DEEP WATER

MATURE FIELDS

UNCONVENTIONALS

Emulsion Breaker Product Selection and Treatment Philosophy

Multi-Chem custom formulates field-specific emulsion breaker chemicals for the treatment of water-in-oil emulsions to cost effectively separate produced water and reduce the salt content of crude oil to meet export specifications.

The application of well-designed emulsion breaker chemicals delivers significant CAPEX cost savings for treatment facilities performing the required product separation. It also maximizes crude oil sales value for the customer.

Emulsion breaker chemicals, commonly known as demulsifiers, are multi-component formulations specially designed to treat the produced fluids and process treatment facilities where they are applied. As the composition of produced fluids varies across fields, custom demulsifier chemicals are formulated on site by highly experienced Multi-Chem phase separation specialists for field-specific applications. Extensive bottle testing is conducted on representative fresh produced fluid samples in order to select the best performing chemistries and component blends to formulate optimized, tailored chemical treatment solutions.

HALLIBURTON

HOW ARE WATER-IN-OIL EMULSIONS FORMED?

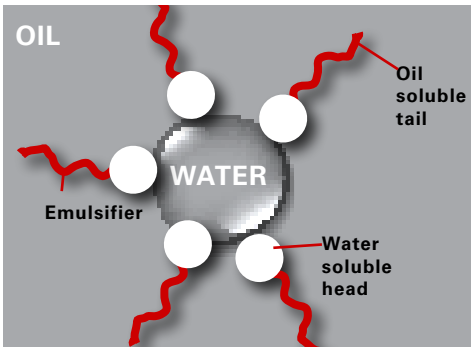
Water-in-oil emulsions are formed when crude oil and water are forced to mix in the presence of emulsifying agents, which can include naturally occurring surfactants, such as resins and organic acids, solids in the produced fluids, and other production treatment chemicals applied in the system. Many factors in oil and gas production operations can contribute to the generation of water-in-oil emulsions, including artificial lift operations and fluid flow through chokes, valves, pumps, pipelines, and other equipment. The extent of fluid mixing and level of shear determines the severity of the emulsion generated. The higher the shear rate, the smaller the droplets of water dispersed within the crude oil phase.

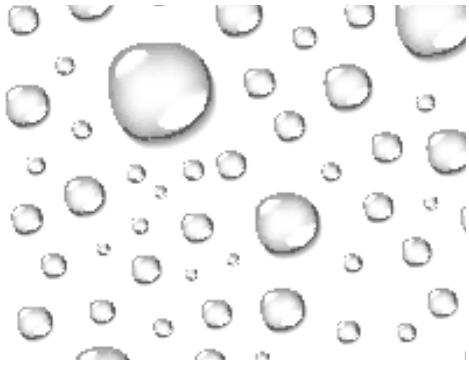
Only a very small amount of an emulsifying agent is needed for an emulsion to form. Emulsifying agents collect at the boundary or interface between the oil and water to create a strong, resilient film that is difficult to break. This film prevents the dispersed droplets of water from coalescing into larger droplets and falling out of the oil/water mixture.

The presence of solids in the produced fluids can greatly enhance the severity of emulsions generated within production operations.

Typical solids that can be present in the produced fluids and can act as mechanical stabilisers include:
- Wax
- Asphaltenes
- Clays
- Silica
- Mineral scales (carbonates, sulfates)
- Corrosion products
- Iron sulfides

The stability of an emulsion depends on a number of factors, including:
- Type and concentration of emulsifying agent(s)
- Oil and water composition
- Viscosity of the fluids
- Density of the oil and water
- Amount and size of water droplets
- Age of the emulsion
- System temperature





DEMULSIFIER CHEMICAL TREATMENT THEORY

To break a water-in-oil emulsion, the film surrounding the internal phase must be disrupted so the water droplets can unite and collect in a layer separate from the crude oil phase. This can be achieved with the application of heat and/or suitable demulsifier chemicals.

Demulsifiers are typically blends of several different chemical components formulated in an aromatic hydrocarbon solvent. They are designed with unique solubility, which provide hydrophobic and/or hydrophilic properties as required for the specific emulsion to be treated, enabling the demulsifier to weaken the stabilising film that surrounds each water droplet at the oil-water interface.

