Why Gas Well Drilling is Environmentally Risky

By
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"Despite recent advances in the cementing of oil and gas wells, many of today's wells are at risk. Failure to isolate sources of hydrocarbons early in the well construction process, or later after production has begun, has resulted in abnormally pressured casing strings. In addition, produced water can contaminate other subsurface zones, such as fresh water aquifers. This results in wells that are environmentally and operationally hazardous. The well's revenue stream can also be interrupted or reduced because of the loss of lift efficiency in the pump, excess water or gas handling issues, inefficient remediation or stimulation treatments, and potential loss of the well owing to casing collapse. The environmental impact of contaminating a single fresh water aquifer is extremely serious. Therefore, the initial and long-term quality of the cement sheath and bond should be of prime importance to the operator, because it is essential for the safe and successful production of a well."

Well Cementing, Second Edition, 2006, Schlumberger, Introduction

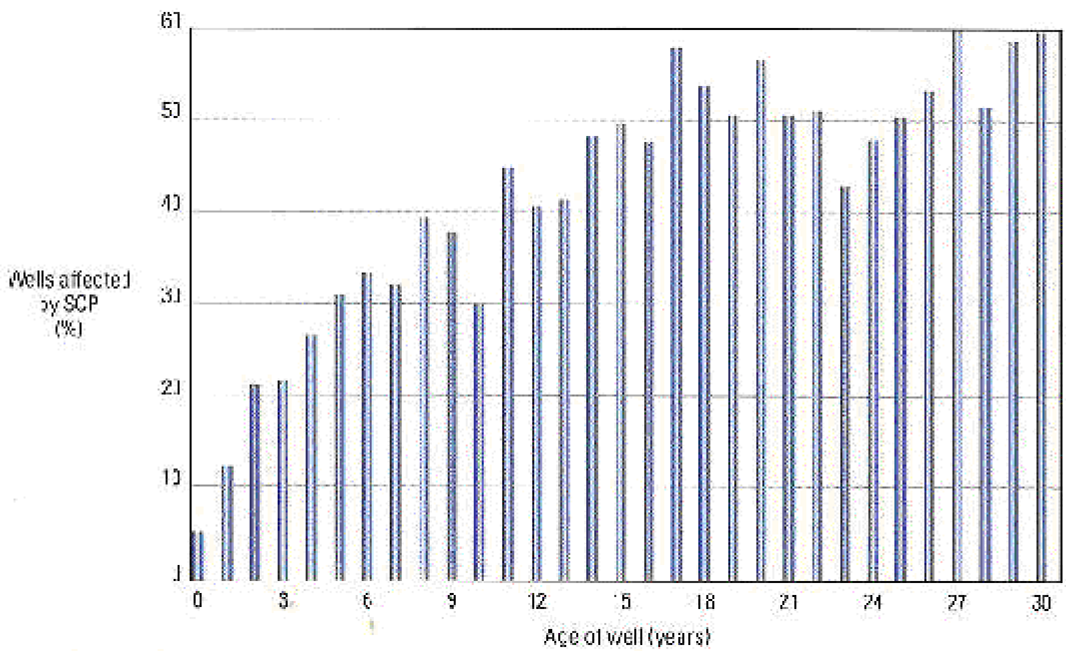

Fig. 1-1. Gulf of Mexico wells with SCP (from personal communication, J. Levine, 2003). Figure from U.S. Minerals Management Service.

The above figure, from the Schlumberger well cementing book shows how the percentage of wells that have developed cementing failures rises with the age of the well. In this figure, SCP means "sustained casing pressure". This is measured at the wellhead and is often called the Bradenhead pressure. These data, published in 2003, are from the 22,000 underwater wells in the Gulf of Mexico, but the failures have nothing to do with the fact that these are underwater wells. After 10 years about 40% of wells have cement failure. After 30 years about 60% of wells have cement failure.

There are a lot of reasons why failures develop, and bad initial cement jobs are one of these reasons. Debonding and fracturing can happen regardless of the quality of the initial cement job. This paper will explain how failures can develop.

There can be no explanation for the many documented cases of the ignition of water coming from a kitchen faucet fed by a well except contamination by gas wells that weren't in place before the water began to be ignitable. Ignition of faucet water has been recorded many times on video in recent years. That is undeniable documentation.

Yet, the industry claims there are "no documented cases" of drinking water contamination due to gas drilling. For example see http://www.energyindepth.org/2011/03/fact-checking-the-usa-today-hydraulic-fracturing-is-a-critical-environmentally-proven-energy-production-technology/. Proponents of gas drilling will stand up in public and chant this lie as a mantra—never mind what an obvious lie it is. And so far they have not been taken to task for this brazen dishonesty. In fact, as a defense it continues to work quite well with the media.

But the fact is that the industry's own research shows how and why ground and surface water can be contaminated by gas wells whose pay zone is thousands of feet below the surface. This research is documented in the Schlumberger book under discussion here.

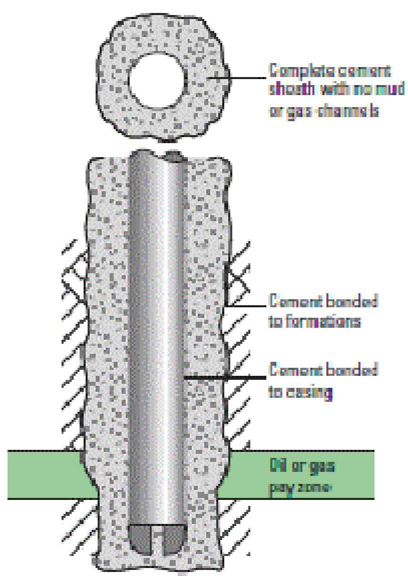

Fig. P-1. Objectives of primary cementing.

