

Introduction to bottom hole sampling

Bottom hole sampling is especially designed for in-situ sampling from black oil, formation water and under-saturated gas reservoirs. Black oil is identified by gas oil ratio (GOR) up to 2000 scf/bbl, oil gravity up to 45° API and formation volume factor (FVF) less than 2 bbl/bbl.

If the well is known to be producing water, a down hole pressure gradient survey is recommended in order to determine the oil water contact. With this information, sampling of water and the waste of expensive rig or production time can be avoided.

Normal requirements for well sampling are:

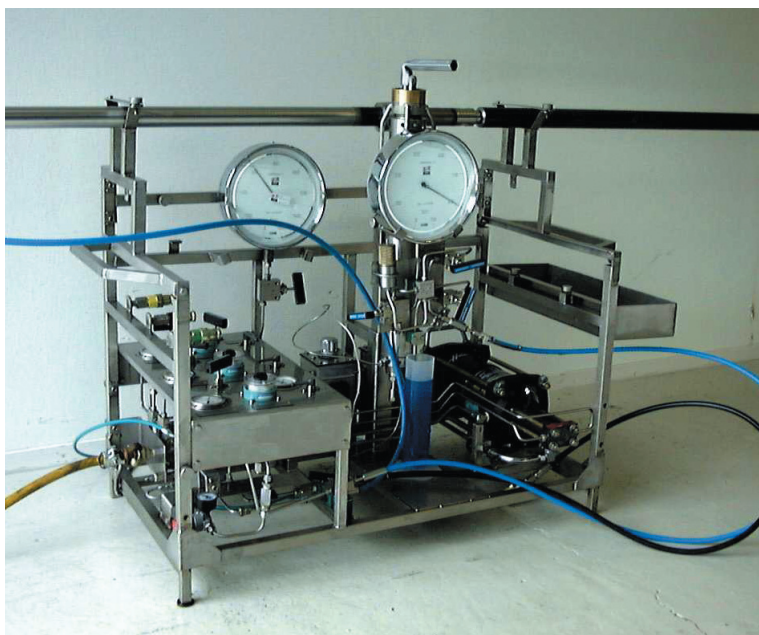
- High reservoir pressure
- Non-depleted wells
- Low Gas-Oil ratio
- No free water

Data required from the client:

- Gas/Oil Ratio (GOR)
- Flowing Bottom Hole Conditions (P&T)
- Water Cut
- Depth
- Pour Point
- Bottom Hole Completion Diagram
- API Gravity Of Oil
- Choke Size
- Producing Interval

Expro currently employs two different Bottom Hole Sampling Systems both of which are Single Phase:

1. Standard Single Phase Bottom Hole Sampling System in 17-4 PH material.
2. Extreme Service Non Reactive Pressure Compensated Sampler (PCS) in Inert Materials.



Standard single phase bottom hole sampling system (17-4 PH)

To keep pace with reservoir engineering and PVT analysis techniques the industry now demands that down hole fluid samples are truly representative. Expro aim to fulfill this requirement with their single phase bottom hole sampler. Drawing upon extensive experience in the recovery of reservoir samples, a unique bottom hole sampling system has been developed. The single-phase system brings together all the best features of current designs and introduces a number of innovative ideas with the aim of recovering an unequalled quality of reservoir sample.

Traditional sampling methods

Traditional bottom hole sampling systems currently in use capture a sample using either a “flow-through” or, more recently, a “positive displacement” type of sample chamber. Once the samples are secured and recovered to surface the sample is required to be recombined into a single homogeneous state by depressurizing and agitation. This process often takes hours to perform correctly. The sample is then transferred into a sample bottle and a field bubble point validity check performed before being shipped to the laboratory for analysis. There is always a risk that the sample has not been thoroughly recombined and is no longer truly representative after transfer.

