Baker Hughes

Dubai regional support laboratories

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GENERAL OVERVIEW

Dubai regional support laboratories is a newly built facility in Techno Park, Jebel Ali in the UAE that was established in August 2014. This facility incorporates three different product line laboratories that consist of Drilling and Completion Fluids (DCF) lab, High Pressure Pumping lab, and Upstream Chemicals lab. All three work collectively and hand in hand to provide, each in their own specialized fields, the best technical and operational support services to the Middle East, North Africa, Turkey and India (MENATI) region. This document provides detailed information regarding the capabilities that each lab can offer to our customers in terms of services, tests, and specialized equipment.

1: Baker Hughes Drilling and Completion Fluids laboratory

A. Background

The Baker Hughes Drilling and Completion Fluids Dubai Technology laboratory is one of the technology laboratories established to provide technical support to Baker Hughes Drilling and Completion Fluids operations and also of equal importance, to our customers.

The Dubai laboratory is overseen by the Regional Drilling Fluids Technical Manager, who has access to technical support from regional as well as global technical groups of both fluids as well as all other product lines of Baker Hughes if required. The laboratory provides technical support and assistance to Baker Hughes Drilling Fluids Operational personnel as well as to our customers in the Middle East. It also supports other regions if and when required.

This support includes but is not limited to customized oil and water based mud formulations, drilling fluid analyses, completion fluid analyses, meso-phase near well bore remediation tests and analysis and QA/QC checks of locally purchased products. Full field mud testing is also undertaken if requested by the operator or thought necessary by Baker Hughes and can include hot rolling and static aging of samples.

This facility also has direct contact with Baker Hughes Drilling Fluids Instrumental Analysis laboratories in Houston, whereby the laboratory personnel have access to highly detailed analyses performed using instruments available to a few laboratories around the world.

Furthermore, all Drilling Fluids Technology labs are connected through our Baker Hughes lab link server where research results and experimental data are shared between one another. It is also used by lab personal to extract historical reports and data from previous tests that may have been performed in any of the other regional laboratories. This does not only improve the efficiency of our testing methods and formulations but also allows for a smaller time frame to carry out laboratory work and provide quick and accurate solutions to our customers.

Finally, it is important to highlight that our main goal after all, is to be a key component of the Baker Hughes Fluids Team; supplying our customer with good laboratory, technical, and operational services that will exceed their expectations.

B. Standard laboratory testing

TThe laboratory pilot tests and provides direction in the development and application of the Baker Hughes Drilling Fluids water-based mud systems, oil-based mud systems and Mesophase technology: DELTA-TEQ™, PERFORMAX™, MAX-BRIDGE™, PYRO-DRILL™, MICRO-WASH™, MICRO-PRIME™, and MICRO-CURE™ systems.

Test analyses performed:

- Water base mud checks
- Oil–based mud checks
- Particle Size Distribution
- Static rheology
- Static filtration control
- Dynamic flow rheology
- Low shear rheology analyses
- Mud formula proposals
- Enhancement of mud properties
- Development of completion fluid formulas
- Water analyses
- Well remediation/MICRO-WASH™ analyses
- MICRO-CURE™/MICRO-PRIME™ analyses
- Permeability Plugging Tests
- Relative comparisons of effectiveness of similar products/ product evaluations and QA/QC testing

Testing equipment:

- Fann model 35 v-g meters (four)
- Ofite model 900 viscometer
- Brookfield viscometer
- Chandler 7500 viscometer
- Particle size Analyzer-Malvern Mastersizer 3000
- Density meter-DMA-4101
- Pycnometer-Ultrapyc 3000
- Linear swell meter-ofite
- Bulk hardness tester
- Differential sticking tester
- Turbidity meter
- Silverson mixer (two)
- Hamilton beach mixer (four)
- Ion selective electrode meters for k+ and fl-
- Ph meters
- Rotap sieves and agitator
- Permeability plugging tester with LCM evaluation capability
- Equipment's to perform standard API mud checks.
- Five hot rolling ovens (sixteen samples at any one time)
- Two static aging ovens (sixteen samples at any one time)
- Lubricity meter-ofite
- CST
- Do meter
- GGT kit
- Centrifuge
- Water activity meter
- Temperature bath for cold temperature testing (two samples at any one time)

