Chapter 8 - Drilling for Oil or Gas

When more than one company joins together to drill an oil and gas well, one of the companies is designated as the operator of the project. This company works on behalf of the entire group of non-operators to drill, test, complete, produce, and manage the operations and administration of the well.

Most exploration and production companies do not staff their own *drilling* personnel nor do they have their own drilling rigs. When this is the case, the operator solicits bids from drilling contractors for the drilling of the proposed well. A document which reflects these estimated costs and is used to determine the commitment level of each of the non-operators is sent to these owners. This document is called an *authorization for expenditure* (AFE).

The AFE gives each of the non-operators a certain time frame in which they can elect to either 1) join in the drilling project with their participation or 2) not join in the drilling project with their *non-consent election*. Since a commitment to drill may involve hundreds of thousands of dollars or even millions of dollars, if a non-operator feels that the well is too risky or the geology does not indicate the possibility for success, they may not join in the drilling of the well.

Once the drilling project is approved through the AFE process, permits are obtained, state regulatory agencies are notified and drilling operations can proceed.

Since the exploration company would desire to drill the well in the most advantageous location for the discovery of oil or gas and to make sure that the drilling site is exactly the same spot as the company geologist had in mind, a surveyor is called upon to stake the location. Because the surface location must be nearly level and of sufficient size to hold the drilling rig, tanks, equipment and to build pits, not every surface location would be ideal. Usually road building equipment is needed to create access to the site and to excavate the spot for the drilling rig which may be trucked to the location in several parts.

The Rat hole

Very often drilling begins with a small drilling rig called a *"dry-hole digger."* A smaller-diameter hole is drilled near the main bore hole 20 to 35 feet deep. This is called a *"rat hole".* It is lined with casing and is used for the temporary storage of a piece of equipment called a "kelly". The kelly is a part of the drill string that rotates the drill bit. At one point, the operator will replace the dry-hole digger with the larger drilling rig.

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Rigging up

Large pits are dug that contain water for drilling operations or to hold the rock and mud that comes out of the hole. Pipes, drilling fluid, drill bits, engines, pumps, rotating and hoisting gear, and other equipment are all laid out in preparation for the drilling. Water and fuel tanks are filled and drilling mud is placed in pits. This process is referred to as *"Rigging up".*

Spudding the well

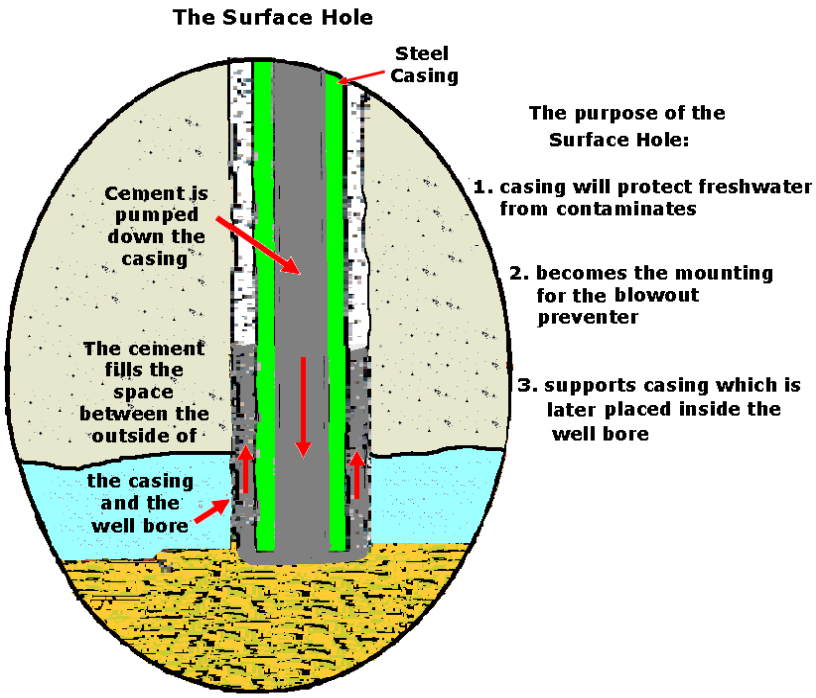
At the point in time that everything is in place, drilling begins. The initial drilling is called "spudding the well" or "spudding in". The word spud is derived from the Middle English word, "spudde" (a short knife). In the oil and gas industry, spudding simply means the beginning of the drilling of the new well.