Single phase sampling methods

The single-phase bottom hole sampler employs a positive displacement sample chamber fitted with a reliable multipurpose regulator valve to ensure precise filling of the sample chamber preventing any gas breakout. Once the sample has been secured an accumulator type pressure compensation system ensures that the pressure inside the sample chamber never falls below reservoir pressure. This prevents any gas coming out of solution during recovery to surface. The sample is at all times maintained in single phase, thus requiring no lengthy recombination on surface. Samples can be immediately transferred into sample bottles and validated. The transfer is performed quickly without the use of Mercury (Hg).

The transfer system enables samples to be transferred into either a standard sample bottle or our single-phase sample bottles. Both types of sample bottle are mercury free.

The single-phase sample bottle maintains the sample above reservoir pressure during transport to the laboratory. This is particularly useful for providing samples for more detailed analysis such as asphaltene, bacteria and corrosion (pH) studies (see page 3).

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Features

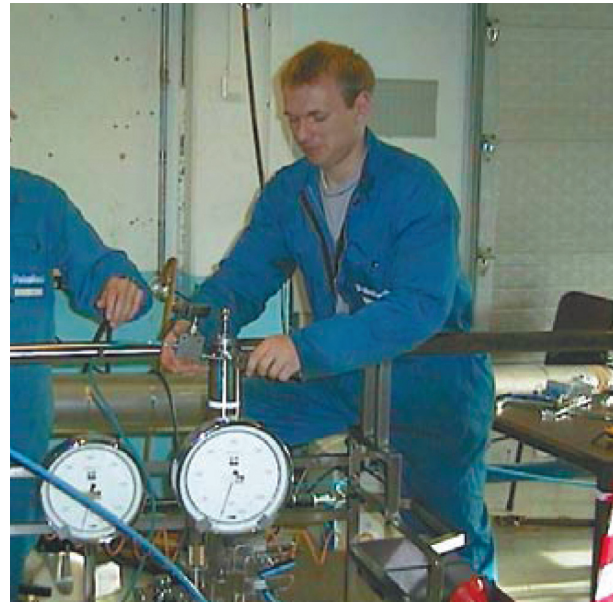
The single-phase sampling system represents the most advanced sampling technique available. The sampler can also be fitted with a inert sample chamber for trace element analysis, especially designed for analysis of hydrogen sulfide, mercury and mercaptans etc.

Features:

- Positive Displacement Operation
- Mercury-Free
- Pressure Compensation (single-phase)
- No Recombination Necessary

Technical Specification:

Length	13'10" (4.19 m)
O.D.	1 ³ / ₄ " (44.5 mm)
Material	17-4 PH
Capacity	600 cm ³
Working Pressure	15,000 psi
Temperature	350°F
Service	H ₂ S



The bottom hole samplers are tested at downhole conditions before they are mobilised to the well site.

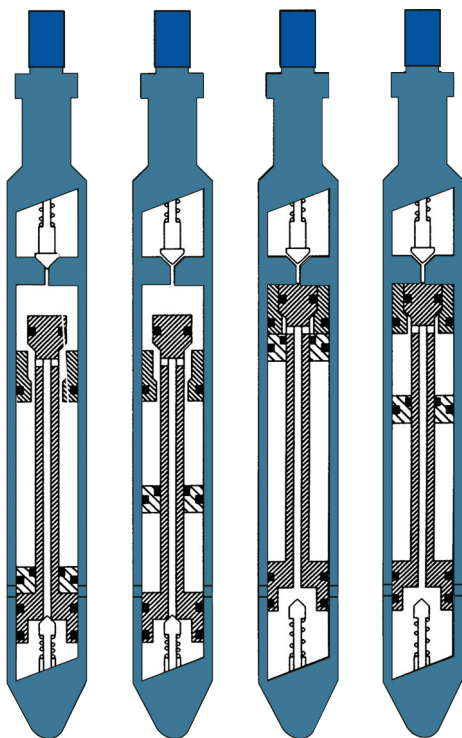


Fig 1 Running Position
Fig 2 Start Sampling
Fig 3 Complete Sampling
Fig 4 Pressure Compensation

Drawings

The operating principle of the single-phase bottom hole sampler is presented below. The bottom hole samplers are tested at down hole conditions before they are sent offshore/on-site.

Operating procedures

Running position (fig. 1).