Project requests

Any project requests should be submitted to the laboratory with a complete detailed Technical Service Request (TSR) form. The TSR form should include as much information and background as possible regarding the project requested or the Mud samples to be analyzed. This will help the laboratory team get a better understanding of which tests need to be performed and what results are expected. Upon completion of the TSR form, please contact us at:

- DCFTSRDUBAI@bakerhughes.com

C: Drilling Fluids equipment

Equipment inventory	
Equipment	**Use**
Dynamic aging ovens	Dynamic aging samples up to 482°F (250°C) Total capacity
Static aging ovens	Static aging samples up to 482°F (250°C)
Stainless steel pressurized cells	Aging samples with pressure up to 482°F (250°C)
Stainless steel non-pressurized cells	Aging samples without pressure up to 302°F (150°C)
Silverson mixers	High shear mixing devices for preparing fluids
OFI 50 mL retorts	High temperature mud stills for determining water, oil solids content
Three station Hamilton Beach® mixers	Low shear mixers for fluid preparation. One with speed control to all three shafts.
Top loading balance	Balances (4,000 to 0.01 grams) for weighting products mud testing
WS tyler sieve shaker	Used for sieve sizes of solids
Sieves set-all sizes	Used for sieve sizes of solids
Pascall grinder	For grinding shales or oversized materials
Six speed Fann viscometers and heating cups with digital temperature controllers	Viscosity measurements
350 ml HTHP's mounted in one banks with common nitrogen supply and digital heating controls	High temperature (392°F/200°C) high pressure (600 psi/4.13 MPa) filtrate units
Automated HPHT four unit	High temperature (392°F/200°C) high pressure (600 psi/4.13 MPa) filtrate units
Four station API filtration unit plus cells	100 psi (0.68 MPa) differential pressure filtration unit
Chandler 7500 viscometer	Pressures and temperatures up to 30,000 psi/207 MPa and 600°F/316°C
pH meter	pH measurements
Electrical stability meter	ES measurements
Selective ion meter	Used for determining the concentration of potassium, iodide, aluminum ions
Pressurized mud balance	Pressurized mud balance for determining mud densities
Mud balances	Determination of mud densities
Brookfield viscometer	Used to measure the viscosity of thixotropic fluids at ultra-high and ultra-low flow rates

Equipment inventory (continued)	
Equipment	**Use**
OFI Model 900 low shear rate viscometer 230V	Viscosity measurements at ultra-low shear rate
Garret gas train	Used for determining sulfides and carbonates
Water activity meter	Used for determining water activity
Laboratory centrifuge	Used to separate out solids
Particle plugging apparatus	Test sealing effectives of mud systems
Slotted discs	For LCM evaluation
Lubricity meter-ofite	Used to determine lubricity coefficient
CST	Used for capillary suction time for clay inhibition
Turbidity meter	Used to measure turbidity in NTU
DO meter	Used to measure dissolved oxygen
Malvern Mastersizer 3000	Particle size measurement
Density meter-Anton Paar, DMA 4101	Liquid density measurement
Pycnometer- Anton Paar, Ultrapyc 3000	Solid density measurement
Linear swell meter-Ofite	Shale inhibition
Bulk hardness tester-Ofite	Shale hardness after getting contact with mud
Differential sticking tester	Differential sticking tendency of drill pipe
Furnace, 1100°F (593°C)	Evaluation of LOI

D. Specialized equipments and techniques

Chandler 7500 high temperature high pressure (HTHP) viscometer (under installation)

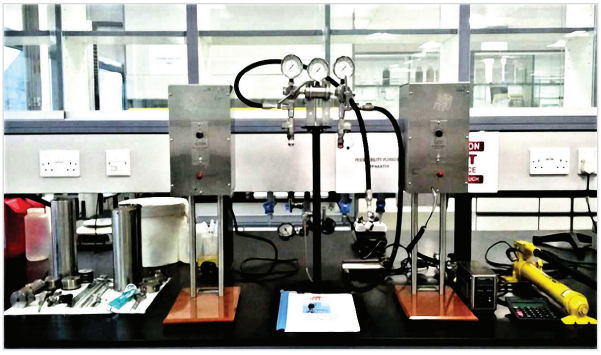
Model 7500 small footprint viscometer is designed for deep reservoirs in harsh environments where testing the limits of drilling and completion fluids can be a problem. The HPHT (high-pressure, high temperature) viscometer tests fluids in accordance with API and ISO standards, at pressures and temperatures up to 30,000 psi/207 MPa and 600°F/316°C.

