Eastern Hemisphere Laboratory Capabilities
Maximizing Oilfield Production Through Chemistry

Providing custom-engineered, chemical solutions to maximize oil field production is the operating directive for the Multi-Chem Laboratories worldwide. We work in close collaboration with our customers to understand their challenges, and then apply our command of oil field production chemistry to resolve issues in a scientific, cost-effective manner.

Multi-Chem’s Amsterdam laboratory is strategically positioned as the principal research center for the Eastern Hemisphere. This fully equipped facility performs extensive testing, evaluation and product development in accordance with the stringent quality standards of ISO 9001, ISO 14001 and OHSAS 18001 requirements. The 200 m² laboratory is staffed with a highly qualified team of five chemists and technicians, who specialize in four application areas:

- Asset integrity
- Scale management
- Phase separation
- Flow assurance

Technical support services are also available at this location to fulfill customer requests for production fluid analyses, product performance assessments and other chemical-related needs.

BEING PROACTIVE WITH PRODUCTION FLUID ANALYSIS

Multi-Chem realizes the importance of routine fluid analysis to pro-actively identify and mitigate potential production risks at an early stage, thereby, preventing costly downtime. Using actual, customer-provided fluid samples, the Amsterdam laboratory offers accurate characterization of fluid properties, including:

- Pour Point (ASTM D97)
- Heptane insoluble/asphaltene content, using modified ASTM D3279 and ASTM D6560
- Wax Appearance Temperature (WAT)
- Dynamic viscosity versus temperature
- Yield stress
- Water content via Karl Fisher (ASTM E203)
- Basic Sediment and Water (BS&W) determination

MEETING REGIONAL NEEDS WITH PRODUCT DEVELOPMENT AND FORMULATION

Every field has its unique oil and gas drilling and operating conditions with area-specific challenges and/or regulatory policies that call for new or customized chemical formulations. Multi-Chem’s Amsterdam laboratory has the capability to complete product development and formulation projects to meet such regional requirements, including:

- Flash point
- pH
- Specific gravity and density
- Non-volatile residue
- Thermal stability, from -20°C to 240°C
- Dynamic viscosity versus temperature
- Fourier-transform infrared spectroscopy (FTIR)
Protecting Asset Integrity

The laboratory has its own asset integrity lab specially designed to accommodate new product formulation, product selection, corrosion inhibitor performance screening and robust compatibility evaluation. These lab procedures support the development of successful chemical mitigation strategies for field application, ensuring the integrity of hydrocarbon assets is protected.

CAPABILITIES

| Mechanistic CO₂ and H₂S Corrosion Modeling | Multicorp, a corrosion modeling program developed at Ohio University’s Institute for Corrosion and Multiphase Technology (ICMT), is a risk assessment tool that is capable of predicting steady-state corrosion rates across a wide range of temperatures, acid gas partial pressures, brine chemistries and flow regimes. |
| Corrosion Rate Determination and Corrosion Inhibitor Performance Testing | Reaction Kettles, Bubble Test Six static bubble test units to replicate non-turbulent flow conditions. Testing under sweet (CO₂) conditions at a temperature range from 20°C to 90°C. Rotating Cylinder Electrode (RCE) Test Six rotating cylinder electrode (RCE) units to replicate mildly turbulent flow conditions [6 Pa at 1,900 RPMs]. Pressure and temperature limits of 1 bar and 80°C. This test allows for surface analysis of electrodes and weight loss data. |
| Evaluation of Microbial Activity in Aqueous Samples | ATP Luminometer Rapid monitoring of microbial activity in aqueous samples. Luminescence is used to detect activity for all sources of ATP including bacteria, fungi and algae. |

PRODUCTS

Multi-Chem has a comprehensive portfolio of corrosion inhibitors, H₂S scavengers, O₂ scavengers and biocides, including the option for customized formulations to meet your specific performance and physical property requirements. The asset integrity product portfolio includes:

» Corrosion inhibitors for sweet and sour environments and high dissolved solids concentrations
» Gas lift approved corrosion inhibitors
» High temperature (175°C) capillary certified corrosion inhibitors
» Combination products that also include scale inhibitors, oxygen scavengers, and/or paraffin dispersant components
» DeepSEAL® certified corrosion inhibitors
» MultiSweet® H₂S scavenger products (MEA-triazine, MMA-triazine, aldehydes, etc.)
» Oxygen scavenger products (ABS, SBS, catalyzed or not)
» Biocides (THPS, glutaraldehyde, quaternary ammonium)
» Oxidizing biocides (sodium hypochlorite, peracetic acid, ClO₂)
» Acrolein-based products
» Long-term protection (DMO, slow release DBNPA granules)
**The Importance of Scale Mitigation**

