Oil Well Drilling Process

from Shell Oil Company

[MACHINERY OPERATING]

PRESENTER: When your job is drilling for oil, you lead a nomadic kind of existence. You're rarely in one place for long. And every time you move to a new location, you take your drilling rig with you. 800 tons of machinery, and a few thousand horsepower to drive it. Setting it all up can take anything from a few days to a couple of weeks.

The choice of site for drilling an exploration well isn't ours. It's made by the geologist and geophysicist from their knowledge of the rocks that lie below, 10,000 feet or more. A classic choice would be over a dome-shaped fold in the rock layers, revealed by seismic survey.

But in this business, that choice is a gamble. The chance you're counting on is that oil and gas, formed somewhere in the vicinity millions of years ago, could have migrated into the dome through layers of permeable rock and have accumulated there, hemmed in by an impermeable layer above. Once there, they would have separated-- the gas on top of the oil, with groundwater round the flanks, all of them at high pressure. That's what we hope has happened. But it could take eight weeks or more to prove it.

We start with a relatively large bit to drill through the soft surface layers, down to 1,000 feet or so. When your target is over 10,000 feet down, you don't just sink a deep hole. You build it carefully, stage by stage.

[CRANE OPERATING]

The drill is driven from the surface, turned by a rotary table on the platform, The drill spring suspended from the derrick. Down below, the teeth of the drilling bit break the rock into fragments. They'd soon choke the hole unless we had a way of flushing them out. What we use is a special drilling fluid, pumped down the drill pipe to cool the bit and carry the cuttings away back to the surface.

The mud, as we call it, is channeled out over fine mesh screens-- the shakers-- to remove the coarse cuttings, and then passed through separators and settling pits to get rid of the finer material before it's recycled back down the hole. As long as the drill is turning, the mud must be kept circulating. But every 30 feet, drilling has to stop to add another section of pipe.

[WORKER YELLING]

[WORKER YELLING]

[WORKER YELLING]

It's a tough job, and it calls for some slick coordination from the floor group. But they all get plenty of practice. On an average well, they'll add pipe over 300 times before they reach the bottom of the hole.

Everything's done to a schedule, supervised by the tool pusher. Nowadays, he doesn't push anything but the drilling program. He's responsible, among other things, for ordering supplies of materials as they're needed, and making sure they arrive on time.

This steel casing, for instance, will be run into the hole when the drill has reached 1,000 feet. It's essential to stabilize the well at this stage to prevent the softer rocks found at shallow depths from caving in. This will be the next job coming up in his program, within the next few hours.

The casing, like drill pipe, is assembled section by section. And each of them weighs a ton or so. These centralizers are fitted at regular intervals to keep the casing central in the hole as it goes down. The casing is lowered in until it reaches a point just above the bottom of the hole. The next job is to cement it home.

The cement is a wet slurry, pumped down the inside of the casing under pressure. Downhole, it flows through the end of the casing and is circulated around the outside and back to the surface, displacing the drilling mud ahead of it. The cement is followed by drilling mud to the bottom of the casing. The pumps are stopped, and the cement is given time to set.

Now we can cap the top of the casing with a set of safety valves, known for obvious reasons as the blowout preventers. If further drilling were to encounter extremely high pressure gas, oil, or water, we could have a problem. To contain it, we need a means of sealing off the hole of the surface. It's done by hydraulic rams that close off the gap between the drill string and the inside walls of the casing.

As we go deeper, heavier wellhead equipment will be installed to control the higher pressures. Once the blowout preventers are fitted, drilling can continue safely to greater depths.

But what if we were drilling not on land, but way out at sea? Our rig might be on a floating platform, anchored 500 feet or more above the drill hole. But we'd still have to follow the same procedures. On a marine well, blowout preventers are every bit as vital, but they have to be put by remote control, sent down on guide wires and locked onto the casing under the watchful eye of a television camera.

[WATER BUBBLING]

On top goes a marine riser, a conductor tube to connect the rig directly to the blowout preventers and the drill hole down below. This gives us the closed system we need for running pipe and circulating mud, just as if we were working on land.

As drilling goes on, the mud return shows the succession of different rock layers we're passing through. Some of them could contaminate the mud and prevent it from functioning properly, so we need to keep a constant check on its composition. The mud must also be maintained at a given viscosity and density. We don't want it altered too much by the rocks we're drilling through.

Frequent checks are also made for any changes in the chemical composition. If we were to hit a layer of salt, for instance, we could be in deep trouble. The mud would cease to do its job, causing the hole to collapse and prevent drilling. We might have to replace the mud with a new supply of an entirely different composition to neutralize the salt.

Up on the platform, an equally close eye is kept on the performance of the drill bit. Cutting through hard rock, its life is usually less than 12 hours. Loss of cutting power occurs when the bit becomes dull, and it makes a distinctive noise. Now it's time to pull the whole string, 90 feet at a time, and stack it in the derrick.

