EXPRO FLUIDS

SmartLab® service for validity and analysis of wireline formation samples

SmartLab®

A common problem to wireline formation testing and sampling tools has been the degree of contamination in the samples, pressure losses in chambers, limited success in sample transfer, limited PVT background with the sampling personnel, etc. These problems have, more and more, become a challenge to overcome. As WFS has become an important tool in reservoir description and an important tool for planning well tests, extended well tests or early production, Expro Petrotech® has packaged its current technical competence into a new integrated service.

SmartLab®

In order to obtain the highest quality of wellsite data from these tools, Expro Petrotech® has designed and constructed a mobile offshore laboratory called "SmartLab". The aim of the SmartLab is to determine the quality of samples retrieved and also measure as many parameters as possible with regard to hydrocarbons, water and trace elements. As Expro Petrotech® is not operating the WFS-tools, we will offer our technical knowledge and experience on site to assist the tool operator in securing the best possible fluid sample.

The current trend of obtaining reservoir information by the use of WFS, and thereby reducing the need for full production testing, is likely to increase. With this in mind, we have worked towards being able to offer our clients a full package of services based upon the accurate analysis of the oil, water and gas retrieved via the use of WFS.

The services

The services offered by Expro Petrotech® will be tailored to meet the requirements of the oil companies in each instance. This means a range of services from basic validity checks, sample transfer and measurement of trace elements in gas, through to a complete and comprehensive package of services covering detailed gas, oil and water analysis together with PVT parameters such as, GOR, GWR, Bo, density and viscosity under pressure.

BACKGROUND

Requirements

Accurate description of hydrocarbon fluids is critical to field development planning, including facilities design and recovery efficiencies.

Problems

Often unrepresentative samples are collected downhole due to phase separation. This phase separation is due to drawdown during sampling and leakage during recovery and transportation of the sample. When a two-phase sample leaks, the resulting loss of hydrocarbons (usually gas) causes the fluid to appear denser than the actual reservoir fluid. These fluids, when characterised would underestimate the gas-oil ratio (GOR) or show higher condensate gas ratio (CGR) than what the field may produce. This error can result in under sized gas facilities and/or constrained oil rates from wells.

Two-phase flow into the sample chamber typically results in GOR greater than or equal to the actual reservoir fluid GOR. If the fluid in the chamber is in a two-phase non-equilibrium state when the sample chamber is closed downhole, the opening pressure could be slightly depressed. As gas dissolves into the oil, pressure drops in the chamber. Also, any leakage after the fluid has cooled and split into two phases, results in lower GOR and low tool opening pressures. In either case, a low opening pressure is a warning flag for a nonrepresentative sample.

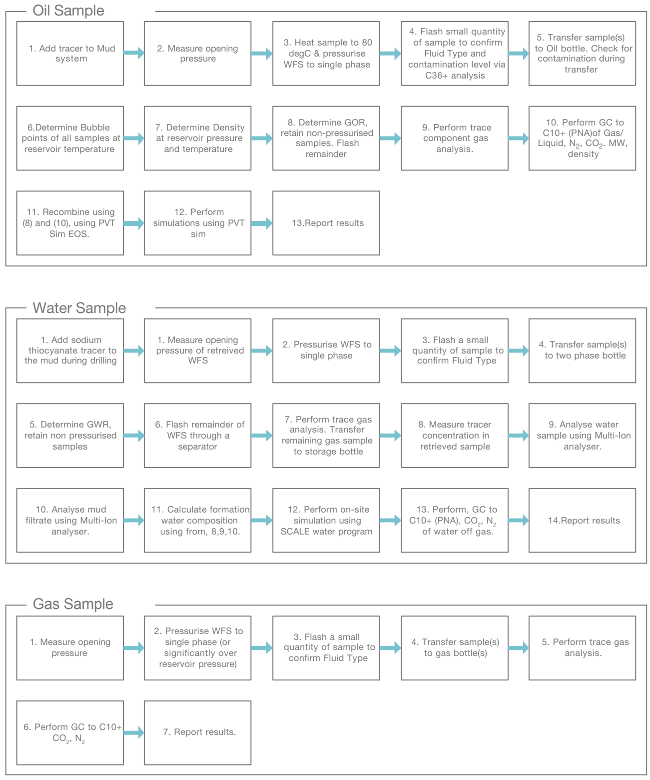
Increasingly, in new fields, the only source of reservoir composition, pressures and gradient data, is from the use of wireline formation tools. If the collected samples using this method are not representative, and no further recombination samples or data is available from a surface test, then further reservoir planning becomes increasingly difficult and erroneous.