The presence and extent of solids in the produced fluids can greatly increase the parts per million (ppm) treatment rate of demulsifier required to achieve efficient separation. Where possible, addressing the cause of solids to prevent them from forming (e.g., application of scale inhibitor or wax/asphaltene inhibitor chemicals, etc.) can help to minimize the severity of oil-in-water emulsions generated, resulting in a reduced quantity of demulsifier chemical required to meet crude oil export specifications.

Demulsifier Product Design

The adjacent diagram outlines the process followed for the development of field-specific custom demulsifier chemicals and treatment performance evaluation.

1: TSA, Field Visit and Bottle Test
Elucidate the influence of chemistry on production fluids
Field activities include:
» Extensive field survey and fluids characterization
» Bottle testing simulating process conditions, providing consistent results and a benchmark with reference sample

2: Develop Product
Formulate identified intermediate(s) into a stable and compatible product. Judicious solvent selection considers cost and supply chain.

3: Field Evaluated Trial Design
Evaluate selected product performance from onsite bottle testing.
Design performance KPIs for field trial.
Determine chemical consumption volumes and trial duration.

4: Field Trial
Provide Phase Separation SME Technical Support throughout the duration of trial to provide expertise during optimization of treatment dosage.

THE CHEMICAL DEMULSIFICATION PROCESS OCCURS IN FOUR DISTINCT STAGES:

Stage 1

Destabilize/Disrupt Emulsifying Film » The demulsifier chemical migrates through the emulsion to reach the small water droplets, changing the surface tension at the interface to destabilize or disrupt the emulsifying agent film.

Stage 2

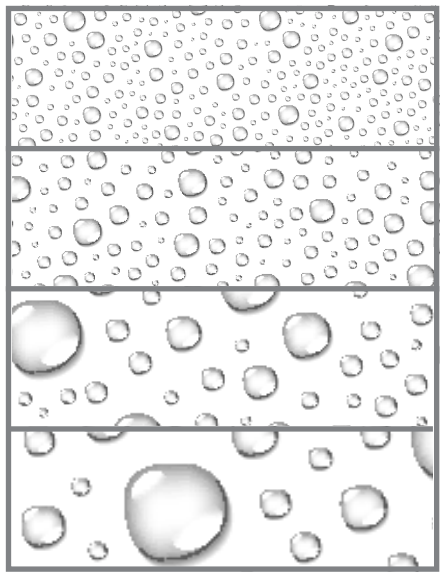
Flocculation » The surface of the water droplets have an affinity for each other and will flocculate, or move toward each other.

Stage 3

Coalescence » The released small water droplets combine (or coalesce) together to form larger water droplets.

Stage 4

Separation of Water » As the water droplets coalesce and grow larger, they become heavy enough to fall by gravity differential through the crude oil phase and settle out in the bottom of the process separation vessels.



TOTAL SYSTEM ANALYSIS (TSA)

Understanding the production system and associated risks are critical for any oilfield chemical treatment application. As a first step in managing the treatment of water-in-oil emulsions, an in-depth system review and analysis of the process and separation facilities is conducted on location.

The Total System Analysis (TSA) process takes into consideration all of the current production chemical treatment applications, fluids and solids analysis. This includes reviewing field operations to establish a complete and detailed understanding of the overall production system and phase separation challenges.

Many parameters associated with the specific production system can impact the likelihood of generating produced emulsions and the severity and stability of the emulsions that are created, including:

» Well design, completion and lift method
» Crude oil and water chemistry and characteristics
» Oil, water, and gas production rates
» Chokes, valves, pumps, and pipelines
» System temperatures
» Fluid agitation and shear rate throughout the process
» Other production chemicals being applied and treatment effectiveness
» Separation vessel design, residence time and turbulence

During the system survey, oil and water separation performance is assessed along with a detailed review of demulsifier chemical treatment history and performance to identify opportunities for treatment improvement with a focus on optimizing total cost of operations.