OFITE Model 900 low shear viscometer

Drilling for oil and gas requires sensitive viscosity instrumentation, especially at low-shear rates to ensure that the drilling fluid has sufficient structure to prevent the settlement of solids. The OFITE Model 900 is a cylindrical rotational viscometer which can be used at paticularly low shear rates. The Model 900 can be used manually or as a fully automated system. In addition, the Model 900 is portable and can be transferred to the rig site where necessary. This low shear testing can be used to ensure drilling fluids possess sufficient low shear viscosity to adequately suspend weighting materials, cuttings and drill solids.

Permeability Plugging Apparatus

The Permeability Plugging Apparatus (PPA) is designed to provide accurate simulation and measurement of down-hole static filtration. This 4,000 psig rated PPA is ideal for predicting how a drilling fluid can form a permeable filter cake to seal off depleted / under pressure intervals. The PPA utilizes an HTHP Heating Jacket to simulate reservoir temperature. The fluid cell has pressure applied from the bottom of the cell and filtrate collected out the top. Pressure is transferred to the mud by a hydraulic hand pump through a small floating piston within the cell. The PPA employs a ceramic filter disc, which is available in varying porosities. The disc offers a more authentic representation of the formation. This test can be performed at conditions up to a pressure of 4,000 psig and temperature of 500°F/260°C.

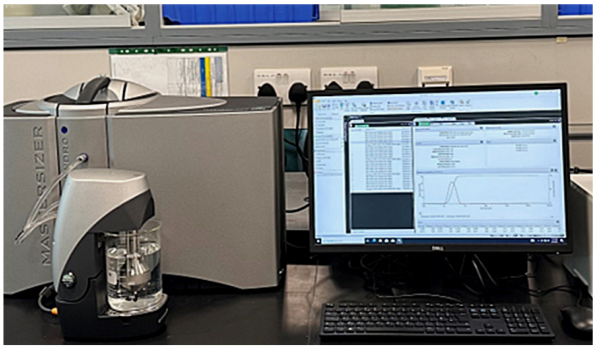


Lubricity testing

Measure of friction is a requirement for the determination of the film strength of a lubricant, for bit bearing wear, as is obtained in extreme pressure test and for the determination of torque or drag of the drill pipe as determined in the lubricity test. Lubricity is determined using a Lubricity tester from OFITE.

Malvern particle size analyzer

The Mastersizer 3000 uses the technique of laser diffraction to measure the particle size and particle size distribution of materials. It does this by measuring the intensity of light scattered as a laser beam passes through a dispersed particulate sample. This data is then analyzed to calculate the size of the particles that created the scattering pattern.



Density meter Anton Paar, DMA-4101

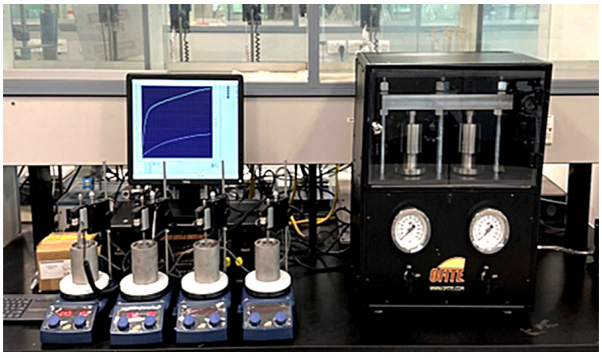
Liquid density measurement with variable temperature from 32°F to 212°F (0°C to 100°C) and with accuracy of 0.0001g/cm^3.

Pycnometer Anton Paar, Ultrapyc 3000

The Ultrapyc gas pycnometer measures the density of solids and semi-solids, which is used to track purity or porosity.

