The availability of equipment is clearly important. However, the ability to correctly utilize this equipment and properly interpret the data to deliver tangible fluid performance improvements to our customers is paramount. Through utilization of this equipment, customized and state-of-the-art fluid solutions are determined, complex drilling problems are solved, and cost savings to the operator are realized.
Worldwide Laboratory Support

Providing custom engineered solutions to maximize wellbore value is the operating directive for the Baroid Laboratories worldwide. Research and development (R&D), technical services, analytical testing, quality assurance (QA), and environmental compliance are all addressed within the worldwide Baroid laboratory infrastructure. Dedicated scientists and engineers staff these laboratories which are equipped with standard and state-of-the-art equipment for evaluating drilling, drill-in, and completion fluids and products.

Baroid’s global laboratories – principally headquartered in Houston, Texas, and in Pune, India – provide a complete spectrum of laboratory services. In addition to comprehensive drilling, drill-in, and completion fluid services and support, these facilities have the capacity to address a wide range of operational issues related to well construction, completion, and production. These laboratories perform research and development, provide quality assurance services, and have analytical capabilities. In addition, the U.S. labs have bioassay testing capabilities that enable evaluation of aquatic toxicity and aerobic biodegradability of products and fluid systems. The Halliburton Industrial Products laboratory, supporting the Industrial Drilling Product and Bentonite Performance Mineral product lines, is also included in the U.S. labs.

Baroid is fully committed to the concept that the first line of technical services and quality control is at the wellsite; therefore Baroid extensively trains its engineers to perform American Petroleum Institute (API) testing and other field tests to monitor fluid properties, as well as pilot tests, and recommend and implement appropriate treatments to help ensure that the drilling, drill-in, or completion fluids meet operational specifications. In support of the engineers in the field, there is a network of Baroid’s global laboratories – principally headquartered in Houston, Texas, and in Pune, India – can perform more extensive and complex tests that cannot reasonably be performed at the wellsite. When situations arise that cannot be adequately addressed by the Area and Country labs, then the Baroid regional labs are called on for support and solutions.
Global Laboratory Support

The chart below shows the testing capabilities of the Baroid laboratories based on geographic hierarchy. The principal global (in Houston and Pune) will have all of the capabilities shown; the regional, country, and area laboratory capabilities are dependent on the technical needs for supporting the operational requirements of the respective region, country, or area. In some cases, area labs can have capabilities almost on par with those of country labs, and country labs can have capabilities almost on par with those of the regional labs.

General Laboratory Capabilities

<table>
<thead>
<tr>
<th>Laboratory Classification</th>
<th>Region</th>
<th>Country</th>
<th>Laboratory Classification</th>
<th>Region</th>
<th>Country</th>
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<tbody>
<tr>
<td>Drilling Fluid Testing</td>
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<td>Special Testing</td>
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<td>Tender/Formulation Work</td>
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<td>Completion Fluid Testing</td>
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<td>Cloud Point Determination</td>
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<td>Crystallization Point Determination</td>
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<td>Variable Pressure Crystallimeter</td>
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<td>Quality Control Testing</td>
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<td>Proprietary Products</td>
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<td>Lubricity (EP and Low Load)</td>
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<td>Aniline Point</td>
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<tr>
<td>Particle Size Distribution</td>
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<td>Solids Analysis (Retort, PSD, MBT)</td>
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<td>Static Aged Properties</td>
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<td>Flash Point</td>
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<td>Stickometer Testing</td>
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<td>FTIR Analysis (ID of Organics)</td>
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<td>Water Activity (Hygrometer)</td>
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<td>GC/MS</td>
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<td>Drill-In Fluid Testing</td>
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<td>HP Kjeldahl Nitrogen Test</td>
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<td>Particle Plugging Test</td>
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<td>HPLC/GPC</td>
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<td>Return Permeability Test</td>
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<td>ICP Analysis</td>
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<td>Shale Testing</td>
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<td>Ion Chromatography</td>
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<td>Accretion Tests</td>
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<td>Mercury Analysis</td>
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<td>CST (with Various Salts)</td>
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<td>Optical Microscope</td>
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<td>Linear Swellmeter Test</td>
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<td>SEM Analysis</td>
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<td>Methylene Blue on Cuttings/Mud</td>
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<td>SUS/Kinematic Viscosity</td>
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<td>Thermo Gravimetric Analysis</td>
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<td>Pore Size Analysis</td>
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<td>X-Ray Diffraction</td>
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<td>Shale Erosion Test (Slake/Screen)</td>
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<td>X-Ray Fluorescence</td>
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</tbody>
</table>
Research and Development

