جامعة الملك سعود
King Saud University

كلية الهندسة
جامعة الملك سعود
King Saud University
College Of Engineering

Properties of Reservoir Fluids (PGE 362)

Reservoir Fluids Sampling

By
Dr. Mohammed A. Khamis
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Outlines

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  - Sampling methods
- Preparing The Well for Sampling
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Objectives

Obtain a sample of the original reservoir fluid by collecting samples before the bottom hole flowing pressure has dropped below reservoir fluid saturation pressure. This fluid will be representative of the original reservoir fluid

Planning The Sampling Program

Factors that influence planning

- Types of reservoir fluids
- Effect of reservoir fluid type on planning
- The production characteristics of each well
  - No water production (even small amount)
  - Gas oil ratio and tank oil gravity
  - Relatively high productivity index

Avoid sampling from an oil well

- Near GOC
- Near OWC
- Oil water transition zone

Planning The Sampling Program

The choice of sampling method influenced by

- Volume of sample
- Type of reservoir fluid
- The degree of depletion of the reservoir
- The mechanical condition of the wellbore
- The type of available gas oil separation equipment.

Sampling methods:

- Subsurface sampling
- Surface sampling
- Wellhead sampling

Planning The Sampling Program

Subsurface sampling

- Bottom-hole samplers:

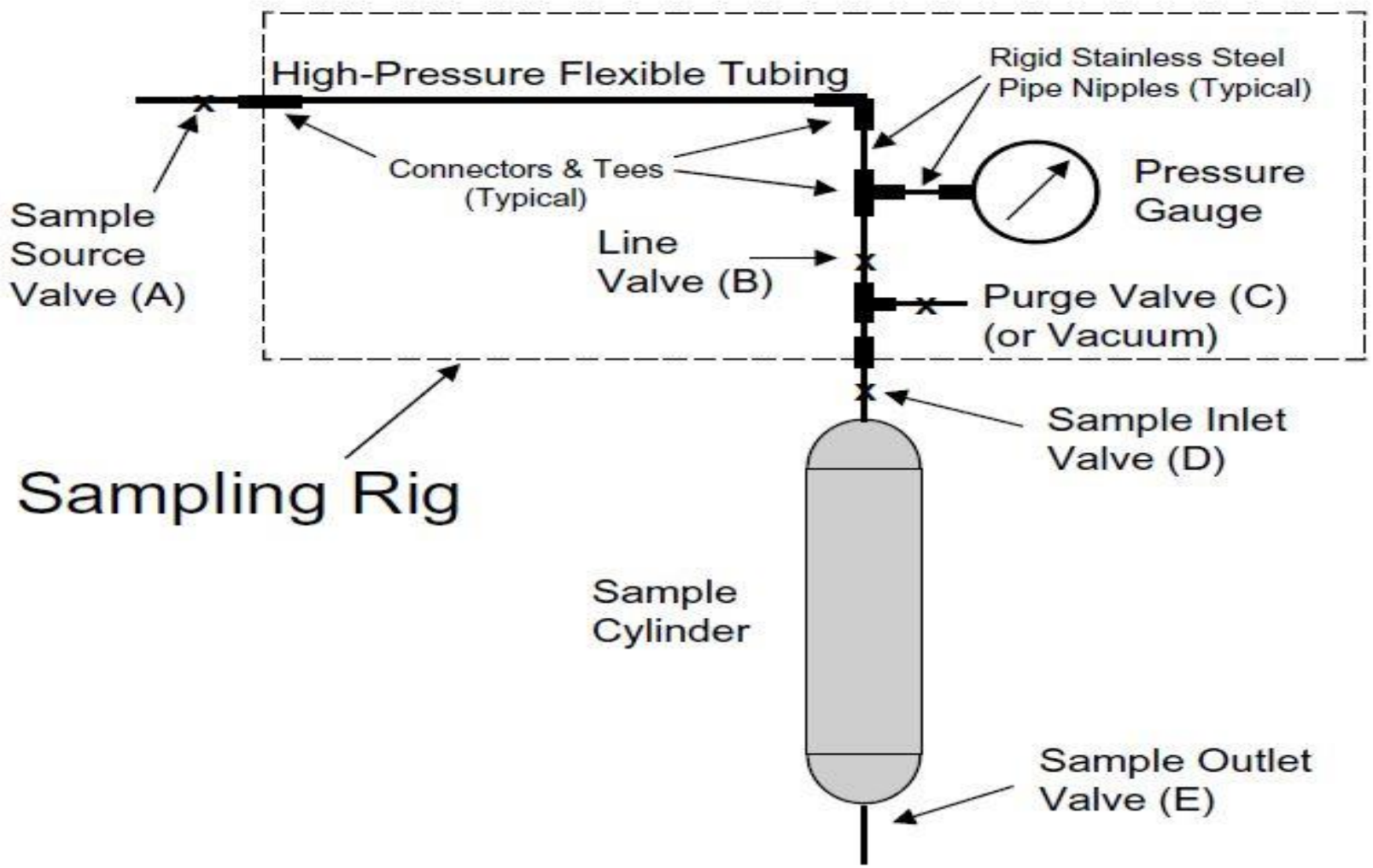
Tool to collect sample from the well-bore that can be used in either open-hole or cased-hole wells and can be run in tubing.

- Formation testers

Modern open-hole wireline sampler that can collect fluid samples directly from the formation.