Linear swell meter-Ofite

The dynamic linear swell meter is designed to simultaneously test up to four drilling fluids (expandable to eight) on a representative shale sample for extended periods of time at temperatures up to 180°F (82°C). The linear swell meter is the only swell meter on the market capable of dynamically testing your fluids, so you obtain the most accurate data possible.



2: High Pressure Pumping laboratory

A. Background

The Baker Hughes High Pressure Pumping Dubai Region Laboratory is one of four region laboratories established to provide technical support to Baker Hughes high pressure pumping operations and also of equal importance, to our customers.

The four region laboratories are:

- NAR, North America Region
- LAR, Latin America Region
- EARC, Europe Africa Russia Caspian
- MEAP, Middle East Asia Pacific

The Dubai Laboratory is overseen by the Sales and Technical Director - Pressure Pumping, who has access to technical support from regional as well as global technical groups of both fluids as well as all other product lines of Baker Hughes if required.

B. Dubai regional lab objectives and strategy

The laboratory provides technical support and assistance to cementing (primary, remedial) fluids and stimulation fluids (fracturing, acidizing, sand control, water control, scale control) to our customers in the Middle East. It also supports other regions if and when required.

This support includes:

- BHI geo-market Labs
- Investigation of service quality incidents
- Auditing and training
- Testing for new tender/bid special requests
- Specialized testing according to equipment classification and Minimum requirement
- New technology projects enhancement and development

C. Dubai regional lab standardization reference method

All Dubai region lab testing procedures under:

- API
- ISO

D. Dubai regional lab testing

The aim of Dubai regional lab testing is to simulate all pumping and surface conditions which will face and effect on Pressure pumping fluids mixing and/or pumping, so that Testing will control, design and development our High Pressure Pumping to mimic job design, client requirement as well. Dubai region lab testing which written below gathering lab testing in functionality regards type of fluids.

Test analyses performed:

- Rheology and viscosity test
- Strength test
- Fluids loss testing
- Consistency
- Gas flow
- Mechanical properties
- Specific gravity
- Surface tension
- Water quality control
- Fluids compatibility
- Grain size distribution

E. Dubai regional lab equipment

Rheology and viscosity measurement equipment

Viscometer	
Maximum temperature	190°F/87.7°C
Shear rate range	0.01 to 1,700 sec-1
Shear rate accuracy	±0.001 rpm
Shear stress, maximum	0 to 1,500 (R1B1 & F1) dyne/cm_2
Motor speed	12 fixed speeds (600, 300, 200, 100, 60, 30, 20, 10, 6, 3, 2, and 1); variable speed range .006 to 1,000)
Compliance	ISO 13503-1, API RP 39

Ultra HPHT Rheometer	
Maximum temperature	600°F/315°C
Maximum pressure	30,000 psi
Shear rate range	0.0082 to 1020 sec-1 or 0.01 to 600 rpm
Torque	7 uN.m to 10 mn.m)
Shear stress, maximum	2 to 1600 dyne/cm_2
Viscosity	0.5 to 5,000,000 Cp
Compliance	ISO 13503-1, API RP 39
Resolution	0.3% of full scale range or better
Repeatability	±1 % of torque span or better

HPHT Viscometer	
Maximum temperature	500°F/260°C
Maximum pressure	2,000 psi
Shear rate range	0.17 to 1700 sec-1 or 0.1 to 1000 rpm
Shear rate accuracy	±0.01 rpm
Shear stress, maximum	4,900 dyne/cm_2 F440 spring
Compliance	ISO 13503-1, API RP 39
Operating temperature	32°F (0°C) to 120°F (49°C)
Cool down	Less than 15 minutes typical
Nitrogen	1,000 to 2,000 psi

Strength measurement equipment

Static Gel Strength Analyzer	
Maximum temperature	400°F/204°C
Maximum pressure	20,000 psi
Operating temperature	32°F (0°C) to 120°F (49°C)
Cooling water	20 to 80 psi
Compressed air	50 to 100 psi