TOOL OPERATION

Fluid sampling with Formation Tester Tools

The wireline formation tester tools are usually run after a logging and a cleaning trip. The tools are designed for multiple pressure measurements to establish fluid gradients and collect single or multiple samples for fluid characterisation. Some of the tools that belong to this class are RFT (Repeat Formation Tester), MDT (Modular Dynamics Tester), RCI (Reservoir Characterisation Instrument) and RDT (Reservoir Description Tool).

Figure 1:
WFS VALIDITY AND DETAILED ANALYSIS



There are a number of variations within different types of tools and modules. During fluid sampling, the reservoir fluid is usually preceded with mud and/or mud filtrate. Modern tools look for resistivity contrast or optical transmissivity and reflectivity to detect unwanted fluids.

PROBLEMS AND SOLUTIONS

Problems

Despite all the advances, there are a number of reasons why representative samples or sufficient sample volumes may not be obtained with these tools.

Some of these are:

- packer leakage due to high differential pressure.
- inadequate probe contact with the formation.
- sand lodging causes leakage.
- mud filtrate collected in the sample chamber.
- sand lodging in the probe or excessive plugging causes excessive drawdown flash gas collected in sample chamber.
- high drawdown in low permeability or highly laminated formation.

After the samples are collected, the tool is brought back to the surface. The sample chambers are disconnected from the tool and are either sent directly onshore for testing or are first transferred on site to a laboratory test vessel before transportation.

Expro Petrotech® Analysis Services

Consistency checks

Often multiple samples are not available from a single reservoir rock to check consistency and provide back up. In such cases, consistency between the numerous sets of data from each individual sample must be checked.

This should include:

- estimated in-situ fluid density
- sample composition
- opening pressure
- saturation pressure
- proximity of the gas-oil contact
- viscosity measurements

The viscosity technology for live fluid is based on a reliable electromagnetic concept to measure absolute viscosity. The system measures viscosity, temperature and temperature compensated viscosity. Viscosity at ambient pressure and specified temperature can also be measured with Cannon-Fenske viscosity tubes. All these pieces of information should fit together to form a consistent fluid description.

Solution

The objective of Expro Petrotech's WFS service is to provide sample validity information accurately and rapidly, thereby enabling an immediate on-site decision whether to re-run the tool to obtain further samples.

TRACER TECHNIQUES

Tracers

For samples retrieved via the use of WFS, the use of tracers introduced into the oil or water based mud must also be considered. The degree of contamination from the drilling fluid has to be determined in order to enable corrections to be made and accurate fluid compositions determined. For example in a water based mud system, sodium thiocyanate can be used as a tracer. The tracer is added to the mud approximately 100 meters above the zone of interest. The concentration of tracer in the mud is kept stable at about 400 mg/l when drilling through the target zone. By analysing the mud filtrate and the retrieved sample, and by determining the concentration of thiocyanate in the retrieved sample, the composition of the formation water can be calculated. For oil based mud, contamination is found by C_{36+} analysis of mud filtrate and WFS, and calculation based on skimming or ratio of known components.

ON-SITE PROCEDURE

Individual samples

After retrieval of the WFS, the physical properties of the fluid are determined to give an indication of the quality of the retrieved sample. Tracer concentrations are determined, the degree of contamination calculated and a recommendation made as to whether the sample is acceptable or a new sample should be taken.

Multiple samples

When multiple samples have been retrieved from different intervals, Expro Petrotech will also look at the overall picture of the samples. If one set is not consistent with the others, although individually it looks OK, then this will be flagged to the operator and a resample can be considered to correct or verify the sample data.

Reservoir pressures

The WFS tools will provide reservoir pressures from the formation. These are interpreted to provide information on fluid contacts, reservoir discontinuities, etc.

Densities are also determined at each fluid sample point. The fluid density provides a very accurate fluid gradient at this specific point of the reservoir. These density measurements combined with the obtained reservoir pressures will provide a much more accurate basis for drawing the fluid gradients through the reservoir.

The definition of fluid gradients and reservoir pressure discontinuities can be found with a very high degree of accuracy. This can also be an important tool to establish a basis for describing compositional gradients in the reservoir at an early stage.

