Introduction to Oil&Gas Well Drilling

Drilling | Introduction to Oil&Gas Well Drilling

The term drilling indicates the whole complex of operations necessary to construct wells of circular section applying excavation techniques.

To drill a well it is necessary to carry out simultaneously the following actions (drilling process):

- to overcome the resistance of the rock, crushing it into small particles measuring just a few mm;
- to remove the rock particles, while still acting on fresh material;
- to maintain the stability of the walls of the hole;
- to prevent the fluids contained in the drilled formations from entering the well.

This can be achieved by using rotary drilling rigs which are the ones operating today in the field of hydrocarbons exploration and production.

The drilling rigs are complexes of mobile equipment which can be moved (onshore and offshore) from one drill site to another, drilling a series of wells.

In rotary drilling the rock is bored using a cutting tool called the bit, which is rotated and simultaneously forced against the rock at the bottom of the hole by a drill string consisting of hollow steel pipes of circular section screwed together.

Land Drilling Rig

The cuttings produced by the bit are transported up to the surface by a drilling fluid, usually a liquid (mud or water), or else a gas or foam, circulated in the pipes down to the bit and thence to the surface.

The rotation is transmitted to the bit from the surface by a device called the rotary table or, in the modern rigs, by a top drive motor with the rotary table as backup; additional rotation can be added by downhole motors located directly above the bit.

After having drilled a certain length of hole, in order to guarantee its stability it has to be cased with steel pipes, called casings, joined together by threaded sleeves.

The space between the casing and the hole is then filled with cement slurry to ensure a hydraulic and mechanical seal.

The final depth of the well is accomplished by drilling holes of decreasing diameter, successively protected by casings, likewise of decreasing diameter, producing a structure made up of concentric tubular elements.

Planning the drilling of a well

The planning of a well is a fundamental part of the drilling process – it is the basis for making all the important technical choices, for assessing the costs and organizing the actual construction of the well in the most efficient way.

The well planning starts the moment when the interpretation of the seismic data and the reconstruction of the geology of the area reveal the presence of a structure favourable to the accumulation of hydrocarbons.

These data also enable an estimate to be made of:

- depth of the productive levels; stratigraphic and

lithological sequences; problems that could emerge in an operational phase.

Geologists prepare a document containing estimates and proposals for drilling the well on the basis of the information in their possession obtained from:

- geological surface campaigns; regional geological studies; studies conducted on seismic maps; profiles of wells already completed in the area.

This document is the introduction to the drawing up of the proper drilling program to give the data necessary for:

well location, drilling objectives, foreseen of the final depth, forecasts of the litho-stratigraphic profile, possible drilling problems that could be encountered, etc.

Overview of the well planning process (from PETEX, University of Texas)

The analysis and processing of all this large mass of information provides the drilling engineers with the essential elements for drawing up the drilling program.

These data are available from existing documents such as:

- Geological profiles; Well Logs; Pressure reports; Drilling reports; Drilling fluid reports; Cementing reports; etc

Every well has its own specific features (depth, exploratory, development or appraisal well, onshore or offshore, vertical, directional or horizontal..) but the basic criteria are the same for all well types.

The first step to be taken by engineers to work out the drilling programme is to construct, the trend of the pressure gradient curves according to depth (geostatic, pore pressure and fracture gradients) to design the well casing profile.

Choice of rig, wellhead and BOP

The casing levels, the diameters and weight of the strings, the pressures and temperatures concerned, and the volumes of drilling mud to be used, are all aspects participating in determining the choice of rig type, blowout prevention systems (BOP, choke manifold, hydraulic circuit) and wellheads.

The choice of rig is closely bound up with the depth it is wished to reach and with the weight of the strings concerned.

According to the weights of the strings to be handled, rigs are used that have different characteristics, and what is of basic importance is the strength of the whole assembly, (travelling block, crown block, hook and derrick floor) from which the string hangs while being lowered into the well.

In offshore activity, the choice of the rig is determined, not only by the weight of the strings, but also by the depth of the water in the area of operations.

Drilling rigs installed on offshore vessels or platforms are built to reach the maximum possible depths and have all the material and equipment necessary for drilling on board.

The composition of the wellhead depends on the pressures that can be reached during the various working phases – both drilling and production – and on the diameters of the strings to be lowered into the well.

Control of drilling operations

The great complexity of the drilling process, its high costs, the need to ensure the full efficiency of the rig and the respecting of safety and of the environment call for a continuous optimizing of operations, which are achieved through the monitoring and processing of all available data, both geological and drilling.

To reach these objectives, every drilling rig, and in

particular those that have to drill complex, deep and therefore costly wells, is endowed with more or less sophisticated mud logging units, which permit – through appropriate sensors and the activity of specialized personnel – the acquisition, processing and interpretation of a vast range of information of interest both to the geologist and to the drilling engineer.

Mud logging units are equipped with sensors, positioned in appropriate parts of the rig, permitting the automatic, continuous acquisition of the most significant parameters, and advanced information systems, based also on expert systems, as the means of managing operations in real time, with the consequent reduction of time and costs.

A mud logging unit (from Petroservices GmbH)

These sensors transmit their signals to a computerized system housed in the mud logging cabin, which provides for their representation also in graphic form, their storage in special local data banks, and the sending by means of radio links, dedicated telephone lines and communications via satellite, of selected data to operational centres.

Drilling costs

The drilling programme indicates also the budget that it is necessary to allocate to reach the targets, and which has to be adhered to during the construction of the well.

The costs of drilling a well can vary, depending on the particular type of well planned and the environment.

The budget contained in the drilling programme indicates the amount of the economic resources available in the estimate, which has to be adhered to as far as possible; but it is obvious that the real amount depends on the problems that crop up during drilling and on the capacity of the engineers to address them promptly without compromising the achieving of

the objectives.

Well abandonment

If, when drilling has been completed, the well is productive hydrocarbons, a start is made on all those operations that will ensure its economically advantageous working, whereas if, on the contrary, it should prove to be barren or in any case not economically exploitable, it will be shut down.

Well shutdown entails the restoring of the initial conditions of the section of the well not lined and possibly also the lined part, if separation of the permeable levels of different pressure is not assured.

The purpose of these measures is to prevent the transfer of fluids from one level to the other.

The final shutdown of a well must satisfy not only the requirements set out in the engineering best practices fixed by the operator, but must also respond to all the requisites of law aimed at safeguarding the environment and the safety of the people living in the vicinity of abandoned wells.

Well Site Restoration (from Marcellus shale, US)

Well Plug & Abandonment (from Schlumberger)