From maximizing production in unconventional, small, or remote fields to economically drilling and developing deepwater reservoirs, we collaborate with our customers to understand their challenges and then apply the latest advancements in fluid technology to resolve those challenges.

Baroid’s global laboratories in Houston and Pune are regarded as the Company’s principal R&D centers. Design planning is completed in accordance with the stringent quality standards of ISO 9001:2000 requirements.

Baroid has developed a number of new products, fluid systems, and testing equipment capabilities to support the challenges associated with changing well conditions, technology, and field/well economics. The R&D groups are actively working on projects in a variety of areas in support of our drilling and completion fluids business. Our project portfolio aligns with our knowledge platforms of:

» Wellbore fluids
» Wellbore management
» Reservoir producibility
» Environmental assurance

In addition, Halliburton technology centers in Dhahran, Saudi Arabia, and in Rio de Janeiro, Brazil, have a number of projects that are run in collaboration with universities around the world. These universities have been selected based on their specific technical knowledge and world-class capabilities in support of our knowledge platforms.

Baroid’s R&D efforts support a number of key technology areas to meet unconventional, mature fields, and deepwater challenges relevant to land operations, fluids management, oil-based fluid development, water-based fluid development, shale stabilization, engineering design, wellbore monitoring/stabilization, and environmental compliance.

Engineering Services

The Engineering Services group provides a complementary set of capabilities for fluids R&D. These include the development of:

» Engineered solutions for support of fluid design and management
» Instruments that expand the scope and capabilities of existing testing methods
» Software for drilling simulation and wellbore pressure management – Drilling Fluids Graphics (DFG™) software and Completion Fluids Graphics (CFG™) software
» Leading-edge capabilities in well planning and real-time problem solving
**FANN® Equipment Development**

The FANN® Equipment Development group designs and brings to market instruments used across the industry:

» High-pressure/high-temperature (HP/HT) viscometers, which are used in both drilling fluids and production enhancement, are utilized in both the R&D and field operations labs.

» Cement analysis instruments are used to measure thickening time, static gel strength, and compressive strength.

The group provides next-generation instrumentation software:

» This new software uses a common platform so that training of operators across product lines becomes more seamless. The use of a test input “wizard” has been implemented to ensure that all required data has been entered.

» The software connects to a searchable database to provide field engineers access to historical and geographical data (for more efficient solution determinations) and enables remote real-time monitoring of test progress and results.

In addition, the FANN group supports Baroid lab schools by providing theories of operation and practical applications on currently used instruments.

**Industrial Drilling Products**

Since 1958, Baroid Industrial Drilling Products (IDP) has been providing products and services to the industrial drilling industry for non-oil and gas exploration applications. The IDP laboratory in Houston is committed to product development and technical service to fulfill the industry needs and support IDP field engineers. The IDP product line includes drilling fluid additives, bentonite grouts, well remediation products, and well development products specifically engineered to optimize performance and lower end-user costs. Baroid IDP serves wide-ranging and diverse markets including:

» Water-well drilling
» Mineral exploration
» Horizontal direction drilling
» Deep foundation/drilled shaft/slurry trenching
» Pipe bursting/pipe jacking
» Tunneling and micro-tunneling
» Construction/micropiles/auger boring
» Geotechnical investigations
» Geothermal heat loop applications
» Environmental monitoring and horizontal drainage/recovery wells
» Shot hole drilling
» Water impedance and pond sealing/vertical barriers
» Pipeline river crossings
Technical Services: Drilling Fluids

Baroid’s global laboratories have the equipment and staff needed to conduct all standard and virtually all non-standard testing on drilling, drill-in, and completion fluids. Our regional laboratories have equipment and staff to conduct all standard tests and many specialized tests.