According to the *American Petroleum Institute,* the spud date is when the drilling bit penetrates the surface utilizing a drilling rig capable of drilling the well to the authorized total depth.

Drilling the surface hole

When the well is spud, a large drill bit begins to drill what is known as the *"surface hole."* This hole is drilled to a preset depth (several hundred to several thousand feet deep) and will be used for several purposes. The surface hole will be lined with casing in order to protect freshwater from contaminates; will become the mounting location of the blowout preventer; and will support later casing placed inside the length of the well bore.

Once the target depth for the surface hole is reached, the drill string is removed and steel casing is inserted. Cement is then pumped down the casing. As it is pushed to the bottom of the hole, the cement begins to move back up-hole filling the space between the outside of the casing and the well bore. The cement is forced all the way back to the surface.



This procedure will protect freshwater from being contaminated and also encase the surface casing. Once the cement is secure and set, another vital piece of equipment is set in place known as the *"blowout preventer".* This device is required and will contain any high-pressure gas from blowing out through the well bore. Once this happens, normal drilling operations can resume.

Drilling to total depth

The drilling rig is equipped with its own generator which provides the power to turn the drill string (drill pipe, drill collars, drill bit, and kelly). At the end of the pipe is attached the drill bit made from very hard material, often steel or diamond.

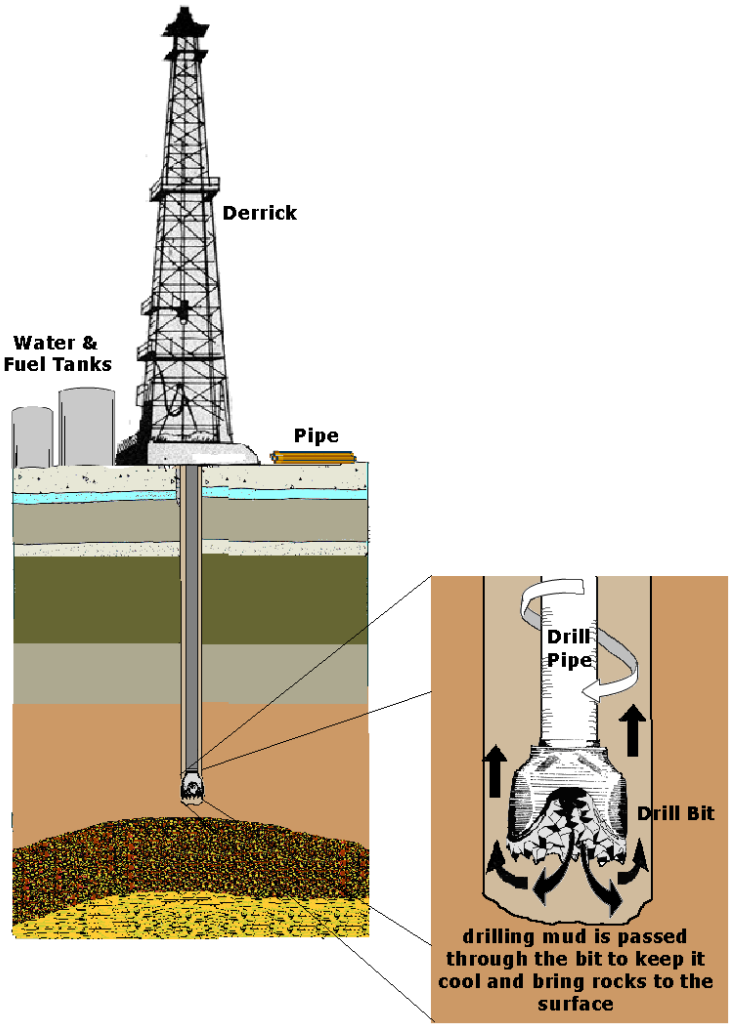
The concept for drilling an oil and gas well is similar to that used with any type of drilling. A drill bit is attached to a string of hollow drill pipes. The bit bores a hole in the ground by cutting through the rock. As the bit turns, rock and other layers of sediment are broken up. As the bit reaches deeper, additional pipe is added.