Planning The Sampling Program

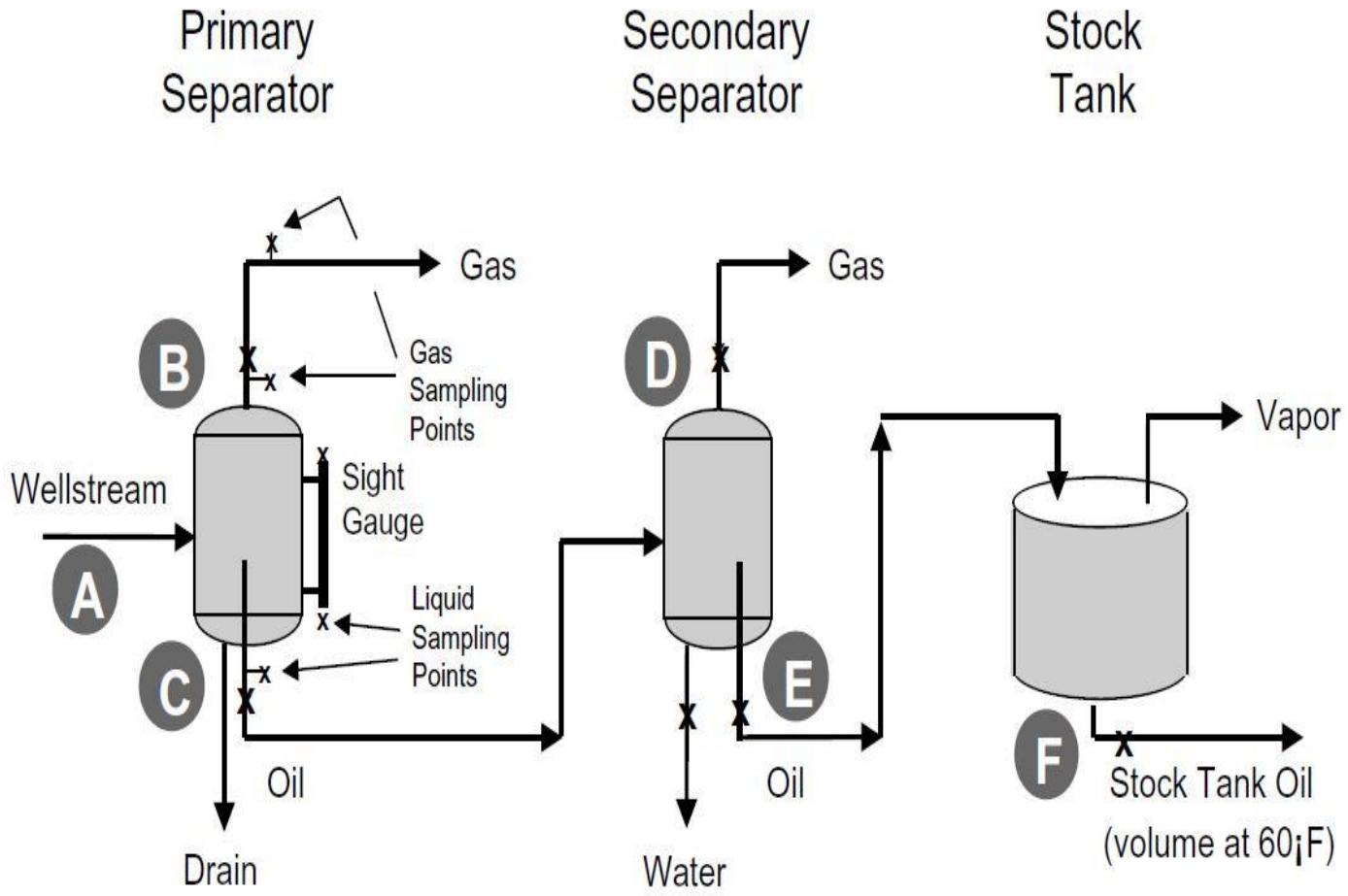
Subsurface sampling



Planning The Sampling Program

Surface sampling

Taking samples from separator of oil and gas.



Planning The Sampling Program

Wellhead sampling

Less common but potentially valuable.

If the fluid is in the single-phase state at the wellhead condition of temperature and pressure, this technique can produce the easiest and more reliable results.

Planning The Sampling Program

Advantages of subsurface sampling

- Collects the desired sample directly.
- Can maintain full pressure on sample (with special sampling tool).
- Avoids use of surface separators, and the proper sizing of separators.
- Avoids the need for flow rate metering devices, and their proper sizing and calibration (for determination of producing GOR).
- Requires less sampling information to be transmitted to testing laboratory.
- Eliminates potential errors in recombination of gas and oil samples required for surface samples.

Planning The Sampling Program

Advantages of surface sampling

- Relatively easy, convenient and less expensive compared to subsurface sampling (e.g., no rig or wireline unit is required on location).
- Avoids loss of production during required shut-in period for subsurface sampling (period of 1 – 4 days, or more for low deliverability wells).
- Avoids the potential for getting the subsurface sampling tool stuck or lost if the tubing is damaged or deviated, or if the sampling tool is lowered below tubing level.
- Applicable to cases where water is expected in tubing at the depth of the producing formation, where subsurface sampling cannot be used.
- Does not require that single-phase fluid be produced into the wellbore.

Planning The Sampling Program

Advantages of formation testers

- Same advantages as subsurface sampling above.
- Collects the desired sample directly from the formation.
- Sample represents reservoir fluid over a very narrow depth interval.
- Sample not affected by fluid segregation in the wellbore.
- Can sample reservoir fluid even if water is standing in wellbore.
- Can sample reservoir fluid at original conditions (before any reservoir fluid has been produced).
- Controlled pressure draw-down during sample collection.

Preparing The Well for Sampling

Considerations of reservoir fluid type and well operating conditions

- Understanding of the type of fluid.
- The current status of the production operation.
- The production history of the well.
- All chemical injections which may affect the sample quality should be stopped prior to sampling or minimized.

Preparing The Well for Sampling

Conditioning the well before sampling

- The well is produced long enough to clean up all chemicals that used during the well completion
- The flow rate is stepwise decreased until the p_{wf} > the estimated saturation pressure (if possible)
- The final rate must be large enough to maintain a stable producing GOR and wellhead pressure.
- The final rate should be maintained long enough to ensure that the producing GOR is constant

Preparing The Well for Sampling

Flowing oil wells

Making accurate measurements of the oil and gas rates and measuring the bottom-hole pressure for the last 24 hours of normal production rate.

Pumping oil wells

Generally, they are undesirable for sampling unless it is the only available option.

If the surface sampling method is used, the well should be pumped for several days after steady oil and gas rates achieved.

If the subsurface sampling is used, pumping is stopped after the well is conditioned and the rods and pump (or ESP) are pulled out of the tubing.

Preparing The Well for Sampling

Duration of the well conditioning period

The period depends on:

- The volume of reservoir fluid that has been altered.
- Contamination by drilling fluid.
  - Producing the well at $p_{wf} < p_b$
  - The rates at which the altered reservoir oil is produced.

Preparing The Well for Sampling

Field measurements during well conditioning

- Tubing (wellhead) pressure and temperature
- Gas rate
  - Gas gravity
  - Gas temperature
- Oil rate
  - Primary separator rate
  - Stock tank oil production rate
- Water production rate
- Separator pressure
- Separation temperature

Conducting The Sampling Operation

Subsurface sampling

The well should be cleaned up of drilling and completion fluids. The sampling process must be preceded by the selection of:

- The type of subsurface sampling tool.
- The appropriate sampling point in the wellbore.

Sampling tools

- Conventional bottom-hole samplers
- Piston-type bottom-hole samplers
- Formation testers

