Overview

Following topics will be addressed in this course:

- A zone can be defined for any interval between two selected depth.
- Estimating Water, oil and gas production from every defined zone.
- Productivity index for each selected zone.
- Reservoir pressure for each zone. Variations in zone-to-zone pressure highlights uneven depletion.
- Detection of leaks behind and inside casings.
- Estimation of cross-flow between zones caused by uneven depletion, without the need to shut the well.
- Water coning: estimating the effects of water coning by using different chokes.
- Single-phase, two-phase and three-phase production in vertical, deviated and horizontal wells.
- Theory and applications of modern logging tools: spinners, micro-spinner, hold-up tool, direct fluid velocities logs.
Production Logging Challenge

Production Logging Basics:
Oil, water and gas can be produced anywhere over the producing intervals. To estimate the production of water, oil and gas (Qw, Qo, and Qg) from every zone and subzone.

Productivity Index and zone pressure:
The productivity index (PI) is affected by many factors that can’t be estimated theoretically. By running production logs using 2 or 3 chokes, the PI and zone pressure can be estimated for any production interval.

Uneven Depletion and cross-flow: Most reservoirs have a large heterogeneity in permeability, hence flow profiles resulting in uneven depletion and variations in zone-by-zone pressure. This will result in cross-flow for both: when the well is shut-in and at small chokes.

Horizontal Well Production: Flow regimes in horizontal wells tend to be more complex with large variations in velocities and hold up. A new generation of logging equipment (micro-spinners, micro hold up probes) are deployed.

Leak Detection: Most wells will develop leaks at some stage in their operational life.

Logging Tools and applications:
- Spinner calibrations
- Direct velocity measurements of the 3 phases
- Hold up measurement of the 3 phases
- Estimating the effects of water coning
This course addresses very important aspect of well performance, which is production logging. This has a critical role in controlling the recovery factor.

**Production Logging:**
The course focuses on outlining the process of production data acquisition and interpretations in vertical, deviated and horizontal wells. The objectives are aimed at:

- Estimating productivity index (PI) and reservoir pressure for each selected interval.
- Estimating inter-zone cross flow without shutting the well
- Evaluating the water production intervals caused by coning and behind the casing leaks.
- Strong emphasis on horizontal wells production, because of the complexity of flow regimes, and large variations in hold-ups and fluid velocities for small variations in the well trajectory angle.
- 20 field examples are used. The interpretations steps are simplified so the most complicated data set should be completed within 10 minutes.

This course is a must for anybody involved in field development to optimise field recovery factor and minimise water production.
Running the spinner at different velocities, in the opposite direction to the flow, provides the basis for spinner calibrations at any desired station, above perforations (B and C above) and at any station within the perforations (e.g. X). The slope of the straight line plot is the spinner sensitivity (velocity/rps which for a given spinner depends on the fluid type) and the intercept on the y-axis which is the raps due to the flow.
Microspinner calibrations in horizontal wells are often limited by the number of passes. In most cases, there will be a logging-in at a given speed, then a logging out at a given speed. Moreover at selected stations, stationary spinner readings are also taken. The stationary readings are essential for the case when logging out shows a negative or zero values as shown on the two bottom stations above.
Two chokes to obtain PI and Pr for each zone Calibrations

Having Pr and PI for each layer will allow the shut in pressure to be computed and hence the volume of cross-flow when the well is shut-in, or the cross-flow at low chokes and flow rates. This technique is the most accurate approach to characterize each zone without the need for any assumptions of value of permeability, skin or drainage area.
Water production is a serious production limiter in most fields. One common reason in high producers is water coning. Example shows how the water production drops by 80% without reducing (and often increasing) the oil production when the choke is decreased. A change in the choke from 2 1/8 to 1 7/8 reduced the top of the water entry level by 25 ft and increased the oil production by 700 bl/d.
Production Logging in Horizontal Wells

Horizontal wells provide more challenges to production logging. Variations of velocities and hold-ups will span a wide range for little variations in flow volumes. This is caused mainly by small variations in the well trajectory around 90 degrees.

New technology, like the FlowScanner Imager (FSI) are effective in evaluating multi-phase flow in horizontal wells.
Production logging in gas well is also essential to determine the flow profiles and the AOF (Absolute Open Flow) for each selected zone or intervals. This is an important tool for problem diagnostics and optimized production. This production profile data is obtained by running two production logs at two chokes.
Leak Detection

Temperature profiling is one of the most accurate means to detect leaks inside and outside the casing. The example is using fibre-optics permanent sensors to monitor leaks on a continuous basis.

Oxygen activations is a very effective way to detect water flow inside and behind the casing.
Agenda

Day-1
• PL Overview
• Inflow Performance (IP) in oil and gas wells
• Well Completions
• Flow regimes in vertical, deviated and horizontal wells

Day-2
• Slippage velocities: theory and empirical charts applications.
• Various techniques to measure fluid velocities
• Spinner calibrations in multi-phase flow regimes.
• Holdup measurements in 3 phase flow: Various tools and their applications.
• Reynolds number and its applications to production logging

Day-3
• Temperature profiling to detect leaks.
• Temperature profiling in flowing wells to estimate production and to detect leaks.
• Permanent temperature sensors using fibre optics: Theory and applications.

Day-4
• Equations applied in multi-phase flow regimes
• Single phase flow
• Water coning and its interpretations
• Production logging in gas wells.
• Uneven depletions and cross flow computation without shutting the well.
• Two phase Flow

Day-5
• Three phase flow.
• Production logging tools in horizontal wells
• Production log interpretations in horizontal wells.

There will be daily practical workshops on each of the topics covered using field examples