Baroid’s country and area labs have equipment required to support the technology being implemented in their respective country or area. All test equipment that performs measurements are subject to programmed calibration and maintenance in accordance with documented procedures. Technical service laboratory project requests are entered, each project status tracked, lab test data logged, and lab reports generated using the iFacts™ global database. Every Baroid laboratory utilizes this iFacts™ system.

RHEOLOGY/VISCOSITY TESTING

Anton Paar MCR Rheometer
Anton Parr rheometer allows for any type or combination of rheological tests, both in rotational and oscillatory modes. The modularity of the system allows the integration of a wide range of temperature devices and application-specific accessories.

FANN 45 Viscometer
The FANN 45 viscometer is an automated version of the FANN 35 viscometer. Both instruments are concentric cylinder viscometers that provide rheology measurements at ambient pressure and temperature from 0°F to 150°F (4.4°C to 65.5°C). FANN 45 viscometer is more versatile because it can take rheology measurements at any speed between 600 rpm and 0.1 rpm.

FANN 77 or iX77 HP/HT Viscometer
FANN’s newest viscometer operates at temperatures up to 600°F (315°C) and in pressures up to 30,000 psig to allow rheological measurements on fluids designed for extremely hot, deep wells. This instrument has an improved embedded electronics control module; data acquisition and control software; and pressure, temperature, and speed controllers.

RheoVADR® 50 Variable Automated Digital Rheometer
The RheoVADR® 50 variable automated digital rheometer, which advances the accuracy of the previously released FANN Model 50 HP/HT rheometer into a new space-saving footprint for the benchtop. Tests are performed with greater confidence through enhanced control of fluid shear, temperature, and pressure. RheoVADR 50 rheometer is a Couette-style rotational viscometer, designed for testing fluids at temperatures to 500°F (260°C) and in pressures up to 5,000 psig in a coaxial cylinder chamber.
Lost Circulation Material (LCM) TESTING

Automated Permeability Plugging Apparatus (APPA) Model 389 AP/MC
The APPA 389 AP/MC model provides an exceptional reproducible environment for testing a drilling fluid’s ability to minimize filtrate and achieve an optimal filter cake on the wellbore. Traditional permeability plugging tests require the operator to manually manage the timing, pressure control, and filtrate collection for the entirety of the test – the Model 389 AP and MC combination eliminates the necessity for continuous operator intervention, and promotes testing automation and repeatability.

Permeability Plugging Apparatus
The Permeability Plugging Apparatus (PPA) measures fluid loss by using ceramic discs to simulate a variety of reservoir pore throat diameters (10 to 190 microns). Filter cake is built on the underside of the ceramic disc. This orientation eliminates the effects of settlement during formation of the filter cake. Overbalances to 2,500 psig can be reproduced and the cell can be heated to 500°F (260°C). PPA is used extensively for optimization of reservoir pore throat bridging formulations using the BARACARB® bridging agent and other acid-soluble bridging agents. The continued ability of field muds to provide suitable bridging is typically evaluated by using a combination of PPA testing and particle size analysis.

Resiliency Tester
The Resiliency Tester measures the ability of granular lost circulation material (LCM) to resist deformation under compression. The test is designed as a simple analogue of a near-wellbore LCM-filled fracture where compressive forces are attempting to close the fracture. Ideally, a resilient LCM will resist the applied deformation without crushing, breaking, or plastically deforming. The test apparatus utilizes a Buehler specimen mounting press. In the test, compressive stress is applied to a confined sample material for 5 seconds at pressures of as high as 10,000 psig; at the end, pressure is removed and the sample is allowed to relax. The amount of permanent deformation is recorded. Resilient materials will show little permanent deformation, returning to their near-original state.

