Fluid Sampling and Analysis

Overview

Halliburton delivers advanced capabilities for performing reservoir fluids sampling services, routine laboratory services, and unconventional pressure/volume/temperature (PVT) analyses. Physical properties and chemical composition of reservoir fluids play a crucial role in all aspects of petroleum and reservoir engineering. Accurate sampling and analysis techniques often provide critical input to reservoir simulation models and help to optimize processing facility designs while boosting the profitability of an oil or gas field.

T-FASTM total fluids assessment services offers full field-based services for reservoir fluid capture, validation, and analysis. This service consists of three primary components which can be provided individually, collectively, or in selective groups; the choice being dictated by the options that are best suited for the opportunity at hand:

• wireline-conveyed bottomhole sampling services in a cased hole environment, with single phase sampling capability to 15,000 psi;
• SIMBA® tubing conveyed bottomhole sampling services in a cased hole environment, with single phase sampling capability to 15,000 psi;
• a field transfer service including fluid sample validation and, if requested, a basic PVT analysis;
• a fully functional laboratory primarily directed at delivering complete PVT analysis on hydrocarbon or water samples, but readily expandable to include additional analysis. This includes, but is not limited to, routine/special core analysis, flow assurance, core flow studies, etc.

A state-of-the-art reservoir fluids laboratory is also available and can perform anything from routine laboratory services to unconventional PVT analyses.

The reservoir fluids sampling and analysis solutions that Halliburton offers add value to:

• deepwater well tests where data is at a premium.
• high-pressure/high-temperature jobs.
• multiple reservoir production scenarios.
• gas-condensate testing.
• standard drillstem tests and clean-ups.
• remote wells and wells with high intervention costs.

The Halliburton integrated approach toward a complete reservoir fluids sampling and analysis solution will be a valuable tool in helping to increase your knowledge of the reservoir and maximize the net present value of the assets. Improved reservoir management can lead not only to lower production costs but also to maximizing the recoverable reserves while reducing well intervention expenses.
Reservoir Fluid Sampling

Representative reservoir fluid samples are essential prerequisites for providing quality data. Therefore, accurate sampling is of the utmost importance. Special sampling equipment (including pressure compensated and mercury-free single phase samplers) and procedures have been developed to secure the highest quality sampling possible.

Surface Sampling

Sampling at surface conditions allows for exact control of sample taking and does not put any restrictions on sample volumes. If the same gas/oil ratio (GOR) value is obtained during several or all flow rates, one has a strong indicator for representative samples. Separator sampling is the best method for a reservoir fluid close to or at the saturation pressure (either bubblepoint or dewpoint). A special case exists where there is a gas/oil contact in the reservoir. Perforations across the contact will give samples at the surface that can be recombined based on the pressure in the contact and not in agreement with the measured GOR.

When sampling downstream of the choke manifold, the well fluid has been subjected to severe conditional changes. The Joule Thompson effect (cooling due to pressure changes) at the choke manifold can result in a large volume of liquid drop out. This can be followed by considerable heating in a heat exchanger. These excessive changes in conditions are not conducive to obtaining good equilibrium and representative fluid samples. In the test separator, there is also a temperature and pressure change that will influence the equilibrium composition of the gas and liquid phases.

Heat exchangers can be used to prevent hydrate formation when flowing gas condensates to surface. If inhibitors need to be used, glycol is often preferred to methanol as it has less effect on the measurement of fluid properties.

The validity of recombined separator products is dependant upon separator design and efficiency, flow-rate measurement, and sampling technique. Low liquid flow rates (less than 100 B/D) are difficult to measure and often result in a reduced GOR accuracy. Tank measurements may be more accurate than meter readings in the case of low flow rates.
Bottomhole Sampling

The most important success factor for obtaining representative reservoir fluid samples is to maintain the fluid in single phase during sampling and transfer. This can be accomplished by accurately controlling the sample drawdown pressure and keeping it above the saturation pressure and as close to the reservoir conditions as possible, eliminating the need for a lengthy and sometimes flawed transfer process on surface.

For some fluids, the saturation pressure increases with decreasing temperature. A large drawdown during sampling and subsequent temperature drop could increase the saturation pressure to above the reservoir pressure, resulting in liquid drop-out (two-phase flow), and therefore, non-representative fluid samples would be collected.