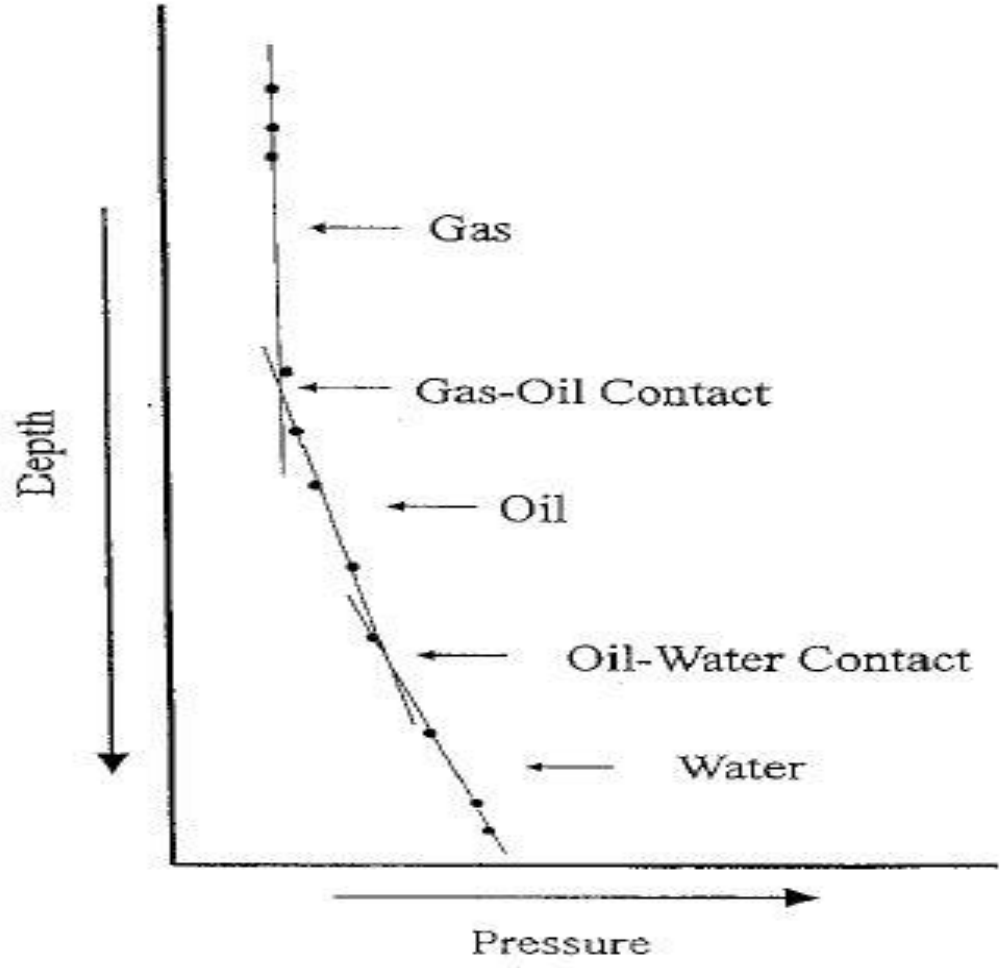
Conducting The Sampling Operation

Subsurface sampling

Selecting the sampling point

The best place is the lowest point in the wellbore passed by all the fluid entering the wellbore and when the static pressure is not less than the estimated reservoir fluid saturation pressure and avoiding water producing zones.

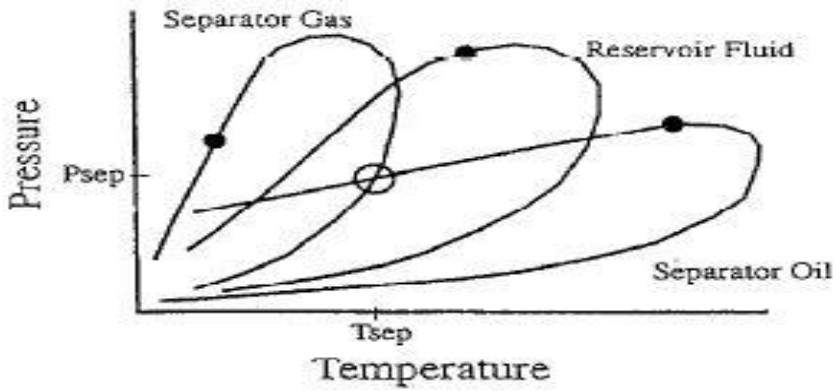
The pressure survey data will be used to determine the GWC or OWC depths.

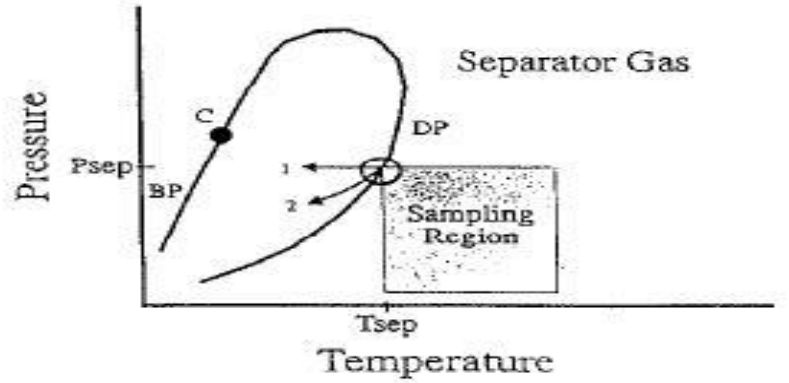


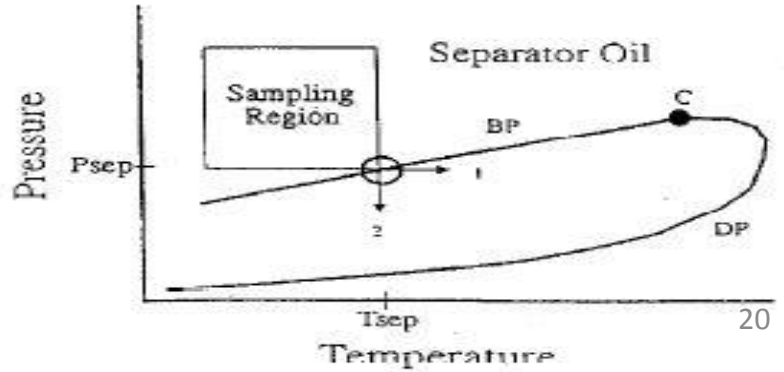
Conducting The Sampling Operation

Surface sampling

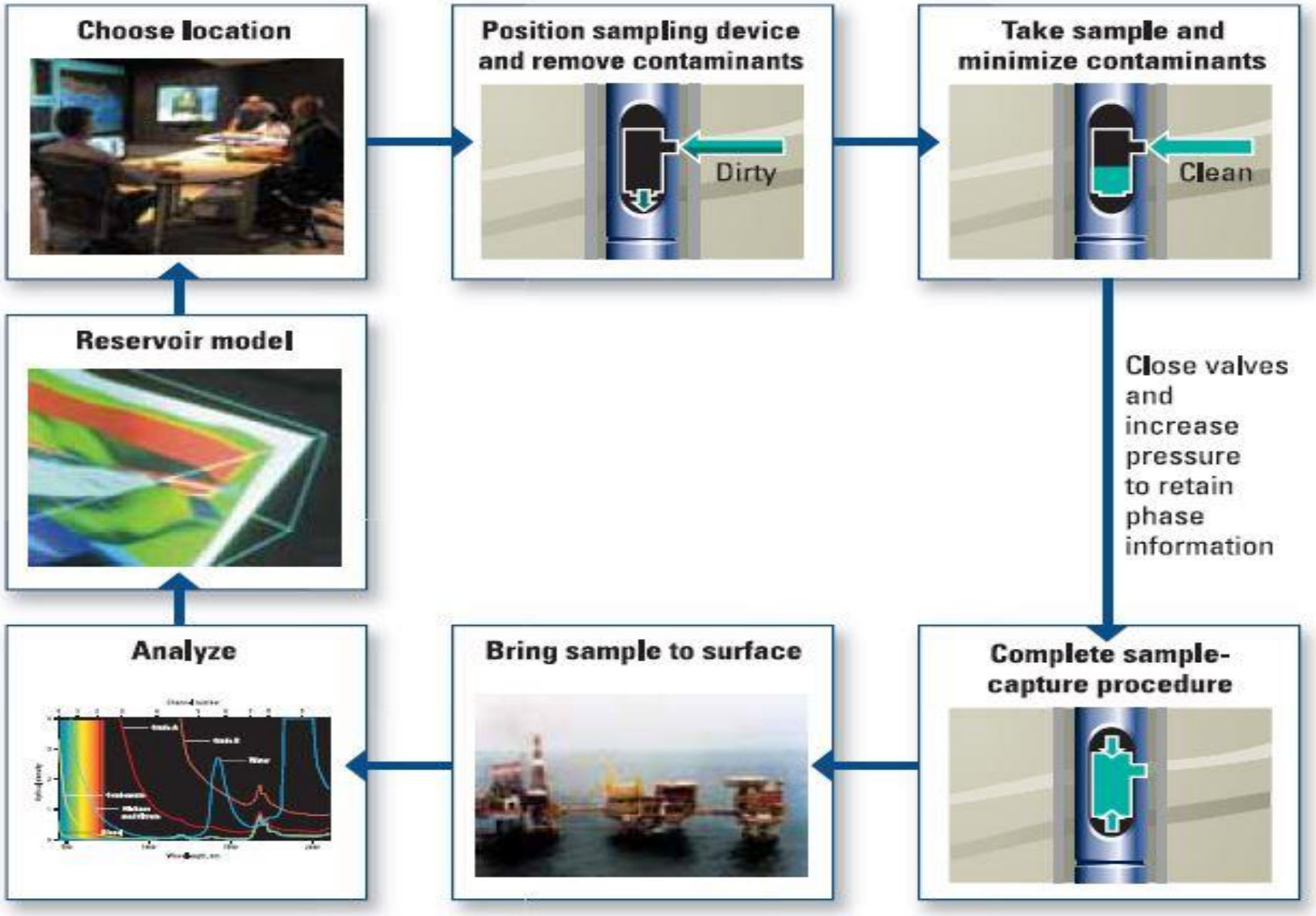
- It is satisfactory for nearly all types of reservoir fluids.
- The producing rate should not be changed after the well has been conditioned.