LUBRICITY TESTING

Falex Pin and Vee Lubricity Meter
The effectiveness of a lubricant is evaluated by measuring the resistance of a test pin rotating between two vee blocks immersed in the lubricant. The vee blocks apply a line load on the pin through a ratchet wheel, spring gage, and eccentric arm mechanism. The load can be applied continuously or incrementally.

FANN EP Lubricity Meter
The FANN Extreme Pressure (EP) and Lubricity Tester evaluates lubricant performance by applying a measured force with a torque arm through a steel block to a torque-sensitive, rotating bearing cup. The measured resistance gives a direct indication of the film strength of the fluid being tested and a lubricity coefficient. The EP/lubricity tester was designed to simulate the torque and drag observed in drilling operations by approximating the speed of rotation of the drillpipe and the pressure with which the pipe bears against the borehole wall or casing and where the friction is generated. Water-based mud lubricants are evaluated by the measurement of lubricity coefficient reduction following addition of the lubricant to the drilling fluid. The relative performance of lubricants is often dependent upon the fluid type, with factors such as solids loading and pH having a marked effect on the performance of certain lubricants. Lubricity coefficient is typically found to reduce with increasing lubricant concentration. However, it is usual to find one concentration at above which the addition of further lubricant is no longer cost effective. Hence, use of the lubricity meter allows identification of the optimum lubricant and lubricant concentration for a particular application.
SHALE TESTING

Capillary Suction Time
The Capillary Suction Time instrument measures the water retained by shale/brine slurries. Water retained by the shale will result in shale swelling and loss of mechanical properties. Water retention is measured as the time taken for “free” water from the slurry to travel radially between two electrodes on thick, porous filter paper. This test is used principally to validate increases in brine salinity and cation selection.

Linear Swell Meter
The Linear Swell Meter measures dimensional changes of constrained shale pellets exposed to candidate fluids. Measurement is effected by means of a Linear Displacement Transducer probe maintained in contact with the upper face of the shale pellet. Testing may be conducted at ambient or elevated temperature. Results are recorded as plots of swelling or contraction versus time. This test provides a graphical comparison of up to four inhibitive fluids simultaneously. Ideally, comparisons using this technique would involve sections of representative shale cut such that bedding planes lie perpendicular to the direction of measurement. Rarely is it possible to obtain such samples and therefore, most linear swell testing is conducted using compressed shale pellets formed from powdered shale.

Shale Recovery and Shale Erosion Tests
These two tests are very similar, differing only in the amounts and sizes of shale particles used. A known weight of dry sized shale is hot rolled in the test fluid (mud or brine) for hours. The shale/brine mixture is then passed through the sieve used to size the original particles. The shale retained on the sieve is washed, dried, and weighed. This recovered weight is expressed as a percentage of the original weight. The greater the inhibition qualities of the mud or brine, the higher the shale return weight will be.

Slake Durability Test
Samples of sized test shale are placed into mesh-covered cylindrical cages. The cages are then rotated at a constant 20 rpm while immersed in the drilling fluid. Tests are typically run for four hours at room temperature. However, longer runs at elevated temperature can be conducted where appropriate. The weight of shale recovered as a percentage of the original weight enables the inhibitive qualities of the drilling fluid to be compared. Results obtained using the Slake Durability Test generally follow the same trends as those obtained from shale recovery testing. However, shale samples that are particularly susceptible to mechanical damage will give lower recoveries in this test than those in shale recovery tests. Therefore, data from both test methods provide an insight into the effects of candidate fluids on shale hydration/ dispersion and attrition.