The figure above, from the book, illustrates the objectives of primary cementing. It shows that the well bore is not precisely cylindrical. The cement job must fully surround the casing, with the casing approximately centered in the bore. There must be no drilling mud or gas channels in the cement or around its interfaces with the bore and the casing. The cement must form a bond with the rock formation and with the casing. If these conditions are not met then gas can migrate from the pay zone up the well bore as far as the surface. In fact, that is exactly what happens to produce SCP in a well.

How can the initial cementing job be faulty?

There are two principal problems identified in Chapter 5 of the book. One is well preparation, and the other is mud displacement.

"Events occurring during the drilling and casing phases will affect the cement job… A borehole in good condition for cementing operations has the following attributes:

- Controlled subsurface pressures
- A smooth wall with doglegs of low severity
- In-gauge (i.e., the expected diameter according to the bit size)
- Stable (i.e., free of formation encroachment or spalling)
- Clean (i.e., free of cuttings)
- A correctly treated and mobile mud that will deposit thin filtercakes in front of permeable zones."

"Failure to achieve these requirements may have the following consequences:

- Differential sticking problems while logging or running the casing
- High drag forces, preventing the running of casing to the planned depth
- Influxes or losses while running the casing
- Poor mud removal resulting in poor cement placement."

The chapter goes on to discuss laminar and turbulent flow, circulation and displacement efficiency, geometrical problems such as hole eccentricity (deviation from a circular cross section) asymmetric casing placement in the hole, compressible and incompressible mud, deviation of the well bore axis from vertical, and other factors.

All of these factors can affect mud removal through displacement. The complexity of the problem is enormous; there is no fail-safe method of assuring an optimum well preparation job.

Now we turn to the problem of mud displacement.

"Good mud removal is the single most important requirement for a successful primary cement job."

"Chemical compatibility between fluids pumped in succession is equally critical to mud displacement."

Well Cementing, p 445

The problems associated with well preparation and cleaning the drilling mud off of the surface of the well bore rate a complete 46 page chapter (Chapter 5) in the book. It is a very complicated problem that is different for every well. The problems involve consideration of many geometrical factors, fluid composition factors, flow factors, and placement of mechanical aids such as plugs, spacers, and centralizers in the well bore. There is sophisticated software available to simulate the situation, but it depends on many factors that are frequently poorly quantifiable. The software employs neural networks, which implies that the physics is not completely understood. Every case is unique. Basically, effective mud removal remains today an art, one that cannot yield results whose quality is known before cementing.

Suppose the well bore traverses a porous zone. There are three possibilities. The formation pressure is less than, equal to, or greater than the hydrostatic pressure exerted on the bore wall by the weight of the drilling mud or the cement slurry. Ignoring the "equal to" case, drilling mud or slurry will tend to escape from the bore into the formation or be displaced by whatever liquid (or gas) is in the formation. Either situation is bad.

If the pressure in the formation is less than the hydrostatic pressure in the well bore this is supposed to be countered, in the case of drilling mud, by the deposition of filtercake material on the surface of the well bore sufficient to balance the pressure. If the pressure is greater than the hydrostatic pressure in the well bore the liquid or gas comes into the well bore and alters the composition of the drilling mud.

In the case of cement slurry, If the pressure in the formation is less than the hydrostatic pressure in the well bore and if the well bore is clean to start, water in the cement slurry escapes into the formation and the density of the slurry is increased, making the slurry mixture less than optimum for cementing. If the well bore is caked with filtercake, the slurry does not lose water, but neither does the cement bond to the rock formation.

If the pressure in the porous formation is greater than the hydrostatic pressure in the well bore, then whatever fluid or gas is in the formation escapes into the well bore and ruins the cement slurry.

Finally, it is one thing to run sophisticated simulation software that models a newly drilled well bore to the best of the ability of a model to emulate reality, and quite another to accurately mix the prescribed optimum drilling mud or chemical wash or cement slurry in the field.

There are many ways for the initial cementing job to be a bad one. Of course there are cement logs that can be run, but these are not fail-safe either. For example, filtercake remaining on the bore wall in a porous formation may not be detectable.

So…now we come to ways in which the cement can fail over time. Standard stories presented by the industry don't talk about this. Once the cement job is done everyone lives happily ever after. We need a reality check here.

Take a look at the picture below. This is a nice looking flagstone sidewalk just a few years old. But if you look at it closely you see cracks that have developed between the mortar and the stones (See the second picture.) Think about it. Have you ever seen a flagstone walk or patio that didn't have cracks?

A nice flagstone sidewalk

Flagstone sidewalk—closeup

Why does this happen? The stone and the mortar have different mechanical and thermal properties. The ground shifts a little. The temperature changes cause materials to expand and contract at different rates. The bond interface is a surface where stress occurs. This is what causes the cracks.

The same thing happens at the interface between the rock in the well bore and the cement and between the steel pipe and the cement. Over years the stresses produce debonding and/or cracking, and a microannulus or crack develops. This produces a pathway for gas to migrate to the surface and into ground water on the way up the borehole. This sort of failure occurs in 40% of wells by age 10 years, and 60% by age 30 years.

Given what we've been told by industry, the cement failure percentages are surprising to us, but they are consistent with the well water contamination evidence. Industry's chorus of mantra chanting PR employees denying the facts in the face of this solid evidence destroys whatever credibility it could have saved by being honest. But worse, the effect has been to shut down meaningful communication between industry and the public because the media is really an arm of the industry and will not challenge the lie.