ADVANTAGES FOR THE COMPANIES

The value to users (oil companies) lies in the areas of:

- Rapid confirmation of retrieved sample quality.
- Rapid compositional analyses of sampled gas, water and oil.
- Decreased decision time for any reruns or rigdown.
- Decreased rig time.
- Elimination of DST for water and oil tests.
- Economic savings due to reduced need for onshore analysis.
- Reduced risk of sample deterioration due to time and
- transportation.

Expro Petrotech® Analysis Services

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SUMMARY

Many of the component parts of the analytical services are already on the market. However, the ability to provide a comprehensive analysis of all produced fluids to a standard, comparable to those available onshore, has significant benefits for the oil companies.

The service should not be seen as a "quick check" type validity and analysis, but as a comprehensive PVT and analysis package designed to eliminate or reduce the need for repeat onshore analysis.

WFS can offer significant savings for the oil companies if the information provided from the tool is representative of the formation fluid. Currently this cannot usually be confirmed until days or weeks after the samples are obtained.

For the oil companies the Smart Lab® in combination with WFS offers rapid validity control and compositional data of all sampled fluids. This will enable the oil companies to quickly decide whether any sample retrieved was satisfactory or whether further samples should be obtained before proceeding to the next zone or rigging down any equipment. Information provided by WFS is also used to confirm zones of interest and the intervals for eventual production tests.

References

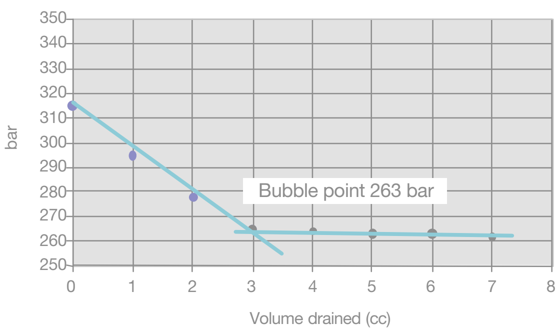
Consistency check and reconciliation of PVT data from:

- Samples Obtained with Formation Testers Using EOS Models. SPE 36743
- Jitendra Kikani, John Ratulowski, Shell E&P Technology Company

Retrieved WFS Sample Data

Depth (mMDRKB)	Reservoir Pressure (psi)	Reservoir Temperature (degC)	BubblePoint @ Res Temp (psi)	Density @ Res P&T (Kg/m³)	BoFactor (m3/Sm³)
1996.5	2915	82	2770	710.0	1.341
2048.5	2988	84	2872	711.2	1.341
2305.0	3350	92	3210	696.0	1.387
2679.5	3931	104	3900	628.3	1.732

Bubble Point Plot of Retrieved Sample at Reservoir



Recombination of Wireline Fluid Sample

Sample No WFS-chamber # 144

Components	Stock tank gas (mole%)	Stock tank liq.(mole%)	Res. Fluid mole%	MW g/mol* Dsty kg/m³**
N_2	0.706	0.000	0.436	
CO_2	5.158	0.000	3.183	
C1	75.258	0.046	46.458	
C2	7.807	0.130	4.868	
C3	5.353	0.513	3.500	
iC4	0.782	0.211	0.564	
nC4	2.174	1.008	1.728	
iC5	0.560	0.753	0.634	
nC5	0.702	1.356	0.953	
C6 total	0.531	6.702	2.894	86.1
P	0.524	6.410	2.778	663.8
N	0.007	0.292	0.116	
C7 total	0.614	7.952	3.424	89.9
P	0.162	2.774	1.162	749.2
N	0.334	3.940	1.715	
A	0.118	1.239	0.547	
C8 total	0.279	10.911	4.350	103.0
P	0.065	2.813	1.117	774.4
N	0.141	5.100	2.040	
A	0.073	2.999	1.193	
C9 total	0.047	8.017	3.098	118.1
P	0.022	3.743	1.447	781.8
N	0.006	0.897	0.347	
A	0.019	3.376	1.305	
C10+	0.028	62.399	23.911	340.6
Sum	100.000	100.000	100.000	879.5
Total				
MW g/mole	23.3	248.8	109.6	*recomb. MW
Density kg/m3	0.984	855.3	714.2	**stabil. dsty
Gas gravity	0.803	-	-	