FILTRATION TESTING

FANN 90 Dynamic Filtration Test
The FANN 90 dynamic filtration test builds on the capabilities of the PPA in that it utilizes ceramic cores available in a range of different pore sizes. The FANN 90 Dynamic Filtration Test differs from PPA in three important respects:

- Filter cake is built on the inner surface of a vertically oriented, cylindrical ceramic core to more accurately replicate the wellbore.
- A motor-driven rod inserted through the center of the core simulates the action and annular fluid velocity on filter-cake deposition and attrition.
- Filtrate volume can be measured versus time.

The FANN 90 Dynamic Filtration Test simulates filtration properties downhole of Baroid filtration models to determine the cake deposition index (CDI) and dynamic solutions, thus preventing differentially stuck pipe.
Technical Services: Drilling Fluids

Completion fluid services encompass a wide range of testing capabilities, including, but not limited to: assessing formation damage resulting from exposure to completion and drill-in fluids; identifying shale inhibition properties; determining the effects of filter cake breakers; and preventing corrosion of drillpipe, casing, and tubing.

Proven processes are established for brine evaluation, treatment recommendations for fluid reconditioning, and the prevention of possible permeability impairment by contaminants.

**Formation Response Tester (FRT) Apparatus**
This device is designed to accurately measure the permeability changes of a formation sample when exposed to a variety of test fluids. This highly flexible, easy-to-use system is capable of simulating nearly any well completion and stimulation schedule on a core sample. The unit is also capable of operating as a dynamic fluid loss tester with the optional slurry cart. The system is designed to handle acids and other corrosive fluids at high temperatures.

**Production Screen Tester**
This apparatus is primarily used to test the flow-through characteristics of the completion fluid used to run the screen in hole (screen running fluid). By design, the completion fluid should not plug or show any tendency to plug the production screen. A known volume of fluid is passed through a screen coupon at a fixed differential pressure without flow being interrupted or slowed (both indications of plugging). The test is normally employed to evaluate clear brines, brines with drill-in filter-cake residue, or preconditioned reservoir drill-in fluid. The apparatus can also be used to help optimize the design of “inside-screen kill pills” – these are LCM-laden fluids used to temporarily seal and hold a hydrostatic pressure on the inside (downstream side) of the production screen; a method occasionally used in well suspension and workover operations.

**Variable-Pressure Crystallometer**
The Variable-Pressure Crystallometer apparatus provides the ability to test crystallization points of brines under elevated pressures (up to 20,000 psig) and low temperatures – up to 23°F (-5°C) – for deepwater applications.
Technical Services: Analytical

Baroid’s analytical labs in Houston and Pune offer a broad spectrum of chemical and material characterization capabilities. Analyses ranging from bulk properties down to ultra-trace elemental quantification can be performed in-house via various types of instrumental and wet chemical techniques. The analytical lab group provides direct support to every technical function within Halliburton, and provides the data required to help customize fluid formulations, characterize formation geology, and identify noncompliant materials.

INSTRUMENTAL METHODS

ATOMIC SPECTROSCOPY

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)
Determines the concentration of various elements in solids and aqueous solutions (EPA 200.7)

Mercury Analyzer
Measures the mercury content in solids and aqueous samples (EPA 7473 or EPA 7470A)

MICROSCOPY

Optical Microscopy
Optical microscopy with the magnification ranging from 50X to 500X
» Contact angle
» Particle size/shape
» Emulsion droplet size
» Optical mineralogy
» Image analysis

MOLECULAR SPECTROSCOPY

Infrared Spectroscopy (IR)
Collects the chemical fingerprints of solids and liquids, and can identify characteristic functional groups
» Near-IR (NIR), mid-IR (MIR), and Raman spectroscopy
» Transmission mode for solids, liquids, and gases
» Attenuated total reflectance (ATR) mode for solids and liquids
» Diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS)
» Mid-IR microscopy contact angle

NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Nuclear Magnetic Resonance (NMR) Spectroscopy
Measures the physical and chemical properties of compounds containing certain atomic nuclei
» 10-, 20-, and 500-mHz instrumentation
» Solid and liquid capabilities
» Proton, carbon, phosphorous, fluorine, and boron probes available
Scanning Electron Microscopy (SEM)
Uses a focused beam of electrons to scan the surface of a solid down to 10 nm
» SEM and Energy Dispersive Spectroscopy (EDS) – Elemental quantitation covering boron to uranium, and elemental distribution mapping of sample surface
» Particle size/shape
» Pore throat size distribution
» Surface texture

Physical and Chemical Properties

Brunauer–Emmett–Teller (BET) Surface Area
Determines surface area of solids by using gas sorption
» Nitrogen adsorbate gas
» Used on fine powders

Differential Scanning Calorimeter (DSC)
Measures the amount of heat required to raise the temperature of a sample as a function of time
» Freezing point/melting point
» Glass transition temperature

Flashpoint
Determines the lowest temperature that a vaporized sample will ignite in air when exposed to an ignition source
» Pensky-Martens ASTM D93A
» Cleveland Open Cup ASTM D92
» Tag Closed Cup ASTM D56
» MiniFlash ASTM D7094

Kinematic Viscometer
Determines the kinematic viscosity of oils (ASTM D7042)

Multi-Angle Light Scattering (MALS)
Measures the molecular weight (size), the radius of gyration (Rg), the hydrodynamic radius (Rh), and the polydispersity index (PDI) for polymers
» Static and dynamic light scattering
» Batch mode or in conjunction with gel permeation chromatography

Particle Size Analysis
Measures particle size distribution of solids from submicron to millimeters by using laser diffraction and automated imaging
» Malvern Mastersizer 3000 (laser diffraction)
» Microtrac S3500 (laser diffraction)
» Microtrac DIA (automated imaging); also provides shape properties

Thermogravimetric Analyzer (TGA)
Measures weight loss as a function of increasing temperature
» Decomposition
» Vaporization
» Adsorption/desorption

Separation Science

Gas Chromatography (GC)
Uses vaporization to separate, identify, and quantify components in a mixture
» Volatile and temperature-stable compounds
» Mass spectrometric (MS) and flame ionization detectors (FIDs)
» Direct liquid injection, headspace, solid-phase microextraction (SPME), and pyrolysis sampling

Ion Chromatography (IC)
Analyzes the ionic species of aqueous solutions through chemical separation
» Anions, cations, and polysaccharides
» Suppressed ion conductivity and electrochemical detection

High-Performance Liquid Chromatography (HPLC)
Uses adsorbent materials to separate, identify, and quantify components in a mixture
» Non-volatile and temperature-sensitive compounds
» Mass spectrometric (MS), ultraviolet/visible (UV/VIS), and charged aerosol detectors (CADs)

Saturates, Aromatics, Resins, and Asphaltenes (SARA)
Determines the relative concentration of saturates, aromatics, resins, and asphaltenes in oils by using thin-layer chromatography (TLC) (IP-469)

X-ray Analysis

X-Ray Diffraction (XRD)
Identifies phases of crystalline material and further quantifies these phases with appropriate crystal structures, which is applicable to cores, cuttings, scales, cement, and organic crystalline materials

X-Ray Fluorescence (XRF)
Qualitative and quantitative analyses of elements in solids and liquids
# WET AND GENERAL CHEMICAL METHODS

## WATER ANALYSIS METHODS

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity</td>
<td>Determines hydroxide, carbonate, and bicarbonate concentrations</td>
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<tr>
<td>Chlorides</td>
<td>Determinations by ion chromatography or titration (ASTM D512-12)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>Determinations by hydrometers (ASTM D1429) or density meters (ASTM D4052)</td>
</tr>
<tr>
<td>Sulfates</td>
<td>Determines sulfate concentrations in aqueous solutions by UV-Vis spectroscopy (EPA 375.4)</td>
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</table>

