New technology repeatedly provided incident-free perforating in wells with high risk of pump-off

Pump-Down Visualization service and Mono-Conductor Tension Device help navigate torturous well paths confidently with real-time feedback

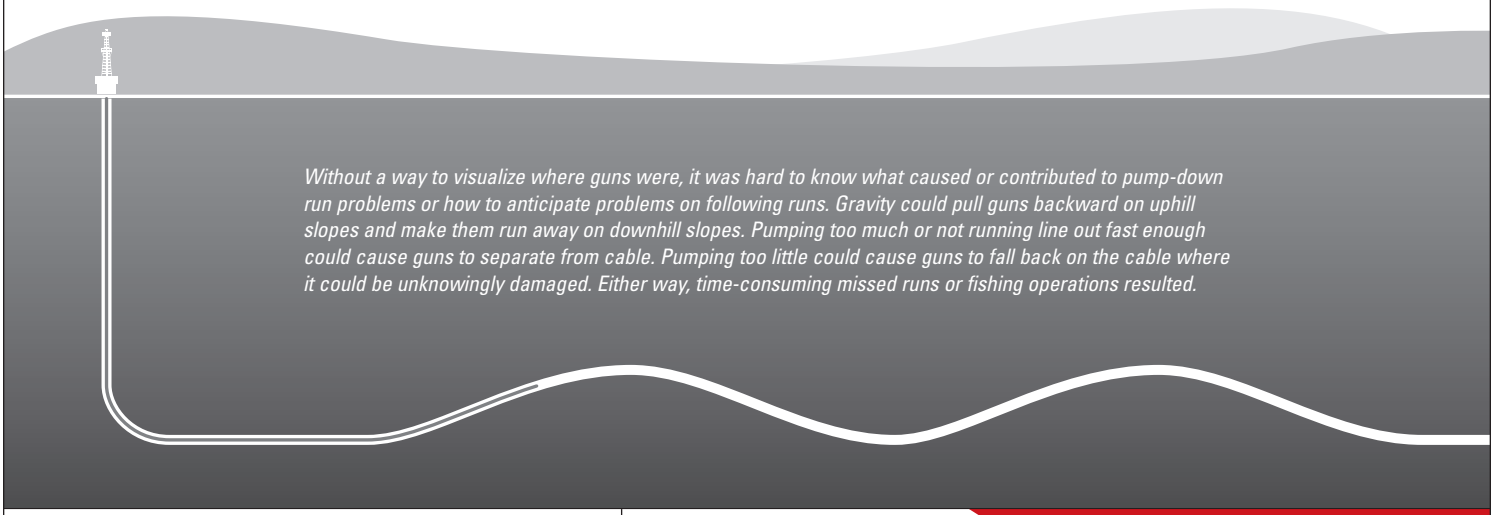
OVERVIEW

As part of a multiwell effort in southern Oklahoma, a major operator was perforating a long horizontal well with two 109° upturns and two 14° doglegs. Until now, crews could not tell the position of guns and the tension at the cable head during pump-down operations in such wells. This sometimes resulted in pump-off (guns separating from cable) or guns backing up over the cable and severing it during perforation. Each could cause nonproductive time (NPT), unplanned fishing expenses, and production delays.

However, Halliburton has two new technologies that – when used together – help dramatically reduce these risks. They visually confirm the position of the guns in the well at all times, so operators know if they are on an upslope or downslope. They also confirm tension on the cable head in real time so operators can keep the working load within safe limits. The client used the new technologies in 31 wells and did not have one pump-off.