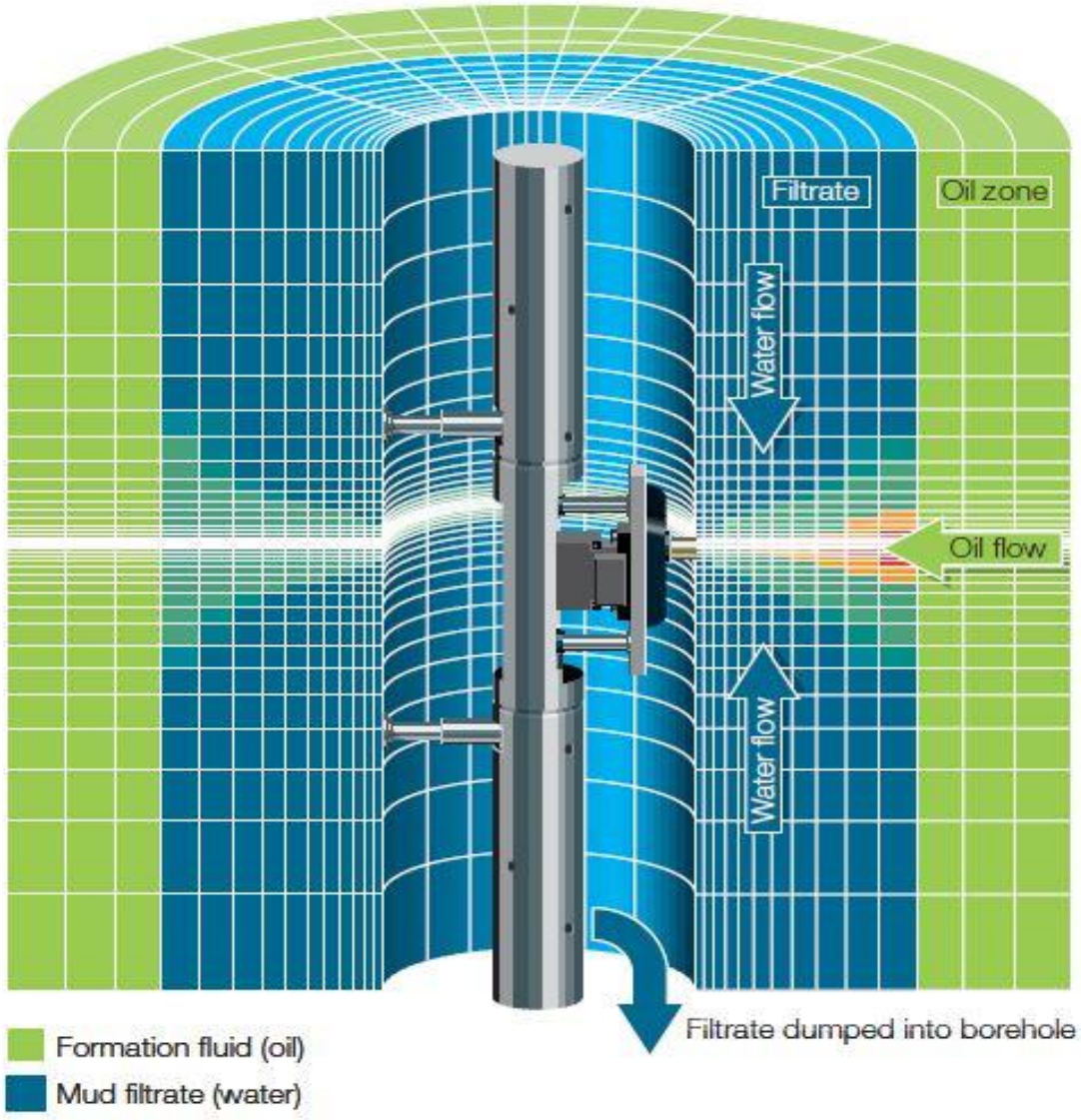




Conducting The Sampling Operation



Conducting The Sampling Operation



Conducting The Sampling Operation

PVT Laboratory Tests

Importance of PVT

Oil and gas samples are taken to evaluate the properties of the produced fluids at reservoir conditions.

- Original reservoir composition(s)
- Saturation pressure at reservoir temperature
- Oil and gas densities
- Oil and gas viscosities
- Gas solubility in reservoir oil
- Liquid (NGL/condensate) content of reservoir gas
- Shrinkage (volume) factors of oil and gas from reservoir to surface
- conditions
- Equilibrium phase compositions

Accuracy of PVT Data ≠ Representivity of Sample

PVT Laboratory Tests

Compositional analysis

- Gas chromatography

Pressure Depletion Tests

- Constant Composition Expansion (CCE)
- Constant Volume Depletion (CVD)
- Differential Liberation (DL)