## OIL ANALYSIS METHODS

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<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aniline Point</td>
<td>Temperature where aniline and oil are miscible (ASTM D611)</td>
</tr>
<tr>
<td>API Gravity</td>
<td>Determinations using thermohydrometers (ASTM D287)</td>
</tr>
<tr>
<td>Cloud Point</td>
<td>Determines the temperature of wax solidification in oil (ASTM 5773)</td>
</tr>
<tr>
<td>Paraffin Content</td>
<td>Gravimetric determinations of paraffin content</td>
</tr>
<tr>
<td>Pour Point</td>
<td>Lowest temperature where a liquid will continue to flow (ASTM D5949)</td>
</tr>
</tbody>
</table>

## CEMENT ANALYSIS METHODS

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Lime</td>
<td>Determines free calcium oxide concentration by titration (ASTM C114)</td>
</tr>
<tr>
<td>Insoluble Residue</td>
<td>Determines acid and base insoluble residue (ASTM C114)</td>
</tr>
<tr>
<td>Loss on Ignition (LOI)</td>
<td>Percent weight loss after heating a sample to 1,832°F (1,000°C) to remove water and organic materials</td>
</tr>
</tbody>
</table>

## OTHER METHODS

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capillary Suction Time (CST)</td>
<td>Offers indication as to the reactivity of swelling clays in order to determine if a formation will be damaged by freshwater-based well treatments</td>
</tr>
<tr>
<td>Methylene Blue Test (MBT)</td>
<td>Measures the cation exchange capacity of drilling fluid solids and clays (API RP 131)</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>Measures the total nitrogen content in aqueous solutions, solids, and other organic materials</td>
</tr>
</tbody>
</table>
Quality Assurance

Quality assurance (QA) standards support our goal of ensuring that our internal and external customers receive the quality and on-time delivery needed for successful business and field operations. There are several Quality functions within Halliburton Fluid Systems and within Baroid, including ISO 900:2008, API registration activities, service quality, operations, support lab quality, and global QA. QA/quality control (QA/QC) testing is completed by the global labs in Houston, Pune, and Dhahran – as well as by regional labs in Aberdeen, Scotland; Rio de Janeiro, Brazil; Cairo, Egypt; Muscat, Oman; and Moscow, Russia.

Several direct activities, related primarily to Baroid’s operations support laboratories and global quality laboratories in Houston and Pune, contribute to our QA efforts:

» We evaluate new source suppliers and ensure that all purchases are made by using only suppliers that are compliant with Baroid QA/QC requirements.

» Our procurement and Quality departments work together to maintain a list of approved suppliers for our trade-named products, along with the raw materials and selected commodity chemicals that are deemed to have a significant impact to the success of our operation.

» Ore samples for manufacturing operations are evaluated by the QA team.

» Product quality complaints and nonconformances are evaluated by the Quality department, which employs approximately 300 different test procedures that are applicable to our trade-name and commodity products.

» Baroid’s QA laboratory, in conjunction with our Technology department (where applicable), evaluates and develops methods that are applicable for the chemical and performance evaluation of our products.

» The Global QA team monitors quality testing of our manufacturing operations.

» A global quality control database (QC DOC) has been implemented in which all Baroid QA labb data and vendor certificate of analysis (COA) data are input, and in which vendor quality compliance agreements (VQCAs) are electronically signed. Alerts are sent out immediately to the Global QA and Procurement teams if any data input into QC DOC does not meet specifications. The Logistics group also generates certificates of quality from QC DOC to send along with shipments of Baroid products. QC DOC globally tracks the quality of Baroid products from the time the material ships from the vendor until the customer receives it.

» Certificates of quality, which are delivered to customers with each lot of material, are generated directly through QC DOC or by QA lab support personnel.