Pressurized Consistometer & Static Gel Strength Analyzer	
Maximum temperature	400°F/204°C
Maximum pressure	15,000 psi
Slurry cup rotation speed	25 to 250 rpm
Gel strength range	100 to 1,000 lbf/ 100 ft_2
Compliance	10A/ISO 10426-1
Operating temperature	32°F (0°C) to 105°F (41°C)
Compressed air	Maximum 120 psi

Pressurized Curing Chamber	
Maximum temperature	700°F/371°C
Maximum pressure	25,000 psi
Number of cubes	16 cubes
Compliance	10A/ISO 10426-1
Operating temperature	32°F (0°C) to 120°F (49°C)
Cooling water	20 to 80 psi
Compressed air	100 to 125 psi

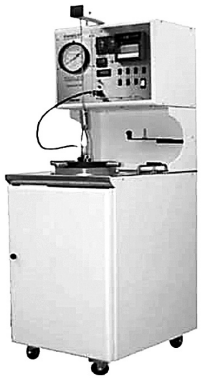
Compressive Load Frame	
Maximum press capacity	40,000 lbf
Maximum pressure	10,000 psi (based on a 2-in. cement cube with surface area of 4-$in._2$
Minimum press threshold	1,000 lbf
Minimum pressure	250 psi (based on a 2-in. cement cube with surface area of 4-$in._2$
Loading rates	250 to 40,000 lbf/min

Fluid loss measurement equipment

HPHT Filter Press	
Rated working pressure	1,800 psig
Maximum temperature	350°F/177°C
Sample volume	173 mL
Filtering area	3.5-in.²
Back pressure receiver volume	15 mL

Stirred Fluid Loss Cell	
Maximum temperature	450°F/232°C
Maximum pressure	2,000 psi
Cylinder volume	500 mL
Filtrate collection volume	100 mL
Paddle rpm	150 rpm
Compliance	10A/ISO 10426-1
Operating temperature	32°F (0°C) to 120°F (49°C)
Cooling water	40 psi
Nitrogen	1,000 to 2,000 psi

Consistency measurement equipment



HPHT Consistometer	
Maximum temperature	600°F/315°C
Maximum pressure	40,000 psi
Slurry cup rotation speed	150 rpm, (adjustable rpm optional)
Thickening time range	0 to 100 Bc
Compliance	10A/ISO 10426-1
Operating temperature	32°F (0°C) to 120°F (49°C)
Turn-around time	20 minutes (typical)
Cooling water	20 to 80 psi
Compressed air	75 to 125 psi

Recording Atmospheric Consistometer	
Maximum temperature	200°F/93°C
Maximum pressure	Atmospheric pressure
Slurry cup rotation speed	150 rpm
Thickening time range	0 to 100 Bc
Compliance	10A/ISO 10426-1
Operating temperature	50°F (10°C) to 120°F (49°C)
Slurry cup volume	28 cubic inches/ 470 mL
Cooling water	20 to 80 psi
Compressed air	75 to 150 psi

Gas flow measurement equipment

Maximum temperature	400°F/204.4°C
Maximum pressure	2,000 psi
Mesh specifications	**Material:** Stainless steel **Size:** 325/60 mesh **Diameter:** .635 cm
Test cell specifications	**Material:** 316 stainless steel **Diameter:** 2.125-in. (5.4 cm) **Height:** 10.25-in. (26 cm) **Volume:** 25.6-in.$_3$ (419 cm$_3$)
Nitrogen	1,000 to 2,000 psi

Electro mechanical measurement equipment

Capacity	150 kN/33,750 lbf
Full and return speeds	20-in./min
Max. force at full speed low gear	33750 lbf/150 kN
Max. force at full speed high gear	11250 lbf/50 kN
Minimum speed	in./min 0.0007
High gear	11250 lbf/50 kN
Clearance between columns	22-in./560 mm
Total crosshead travel	60-in./1525 mm
Frame stiffness	800-in./klbf

Specific gravity measurement equipment

Gas Displacement Density Analyzer	
Density measurement ranges	52 to 164 lb/ft3 6.9 to 21.9 ppg .83 to 2.63 specific gravity 360 to 1130 psi/1,000 ft
Compliance	ASTM and ISO methods
Operating temperature	59°F (15°C) to 96°F (36°C)
Gases	Research grade helium is recommended
Precision	± 0.01% of nominal full-scale cell chamber volume
Accuracy	0.03% of reading, plus 0.03% of sample capacity