Viscosity Test

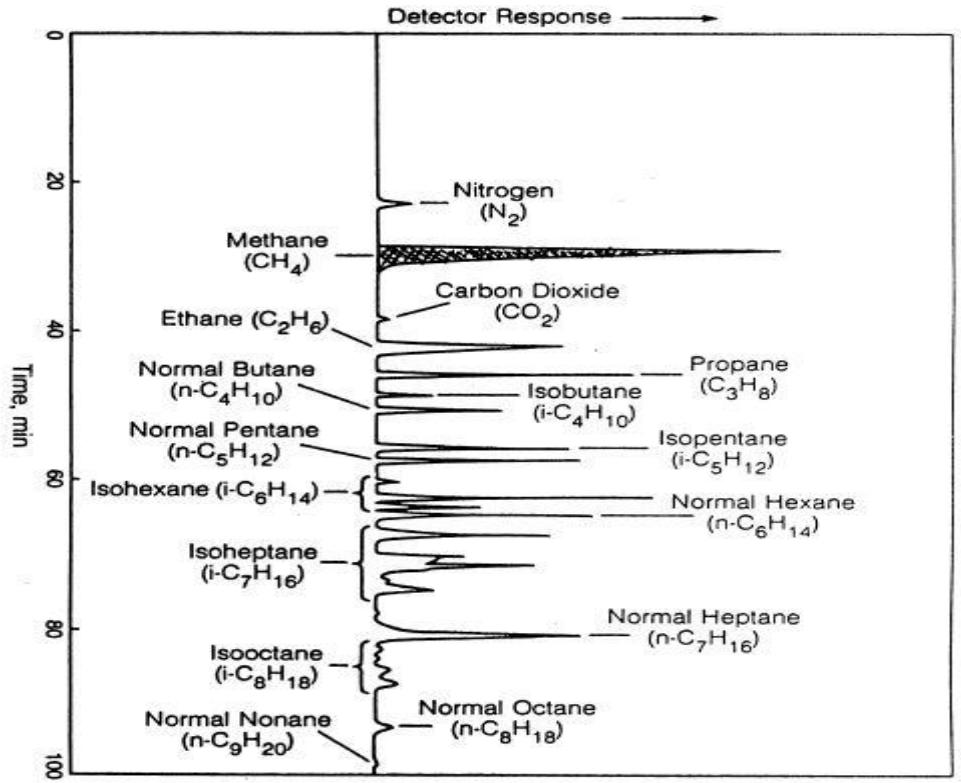
Density Test

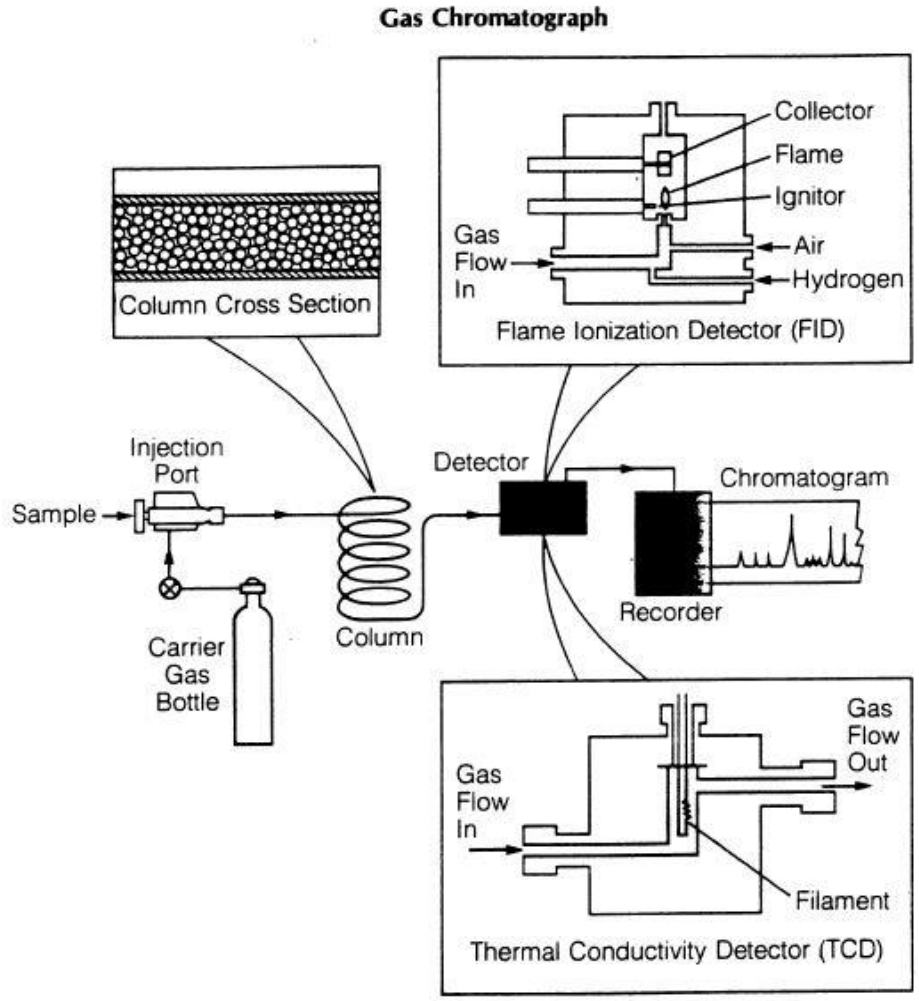
Separator Test

PVT Laboratory Tests

Compositional analysis

- Liquid and gas analysis C_1~ C_{n+}
- Properties of the heavy components
- Properties of the stock tank liquid