» All suppliers electronically sign VQCAs with the Quality and Purchasing departments, in which the suppliers are directed to input certificates of analysis data into the QC DOC database and send samples to the nearest approved QA/QC laboratory as identified in the supplier VQCA. VQCAs for all trade-named products are included in QC DOC, along with commodity chemicals, such as salt and caustic soda and many others, as agreed upon by stakeholder departments or customer requirements.
Technical Support: Bioassay

Our goal in the Baroid bioassay laboratory is to provide accurate environmental data to comply with state, federal, and international regulations and permits. We strive to conduct business without adversely affecting the environment, and we can help to achieve that goal by providing our customers with the best products and services that meet these regulatory requirements. Laboratory testing capabilities include evaluation of aquatic toxicity and aerobic biodegradability of products, brines, base fluids, and fluid systems. Our services are not limited to Baroid, and they are not limited by location. While our bioassay laboratory is located in the Houston Technology Center, it provides support to all Halliburton product service lines worldwide.

Laboratory Certifications and Testing Capabilities

The bioassay laboratory has an internal QA/QC program to monitor regulatory compliance on all data generated and reported. The laboratory maintains ISO 9001 certification, and is also Good Laboratory Practices (GLP) qualified to submit results to the U.S. Environmental Protection Agency (EPA), the North Sea Network/OSPAR Commission, and other international regulatory bodies. Toxicity testing may also be performed during the R&D phase of a project to help determine whether a product warrants further investigation.

The laboratory can provide both freshwater and marine species to meet a wide range of testing needs. Most organisms used for testing are cultured in-house under strictly controlled environmental conditions. Our team of trained marine biologists and scientists work seven days a week to care for these organisms and perform necessary testing procedures.

<table>
<thead>
<tr>
<th>SPECIES AVAILABLE FOR TESTING</th>
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<tbody>
<tr>
<td>» Americamysis bahia</td>
</tr>
<tr>
<td>» Cyprinodon variegatus</td>
</tr>
<tr>
<td>» Daphnia magna</td>
</tr>
<tr>
<td>» Leptocheirus plumulosus</td>
</tr>
<tr>
<td>» Pimephales promelas</td>
</tr>
<tr>
<td>» Skeletonema costatum</td>
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<tr>
<td>» Vibrio fischer</td>
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<table>
<thead>
<tr>
<th>TESTS AND REGULATORY GUIDELINES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EPA/Gulf of Mexico Guidelines:</strong></td>
</tr>
<tr>
<td>» Static Sheen Test (EPA 1617)</td>
</tr>
<tr>
<td>» 96-hour Drilling Fluids Toxicity Test (EPA 1619)</td>
</tr>
<tr>
<td>» 96-hour Sediment Toxicity Test of Synthetic-Based Drilling Muds (EPA 1644)</td>
</tr>
<tr>
<td>» 10-day Sediment Toxicity Test of Non-Aqueous Drilling Fluids (EPA 1644)</td>
</tr>
<tr>
<td>» 24-, 48-, and 96-hour Acute Toxicity to Freshwater and Marine Organisms (EPA-821-R-02-012)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Sea Network/OSPAR Commission Guidelines Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>» 96-hour Acute Fish Toxicity Test (OECD 203)</td>
</tr>
<tr>
<td>» 72-hour Acute Algal Growth Inhibition Test (ISO 10253)</td>
</tr>
<tr>
<td>» 28-day to 63-day Aerobic Biodegradability in Seawater Test – Closed-Bottle Method (OECD 306)</td>
</tr>
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<thead>
<tr>
<th>OECD Freshwater Testing for Land-Based Operations</th>
</tr>
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<tbody>
<tr>
<td>» 96-hour Acute Fish Toxicity Test (OECD 203)</td>
</tr>
<tr>
<td>» 48-hour Acute Immobilization Test (OECD 202)</td>
</tr>
<tr>
<td>» 21-day Daphnia Magna Reproduction Test (OECD 211)</td>
</tr>
<tr>
<td>» Microtox® Acute Toxicity Test to expose bioluminescent bacteria</td>
</tr>
</tbody>
</table>
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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