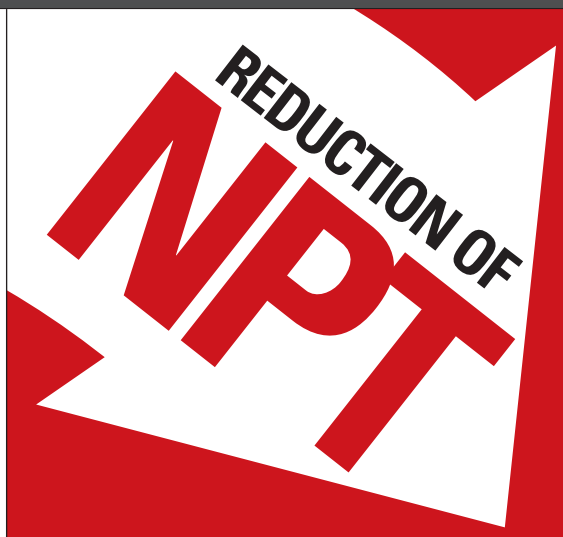
CHALLENGE	SOLUTION
Understanding what's happening downhole In complex horizontal wells, crews may not understand exactly where guns are. For instance on an upslope, guns could slide back over the cable. When firing the guns, if the guns are across the cable, the cable could be damaged or severed, requiring an expensive fishing operation.	**PDV and MCTD** Halliburton's unique Pump-Down Visualization (PDV) software and Mono-Conductor Cable Tension Device (MCTD) help pinpoint the location of guns in real time over a map of the well. This enables the crew to apply the right strategy/pressure at the right time to help avoid problems.
Reacting fast enough to avoid disaster When guns crest a ridge, they may begin to run away downhole. If crews do not adjust pumping rates and line speed quickly, pump-off could occur. Again, this would require expensive fishing to remedy, and delay fracturing and production.	**Technology allows crews to anticipate** The combination of Halliburton's PDV software and MCTD enables crews to see the location of guns in the well at all times. Thus, when they begin cresting a ridge, they can begin running out line faster to help reduce the possibility of pump-off, delays and unanticipated expenses.
Planning the next job Before PDV software and the MCTD, planning the next stage or next job was impossible because crews were "flying blind." They knew what happened on the last stage, but did not know conditions that may have contributed to problems, so they could not correlate run issues to well conditions.	**Accurate stage-to-stage comparisons, post-job report** PDV software and the MCTD correlate pump rate, treating pressure, barrels of fluid pumped per minute, gun string depth, cable speed and tension over time into easy-to-read graphics, overlaid on a well map. This helps crews compare stages, prepare post-job reports, and plan the next job.

TORTUROUS WELL PATHS USED TO MAKE PUMP-DOWN OPERATIONS DIFFICULT AND RISKY



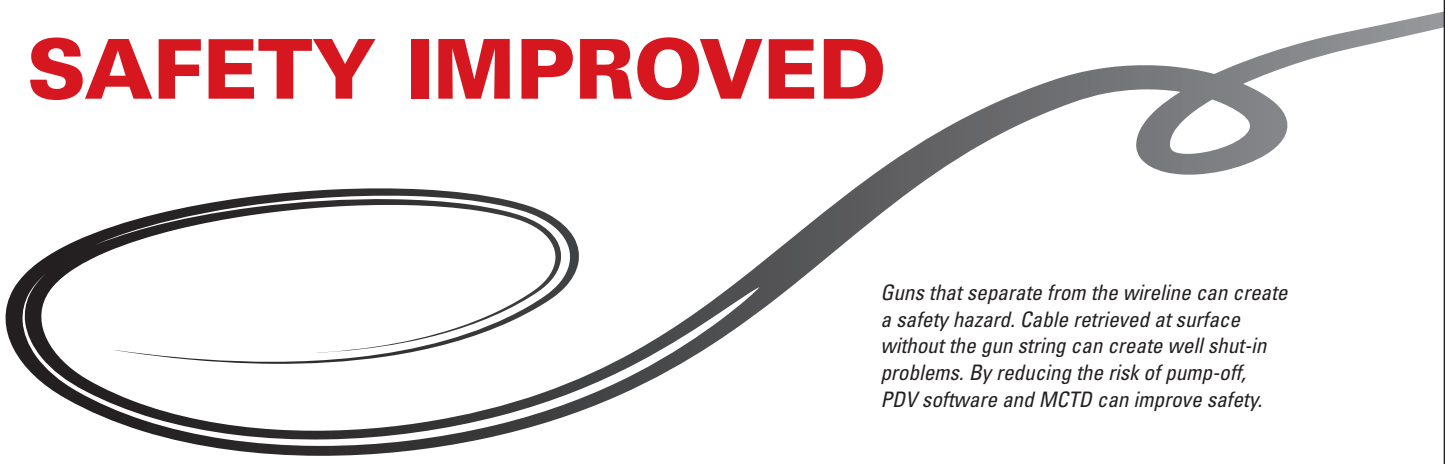
Without a way to visualize where guns were, it was hard to know what caused or contributed to pump-down run problems or how to anticipate problems on following runs. Gravity could pull guns backward on uphill slopes and make them run away on downhill slopes. Pumping too much or not running line out fast enough could cause guns to separate from cable. Pumping too little could cause guns to fall back on the cable where it could be unknowingly damaged. Either way, time-consuming missed runs or fishing operations resulted.

Now operators can see precisely where guns are in the hole during pump-down operations thanks to Pump-Down Visualization (PDV) software. They can also tell exactly how much tension is on guns at any given moment thanks to real-time feedback from the Mono-Conductor Tension Device.



