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A Hart Energy Publication

February 2009



SHALE GAS

Development

*Reservoir
Characterization*

*Drill Bit
Technology*

*Advanced
Well Testing*

*Deepwater
Intervention*

**SPECIAL REPORT:
CANADA**

Innovative test equipment expedites data availability

Well testing provides answers that are not available any other way, supporting critical decisions that can affect reservoirs for their active life. Getting test data more swiftly allows operators to make faster production decisions.

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Reservoir characterization is about proving a reservoir's potential, confirming its performance, and improving its productivity.

The easiest way to solve production problems is to anticipate them and take steps to prevent their occurrence. Periodic production testing can help resolve changes in reservoir behavior over time, detect inter-well communication, or help optimize artificial lift programs. Testing provides a reliable and accurate way to re-calibrate the dynamic earth model which, when enhanced by test data, becomes a proxy for the reservoir.

Over the years, tools that allow early well testing and analysis to take place have evolved from the most basic drillstem testers — which were little more than a downhole packer element and valve — to a variety of dynamic measurements.

Today, testing provides a way to safely and efficiently perform a temporary well completion and flow a well under realistic conditions to obtain critical dynamic measurements. Augmenting a well test using multiphase flow measurement, multiphase sampling, and pressure/volume/temperature (PVT) analysis allows a much clearer production picture to develop.

Multiphase comes of age

A family of new testing measurements has enhanced operators' ability to make critical decisions at the well site. These decisions go beyond the traditional

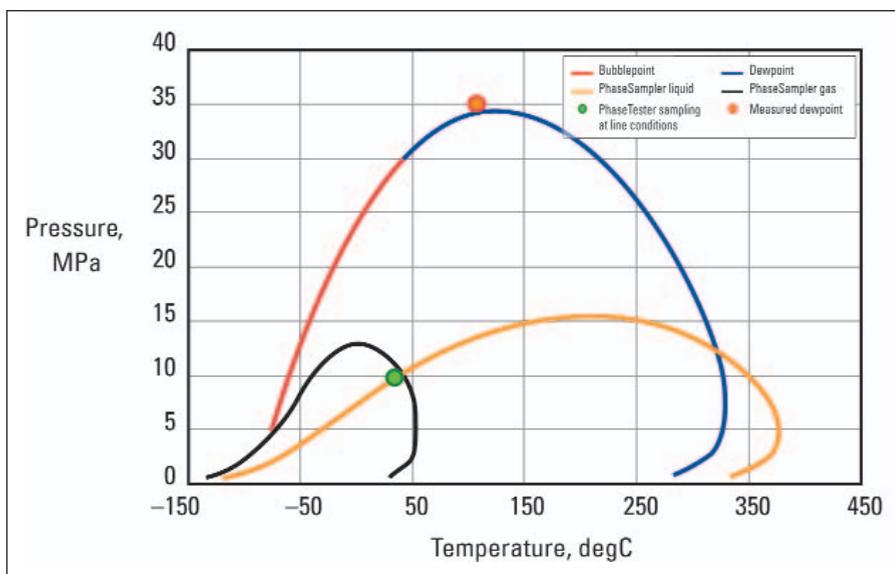


Figure 1. Compositional model of multiphase samples with the mathematically recombined single-phase fluid provides vital clues for reservoir management. (Images courtesy of Schlumberger)

go/no-go calls that emanated from early well tests. With sophisticated fluid analysis, answers never before available can be obtained routinely on site.

In the Urengoiskoe field, located 50 miles (80 km) from the Arctic Circle in northwestern Siberia, Russian operator Rospan International combined the PhaseTester multiphase flowmeter, PhaseSampler multiphase sampling, and PVT Express onsite laboratory services to characterize and measure multiphase fluids passing through the wellhead at line conditions.

Most of the production from this field comes from the Achimovsk formation more than 9,800 ft (3,000 m) below the surface. Obtaining representative fluid samples and analyzing them in a laboratory thousands of miles away was impractical and prohibitively expensive. The multiphase flowmeter, multiphase sampling, and laboratory services combined to enable comprehensive production

testing at the well site in near-real time.

The multiphase flowmeter takes measurements in real time under flowing well conditions. It does not require prior fluid separation and is unaffected by changes in fluid density or flow regime. Previously, sampling was conducted downstream at a separator, where it was challenging to acquire samples that were representative of line conditions. Accurate sampling was particularly difficult in gassy environments where small droplets of condensates can have very low settling velocities. Decisions made from separator data could be in error, resulting in unacceptable risk.