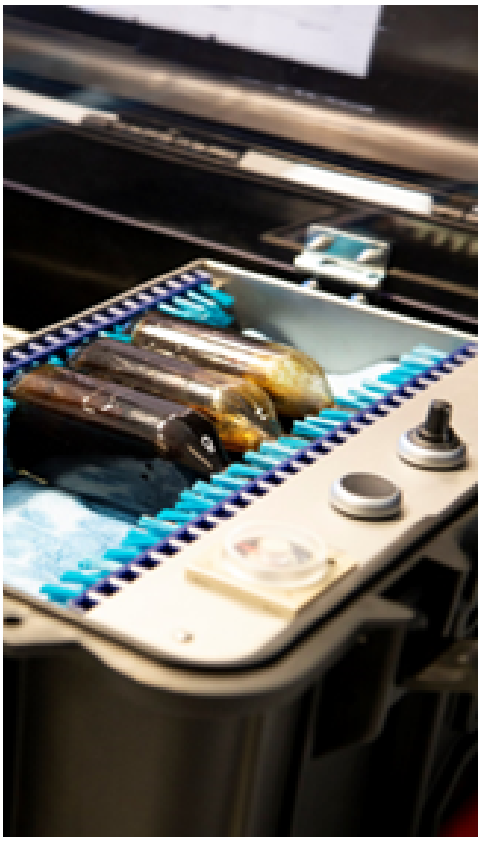
BOTTLE TEST

Following the completion of a TSA, the development of a fit-for-purpose custom demulsifier product takes place on location to suit the individual needs of the field and process system where the chemical will be applied. A system-specific, bottle test procedure is designed to take into account the critical information gathered during the TSA to replicate the dynamics of the produced fluids passing through the various stages of the separation facilities.

Bottle testing is an oil industry standard methodology in which a wide range of different demulsifier intermediates are added to samples of emulsion to determine what chemistries, and various blends, offer the most cost-effective performance for breaking the emulsion, dehydrating the oil and reducing the salt content of the treated oil to meet the required specifications. The key parameters used to design a field-specific, bottle test procedure include:

» Export oil and water-quality specifications
» Representative fresh produced fluid emulsion sample
» Temperatures at various points throughout the process system
» Level of fluid agitation and shear through each stage of the separation process
» Retention times and degree of turbulence within each of the separation vessels

Representative produced fluid emulsion samples collected for bottle testing must be demulsifier-free. Ideally, fluids should be collected from a suitable sample point located upstream of the demulsifier chemical injection point. If this is not possible, then the demulsifier injection needs to be turned off for a short period to allow representative produced fluid samples to be collected. All other production chemicals applied in the system should remain online.



Exposure of produced fluid samples to air causes oxidation of the emulsifying agents, which results in increased emulsion stability. This is referred to as ***sample aging,*** and this can significantly affect treatment performance. In order to avoid issues with sample aging, it is recommended (wherever possible) to conduct bottle testing on location with fresh produced fluid emulsion samples.

Control demulsifier chemicals are used to validate and refine the bottle test procedure in order to replicate the benchmark system performance.

The following properties are assessed and recorded with each test:

- Speed and amount of water drop
- Water content and residual emulsion in the oil
- Oil/water interface quality
- Salt content of treated oil
- Separated water clarity
- Tendency of oil and water to re-emulsify with agitation

Based on the results and observations from the initial screening tests, the best performing intermediate chemistries are then blended in varying ratios and further tested to refine treatment performance and to identify the optimal treatment dose rate (ppm) required to achieve the necessary oil export specifications.

COMMERCIAL DEMULSIFIER PRODUCT DEVELOPMENT

Following completion of the bottle test campaign, a commercial demulsifier product is developed in the laboratory from the best performing blend of intermediate chemistries. Finished products are formulated in a cost-effective, hydrocarbon solvent package to ensure product stability for transport, storage and application for specific field conditions, and compliance with customer specifications.

DEMULSIFIER FIELD TRIAL EVALUATION & CONTINUOUS PERFORMANCE MONITORING

A field trial is required to evaluate the performance of the newly developed commercial demulsifier product in the dynamic production system and to determine the optimal treatment dosage (ppm) to ensure the treated crude oil meets the required export specifications.

Performance monitoring during the field trial evaluation should include the following key performance indicators (KPIs):

PERFORMANCE AREAS	KPIs
Oil and Water Resolution	Separated water (v%)
Dehydration	Basic, sediment and water (BS&W)
Water Quality	Oil in water (OIW)
Interface Quality	Visual Inspection
Desalting of Crude	Salt in Crude (µS or PTBs)