Casing a Well

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There has been some concern (that among other things has led to the actions in the House to bring hydrofracing fluid under the Safe Drinking Water Act) about the use of different fluids in oil and gas wells and the risk that they can get into and contaminate surface ground waters that may be used as drinking water. So I thought that I would write a little about **well casing** today.

Not that well casing is the only thing in the local environment that has to be protected or designed for. Because the odds are that where you want to drill does not sit right next to a highway. That means that you are going to have to install some sort of a road to get to where you want to put the drill. That may sound fairly straightforward in somewhere like Texas, (though it got some folks upset in Wyoming), but it becomes a lot more complicated if your oil patch is in the middle of the North Slope of Alaska, or the Empty Quarter in Saudi Arabia.

In the North Slope, for example, they make the roads out to the sites out of ice. Because the ice must carry the weight of the units that haul the rig into place, the road has to be of a certain thickness, and it has to be at a certain level of coldness to give it strength, (which means winter which is also dark). This means that they can only move rigs at certain times of the year and that restricts the rate at which they can develop new fields and wells. As a result the season is only about four months long, I believe (though have not been up there at that time of year to check).

Having got to the site then it has to be prepared, among other things we need to have a way of getting the cuttings that come out of the hole separated from the drilling mud, and then having a place to put both them, and to store the mud until it can be drawn back into the pumps and circulated back into the hole. And we need to create an initial hole, or **cellar**, where we can start the drilling pipe into the ground. I will cover all the different things that go into the surface layout in another post, let’s for now concentrate on that hole, that is going to head down for up to several miles in order to get to the oil or gas.

This initial part of the well has to be fairly large, for reasons explained below. Let us begin the well with a fairly large sized drill bit, say 9-7/8 inches in diameter. So we thread this into the drill collar, lower it to the rock surface and start to rotate the string. As the bit advances we can monitor the rock that it drilling through by looking at the cuttings that come out of the hole. We have some idea of what rocks are down there from the surveys that convinced us to drill here in the first place, but it helps to have this confirmed. Plus we need to know if there are any unpleasant surprises down at the sharp end. As the hole gets deeper the time for these cuttings to reach the surface, and be cleaned and examined, the **lag for return**, gets longer, and so it gets a bit trickier to know what is happening at the bottom of the well.

This can lead to short-term problems. Bear in mind that the hole is being drilled as an **open hole**. In other words, once the drill goes beyond the conductor pipe, it is drilling in rock, with only the rock walls on either side of the well holding it open. This can be a problem in drilling through weak or jointed rock, since bits can fall into the hole behind the bit, and if enough of those fall they can jam the bit in place (since they fall on the bit above the cutting surfaces).

As the bit goes deeper we add additional lengths of drilling pipe to form the drill string, and the bit penetrates through rocks that are of different types and some of these will have fluid in them. Water, whether fresh, which might be the supply for a local community, or salt, is quite common. The hole cannot be left open any longer, because the water flowing from the surrounding rock into the well will dilute the mud, so that it no longer works as it was supposed to, plus, we might start losing some of the drilling fluid into the surrounding rock. Plus different layers of non-drinkable water can work back up the well into the drinking water aquifer.

To stop this from happening we have to stop drilling and seal off the rock on the sides of the well from the well itself. This is known as **casing the well**, and **running casing** will hopefully (but not always) be only needed once before we get to the bottom of the well.

So we pull all the drill string out of the hole, remove the drill and lower steel pipe into the well to encase the well, from the bottom of the conductor pipe down to where the bit has found (and hopefully drilled through) the rock that is giving us the problem. (Hence the name **casing**). Having this continuous length of casing in the hole will likely stop, say water, from getting in and diluting the drilling mud, but if this was all that we did, then it would still leave a problem, since the steel pipe does not completely fit up against the rock wall created by the drilling bit. In other words there will be a gap between the casing and the rock wall, that will allow fluids to travel up or down. This gap has to be filled, and the filler is normally a special form of cement.