Clean up of the sampled fluid is essential to remove soluble contaminants such as oil-based mud (OBM) filtrate and hydrate inhibitors. When the reservoir is saturated, or if the pressure is close to the saturation pressure, obtaining representative single-phase bottomhole samples is difficult if not impossible. Any production with its associated drawdown will cause the producing reservoir pressure to drop below the fluid’s saturation pressure yielding two-phase flow. During short flow periods (such as bottomhole sampling), some liquid may remain in the reservoir, resulting in unrepresentative fluid samples. A similar problem can occur when transferring the bottomhole samples at surface for transportation to a laboratory for analysis. Small amounts of non-solubilized gas or liquid can potentially adhere to the sample chamber walls (wall wetting) and will significantly affect the volumetric properties (and measured saturation pressure). Infrared, capacitive, and density sensors can be installed in the transfer line to verify if the sample is in single phase. These sensors may also give an indication of the liquid fraction in a gas sample.

The Halliburton bottomhole single-phase samplers can be wireline or slickline-conveyed or run inside the SIMBA® sampler carrier, a dedicated drillpipe conveyed sampler carrier that holds two single-phase samplers. These samplers offer a cost-effective solution for obtaining samples when precipitation will occur during flow to surface. Due to better well cleanup in a cased hole situation, mud contamination is typically less of a problem than with (openhole) wireline formation tester samples.

Bottomhole sampling often requires an extra flow period. The flow rate should be low but sufficient to lift all production to surface. A variety of sampler triggers is available to meet any type of situation, from conventional timer-based triggers to new pressure-activated triggers and state-of-the-art acoustic triggers.

If required, non-corrosive single-phase samplers are available to operate in harsh environments with high H₂S or other corrosive reservoir components.
Reservoir Fluid Analysis

Routine Laboratory Services
and Unconventional PVT Analyses

Westport Technology Center International, a Halliburton wholly owned, technical services company, provides the petroleum industry with high-quality exploration and production services to help accurately assess complex drilling, exploration, and production questions. A state-of-the-art laboratory meets today’s demands for accurate and high-quality reservoir fluids analysis. Examples of black oil and condensate studies and analyses are:

- High pressure/temperature (visual cell to 15,000 psia and 400°F, blind cell to 30,000 psia and 600°F)
- Compositional analysis up to C70
- Constant composition expansion with relative volumes (ranges up to 30,000 psia and 500°F)
- Viscosity measurements using capillary viscometers to 20,000 psia and temperature range from 30°F to 600°F (viscosity up to 1 million cP)
- Differential liberation (black oil) or constant volume depletion (condensate or volatile oil)
- Swelling, solubility, and mixing studies
- Compressibility measurements on hydrocarbons and hydraulic fluid systems from 30°F to 600°F and up to 30,000 psia
- Determining the effect of mud additives on fluids behavior for equation-of-state modeling
- Testing additives for viscosity improvement
- Handling heavy oil or sour gas systems
- Performing benchmark compositional analyses
- Performing solid deposition studies
- Drilling mud additives under reservoir conditions
- Slim tube studies to examine fluid behavior for miscible flooding and gas cycling projects

Unconventional studies address problems that require a unique understanding of the tough challenges facing the modern petroleum industry. If needed, customized tests can be designed to meet specific client needs.

Verification of Fluid Samples

Non-representative samples are often collected downhole due to phase separation. This phase separation can be due to drawdown during sampling or 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 more dense than the actual reservoir fluid. These fluids when characterized 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 undersized gas facilities and/or constrained oil rates from wells.

Two-phase flow into the sample chamber typically results in GORs greater than 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 GORs and low tool opening pressures. In either case, a low opening pressure is a warning flag for a non-representative sample.
A common challenge with wireline formation sampling tools is the degree of mud filtrate contamination in the samples, pressure losses in chambers, and the limited success in sample transfer. If the samples that have been collected using this method are not representative, and no further recombination samples or data is available from a surface well test, then further reservoir planning becomes increasingly difficult and potentially erroneous. Once the sampling process has been completed, the sample chambers are disconnected from the sampling tool and are either sent directly onshore for testing or are first transferred on-site to a shipping/storage vessel before transportation.

**Non-Hydrocarbons and Trace Elements**

The presence of small quantities of certain components in oil or gas can constitute a health hazard, create pollution problems, cause production problems, or damage expensive production facilities. Specialist engineers and mobile equipment units can be supplied to measure with the greatest accuracy the concentration of such substances and their potential negative effects (water, hydrogen sulfide, mercaptans, other sulfur compounds, carbon dioxide, nitrogen, mercury, heavy metals, and radioactive elements). For process design consideration (for example, re-injection or disposal of production water), the detection and quantification of non-hydrocarbons and trace components is of utmost importance.

**Research and Development Projects**

Halliburton is at the forefront of the technology with groundbreaking research and development (R&D) projects that are reshaping the future. The project results will eventually contribute to setting the standard of the reservoir fluids sampling and analysis business, giving clients direct access to the latest technology and ensuring premier service quality.