Are wells perforated on depth today?

The neglect of +50-yr-old technology results in wells perforated off depth, while packers, cement retainers and bridge plugs are set too high.

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In wireline, the issues are remarkably similar to what they have been for decades. Although pipe manufacturing can create nearly identical joints, pipe stretch is well understood and LWD/MWD reduces wellpath uncertainty, the pipe tally is still done manually, and human error can still trump everything else. Thus, the openhole log remains the standard for well depth, and everything is adjusted to it.

Cable stretch is another longstanding issue. Normally, it is compensated for by gradually dialing into the odometer wheel. Cerebus software by CTES is widely used by many of the major wireline vendors. The software can create a stretch chart simply by typing in the factors the cause stretch, i.e., temperature and coefficient of friction. In openhole, this stretch can be gradually dialed out as the logging sonde ascends uphole. However, the software does not account for creep either in cased-hole perforating, openhole sidewall cores or formation testing.

In cased hole, the openhole log is used as the depth standard. But the issue of stretch, and its related problem—creep—can cause perforations to be off. Tying in to casing collar patterns still has a small potential for human error. Computer-controlled manufacturing can create much more uniform-length pipe joints, and it becomes necessary to insert an intentionally short joint as a marker. However, two identically short joints, placed too close together, can create two identical joint patterns, if the wireline engineer is not careful in his pattern matching. This human error is still a big factor, whether it's the driller or the logger.

To the authors' knowledge, there exists no systematic study to see whether perforations and similar depth-controlled well activity tends to be high, but that seems likely. The Editor of this magazine says that in a few instances, when he had the opportunity to unambiguously see perforations—either as noise on a casing collar log, electromagnetic casing thickness tool, or caliper log—they tended to be high (2 ft to 6 ft). Unfortunately, such opportunities were very limited. In the case of a plug or packer, it's not too important. On occasion, perforations that are a couple feet high could produce less than optimum results, or even shorten the distance to an ocean of water production.

CREEP

In the 1950s and 1960s, determining and adjusting for wireline "creep" was a standard practice when perforating or setting packers, bridge plugs, cement retainers and other downhole tools. "Creep" is generally defined as the upward movement of downhole tools that occurs *after* the wireline winch has been stopped at the surface, since there is no way to know the slack in the line while the tools are moving down the hole.

Creep determination was considered critical to a wireline company's operation and reputation for depth measurement accuracy. It was considered so important that failure to account for creep was grounds for immediate dismissal at some firms in the early 1960s. Creep determination and adjustment were required when shooting sidewall cores or taking openhole formation tests, as well as when perforating or setting packers, cement retainers and bridge plugs in cased hole.

The advent of the logging computer has been accompanied by the frequent neglect of wireline creep in cased-hole work. This is because a wireline operator can put his job in jeopardy using software that doesn't adjust for creep.

The logging computer draws a picture of the perforating gun on the log strip at the depth where the gun is stopped, using the odometer reading at the surface. If the wireline operator adjusts for five feet of creep by stopping the tool below the zone of interest, so that the tool creeps upward to the proper depth, the software will draw perforations where the tool was first stopped (below the zone of interest). Operationally, the boss (and client) will see from the software-drawn log that the wireline operator "shot deep" by five feet. No step in the software allows the operator to program in creep. So, by doing the right thing, a wireline operator could lose his job.

In a recent Oklahoma well, a 30-yr wireline hand told this author that a major wireline company no longer adjusts for creep, and that most crews do not know how to adjust for creep. Regardless of the cause, it appears that creep is being neglected today in many instances. When wireline tools are stopped in the hole to perform some operation, wireline operators neglecting creep will perform the operation at a depth shallower than intended.