Fluid entry to the sample chamber is prevented by the floating piston, which is held against the fixed piston across the sample entry ports by a pressurized charge fluid. When the tool is activated the charge fluid will bleed into the air chamber allowing the floating piston to be pushed up the central rod by well fluid entering through the sample ports. At the lower end of the fixed piston is a sleeve, which houses the power fluid valve. With the fixed piston in the running position the power fluid valve is closed (the power fluid is isolated from the sample chamber).

Tool fired, taking sample (fig. 2).

The mechanical clock has run the preset delay time and has opened the regulator valve. Before firing, the temperature effect on the charge fluid pressure keeps the floating piston hard against the fixed piston across the sample ports. Now that the regulator is open the charge fluid flows into the air chamber at a steady rate causing the pressure within the sample chamber to drop. When well pressure is reached, well fluid starts displacing the floating piston up the sample chamber. The pressure differential acting on the power fluid valve acts as a brake on the fixed piston when the tool is sampling, thereby preventing premature closure of the tool.

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Sampling complete (fig. 3).

When 600 cc of fluid has been sampled, the floating piston has reached the closing piston at the top of the sample. The floating piston closes the isolation piston at the rod end and the rod is pulled up bringing the fixed piston seal into the sample chamber bore, thereby trapping the sample in the chamber. The fixed piston sleeve has now opened the power fluid valve allowing the nitrogen-energised power fluid to act between the isolation and floating pistons through the power fluid port in the hollow central rod. Power fluid pressure acting on the bottom of the fixed piston keeps the tool positively closed (pressure on the upper face of the piston is balanced by the same pressure on the closing piston).

Pressure compensation (fig. 4).

As the bottom hole tool is retrieved from the well, the temperature drops and the sample shrinks. In this case, however, the sample is maintained in a single-phase condition by use of increased, predetermined pressure from the nitrogen, acting via the power fluid.

Operational conditions

For fast and safe rig up we recommend the use of our wireline-lifting clamp in conjunction with the Trinity Quick Coupling. The lifting clamp is hung on a tugger/crane and clamped round the fishing neck at the top sampler, which has one half of the quick coupling on top. The other half is on the bottom of the wire-line running string. The other samplers are screwed onto the top sampler, one at a time and the complete sampling string is then stabbed into the lubricator. The lifting clamp arms are set down across the wire-line BOP and the tugger slacked off to allow the wire-line running string to be connected to the samplers with the quick coupling. The wire-line unit then picks up the complete string and the lifting clamp is removed from the top sampler with the tugger. The lubricator union can now be made up and pressure tested.

External equipment

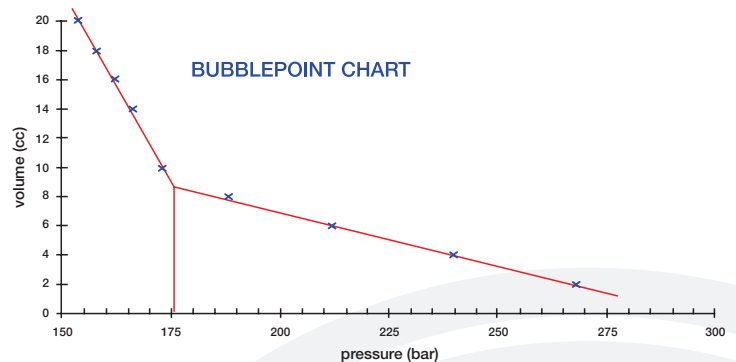
The Standard Single Phase Sampler is equipped with a 15/16" Sucker Rod pin on the top and a 15/16" SR box on the bottom, both standard threads for slick line tools. The tool can also be run on the bottom of an electric line string with the use of a cross over.

Expro's Petrotech PCS sampling tool

The Pressure Compensated Sampler (PCS) is a single-phase reservoir sampling tool that compensates the sample volume shrinkage caused by the drop in temperature when the tool is pulled to the surface. The tool is a displacement type sampler triggered either by mechanical clocks (ranging from 3 to 24 hrs.), electrical wire line or a combination of the two systems. For surface controlled operation only the top PCS is triggered and the PCS tools mounted below are triggered by the closing action of the tool above. Lubricator length or cable rating (for deep wells) may limit the number of tools for this "Tandem Firing" system.