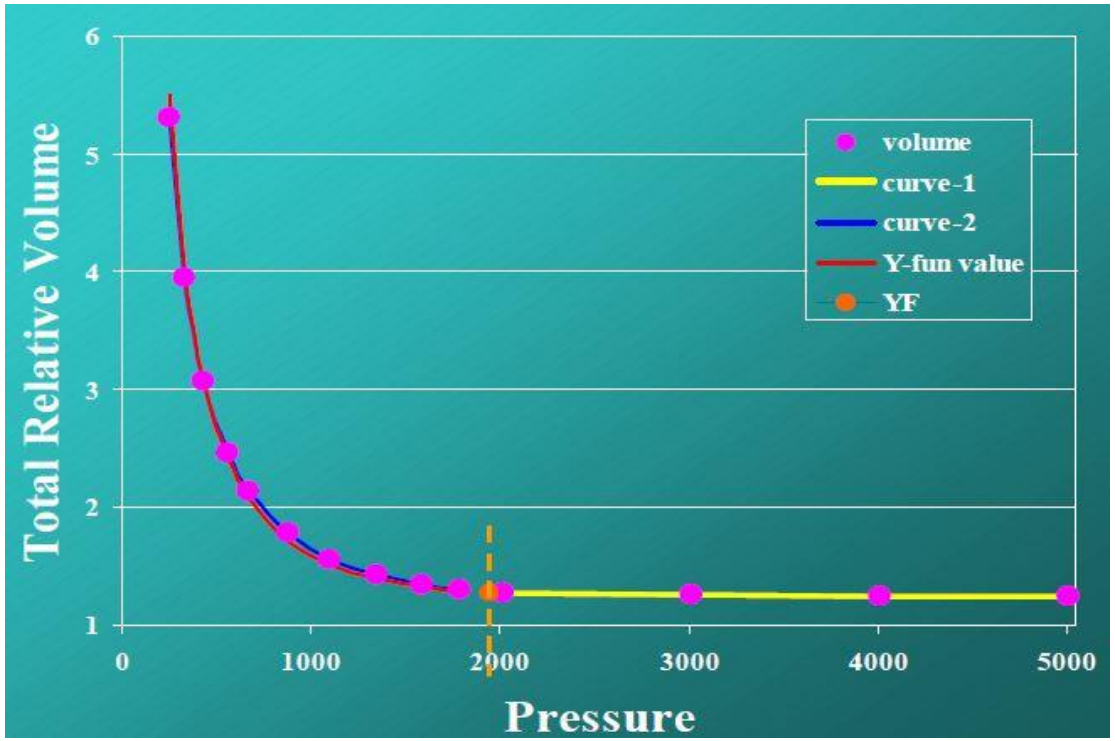


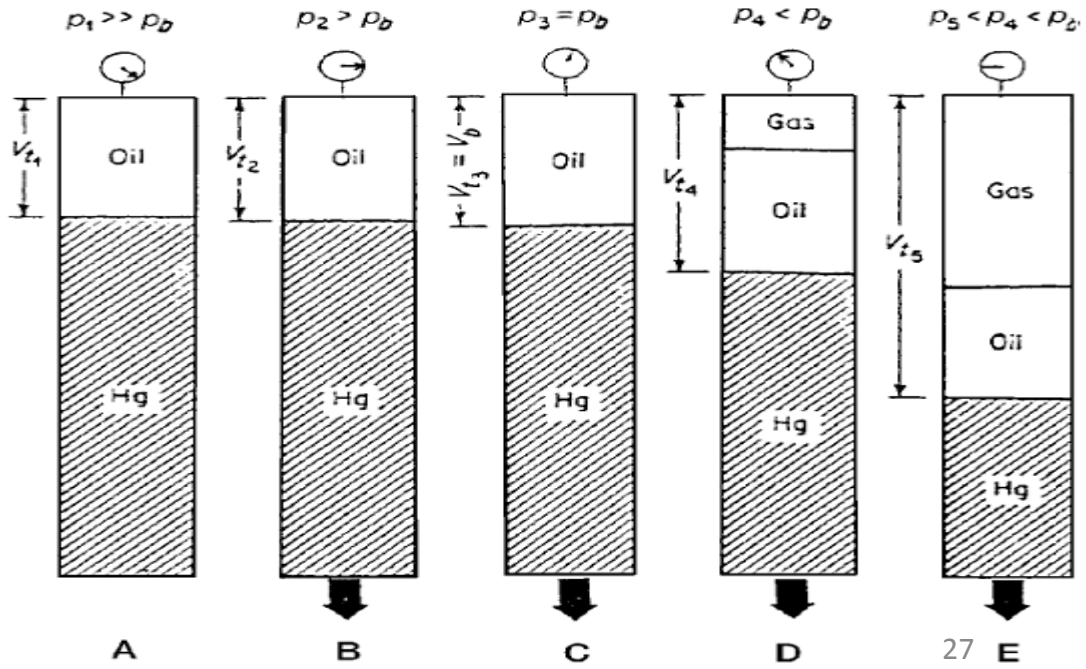
PVT Laboratory Tests

Pressure Depletion Tests

Constant Composition Expansion (CCE)

Black oil



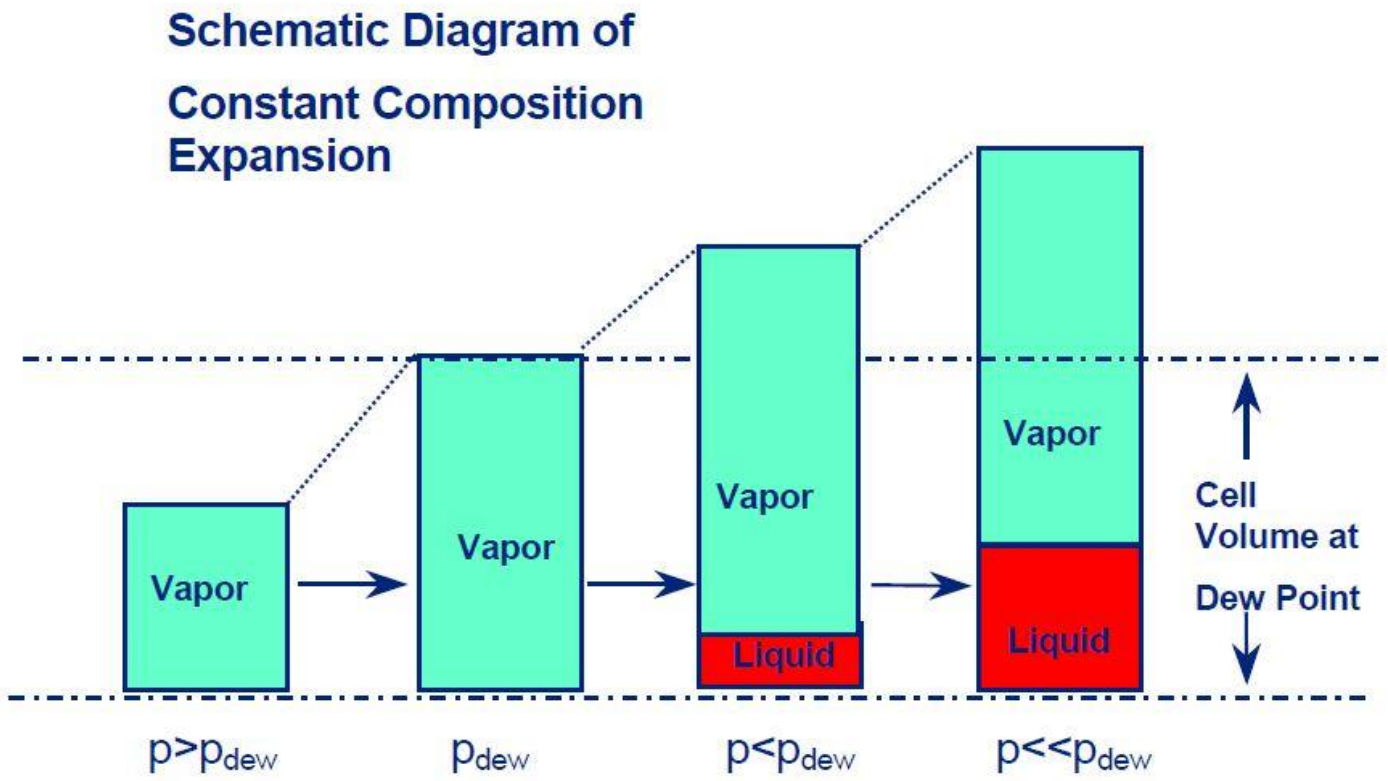


PVT Laboratory Tests

Pressure Depletion Tests

Constant Volume Depletion (CVD)