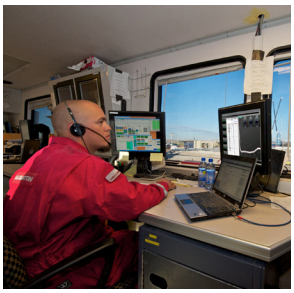
Keeping cable tension within safe limits helps dramatically reduce the risk of pump-off. Reducing pump-off incidents reduces NPT, fishing and cleanout expenses. It also reduces production delays.

SAFETY IMPROVED



Guns that separate from the wireline can create a safety hazard. Cable retrieved at surface without the gun string can create well shut-in problems. By reducing the risk of pump-off, PDV software and MCTD can improve safety.

Pump-Down Visualization service and Mono-Conductor Tension Device reduce risk of pump-off with real-time feedback for difficult pump-down environments



The dangers of "flying blind" in difficult pump-down environments

In southern Oklahoma, a major operator was drilling a series of long horizontal wells, some with deviations as high as 109 degrees. One well in this particular case study needed to be completed in 15 stages. The lateral was 4618 feet in length and had 1,014 feet of rise from heel to toe with two 109-degree upturns and two 14-degree doglegs.

Pumping upslope makes pump-down operations difficult because gravity can sometimes make guns back up. When that happens, crews can perforate and damage cable. Conversely, on downslopes, guns have a tendency to run away.

Knowing how much pressure to apply or how fast to run out cable requires knowing the tension at the cable head and the well trajectory during the pump-down. Unfortunately, until now, there was no way to tell the precise position of guns in such torturous well paths. As a result, crews could accidentally take actions that could cause guns to disconnect from the cable, a condition known as "pump-off."

Such problems required calling out a coiled tubing rig for fishing. They shut down the job, delayed fracturing and production, and incurred added, unplanned costs for intervention and well cleanout.

Two new technologies enable pinpoint positioning of guns at all times

In 2013, Halliburton introduced two new technologies that help avoid such problems. The Mono-Conductor Tension Device (MCTD) and Pump-Down Visualization (PDV) software enhance real-time communication and understanding of what occurs during a pump-down run.

Reducing pump-off incidents and accidental cable perforation

Use of these services has validated tool movement in the well, reduced pump-off of gun strings. and prevented perforating the cable due to gun slide.

Prevention of a single gun-string pump-off and associated fishing costs easily compensates for the per well cost of these services.

MCTD shows tension at top of gun string in real time

The MCTD shows tension on the cable at the gun connection in real time. Studies show that surface tension measurements can be slow to respond or inaccurate compared to downhole tension. Thus, the MCTD gives crews a way to keep tension on the cable within safe limits.

Pump-Down Visualization service and Mono-Conductor Tension Device reduce risk of pump-off with real-time feedback for difficult pump-down environments

PDV software pinpoints position of guns at all times

Halliburton Pump-Down Visualization software displays the position of the guns in relation to the well directional survey supplied by the operator. This enables crews to monitor gun-string transport throughout the pump-down and correlate it with tension readings at the top of the gun string. The combination shows real-time movement of the gun string, helps operators understand the reasons for tension or pressure changes, and react appropriately to help avoid pump-off.

Preventing problems before they escalate to incidents

Now, crews can anticipate problems and plan for them. For instance, when climbing upslope, they can instantaneously "see" (via a reduction in tension) if guns begin slipping back downward. They can then increase the pump rate to keep guns from backing over the cable, and still perforate where planned.

They can also see when guns crest a ridge and begin travelling downslope, so the line speed can be increased to prevent a potential pump-off.

The PDV software combines pumping rate, treating pressure and barrels of fluid pumped from Halliburton stimulation with gun-string depth, cable speed and tension from Halliburton Wireline and Perforating services. The result: easy-to-read graphics that can be displayed in real time in the stimulation TechCommand® Center (TCC), the logging truck or at an off-site office.

Safer, more cost-effective way to transport guns and perforate

The MCTD/PDV services provided real-time visibility and understanding of what was occurring downhole during the pump-down operation in all the stages.

Halliburton completed pump-down operations in 31 wells in the campaign – without delays, issues or expenses that could easily have occurred without the benefit of the new technology.

The customer completed a total of 330 stages using these unique Halliburton solutions with no unplanned events in these high-trajectory wells.

Only pump-down visualization solution in the market

No other company in the industry offers a comparable service. Halliburton can deploy the technology in any pump-down operation.