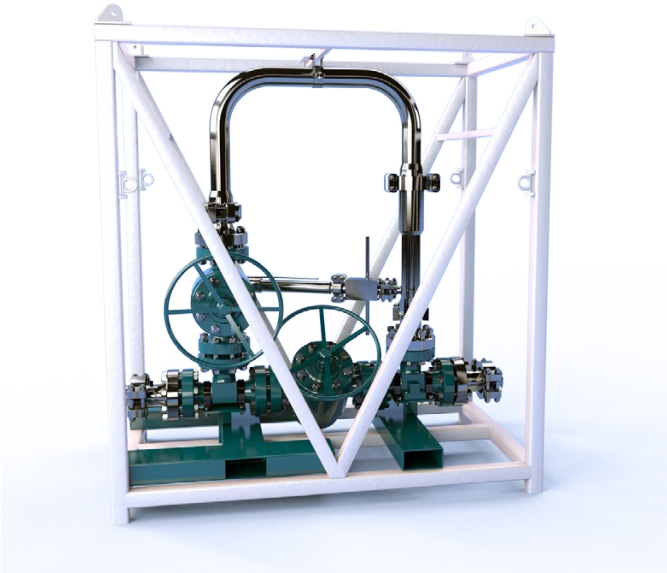
Petrotech® IsoSplit® Wellhead sampling

Testing of gas condensate reservoirs requires careful coordination of all parameters in the analytical process. Obtaining a representative formation fluid sample and accurate volumetric flow measurements for compositional and PVT analysis are crucial in testing gas condensate reservoirs.

The sampling procedure, the design of the testing equipment, the laboratory analysis and the design and analysis of the test itself are all critical components.



Large volumes of gas are associated with only small volumes of liquid and the phase behaviour will be highly sensitive to the quantity and composition of the liquid phase. When sampling close to the dew point the system can become two-phase before the reservoir fluid reaches the surface or even the well bore. Oil based mud (OBM) filtrates can also mix with the produced condensate and create a highly contaminated fluid.

Phase behaviour predictions based on equations-of-state (EOS) are often unreliable due to a poor theoretical basis of the EOS model, incomplete reservoir fluid analysis and incomplete heavy-end characterization. Without proper PVT data the EOS is highly questionable. Because reservoir simulation models are based on EOS, quality PVT data is critical. Accurate PVT data is also needed for flow assurance in wells, transport lines and for process design.

The single most important success factor for obtaining representative reservoir fluid from bottom hole samples is to maintain the fluid in single phase during sampling and transfer. When the reservoir is saturated or if the pressure is close to the dew point pressure, obtaining representative single phase bottom hole samples is difficult, if not impossible. Experience has shown that representative fluid samples and volumetric flow rates can be obtained at surface in spite of producing with a bottom hole pressure significantly below the dew point pressure.

Test Separator Sampling.

Although representative samples can be obtained at surface, there are limitations to the accuracy of the test separator measurements and sample quality to consider.

- Separator efficiency and carry over
- Separator equilibrium, contamination and wax
- Accuracy of flow data
- Meter calibrations, liquid flow volumes, BS&W

Standard PVT sampling, from a production test separator, can produce an incorrect recombined well stream composition due to decrease in the separator performance with the higher gas rate and hydraulic loading experienced with gas/condensate systems. This carry over of liquid into the gas outlet results in inaccuracies in the liquid flow rate, the gas gravity and the orifice plate dimension, due to liquid passing through and the FpV factor. In addition the separator may be in poor equilibrium due to the slow accumulation of low liquid volumes with fluctuating separator temperatures. There is also the possibility that separator fluid is contaminated by the accumulation of oil based mud.

To further complicate matters, the accuracy of the metered liquid rates can also be suspect when the flow volumes fall below the lower limit of the meters and need to be measured at the stock tank, - a process whereby the fluid undergoes a further pressure and temperature change. In addition the BS&W measurements normally used to determine water cut (and condensate cut) are often highly inaccurate.

Isokinetic Test Separator sampling from the gas outlet of the test separator will enable the separator efficiency to be determined thus improveing the test separator data. Separator efficiencies as low as 20% has been measured with this technique. However, correction for efficiency alone will not improve the sample quality and cannot significantly improve the accuracy of the data if there is a large uncertainty in the metered flow rates of the fluid collected in the separator.

Isokinetic Wellhead Sampling.

Gas/Condensate wells are often good candidates for isokinetic wellhead sampling upstream of the choke manifold. Sample quality and CGR data is often significantly more accurate than those obtained from the test separator. The two main items that make up the isokinetic wellhead sampling system are a mixing/sampling manifold and a Mini-Lab separation unit. The manifold incorporates a mixing device to mix the flow and aid representative sampling and a traversable probe. The traversable probe enables sampling at a number of points across the flow stream and, if necessary can correct for flow distribution.

The Mini-lab uses small scale separation vessels fully immersed in heated/cooled baths with accurate pressure and temperature control. Conditions can be set to mimic the test separator or the expected process. Up to 3 stages of sequential separations are possible. The advantages of the system are that the retention time in the separator is long giving a high efficiency at all flow rates; typically 10-16 times longer than a standard test separator. The process is also a “batch process”, in that each sampled fluid will be acquired from a sampling period of typically 15-60 minutes, giving a “virgin” sample each time. Gas volumes are measured on highly accurate turbine meters and all liquids are drained from the separator in a controlled “flash” after each sample run. By using glycol in the first stage, very accurate water cut measurements are also obtained.