CONTRIBUTING FACTORS

Since creep occurs as the tension in the wireline comes into balance, it can be affected by many forces in the borehole including:

- Wireline speed. Increasing the upward logging speed increases creep because the faster you pull, the more the line stretches. When the wireline operator stops the tool, some of that stretch comes out.
- Tool weight. Heavier tools have more creep because they exert more downward force on the wireline, increasing the stretch.
- Depth. Deeper wells require deeper tool placement and those wells generally experience greater creep. There is more wireline in the hole and therefore more line stretch.
- Wireline diameter. Decreasing the line size increases creep. A smaller line will stretch more with the same weight tool compared to a larger diameter line.
- Wellbore deviation. When logging uphole in a deviated well, there is more line tension due to wireline drag on the borehole wall. This produces increased

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line stretch, which is released once the wireline is stopped, thus producing more creep.

• Fluid viscosity. Increasing fluid viscosity in the casing increases creep because pulling the tool through thick fluid puts extra tension and stretch in the line.

• Tool OD compared to casing ID. Closer tolerances in the wellbore increase creep. This is similar to pulling the tool through viscous fluid. The reduced annulus around the tool creates more drag, which increases both line tension and line stretch.

The last factor is the main reason why packers, bridge plugs, cement retainers and other wireline tools can have large amounts of creep. Generally there is only about ¼ in. of clearance for fluid to move around the tool. There is not as much creep with a perforating gun, since they usually have about three inches of clearance. One packer in a deep well in Oklahoma had 30 ft of creep.

WASHING PERFS

After discussing depth issues with 20-40 rig supervisors from south Louisiana and offshore, they routinely reported finding perforations shallower than expected, when they ran perforation washing tools with a mechanical collar locator.

The supervisors would first run the tools below the perforations and affect a pressure test on the wash cup rubbers against unperforated casing. This is done because the perforation process creates a burr on the interior wall that can cut the wash cup. The pressure test is done to confirm that the cups are intact and holding and are capable of washing the perforations. If the cups have been cut, then the burr must be polished off with a scraper run, the cups replaced and the perforations re-washed, all of which adds rig time and other costs.

The tools were then raised to begin washing the perforations, but instead of washing, another blank pipe test was experienced. The perfs were not where they were supposed to be. The tool often had to be raised several times before it reached the perforations to begin washing. The correct length of perforations was eventually washed; they were just higher than expected. One operator said he had to raise the tool five different times. The perf-washing tool has a mechanical collar locator. It doesn't have the kind of creep that the perforating gun has, plus the washing tools are on pipe, not wireline.

There have been wells that had a gas-oil contact in the pay zone. The perforations were picked to minimize gas production. However, when the well was placed on production, gas production was excessive. The explanation was that "the gas coned down" into the perforations. Although this is possible, it just might be that the perforations were higher than planned because creep was not determined and accounted for when the well was perforated.

Rig supervisors often experience stinging into packers, cement retainers, etc. when their pipe measurements indicate that they need to add pipe to be on depth. The explanation has always been the "inaccuracy" of the pipe measurements. In reality, it was the packer or cement retainer that was set higher than planned. If anything will have creep, it will be packers, etc. due to the tight clearances in the well.

ANECDOTAL EXAMPLES

A company in Argentina had a well with two large sets of perforations separated by five feet of blank pipe at a depth

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of about 9,800 ft. Production logs determined that the lower set of perforations had watered out, so a bridge plug was set in the five feet of blank pipe that separated the two sets of perforations. When the well was returned to production, water production was still excessive.

Preparations were being made to squeeze cement into the upper perforations to "repair the bad cement job." The supervisor recommended that they confirm the actual depth of the bridge plug before starting the squeezing operations. The crew found that the plug was not in the five feet of blank pipe, but was set in the upper perforations and had over five feet of the upper perforations below the plug. Water was coming from the lower perforations around the bridge plug thru the upper perforations. The old plug was drilled out and a new bridge plug was set at the proper depth in the five feet of blank pipe after determining and adjusting for creep. The well then tested water-free production. No cement squeezes were required.

A company in Alberta, Canada, checked for creep in a slant hole that turned vertical to drop into the target zone. At about 2,500 ft (800 m), they found 6 ft (2 m) of creep.

Another example is a "straight" hole in southern Louisiana with two bad doglegs. The well had nine feet of creep at 7,200 ft. Another well, in northern Louisiana, had 15 ft of creep at 11,700 ft. When the effort is made, the evidence of creep is abundant. It is a mystery why something as important as determining and adjusting for creep is being routinely ignored today.