Inert materials

The materials selected for the PCS Tool are meeting the requirements in the NACE MR 0175 - 97 standard and are suitable for heavy sour service. The materials have excellent chemical resistance and will withstand very hostile environments. The PCS sample chamber is especially designed for trace element analysis of hydrogen sulphide, mercaptans, carbon dioxide, pH, chlorides and mercury etc.



Use of the single phase sampling system and the single phase bottle makes the determination of the bubblepoint more accurate by the easily identified bubble point curve.

PCS Specifications:	
Type	Monophasic Fluid Sampler
Principle	Displacement
Chamber	Balanced between pistons, plus compensating fluid closing assistance.
Sample Vol.	600 cm ³
Max.Working Pressure	1000 bar / 15000 psi
Max.Working Temp.	180 °C / 356 °F
Test Pressure	1500 bar / 21800 psi
Length	4.25 m / 13.94 ft
Diameter	44 mm/ 1 3/4"
Weight	36 kg / 79 lbs.
Materials UNS	N06625, N07725, N10276, S20910 (Hastelloy C 276) All materials according to NACE MR0175-97



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Principles of operation

Fig.1 Running Position

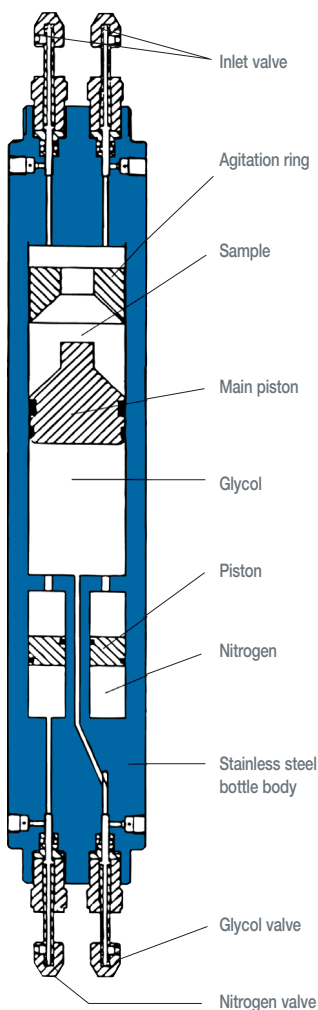
In the running position the sample entry ports are covered by the floating piston so no well fluid can enter the sample chamber. The floating piston is held in this position by pressurised synthetic oil (back up fluid). The compensating fluid is charged with nitrogen pressure and is contained by a sliding valve.

Action between Fig.1 & Fig.2

The sampling starts when the "back up fluid" is released for displacement by the selected trigger mechanism. After sampling the pressure compensation is activated by the closing action of the sampling chamber.

Fig.2 After Sampling

In the filled, sealed and pressure compensated position, the fluid sample is safely contained in the chamber. The closing piston is assisted by a closing action from the pressure compensating fluid. The "back up fluid" has been displaced by the sample and is now contained in the upper section of the tool.



Connections

The PCS tool is equipped with standard slick-line thread $1\frac{5}{16}$ " Sucker Rod, pin at the top and box at the bottom. For electrical wire line: cross-over to Schlumberger, Baker Atlas and Halliburton are available. For Tandem firing: a special adapter with integrated knuckle joint can be used.

The unique single phase bottle for oil and formation water sample preservation and transportation

By using the single phase sampling method the sample is retrieved at surface in single phase state and does not require lengthy recombination before transfer. Transfer to single-phase bottle (below left) keeps the sampled oil or formation water in a virgin condition all the way to the laboratory.

For oil samples this is of vital importance in order to keep wax and asphaltenes dissolved in the oil. For formation water analysis it is of special importance to prevent formation of scale or particles in the sample, especially when the water is to be examined for possible scaling by use of the prediction program MultiScale™ (see separate info sheet).