The way that the cement is placed is simple in principle, but a fair bit more difficult to do properly and effectively. Think of the long thin tube of casing, filled with a cement that acts something like toothpaste. This cement has to be pushed down the tube so that it squeezes out of the bottom and then flows back up between the casing and the rock wall, filling all the gaps as it is pushed back up to the top or surface. (Hence the name **surface casing**). Particularly when this casing is run, it is important that the gap is fully filled. This is because this is the casing that seals the well from local groundwater, used for domestic and industrial supply. Since the cement will move more easily thorough a larger passage, than a very narrow one, this gap has to be above a certain minimum size. Small **centralizers** will be attached at points down the steel casing to keep it in the middle of the hole, rather than pressing up against one of the walls (since this might leave an open channel up through the cement). There are also "scratchers" which are put on the casing so that when it is rotated in place it will scratch the walls of the borehole and remove any mud cake that might have formed, so as to give a better bond between the cement and the rock wall.

Cementing plugs

A small plastic plug (the bottom plug) is put into the casing ahead of the cement. This separates it from the mud that is already in the hole. It is fitted with wipers, that clean mud from the walls of the casing, and it is pushed down to the bottom of the casing by the cement that is pumped into the well behind it. There are some pictures of some of the tools and descriptions of the process here, here and here.

Once the bottom plug gets to the end of the casing, there are ports it passes that allow the cement to flow out of the casing and back up the outside. Once the cement has been pumped into the casing a second, top plug, also fitted with wipers, is put into the casing and this is then pushed down by the conventional drilling mud. As it is pumped down it forces the plug down, and the cement out and back up to the surface. Because of possible variations in hole size and other possible problems, perhaps about 50% more cement might be pumped into the well than the calculations might suggest. When the top plug hits the bottom plug, then there is a pressure spike at the pumping station, telling the operator that it is finished. The rig then **waits on cement** (**WOC**) until the cement is hardened. The drill pipe can then be put back in the hole and drilling can restart.

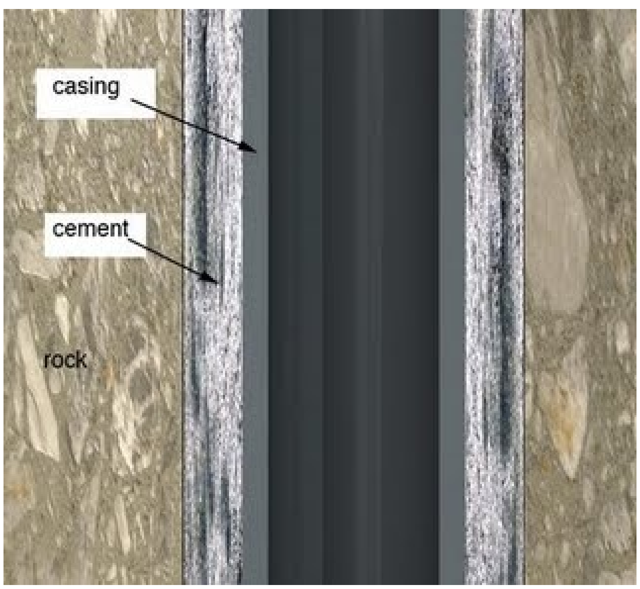

Illustration of a cased well

But whoops, the bit won't fit in the hole any longer! For the sake of discussion lets say we ran half-inch thick casing. And that we had an inch of cement behind it all around the casing. Then the hole we have available to get the drill through down to the bottom is now only 6-7/8th inches in diameter. So we now might use a 6-5/8th inch diameter bit to continue drilling (since we don't want it rubbing against the casing wall).

If we run into another layer of problem rock as we drill down to the bottom of the hole, then we are going to have to run another set of casing. This is known as **intermediate casing**, and the process is the same, and it leaves us with an even smaller hole through which to get a drill bit through.

So that, when you get toward the bottom of the well you may end up drilling with a bit that is only 3-3/4 inches in diameter. These drill with a smaller thrust than the larger bits, and so, although you may have a very powerful drilling platform, with thousands of horsepower available, you may end up, as you approach the **pay zone** where the oil is, using only a fraction of that power.

We'll discuss what happens when you hit oil next time, but perhaps by now you might begin to understand why, in drilling a well that might cost $1.25 million, the actual drilling part alone may be no more than a third of the cost.

As usual I welcome comments, questions or criticism. But to catch the obvious one - yes, after running casing, the first thing you have to drill through are the two plugs and the remaining cement in the bottom of the well, before you can reach and start drilling through the rock again.