

## ISO-SPLIT wellhead sampling

For the detailed characterisation of any well fluid in terms of its chemical composition, representative sampling is essential. Gas/condensate reservoirs pose particular problems in this respect, since in most cases the well flows as a multi phase system. In order to forecast realistic condensate production and how long the production plateau will continue, it is important to test the well at flow rates similar to those anticipated under full production.

During production, phenomena such as turbulent effects, condensate skin, liquid hold up, static connectivity and inter facial tension (IFT) may occur in the wellbore area and affect the produced condensate gas ratio (CGR) in both saturated and under saturated wells. Standard PVT sampling, from a production test separator, can produce non-representative samples because of a decrease in the separator performance with the higher gas rate and hydraulic loading experienced with gas/condensate systems.

The recommended procedure for obtaining representative samples in these circumstances is to sample isokinetically from a turbulent well stream using specially designed equipment and to direct the sample into a mini separation system.

To eliminate problems that may be encountered in sampling non-turbulent heterogeneous well streams a mixing/sampling manifold has been developed. This manifold is normally connected into the well-head flow system upstream of the choke manifold. The manifold incorporates a mixing device which aids the representative sampling. Samples taken even under non-turbulent flow conditions have proved to be representative.

The standard procedure during sampling is to check that the well flow is stable by measuring the condensate 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. 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.

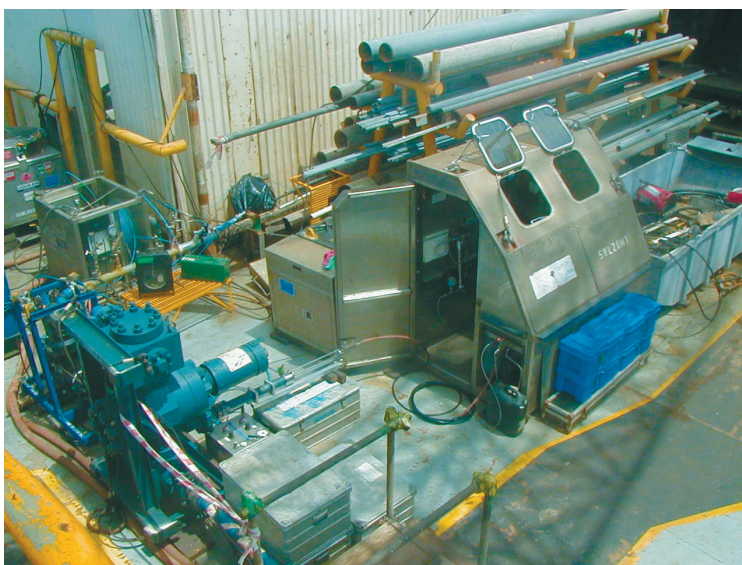
CGR measurements carried out during multi rate flow tests correlate any rate dependency performance of the well.

The mini separation system is housed in an air transportable container, termed a "Mini lab" and comprises all the equipment needed for controlled, quantitative separation of an isokinetically sampled fluid stream from the sampling manifold, as described in section 2.

Additional to sampling for purely compositional purposes the mini lab separation units can also be used to simulate proposed process facility conditions of pressure and temperature, and thus provide quantitative data for design engineers to compare with their theoretical studies. The system can be used to simulate up to three stages of separation.

Ancillary equipment includes; (I) a means for quantitatively flashing and sampling high pressure liquid to liquid and gas at atmospheric pressure, and (II) a means for quantitatively reducing high pressure gas at reduced temperature to liquid and gas phases at atmospheric pressure, with means for sampling these phases.

The equipment is also suitable for investigating process facility gas/liquid separation equipment performance.



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### EQUIPMENT

#### Sampling Manifolds

Four manifolds are available, all of which are rated at a working pressure of 10,000 psi (690 bar) 15,000 psi (1034 bar). These manifolds have been developed as part of a research project in which Expro co-operated with six oil companies and the Royal Norwegian Council for Industrial Research.

The manifolds are air transportable as are the Mini labs. All are suitable for sour gas service. All manifolds are designed so that the well flow can be diverted, bypassing the mixing device during non-sampling flow periods. Additionally the manifolds incorporate an injectable probe which traverses the pipe diameter at the sampling point.

The restriction of the mixing device is equivalent to a 63.5 mm (2.5") choke. Well flows up to  $1.7 \times 10^6$  Sm<sup>3</sup>/d (60 MMscf/d) have been sampled satisfactorily.

### SAMPLING UNITS

#### Mini labs

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

The Mini labs also contain 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, and are fitted with electrical heaters for control of separator temperatures (BASEEFA approved for Zone 1 operation). 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 (solid carbon dioxide)/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.

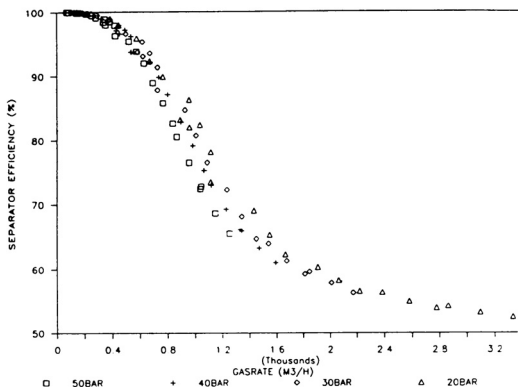
### OPERATING PROCEDURES

#### Manifold

The manifold is connected into the main production flow line, usually between the well head and the choke manifold, and is positioned vertically so that flow through the mixing device is downwards.

A probe, through which the sampled side stream 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 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 to optimise the characterisation of heavier hydrocarbon components and provide a detailed well stream composition.

#### Monitoring

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



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### Sampling

Sampling of gas and liquid phases from production process equipment or test separators and process lines by controlled, quantitative flashes.

### 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 by bypassing the mixing device prior to sampling. This is to avoid blockage and/or damage to the mixing device and sampling probe caused by produced solids.

### Chemicals

If hydrate inhibiting chemicals are to be used, injection should be stopped prior to sampling. (Methanol in particular interferes with hydrocarbon GC analysis.) If injection is unavoidable during sampling the use of glycol is preferable 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<sup>3</sup>/day for the standard manifolds. However, gas rates as low as 100,000 Sm<sup>3</sup>/day can be sampled effectively when using the traversable probe incorporated in the manifold design.

### MANIFOLD

Location: Upstream of choke manifold.  
Connection: 3" Weco 1502 (manifolds requires metal to metal seals in the case of 15 K operation).

### 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.