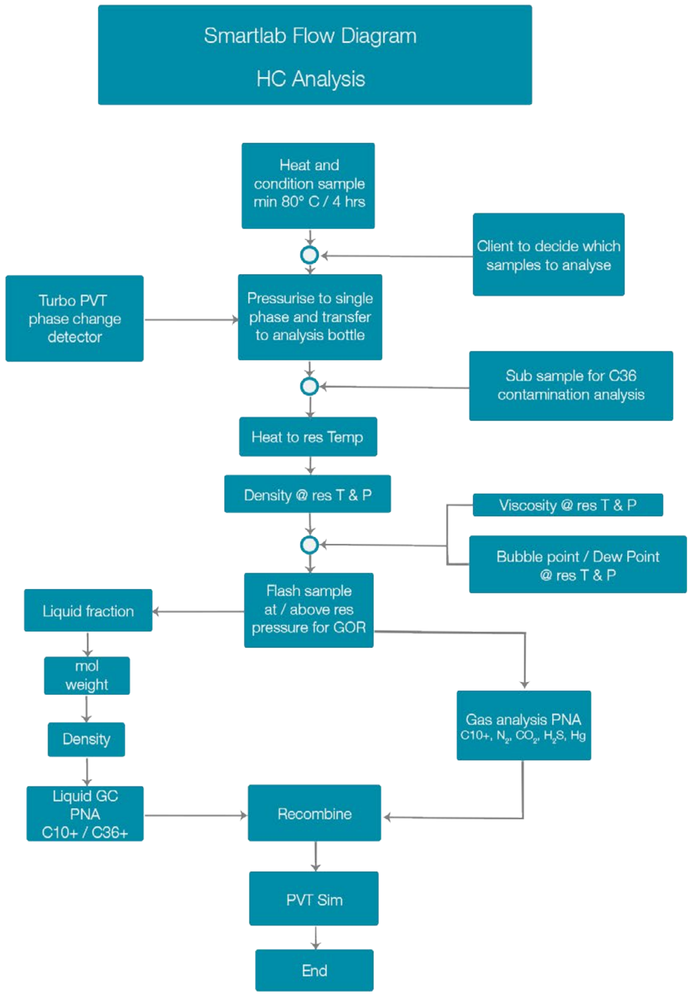
Measurements		
Single flash GOR to STC	131	Sm³/Sm³
Formation volume factor (Bo) ***	1.378	m³/Sm³
Sample density at res. Conditions	708.1	kg/Sm³
Sample bubble point at res. temp.	263	bara
Sample bubble point at amb. temp.	213	bara
*** calculated from gas gravity, GOR and liquid density at STC and res. conditions		
Reservoir conditions	268.47	bara
	97	degC
Simulations based on reservoir fluid composition (PVTsim)		
GOR	129.4	Sm³/Sm³
Formation volume factor (Bo)	1.388	m³/Sm³
Density at res. Conditions	712	kg/m³
Bubble point at res. temp.	260	bara

SmartLab®

Expro Petrotech's mobile on-site laboratory. Easy to customise for analytical services during drilling and logging operations and production well testing.

Detailed hydrocarbon analysis:

- Density at reservoir pressure and temperature
- GOR (gas-oil-ration) measurement
- Detailed gas analysis
  - » Chromatography up to C_{10}+ (with PNA) and N_2, CO_2 for gas
- Detailed oil analysis
  - » Chromatography up to C_{10}+ (with PNA)
  - » C_{36}+ fingerprint for OBM contamination
  - » Molecular Weight
  - » Density
- Recombined Reservoir PVT composition
- Saturation point (bubble point) at reservoir temperature
- Calculation of Bo (oil formation factor)
- Simulations on reservoir fluid behaviour – PVT-sim
- Laboratory reportv



Detailed water analysis

- GWR (gas-water-ratio) measurement
- Chromatography up to C_{10}+ (with PNA) and N_2, CO_2 for gas flashed off the water
- Expro Petrotech's Multi-ion analyser, based on the ion chromatography principle covers the following ions:
  - » Lithium, Li^+
  - » Sodium, Na^+
  - » Potassium, K^+
  - » Calcium, Ca^{2+}
  - » Magnesium, Mg^{2+}
  - » Strontium, Sr^{2+}
  - » Barium, Ba^{2+}
  - » Chloride, Cl^-
  - » Bromide, Br^-
  - » Sulphate, SO_4^{2-}
  - » Acetate, CH_3COO-
  - » Formiate, COO^-
- Iron ($Fe^{2+/3+}$) by Chemets kit, Sulphide ion (S^{2-}) by Kittagawa
- pH, conductivity, density, alkalinity
- Contamination of mud filtrate (WBM) and correction of formation water
- Optional: pH at reservoir conditions
- Preservation for further on-shore analysis
- Laboratory water report

“When we search for answers, we have to know what we’re looking for”