Condensate and volatile oil

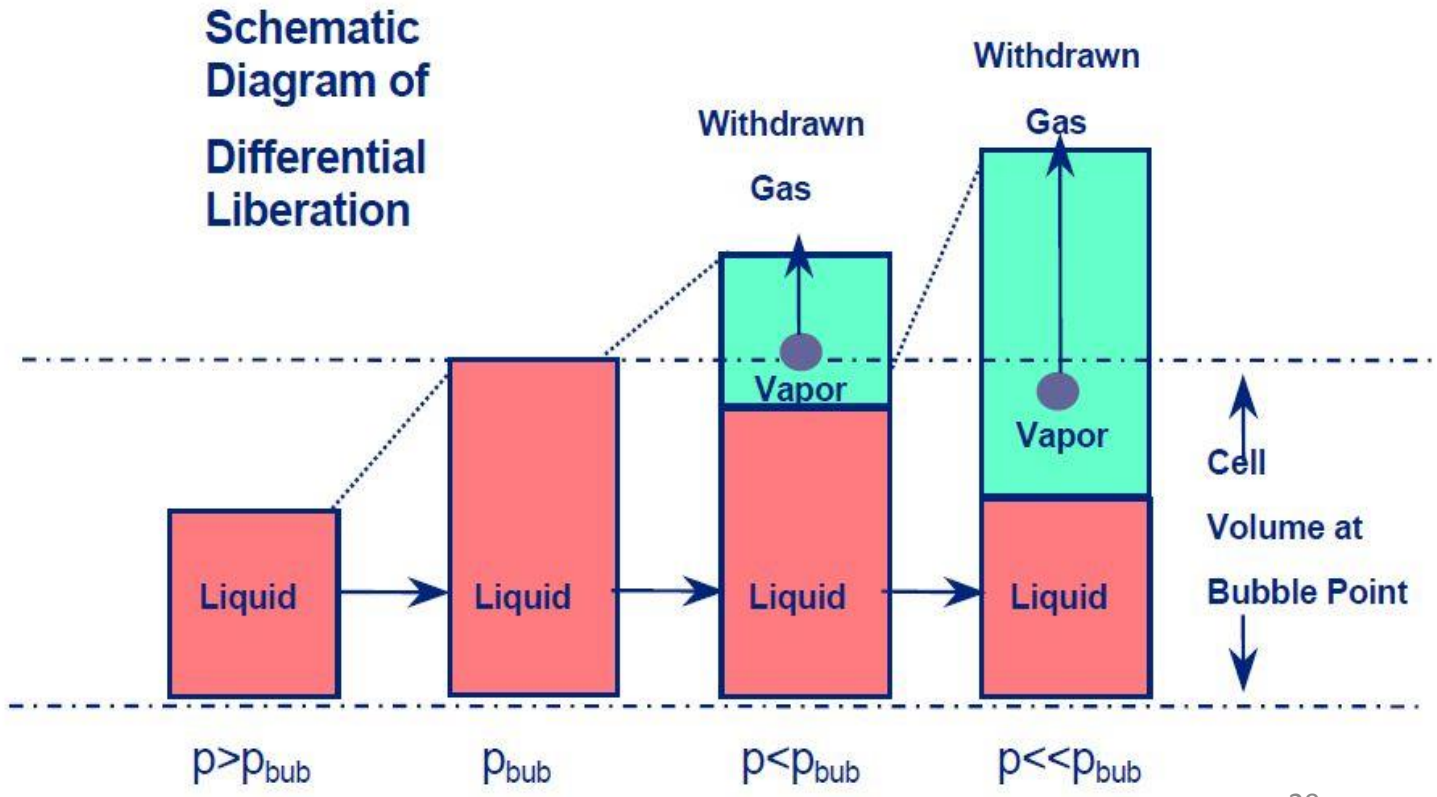


PVT Laboratory Tests

Pressure Depletion Tests

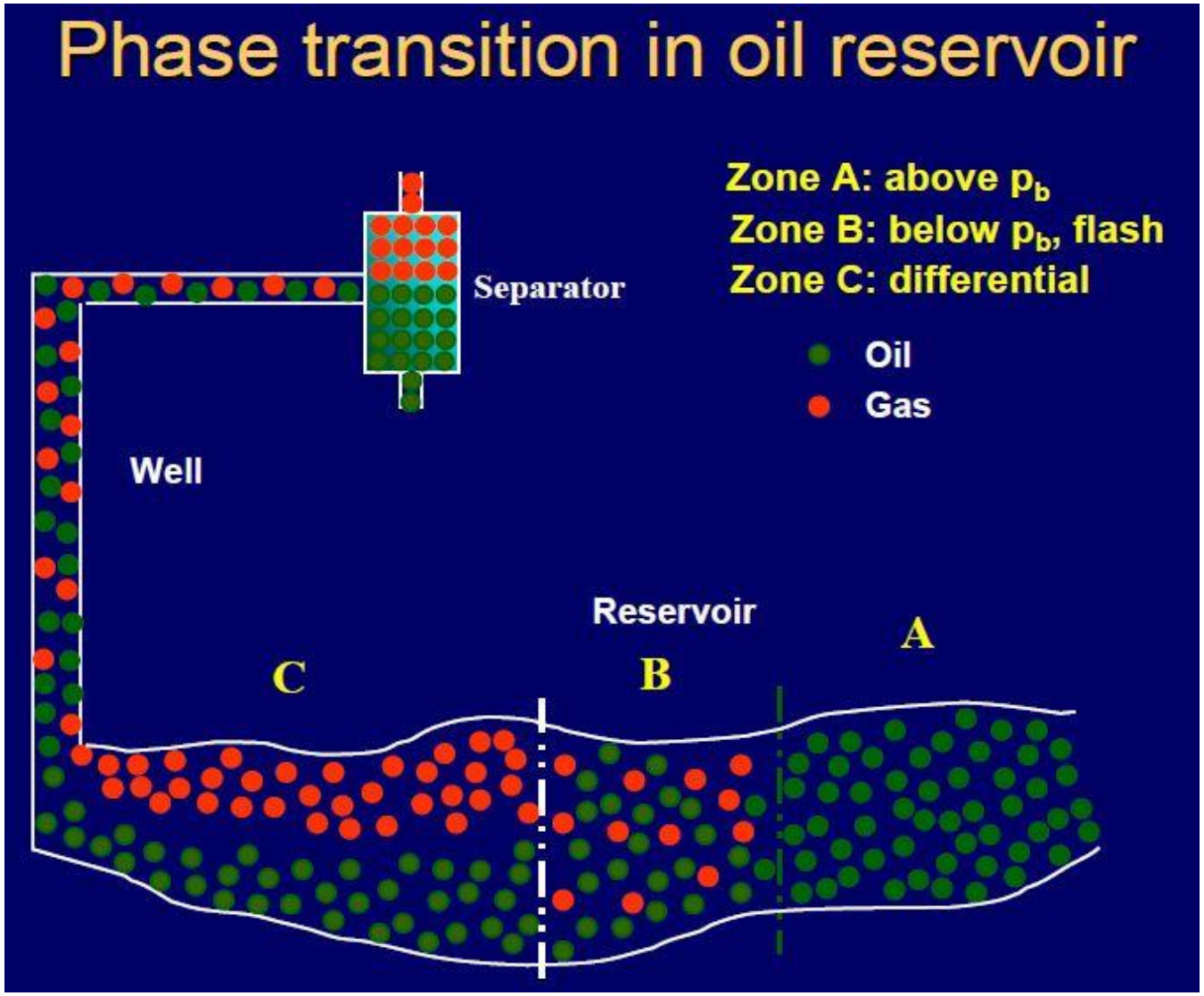
Differential Liberation (DL)