Pressurized Fluid Density Scale	
Density measurement ranges	52 to 164 lb/ft^3 6.9 to 21.9 ppg .83 to 2.63 specific gravity 360 to 1130 psi/1,000 ft
Compliance	ISO 13503-1, API RP 39

Surface tension measurement equipment

Surface tension measurement equipment	Surface tension, Interfacial tension, critical micelle conc CMC and contact angle on solids, fibers and powders
Surface and interfacial rension	**Measurement range:** 1 to 2,000 mN/m **Resolution:** 0.001 mN/m (0.01 mN/for K100C
Weight measurement	**Maximum load:** 210 g (120 g for K100C **Resolution:** 10 µg (100 µg for K100C)
Sample stage position	**Movement range:** >110 mm **Resolution:** 0.1 µm (20 µm for K100C) **Speed:** 0.09 to 500 mm/min
Temperature control	**Range:** 14°F (-10°C) to 226°F (130°C) **Sensor resolution:** 32°F (0.01°C) 32.1°F (0.1°C) for K100C

3: Upstream chemicals laboratory

A. Background

The Dubai facility has the capability for laboratory testing and analysis to industry and/or national/international standards where applicable and Baker Hughes own internal standards to ensure that quality products and services are supplied to our customers. All chemical product selections testing and providing for MER and South East Asia tenders (scale inhibitor, paraffin PPDs, corrosion inhibitors, kill tests [biocides]) including corrosion coupon analysis, materials and chemical compatibility—supporting ALS Oman and Kuwait, deposits and water samples analysis, and chemical residual testing at customer request—supporting Saudi, Qatar, Kuwait, Oman, UAE.

B. Specialized tests

Corrosion inhibitor selection and performance testing

- Standard 'Kettle & Bubble Test' apparatus (5 to 6 place)
- Fluid heating + corrosive gas compositions CO_2 and H_2S
- 3 x high speed RCEs
- Rotating Circular Electrodes: Used to test for high shear performance
- Each fitted with auto corrosion data collection (ACM Gill-12)
- Fluid heating + corrosive gas compositions CO_2 and H_2S
- Essential emulsion and foaming properties with other system chemicals
- Thermal stability properties for determining application down hole or as per cumer requirements

Scale inhibitor selection and performance testing (same setup as UK Baker Petrolite Kirkby lab)

- Automated high temp high pressure, dynamic scale deposition loop
- Scale Inhibitor Static Precipitation tests (2,192°F/1,200°C)
- Scale Inhibitor Compatibility tests (2,192°F/1,200°C)

Wax inhibitor selection and performance testing

- Wax (%) Content Determination
- Cold Finger Wax Deposition tests
- Pour Point Depressant testing (manual)
- Crude oil viscosity profiling (-688°F/-400°C to 1,472°F/800°C)
- System-restart Yield Point and Wax Appearance Temperature (WAT) by viscosity

C. Standard tests

Asphaltene dispersant and inhibitor testing

- Oliensis Spot testing
- ADT asphaltene precipitation testing

Demulsification/water clarification

- Heavy Oil Demulsifier bottle test equipment
- Water clarifier performance testing

Chemical product compatibility testing

- Emulsion tendency
- Foaming tendency
- Material compatibility

Crude oil characterization

- % Wax content, pour point, wax appearance
- Salt in crude
- % Asphaltene content and stability
- Flash Point
- Viscosity profiling

Bacteria

- SRB, APB and GAB analysis
- Kill tests for biocide selection

Water based testing

- HACH (Fe, Ba, calcium, chlorine, alkalinity)
- Conductivity and particle size analysis

Analytical

- pH and 12 ions water analysis
- Corrosion, scale and biocide residuals analysis
- Corrosion coupon analysis
- Material compatibility testing at temp and pressure
- Solid deposit analysis

Chemical product supply

- Reagents and equipment supply and sourcing
- Test methods

Chemical samples verification

- Supplier sample QC testing

Sample and test equipment dispatch

- Bottle test kits
- Portable lab meters: Salt in crude, conductivity, pH