Conventional PVT samples (20 litre gas + 600 cc condensate) obtained from the mini-lab are in excellent thermodynamic equilibrium. Also reported are:

- CGR (Condensate/Gas Ratio)
- WGR (Water/Gas Ratio)
- Bo (Shrinkage Factor)

The standard procedure during sampling is to check that the well flow is stable by measuring the condensate to gas ratio (CGR) at production separator conditions, in replicate tests before commencing the compositional sampling procedures.

These CGR measurements also provide a check on the test separator performance in terms of its separation efficiency and/or metering accuracy. It is well documented, particularly for gas/condensate systems, that test separator efficiency decreases with increasing gas production rate because of the increased hydraulic loading. Test separator efficiencies as low as 20% have been experienced.

CGR measurements carried out at the same pressure and temperature during multi-rate flow tests, easily identify any flow rate dependency of the well.

The mini separation system is housed in an air transportable container and comprises all the equipment needed for controlled, quantitative separation of an isokinetically sampled fluid stream from the sampling manifold, as described.

EQUIPMENT

Sampling manifolds

Five manifolds are available rated at a working pressure of up to 1034 bar (15.000 psi).

The manifolds and mini-labs are air transportable. All are suitable for sour gas service.

The restriction of the mixing device is equivalent to a 2.3” choke. Well flows up to 2.0 x 10^6 Sm^3/d (70 MMscf/d) have been sampled satisfactorily.

Sampling units - Mini-labs

Four mini-labs are available. Their shape reduces the space requirements to half a pallet when air freighted. The mini-labs contain up to three separation stages which can be used in series. The pressure rating of these pressure vessels is either 172 bar (2500 psi) or 125 bar (1800 psi).

The mini-labs also contain the ancillary equipment for quantitative sampling of liquids and gases separated in the stages and for sampling of gas and liquid phases from production separators.

All the separation stages are situated in water baths. Some are fitted with electrical heaters for control of separator temperatures. Electrical power is also required for approved internal lighting.

Temperatures and pressures are measured electronically using approved sensing and display devices. Cooling, when required or necessary, is achieved using ice in the water baths. Sub zero (°C) temperatures can be achieved using ice/solvent or cardice/solvent mixtures. Temperatures in the range -20 to +60 °C have been used.

Other equipment

Where there are specific requirements, smaller packages of equipment can be assembled to facilitate liquid/gas ratio measurements and liquid carry over studies of separators and production process facilities.

Manifold

The manifold is connected into the main production flow line. Usually between the wellhead and the choke manifold, and is positioned vertically so that flow through the mixing device is downwards. A probe, through which the sampled sidestream is flowed isokinetically into the mini-lab, is located downstream of the mixing device, in a highly turbulent region.

The isokinetic sampling rate is maintained by control valves in the mini-lab and thereby ensuring representative sampling.

Mini-lab

An overview of the measurements that can be performed using the mini-lab separation system are listed below.

Sequential separation

Sequential separation of the well fluid in up to three stages down a controlled temperature and pressure gradient.

Monitoring

Accurate monitoring of produced liquid to gas ratio.

Sampling

Sampling of gas and liquid phases from production process equipment or test separators.

Dew points

Determination of gravimetric or volumetric dew points at constant temperature or pressure (correspondingly variable P or T) from plots of condensate quantity vs T or P.

PVT sampling

Provision of standard liquid and gas samples for PVT analysis.

OPERATIONAL CONDITIONS

The following operational criteria should be adhered to before well head isokinetic sampling is used.

Clean well

The well must be thoroughly cleaned up prior to hydraulically inserting the mixing device and traversable probe.

Chemicals

If hydrate inhibiting chemicals are to be used, injection should be stopped prior to sampling. If injection is unavoidable during sampling the use of glycol is preferable to methanol, as it can be removed in the mini-lab.

Stabilisation

The production test separator and wellhead conditions must be stable, indicating a stable gas rate.

Gas rates

Sampling is preferably performed at gas rates between 300,000 and 1,800,000 Sm^3/day for the standard manifolds. However, gas rates as low as 100,000 Sm^3/day can be sampled effectively when using the traversable probe.

Equipment and Services:

Manifold

Location: ..... Upstream of choke manifold.
Connection:..... 3" Weco 1502 and 4" D31 Grayloc.

Mini-lab

Location: ..... As close as possible to manifold.
Connection:..... 220 V single phase.
..... Instrument compressed air.

The following materials may also be required:

- Steam
- Ethylene glycol
- Methanol
- Petroleum ether
- Ice
- Cardice

The technique involves:

- Isokinetic fluid sampling through an injectable probe positioned in the gas outlet of the separator.
- Analysis of upstream and down-stream samples taken via the probe.
- The determination of separator efficiency and thereby correction of the measured CGR for recombination of gas and liquid samples.

The technique has been tested on over 300 wells over a range of fluid systems, i.e. oil, rich gas/condensate and dry gas systems.

Using simulations, it is often possible to predict the expected performance of a test separator under given hydraulic loads and the corresponding requirement for isokinetic sampling. On occasions, however, the efficiency of the test separator has been significantly lower than that predicted.

The technique has been widely used to obtain a correct recombination gas/liquid ratio for separator samples from volatile oil and gas/condensate reservoirs.