When the pay zones are thick, with no contacts in the pay and the perforations too high by 5, 10, or even 15 ft, it probably would not change the production rate very much or the ultimate recovery from the well. However, when the pay zones are thin, 5–10 ft thick, failure to account for creep could result in a "dry hole" with the well plugged and abandoned.

In the US, Argentina, China and many other areas, the pay zones are laminated and fracture stimulations are required for a commercial well. If many of the perforations are in the shale instead of the pay zones, fracture stimulation will connect with the pay zones, but the pumping operation will be through a much narrower fracture in the shale. When proppant is introduced into the fracture, a hard screen-out can occur because the fracture does not have enough width for the proppant concentration that the frac design required.

A recently perforated well had a deviated "S" shaped trajectory. At only 8,970 ft, this well had five feet of creep. Fig. 1 is the correlation log from that well.

The upper set of perforations shown is 10 ft in length with a shale break in the middle of the interval. If the creep for this interval had not been determined and the firing depth adjusted, the lower portion of the sand would not have had a single perforation in it. This would have affected the production rate and ultimate recovery from this interval.

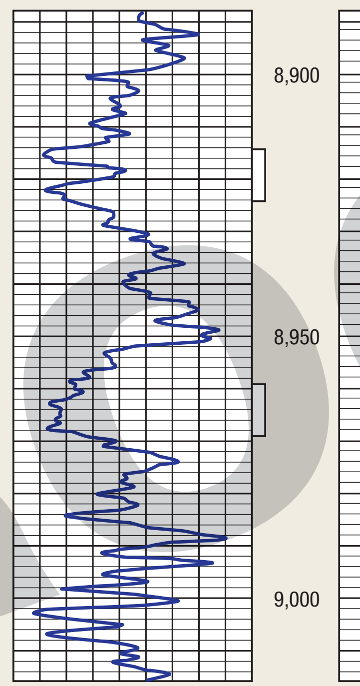

Fig. 1. The upper perforation set is 10 ft in length with a shale break in the middle. If the creep was not determined and the firing depth adjusted, the lower portion of the sand would not have been perforated.

Whenever problem wells, or under-producing wells, are studied, one of the questions that should be asked is, "How would this well perform if the perforations were 5, or 10 or 15 ft higher than shown in the well records?" It might be that the poor performance is due to the perforations being higher than the records indicate.

CREEP CONFIRMATION

When the winch is stopped, how much of the cable stretch that is relieved results in creep? This is difficult to determine in non-true wellbores and it is especially difficult to determine in corkscrew wells, where a capstan effect occurs along the open wellbore or cased hole. The best that can be determined is an estimate of creep.

To confirm that creep either is or is not a problem in a well for a particular operation, do the following:

1. While going into the hole and when nearing the intended zone of operation, slow the wireline speed to normal logging speed, between 30 and 40 ft per minute, and tie into the casing collars while going in the hole.
2. Once at or below the intended zone of operation, stop. Put the winch in gear and log the casing collars, while coming up at 30 to 40 ft per minute. *Do not adjust the odometer.*
3. Compare the collar depths on the two logs. If they are near the same depth and spacing pattern—within one or two feet—creep is small enough that it can be neglected. However, if the collar depths vary by more than two feet, a creep estimate should be made and the depth of the operation adjusted to account for creep.

Another simple way to determine whether creep might be a problem is to stop the winch abruptly and see if the casing collar locator continues to "rattle" for a half a second or more. If it does, it's due to creep.

The usual choices for creep compensate are: to perforate while moving or to estimate a percentage of the difference determined above (perhaps from well design or computer charts of stretch) and then compensate for it in consultation with the operator. Common sense dictates that a worst case scenario be considered. If that is not a problem, then whatever creep occurs can be ignored.

CONCLUSIONS

While it may be true that, short of perforating on the fly, people may not agree on the best course of action, we can all agree creep can be a problem and that creep checks should be made every time a packer, bridge plug, cement retainer, etc. is set on wireline, and that creep checks be made for every perforating interval. **WO**

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