Drilling fluid, also known as, *drilling mud* which is a combination of water, clay and chemicals is pumped from nearby pits or tanks and passed through the kelly, pipes, and collars and is circulated back to the surface. This mixture has a four-fold purpose:

1. Lubricating and cooling the drill bit
2. Transporting rock fragments to the surface
3. Coating the borehole to help prevent cave-ins
4. Equalizing the pressure inside the borehole. This is vital since the pressure from the formation can be greater than the pressure from the well bore. When this occurs, fluids from the formations will begin to

flow up the well bore and inside the drill pipe. Equalizing the pressure will help prevent blowouts.

Periodic testing of the rock cuttings that come out of the ground is performed to determine when the hole has reached the reservoir.

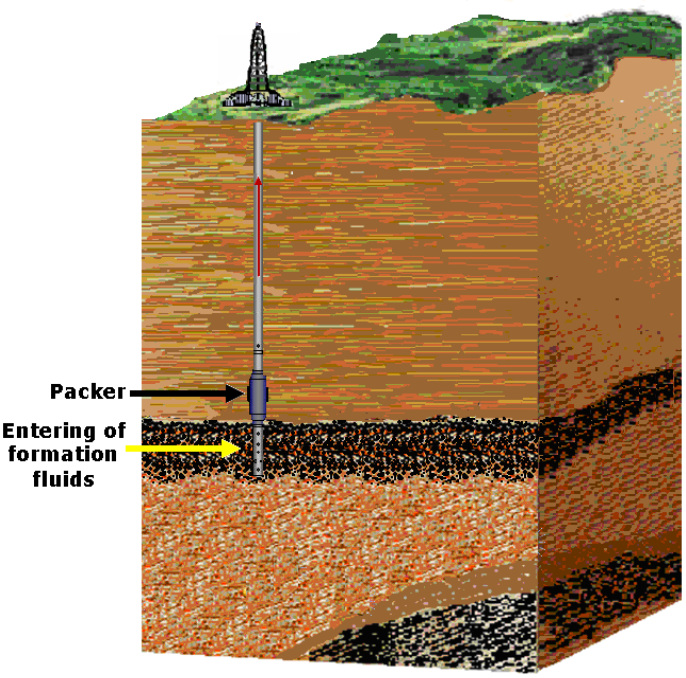


Drilling continues with limited interruptions. From time to time, drilling must stop in order to replace the drill bit (known as *"tripping"*) or to test formations (known as "*drill-stem testing"*). On occasions, the drilling will encounter major problems such as having the drill stem break off (known as *"twisting off"*). Those working on the platform have even been known to accidentally drop a tool down the well bore. This seemingly minor problem can wreck havoc on the drilling schedule unless the tool can be pulled out through what is known as a "fishing tool".

During operations, a geologist is located at the site. His function is to examine the fragments of rocks being pushed to the surface for any sign of oil or gas. The rocks or drill cuttings can tell the geologist the formations and type of rocks the drill bit is encountering.

Drill-Stem Testing

Drill-stem testing is achieved by first removing the drill string and bit. A drill-stem test tool with a packer is fed down the hole to a specific testing depth. The packer is designed to expand in order to isolate the zone that is to be tested. A valve can be opened or closed in order to capture formation fluids into the drill string. The fluids that flow into the test tool and drill string are analyzed for content, pressure and rate of flow.



Well Logging

Drilling a well can take as few as a hand-full of days or as long as several weeks. Each day of drilling equates to additional costs. The deeper the well is drilled, the more expensive the costs run. The more difficulties encountered, the higher the price tag becomes. During this time, daily drilling reports are given to the operator who, in turn, passes these reports on to each of the participating non-operators.