[CRANE OPERATING]

[WORKER CHATTER]

[CRANE OPERATING]

We can easily have 100 strands of pipe in the rack before we reach the bit. Maybe four hours to recover it, another four to run the new one in again. Changing a bit is time consuming, but part of the normal program.

But drilling can sometimes encounter problems that are unpredictable. Conditions downhole might suddenly change and affect the consistency of the mud. If it got too thick, it could bind the drill pipe and stop further drilling. If it happens, you just pull out what you can. Then you go fishing, and with luck, you make contact.

But if the hole itself collapses, you abandon the jammed-in section, and recover the rest by breaking the pipe. You can't drill back down through the blockage. You have to bypass it, using special deviation equipment, offsetting a new hole at a pre-determined angle.

Mechanical troubles don't happen all that often. But on every well, you have to be prepared for hazards of another kind that may lie buried in the rocks below. A sudden increase in mud flow from the well. Stop drilling, and close the blowout preventers. Everything's shut down. The pressures are measured, and the pumps are restarted slowly while the cause cause of the flow increase is identified.

We've encountered high-pressure gas trapped in a shallow sandstone. It's flowing into the well and forcing out the mud. Before we can drill on, we have to contain the formation pressure by pumping down a heavier mud. This is usually kept in the storage tanks, ready for just such an emergency.

At 3,500 feet below, the gas is flowing into the hole. But as the new, heavier mud begins to circulate, the pressure is gradually overcome, and the flow stops. As the pressure returns to normal, the emergency is over. With the mud weight increased, We can now drill the rest of the gas zone. Then the hole can be lined with steel casing. Then with a smaller bit, on towards the target, still a long way to go.

As the drill bites through the cap rock and approaches the target zone, its progress is monitored foot by foot. Inspection of the cuttings will give us the first indication of what really lies below the cap rock, whether or not the choice of drill site was correct. It's sandstone all right, and it could contain oil.

Under the microscope, the sample certainly looks promising. Coarse-grained sand, with a definite dark stain. If it's oil, it will glow yellow under ultraviolet light. It's there all right, but so far only a trace. Not until we've drilled all the way through the formation can we begin to assess its significance.

To find out more about what's down there, we run a special instrument probe. The probe contains devices which measure certain electrical, acoustical, and radioactive properties of the different rock layers and transmits them back to the surface, where they are recorded. As it passes back up through the formations, the nature of the rocks penetrated by the drill, and how much oil and gas they contain, can be determined by the recorded measurements.

Shale. Porous sandstone saturated with oil. Even more porous here. Limestone, nothing much in this case. Then the gas layer. And finally, the impermeable shale of the cap rock.

We know there's oil and gas down there. But there's a lot to do yet before we've any idea of how much can be produced. It certainly looks promising-- encouraging enough to justify a flow test. The hole has been cased right down to the bottom and cemented in. A flow tube is now run into the oil zone.

To get at the oil, we have to perforate both the casing and the cement. We do it by firing a string of specially designed charges. The oil begins to flow as the pressure in the well is reduced. The flare-off of gas that comes up with the oil signals a successful test. To get this far has cost anywhere from $600,000 on land to $4 million offshore, yet all we've managed to assess is the potential of the area immediately around a single drill hole.

What interests us now is the rest of the structure. To find out the full extent of the oil reservoir, we have to drill more wells. The first out-step has found water-bearing sands, and we can now reduce the profile of the reservoir in this direction. Next we drill a third well, in line with the other two. This again finds water-bearing sands, and completes the profile-- the shape of the structure, and the position of the oil, gas, and water contacts.

But the profile is still only a narrow band of information in one direction across the structure. To round out the picture, we now need to drill further out-step wells at right angles to the first three. Even with a classic dome-shaped structure, out-stepping can have its disappointments. Nothing but water, and much lower down than expected. The rocks have slipped along a fault line, blocking off the reservoir. This is what's called a dry hole. But its information was vitally important.

We've now probed the limits of the structure, and at last we have a three-dimensional impression of the reservoir. We can now begin to plan its further development. To bring the oil field into full production, further wells will be needed. These are drilled into the oil-bearing zone beyond the edge of the gas, so we get the maximum assistance from both gas and water pressures in driving the oil to the surface.

As more and more oil is withdrawn, we can inject water back into the structure to maintain the pressure, by drilling more wells outside the limits of the oil accumulation. An oil field may extend over an area the size of a town, with a network of pipelines for gathering the oil and maintaining pressures downhole. If

The oil field were offshore, the whole installation, complete with treating facilities and pumps, would have to be concentrated into a very small area. To be economic offshore, drilling and producing facilities need to be located at a central point from a permanent platform. The oil reservoir is then developed to the same pattern as on land by using the technique of deviation drilling.

Oil reserves are much harder to find nowadays, but when they are, it's most often in locations that are very difficult to develop. But wherever they exist, and however complex the development becomes, it is our job to reach them using every human and environmental safeguard possible, then to recover as much as we can for as long as we can.