Removing, predicting and inhibiting the buildup of inorganic scale in near wellbore areas, perforations, tubing, flowlines, valves and surface equipment is critical to avoid production slowdown, and even abandonment of the well. Various types of chemical and treatment technologies are available to assist with this problem. Multi-Chem’s Amsterdam scale lab conducts scale inhibitor performance testing and high temperature brine compatibility testing, as well as making squeeze treatment recommendations and developing new products, as needed.

### CAPABILITIES

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<tr>
<th>CAPABILITY</th>
<th>DESCRIPTION</th>
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<tr>
<td>Scale Prediction Modeling</td>
<td>ScaleSoftPitzer predicts over 14 different oilfield inorganic scales, including the effect of MeOH and MEG, commingling brines and sea water mixing, as well as the limit of sulfate tolerance. Application ranges are at temperatures from 0 to 200°C, pressure from 14.7 to 20,000 psi and TDS from 0 to 450,000 mg/L.</td>
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<td>Water Analysis – Trace Metal Concentration Determination</td>
<td>Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). This technique is used to conduct field brine water analysis and inhibitor residual analysis.</td>
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<tr>
<td>Scale Inhibitor and Brine Compatibility Evaluation and Minimum Inhibiting Concentration Determination</td>
<td>Method used to screen and select scale inhibitor and evaluate scale inhibitor efficiency (minimum inhibiting concentration determination). Incompatible brines, in the presence of scale inhibitor, are combined and exposed to a defined elevated temperature; scale deposition is monitored visually or with ICP analysis of the liquid phase.</td>
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<tr>
<td>Dynamic Tube Blocking Apparatus</td>
<td>Standard method for evaluating scale inhibitor performance, in which incompatible brines are pumped through a small diameter capillary tube while differential pressure is measured. Scaling conditions are noted by an increase in differential pressure, and scale inhibitor effectiveness is determined by the ability of a product to reduce differential pressure.</td>
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<td>Squeeze Application Investigation</td>
<td>Core Flood Apparatus. The core flood equipment is used to study the interactions between scale inhibitors (SI) and formation rock elucidate the mechanisms of transport and retention of SI squeeze treatments. Core flood results play a key role in determining the sensitivities to inhibitor retention, inhibitor return/squeeze life times and possible formation damage in real reservoir systems.</td>
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### PRODUCTS

Multi-Chem has a comprehensive product portfolio of scale inhibitors, including the option for customized formulations to meet your specific performance and physical property requirements. The wide range of scale inhibition treatments includes:

- Topside scale inhibitors (phosphonates, polymer, etc.)
- Downhole scale inhibitor squeeze treatment
- Inorganic sulfide control
- Combination scale/corrosion inhibitors
- Halite inhibitors
- Solid/encapsulated scale inhibitors
- Barium sulfate inhibitors
- Barium sulfate dissolver
- Tagged polymeric scale inhibitors for residual monitoring
- Deep water and subsea production systems
Dealing with Phase Separation Challenges

Phase separation involves separation of the bulk phases of production – oil, water and gas. Typical challenges include the resolution of emulsion and foams and improvements to produced water quality. This category of products also includes foam assisted lift products to help improve gas production in wells suffering from liquid loading.

CAPABILITIES

Product Performance Evaluation of Demulsifiers, Reverse Emulsion Breakers, Foamers, Defoamers, Water Clarifiers and Sluggers

> Demulsifier bottle testing
> Foamer selection screening – blender and sparge methods
> Antifoam/defoamer selection screening: blender, sparge and bottle test methods
> Water clarifier screening

Field Demulsifier Testing Equipment

Equipment for on-site evaluation, including water baths, reciprocal shakers, centrifuges, oil-in-water analyzers (Hach and Infracal) and salt-in-crude analyzers.