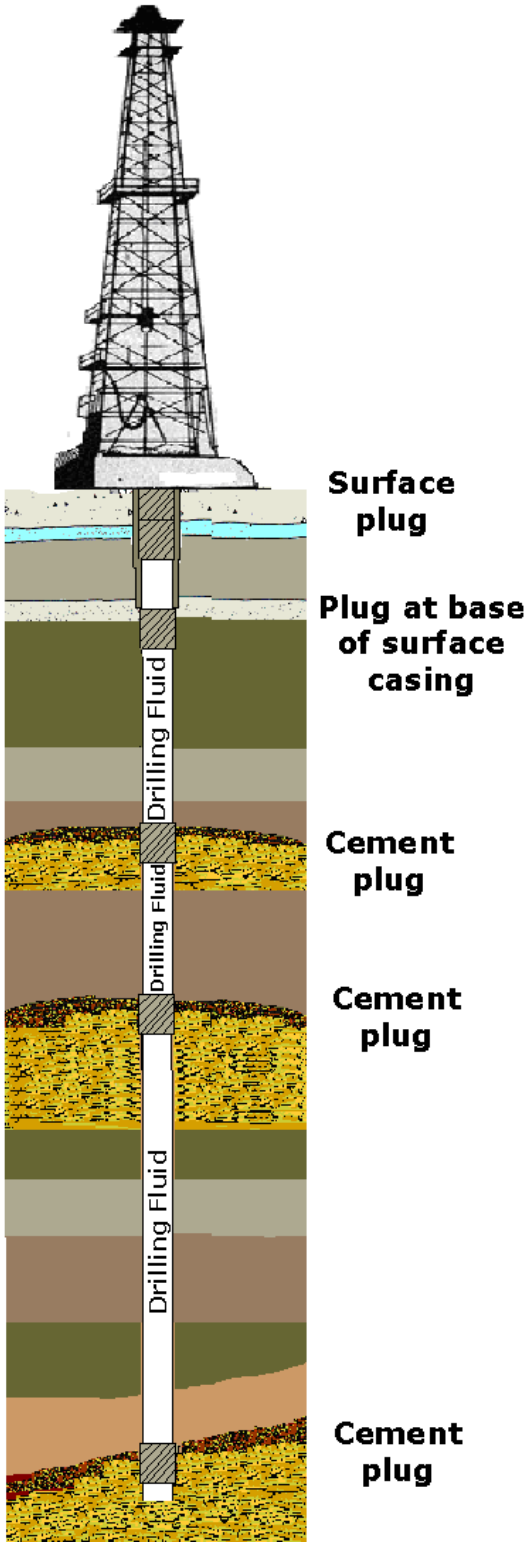
Target depth is reached once the drill bit has penetrated past the cap rock and into the reservoir. The drill string is once again removed from the borehole in order for well logging equipment to be inserted in the hole. These logging tools are lowered to the bottom via a cable which contains electrical circuits that will evaluate and measure several characteristics of the rock formation:

1. Electric logs measure the effect of electricity being induced in the formations
2. Radioactivity logs measure radioactivity and the effect of induced radioactivity in the formations
3. Sonic logs measure the speed of sound waves as they pass through the formations

Each test is evaluated in order to determine the location of various types of rocks, thickness of formations, porosity and permeability of reservoir rocks and presence of oil or gas.

Plugging the well

Once the drill-stem testing and the well-logging has been completed and analyzed, it can be determined if there are sufficient hydrocarbons to produce an economically feasible well. If the outcome is in the positive, plans will be implemented to complete and produce the well. If the well is determined not be commercially viable, the well is classified as a “dry hole” and will typically be plugged and abandoned.