The multiphase flowmeter was used to test Urengoiskoe well production at various choke settings. The compatible multiphase sampling service obtained representative samples under the same conditions that the multiphase flowmeter flow rate and density measurements were made. This increased the certainty of the fluid analysis solution derived by combin-

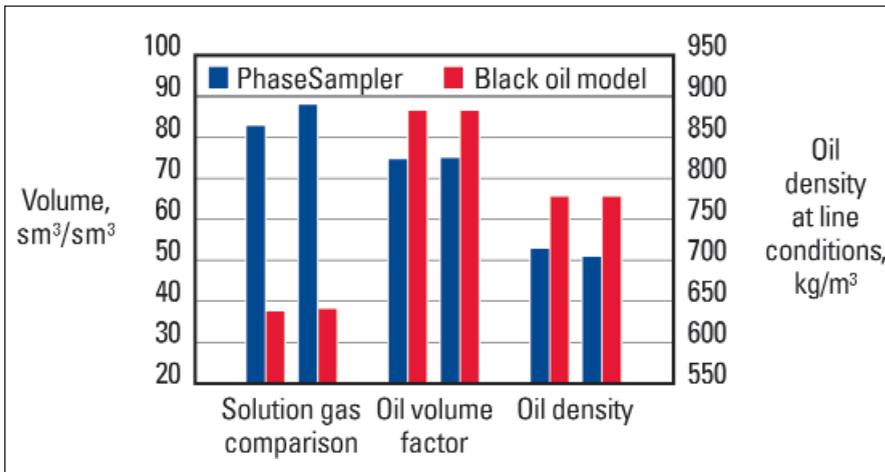


Figure 2. Comparison of PhaseSampler direct measurements with black oil model prediction illustrates the risk of using uncalibrated models to make critical decisions.

ing the measurements. The portable laboratory contributed fast onsite analysis of gas and gas condensate compositions without phase changes for high-confidence sample validation and fluid properties characterization.

Application of this technology allowed three-phase sampling at line conditions, thorough-fluid analysis, and improved multiphase flow rate measurements. In addition, by combining multiphase sampling and measurement technologies with comprehensive onsite fluid analysis, the operator was provided with recombined single-phase samples of the producing well stream and a compositional PVT model using equation-of-state modeling.

Direct measurements

Under very different conditions on a North Africa field in the Berkine Basin in Algeria, an operator needed to determine specific reservoir fluid properties for production from four wells. Fluid parameters varied significantly from well to well. The gravity of produced oils varied from 40°API to 53°API, gas/oil ratio (GOR) ranged from 1,000 cf/bbl to 18,000 cf/bbl, and basic sediment and water ranged from 0% to 33%. In addition, water salinity varied from almost fresh to oversaturated brine. These conditions made apples-to-apples comparisons impossible, but valid comparisons were essential for proper understanding of the reservoir behavior.

The traditional procedure would be to obtain PVT-quality samples and send them to a laboratory for analysis. This solution, however, is both time-consuming and costly. The multiphase fluid sampling and analysis service takes its measurements directly from the flowline under realistic, measurable, and controlled conditions. It allows representative samples to be obtained and basic fluid properties to be analyzed in near-real time at the well site.

The operator was satisfied to use the multiphase sampling data but wanted to compare its accuracy and reliability with laboratory measurements, so a three-step procedure was ordered. PhaseSampler multiphase sampling measurements would be compared with predictions from the black oil model and with GOR and gas composition measurements obtained from the laboratory. The multiphase sampling repeatability would be tested under identical flowing conditions by performing multiple flashes, instantaneous releases of sample pressure to atmospheric pressure while observing fluid phase behavior.

Multiphase sampling data were proven valid through comparison with laboratory PVT measurements, and repeatability was demonstrated in multiple flashes. The match was good between laboratory and multiphase sampling measurements of solution gas even though the ambient temperature in the lab was a comfortable 77°F

(25°C) compared to wellsite temperatures ranging from 104°F (40°C) to 122°F (50°C). Critical free and dissolved gas composition comparisons were excellent.

While comparison of the multiphase sampling measurements with the black oil model predictions was good for gas volume factor and gas density, the model predictions fell off when compared with both the lab and the field measurements. This confirmed the suspicion that using a black oil model to predict these parameters could result in significant underestimation of oil shrinkage and overestimation of oil density. These discrepancies, if implemented, could have led to a serious decision error.

On a reservoir the size of the one tested, decision errors can cost the operator significantly. The ability to obtain valid produced fluid measurements in the field at flowline conditions allows operators to make reservoir-critical decisions in near-real time with confidence.

Why test?

Perhaps one of the most immediately realized benefits of modern well testing is the ability to properly size surface production facilities. Many times, surface facilities have been over- or under-built because of inaccurate reservoir characterization information. In some cases, costly subsea pipelines have been laid that turned out to be inadequate to transport the volume of fluid produced or were only partially filled.

Testing provides vital information required to optimize reservoir injection programs through better understanding of reservoir drainage patterns. Particularly important in deepwater production is a thorough understanding of the conditions that contribute to flow assurance. Fluid composition analysis and phase behavior analysis can accurately predict the potential for asphaltene, paraffin, or hydrate formation or the *in situ* presence of corrosives such as hydrogen sulfide and carbon dioxide.

Investing to protect and sustain the remaining hydrocarbon in a reservoir is essential to prudent production management. **HP**