Non volatile oil



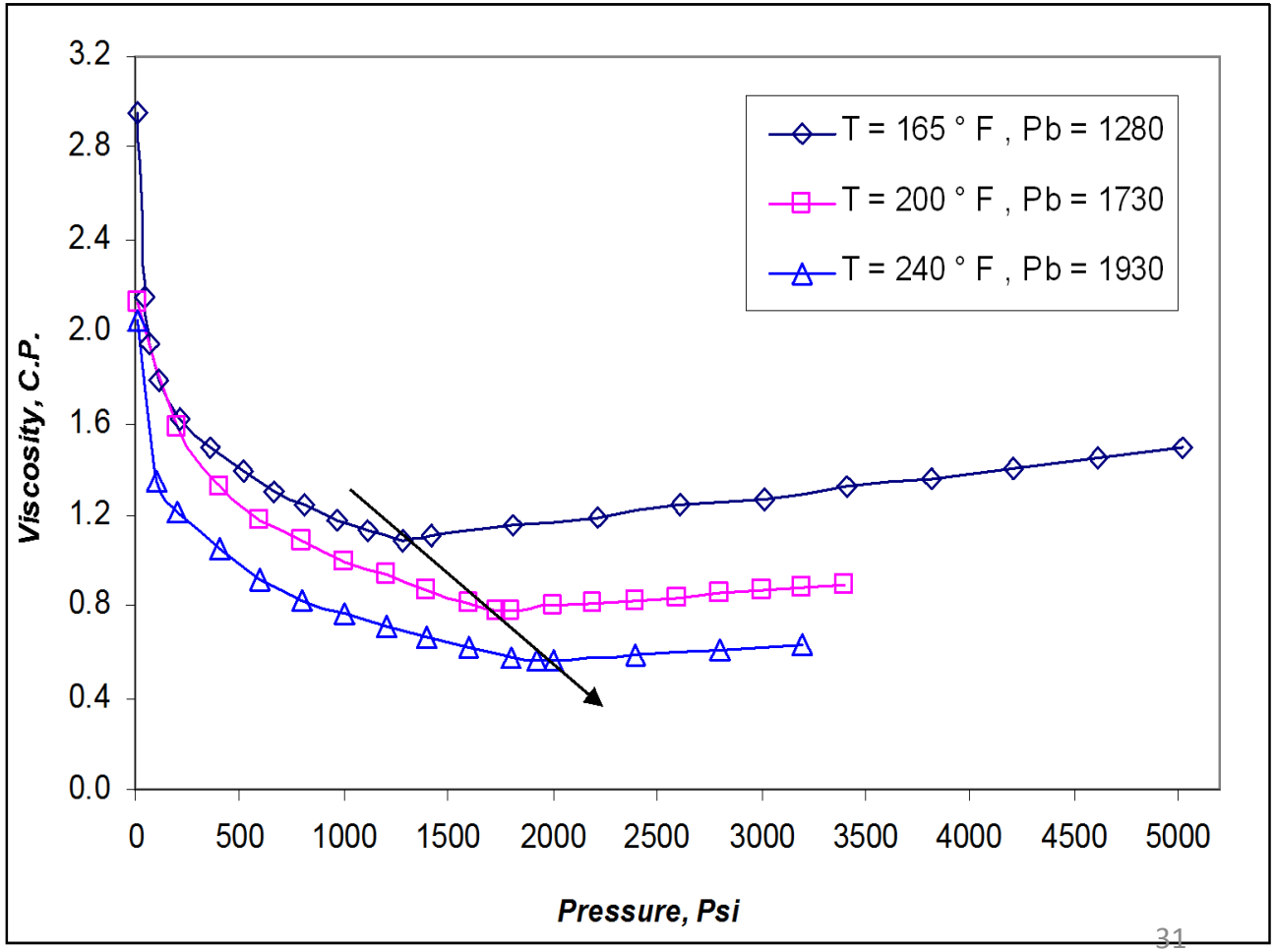
PVT Laboratory Tests

Pressure Depletion Tests



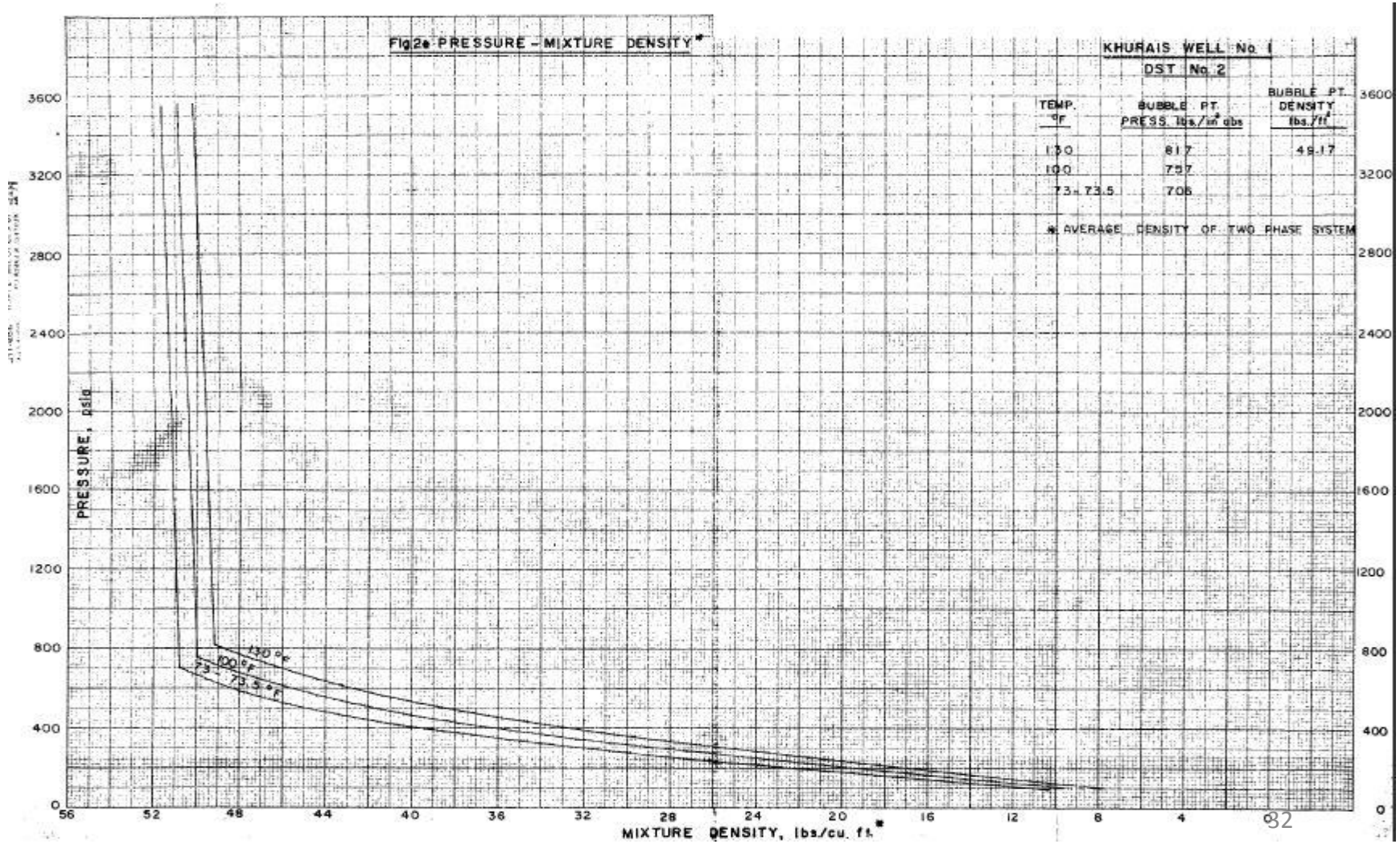
PVT Laboratory Tests

Viscosity Test



PVT Laboratory Tests

Density Test



PVT Laboratory Tests

Separator test

SEPARATOR TESTS OF RESERVOIR FLUID
BLIND CELL METHOD

SEPARATOR				Stock Tank Oil Gravity °API	Formation Vol. Factor V_{sat}/V_r /2	Sp. Gr. Of Flashed Gas
Stage	Press psig	Temp °F	GOR /1			
1	50	100	233			0.9967
2	0	100	55	33.1	1.1765	1.4105
	TOTAL GOR /1		288			
1	100	100	192			0.9215
2	0	100	96	33.1	1.1763	1.4007
	TOTAL GOR /1		288			
1	100	135	210			0.9804
2	25	110	34			1.2110
3	0	100	32	33.2	1.1712	1.5094
	TOTAL GOR /1		276			

Compositional Analysis of Gas from Three Stage Separator Test, Mole % /3

Component	1st Stage	2nd Stage /4	3rd Stage
H_2S	0.02 /5	0.04 /5	0.05 /5
CO_2	4.48	13.78	1.55
C_1	49.25	32.42	5.94
C_2	24.18	29.37	28.06
C_3	14.88	19.71	40.26
i-C_4	1.22	1.64	4.35
n-C_4	3.58	2.18	13.23
i-C_5	0.68	0.31	2.31
n-C_5	1.20	0.55	3.26
C_6	0.51	Trace	0.99
TOTAL	100.00	100.00	100.00

GOR in cu. ft. of gas at 14.7 psia and 60°F/bbl stock tank oil at 60°F.

Formation Volume Factor, V_{sat}/V_r = bbls of saturated oil at 817 psia (Saturation pressure) and 130°F per bbl of stock tank oil at 14.7 psia and 60°F.

Compositional analysis of gases performed by Ras Tanura Oil Operations Laboratory on VPC (Vapor Phase Chromatography).

Analysis of 2nd stage gas does not seem to be correct but there was not enough gas sample for a recheck.

Determined by Tutweiler method; accuracy is ± 0.1%.