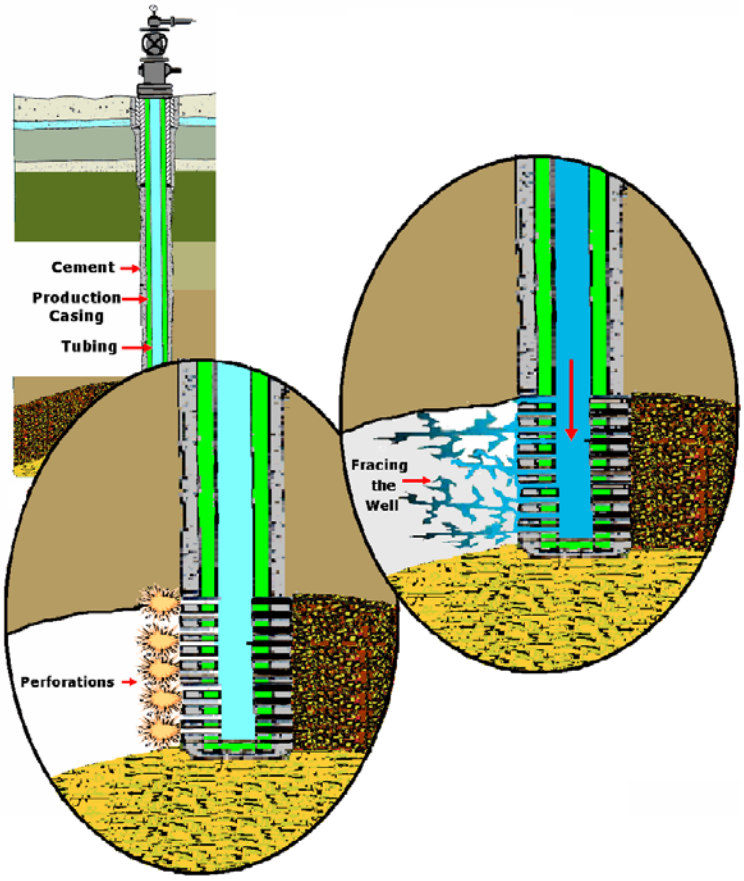
If the decision is to plug and abandon the well, the following steps will be taken:

1. A mixture of drilling fluid and additives are pumped into the well bore hole. The additives in the fluid stop it from being absorbed into the formation walls of the well bore.
2. Cement plugs will be placed at any formations where porosity was detected. These plugs will stop the formation fluids from traveling from one zone to another zone.
3. The cement that forms these plugs is forced into the well bore hole through the drill string placed at the appropriate formation interval where porosity was detected.
4. The drill string is then drawn up the hole to the next interval so that this area of the well bore can be cemented.
5. This procedure continues until the appropriate intervals have been cemented.
6. A cement plug is also placed at the base of the surface casing and at the surface of the well bore.
7. All equipment is removed from the location and the pits are backfilled so that the drillsite can be restored to original condition.

Completing the well

If it has been decided to complete the well, the following steps will be taken:

1. The well bore will be filled with an additive based drilling fluid that will inhibit the deterioration of the casing.
2. The casing (steel pipe) is lowered into the well bore.
3. Cement is injected into the casing and forced to the bottom of the hole, out the end of the pipe, upward to a specific height encasing the steel pipe in the cement.
4. The drilling rig is removed and replaced by a workover or completion rig.
5. In order for the flow of oil and or gas into the casing, holes known as perorations must be blown through the steel pipe and cement. This is done with a tool that is lowered into the hole with a cable. The cable contains electrical circuits. The perforating tool contains a number of charges. When the charges are in position, they are fired.



6. Tubing (a smaller pipe) is then lowered into the casing.
7. Often the reservoir rock must be treated or “fractured” to enhance the permeability or flow of oil or gas. This is accomplished by forcing acid or other fluids into the reservoir rock at very high pressure.
8. Equipment containing valves and known as a “Christmas tree” is placed at the well head. This will control the flow of oil or gas from the well. There are two types of Christmas trees. One is used for a well that has natural pressure causing the substance to flow to the surface. The other has a mechanism which pumps the fluids to the surface.

Methods for Drilling