Drilling a well

Oil and gas wells are drilled down into the earth in order to access hydrocarbon reservoirs. The wells provide a conduit for the oil and gas to flow to surface.

Various types of “drilling rig” are used to drill these wells depending on the application. The rigs are built up of the heavy machinery and specialist equipment required to drill thousands of metres down into the earth.

The rigs use drilling “bits” in order to drill the hole deeper. The bits are connected to the surface via high strength steel “drill pipe” that allows lubricating “drilling mud” to be pumped down to the bit and also for torque to be transmitted from the rig.

Once back at surface the mud is conditioned by shale shakers, desanders, desilters, centrifuges, degassers and mud-gas separators. These tools are used to recondition the mud back to its original spec before being pumped back into the well.

The drilling mud is required to cool and lubricate the bit, support the bore hole, hold back formation fluids, remove drilled cuttings from the bottom and transport the cuttings back to surface.

A well is drilled in sections, the lengths of which are determined primarily by the magnitude of the formation pressure at the bottom of a section compared with the fracture pressure at the top.

Essentially a section can be drilled as deep as possible before the pressure of the formation fluid starts to approach the strength of the weakest exposed rock.

Once a section has been drilled, steel pipe known as “casing” is run into the well and cemented in place. This casing seals off the formations, protects freshwater aquifers from contamination, provides strength and consolidates the well as it is drilled deeper (Figure 4).

At the very top of the well an adaptor (called a wellhead) allows pressure control equipment to be connected to the well. This equipment takes the form of a stack of high-powered rams (called blowout preventers) that can be closed in around the drill pipe.
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Once a well has been drilled to its target depth, the reservoir – if present, can be evaluated using specialist well logging tools or subjected to more extensive testing in the form of a “well test”. If the results of these processes show a commercial hydrocarbon reservoir is present, the well may be “completed”. In a completion equipment is installed in the well that is capable of delivering the hydrocarbons to surface safely.

Following the drilling, testing or completion phase of a well it may be either abandoned or suspended. Abandonment is the process of leaving the well permanently, whereas suspension is leaving with the intention to return. It is common for wells that have not discovered any hydrocarbons to be permanently abandoned and wells that have been tested or completed to be suspended.

Rigs | Types of rig

Land Rigs
Land rigs are designed to be used onshore. As a result, they must be routinely assembled and disassembled in order to move between locations.

Land rigs must; allow for rapid rig up and rig down; must break down into as few pieces as possible; must not require specialist cranes for assembly; must have sufficient power to hoist the drill pipe and casing to depth; and must provide the maximum amount of available power to circulate drilling fluid.

The most common type of land rig is the Mast Rig (Figure 5). On a mast rig the tower that supports the drill string is designed to be very stiff, allowing it to be broken down into fewer pieces than on a traditional Derrick Rig. On a derrick rig the tower must be broken into many small pieces during a rig move.

Some small land rigs are also mounted directly to transport trailers or trucks. This allows for very simple transportation, but significantly limits the capabilities of the rig.

Offshore Rigs
Offshore Rigs are designed to drill on bodies of water. These rigs must provide stability on the water during drilling operations; with the exception of fixed platforms, must be portable to allow transport between offshore locations; must have sufficient power to hoist drill pipe and casing to depth; and must provide the maximum amount of available power to circulate drilling fluid.

Various types of offshore rig are available depending on the environmental conditions. Jack up rigs are one of the most common offshore rig types. Designed to support the rig via legs that extend to the seabed, jack ups are only capable of drilled in water depths up to around 400ft. This feature makes them very stable but limited to drilling in inshore waters only.

Semi submersibles are rigs that are supported by pontoons that extend horizontally beneath the rig. These pontoons are filled with water to stabilise the rig and sit beneath the surface. “Semi subs” as they are known, are suited to drilling in deeper water and are held in place by anchors or dynamic positioning systems.
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Drillships are mono-hulled vessels with a derrick built in the middle of the deck. They can drill in very deep water and are almost always held steady by dynamic positioning systems (Figure 6). Platforms are fixed offshore structures built to produce hydrocarbons from a reservoir.

Many wells can be drilled from a platform with produced hydrocarbons transported back to shore via a subsea pipeline.

Rig systems
The rig derrick/mast takes the weight of the drillstring when it is suspended in the well. The derrick/mast is built onto a substructure which supports both the derrick/mast and the rig floor. Power to the rig is provided by a series of engines. The primary function of the engines is to power the drawworks that is responsible for hoisting the drillstring into and out of the well. The drawworks uses wire rope called “drilling line” wrapped around a large drum to support all items lowered into or pulled out of the well.

From the drawworks the drilling line is run up to the top of the derrick/mast where it is fed around pulleys in the crown block. From the crown block it is fed into the travelling block where it terminates. The travelling block supports the top drive which is a high-powered component responsible for turning the drillstring.

The top drive also provides a conduit for the drill fluid to be pumped from the mud storage pits into the drill string itself.

In order to pump the mud from the storage pits to the top drive, down the well and back to surface high powered “mud pumps” are installed on the rig.

The pumps force the drilling fluid from storage tanks (known as mud tanks or mud pits) through the standpipe and up the derrick, through the rotary hose and into the top drive, down the drillstring and out from the bit. Once out of the bit the mud carries the drilled cuttings up around the outside the drillstring and back to the surface.

Once back at surface the mud is conditioned by shale shakers, desanders, desilters, centrifuges, degassers and mud-gas separators. These tools are used to recondition the mud back to its original spec before being pumped back into the well.

The drilling mud is the primary means of holding back formation pressures. The mud is designed to meet specific density requirements that ensure the column of mud exerts the required pressure back onto the formation. If this effective density gets too low, or the formation pressures are higher than expected, formation fluids can enter the wellbore.

This type of event, known as a kick, must be controlled otherwise large volumes of formation fluid could enter the well and eventually reach surface uncontrolled. This would be known as a blowout. To reduce this risk a large assembly called a blowout preventer (BOP) stack is installed on top of the well.

The stack is made up from a combination of individual blowout preventers, some are ram type with specific pipe profiles they fit around and others are annular type that fit around all profiles. These BOPs can be lifesaving in the event of a blowout.
The “rig floor” is where the main drilling activities take place. It is here that the joints of drill pipe are connected and run into the well, where the pipe is rotated and where mud flow is controlled. In order to connect joints of drill pipe together large wrenches known as tongs are connected to the two joints and torque applied. This can also be done using an iron roughneck which is fully automated.

Once the two joints are connected, they can be suspended from the rig floor itself using “slips”. Slips are a tool that wrap around the pipe and wedge it in place in the rig floor.

When the drill string needs to be lowered or raised the top of the string is connected to an “elevator” tool. The elevator has an in-built shoulder that the top connection of the drill string rests against. This allows the full weight of the string to be taken by the rig when not drilling.