The operator also struggled to attain the shipping specifications. One demulsifier was required to reduce wellhead backpressure, and another was needed to enable continuous fine-tuning of the shipping specifications.

SOLUTION
Schlumberger selected, tested, and prequalified two demulsifiers. EPT-2699 was injected at the wellheads and into downhole casing where ESP efficiency was threatened by heavy emulsion. EB-8956 was also injected at the inlet line of the central production facility.

RESULTS
Backpressure dropped from 400–500 psi to just 80–150 psi. Water content was maintained below 0.5% and salt content below 25 pounds per 1,000 bbl, which meant that the crude met agreed shipping specifications.
Arctic areas have among the most sensitive ecosystems in the world. Several large marine ecosystems (LMEs) are found in northern areas, including the Arctic Ocean, and cold climates present particular challenges for mitigating the potential impacts of material discharge.

Regulations on the use of oilfield chemicals differ to reflect the variation in local ecosystems that need to be protected. Even small disturbances in the fragile arctic ecosystem can have devastating consequences.

Schlumberger’s AURORA production chemical offering guarantees optimal hydrocarbon production with minimal environmental impact.

Under the AURORA product line, Schlumberger also provides industry-leading engineering and design services that ensure compliance with specific technical and environmental requirements.

Schlumberger research scientists have found that, in general, the safest solution is to let nature do the job. This is why AURORA products use naturally occurring chemicals that are readily biodegradable and low in toxicity.

The following geological basins are considered arctic environments:
- North Slope
- Beaufort Sea
- South Arctic Islands
- Franklinian Sendrup
- Baffin Bay
- Labrador Shelf
- Southwest Greenland
- North Greenland
- Kronprins Christian Basin
- West Barents Sea
- East Barents Sea
- North Kara Sea
- South Kara Sea
- Laptev Sea
- East Siberian Sea
- Hope Basin
- North Chukchi Sea
- Pechora Sea
SAFER OPERATIONS IN THE WORLD’S MOST SENSITIVE REGIONS

The AURORA product line provides industry-leading production chemicals, engineering, and design services that ensure minimal environmental impact.
MATURE FIELDS
OPTIMIZING PERFORMANCE

With an increased focus on cost and operating efficiency, securing hydrocarbon resources from the North Sea—one of the world’s most mature basins—presents significant technical, environmental, and logistical challenges.

Schlumberger is a trusted partner for customers at every stage of field life—from developing new subsea infrastructure to asset decommissioning.

Production enhancement
Rapid, efficient extraction of dehydrated crude oil from produced emulsions is critical to optimizing the quality of export specification crude and to minimizing oil-in-water overboard discharge to the sea. Schlumberger offers dehydration, demulsifier, and water treatment technologies that significantly reduce the environmental impact of separation solutions while maximizing the delivery of export-quality product.

An asset’s hydrocarbon production profiles are affected by the properties of the water it produces, whether connate or injected, leading to production chemistry challenges such as scale, corrosion, separation system efficiency and oil-in-water overboard.

Schlumberger offers the full suite of topside and subsea approved technologies that directly mitigate scale, corrosion, emulsion, sand production, and other associated production risks to deliver a fully optimized hydrocarbon production system.

Production chemical solutions
Exceptional production technology performance must be aligned with industry and government best practices, such as Step Change in Safety, LOGIC and PILOT initiatives, and CRINE. In addition, complying with environmental legislation without compromising product performance is the biggest challenge affecting innovation in production technology. Dedicated in-house Good Laboratory Practice (GLP) approved environmental testing and screening facilities in Bergen contribute greatly to Schlumberger’s success in delivering environmentally friendly solutions.

Debottlenecked existing infrastructure
Maintaining performance and availability as a reservoir and asset ages is a challenge. Existing equipment can become capacity constrained, obsolete, blocked or eroded by sand, or it might never have performed satisfactorily at all.

In response, Schlumberger provides high-efficiency, compact process solutions to significantly expand the operating envelope of existing equipment in terms of both capacity and performance. These are simple and efficient upgrades that are superior to standard equipment replacement. These technologies allow excess water and sand to be either
- preseparated upstream with a partial processing system to ensure unimpeded flow
- processed by the upgraded plant with new internals to handle these increased phase loadings.

Decommissioning
As the focus in mature provinces inevitably shifts toward decommissioning, there is a growing need for safer, more efficient, and environmentally sound practices and technologies.

Offering singular technology and experience in descaling, decontamination, and decommissioning asset infrastructure, Schlumberger has a proven track record in assisting operators during this challenging phase of the oilfield lifecycle.

The company was awarded the EI International Platinum Award for technology and service associated with decommissioning of a concrete condeep structure in the UK Central North Sea.
Case Study

PARTIAL-PROCESSING SYSTEM HELPS RESTORE PRODUCTION, NORTH SEA

CHALLENGE
A mature North Sea field had forecast to produce 212,000 bbl/d with water cut of 85–90%. Due to pressure depletion and well backpressuring, which severely constrained pipeline fluids, production was significantly reduced.

SOLUTION
Schlumberger configured a partial-processing package comprising two 50% CYCLOTECH P Series* preseparation hydrocyclone technologies and three 33% CYCLOTECH B Series* deoiling hydrocyclone technologies. The processing program also included recommissioning an existing degassing vessel and developing a comprehensive sand management system.

RESULTS
Once installed, the partial-processing package successfully debottlenecked the export pipeline, allowing production to quickly approach expected levels.
Through Schlumberger’s unrivaled range of integrated services, the Production Technologies team drives production excellence beyond chemicals.

As the largest global oilfield services provider, the company combines its production services, upstream expertise, and industry-leading AVOCET platform to deliver an integrated, end-to-end service that continually optimizes performance.

Multidisciplinary teams deliver tangible results in terms of improved productivity, efficiency, and cost management across a variety of operational areas, including:
- production optimization
- flow assurance
- asset integrity
- procurement and supply chain
- scheduling
- HSE
- human resources
- equipment monitoring and maintenance.