PRODUCTS

Multi-Chem develops field specific demulsifiers for both water-in-oil (regular) and oil-in-water (reverse) emulsions. These demulsifiers are developed on location to optimize their performance, as follows:

> Fast separation rate to optimize vessel efficiency
> Good oil-in-water interfaces for monitoring and increased vessel efficiency
> Dehydration and desalting to specification
> Product storage and application stability in prevailing conditions

Multi-Chem’s line of water treatment chemicals includes all types of water clarifiers with wide ranges of molecular weights and charge densities. Where possible, Multi-Chem combines coagulation and flocculation functionalities in one product to improve efficiency, while minimizing treatment dosage. These products are used in various applications, from optimizing water treatment to solids removal, de-oiling, improving filter efficiency and de-watering of solids waste.

A portfolio of foam control products is offered to act as anti-foam agents for both aqueous and oil-based fluids. Additionally, foamers for foam assisted lift are also available, including products designed for high condensate tolerance and those approved for capillary injection at bottom hole temperatures up to 180°C. These formulations can offer performance and water quality protection at a wide range of brine salinity, brine hardness and natural gas condensate cuts.
Reducing Paraffin and Asphaltene Deposition and Impact on Viscosity to Optimize Flow

Flow restricting challenges from asphaltenes, hydrates, paraffin, scale and other solids can significantly reduce production system performance. Multi-Chem is committed to optimization of flow assurance via modeling, simulating, testing, screening and evaluations to determine levels of wax or sedimentary particles and assess the effectiveness of inhibitor chemical treatments.

CAPABILITIES

| Paraffin and Asphaltene Flocculation Prediction Modeling and Minimum Inhibiting Concentration Determination | Multiflash |
| Model that performs wax appearance temperature (WAT) prediction, percent paraffin precipitation calculations and asphaltene flocculation estimates from live oil samples. Predicts the temperature and pressure range within which the production system is at the risk of asphaltene deposition |

| Pour Point Determination | ASTM D97 Pour Point |
| Automated Pour Point Test |
| Pour Point Depressant (PPD) Screening |

| Viscosity and Yield Stress | HAAKE Viscotester 500 |
| Yield stress is the value of shear stress above which the material flows. This technique is used to evaluate the restart pressure for gelled waxy crudes. |

| Wax Inhibitor Performance Evaluation | Cold Finger Test Equipment |
| Designed to simulate wax depositing conditions via precise control of temperature gradients and used to determine wax inhibitor efficiency, the wax deposition tendency of crude oil is determined. |

| Asphaltene Inhibitor and Dispersant Performance Evaluation | Asphaltene Dispersant Bottle Test |
| Rapid screening technique to assess dispersant performance. |
| Turbiscan Laser Asphaltene Dispersant Test |
| Dedicated to stability analysis and allows monitoring of flocculation and sedimentation of asphaltene particles. |

| Wax Appearance Temperature (WAT) Determination | High Pressure Differential Scanning Calorimetry (DSC) |
| Used to determine wax appearance temperature (WAT) and wax disappearance temperature (WDT) of a crude oil or condensate containing wax. The WAT is critical to understanding at what temperature in a production system wax challenges can be expected. Also, it is essential for most paraffin treatment products to be injected into the crude oil when T > WAT. |

PRODUCTS

Paraffin and asphaltene product portfolio includes:
- Paraffin inhibitors and pour point depressants
- Asphaltene inhibitors
- Paraffin/asphaltene dispersants (anionic/nonionic/cationic surfactants or surfactant mixtures in solvents) for effective removal of paraffin and/or asphaltene deposits or prevention of deposit buildup
- Paraffin/asphaltene solvents (aliphatic, aromatic, pinene derivatives and combinations) for effective removal of paraffin and/or asphaltene deposits
- Paraffin/asphaltene combination products
- Capillary string/umbilical approved paraffin/asphaltene products
- DeepSEAL® certified paraffin/asphaltene products for deep water applications

Hydrate inhibitor product portfolio includes:
- Thermodynamic hydrate inhibitors (THI), consisting of solvents/solvent combinations such as methanol, ethanol and ethylene glycol
- Low dosage hydrate inhibitors (LDHI)
- Kinetic hydrate inhibitors (KHI)
- Anti-agglomerants (AA)
- DeepSEAL certified kinetic hydrate inhibitors for deep water applications
- DeepSEAL certified anti-agglomerant products for deep water applications
- DeepSEAL certified anti-agglomerant/corrosion inhibitor combination products
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.

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